Human Capital and Models of Economic Growth

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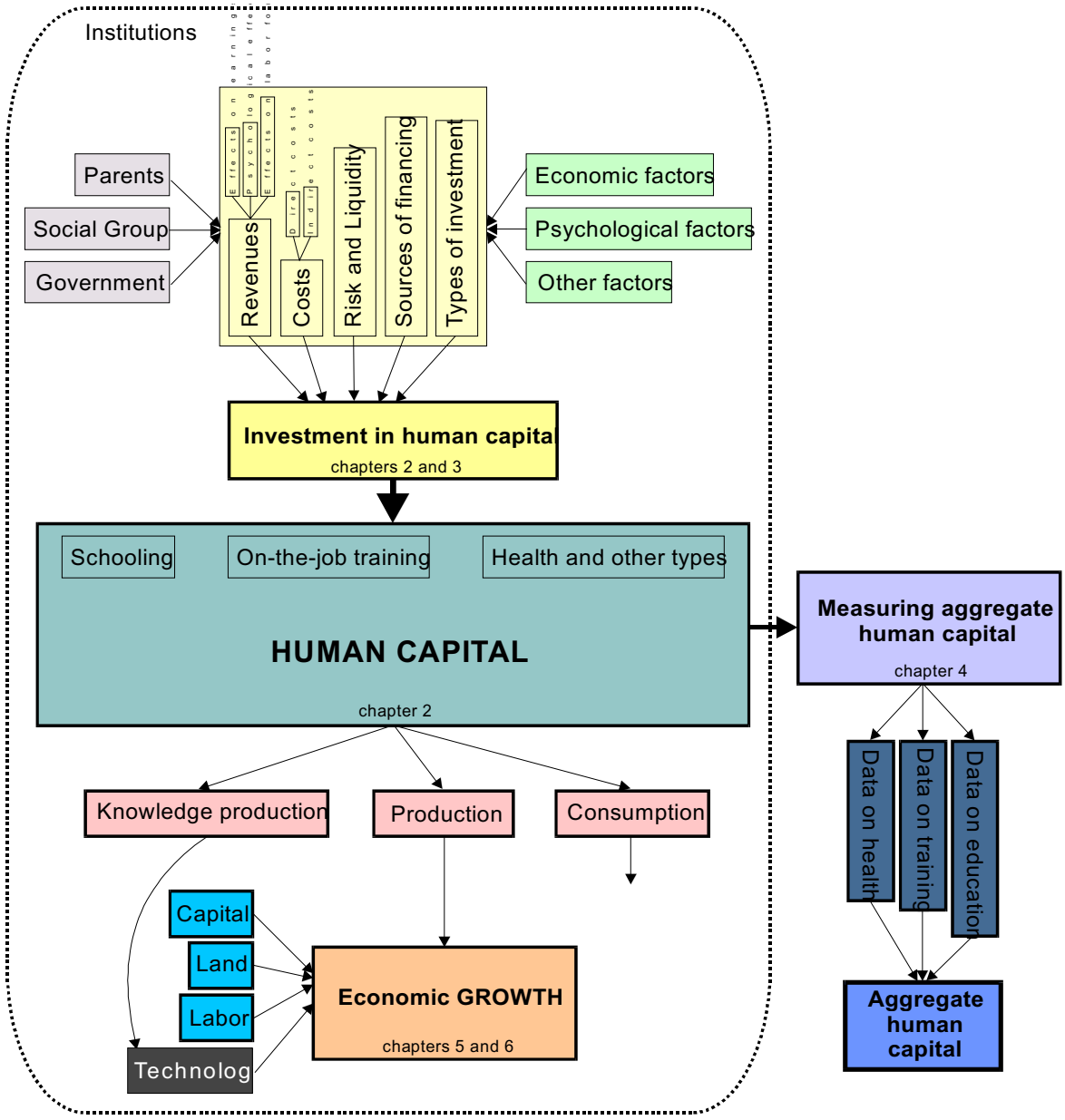
Contents

The Human Capital Concept



1. Introduction

The science called economics has its roots in the analysis of human behavior in the market, that is the analysis of how people act when exchanging goods. There are many theories describing competition, investment in various factors, production, participation it the labor market and other economic activities. Being models, most of these theories (at this point it is not necessary to distinguish between the macroeconomic and the microeconomic level) have to adopt specific assumptions on human behavior, optimal choice, perfect information and other important preconditions. It has therefore become necessary to make an analysis of the conditions, which enable individuals to make the most of their capabilities, to be competitive and productive suppliers of labor, to be competitive producers, etc.

This requirement has been satisfied with a complex theory of marketable human qualities, i.e. qualities mainly designed for use in the labor market, but also for other types of economic activities. This theory is called the theory of human capital. Since its development, many studies on this topic have been published. The theory of human capital has been incorporated in many micro- and macroeconomic models and has become an inseparable part of a number of theoretical approaches.

Chapters 2 and 3 of this thesis summarize the complex theory of human capital and the theory of investment in human capital. Human capital is a set of a person’s abilities and qualities, from which the person can benefit throughout his or her life.

Chapter 4 summarizes the concept of human capital measurement. We will see that many complications arise when we attempt to measure human capital in any part of the world.

Finally, chapters 5 and 6 illustrate the role of human capital at the macroeconomic level. Human capital is used in many models of economic growth, as it helps us to understand the process of producing output and the reasons for differences in growth rates between countries. We can expect countries with higher levels of human capital to prosper more and to be more successful in the modern world of technology.

This thesis also attempts to illustrate the situation in the Czech Republic concerning human capital. Therefore, wherever possible, we have used data on our country to give a clear picture of the situation. We will see that our situation is largely comparable to the situation of highly developed countries.

The appendix consists of a selection of data supporting statements in individual chapters.

1.1 A few notes on the organization of this thesis

On page v, there is a flowchart describing the organization of this thesis. Furthermore, most chapters (and some subchapters) in the thesis start with a smaller flowchart (derived from the main one) describing the main points in the chapter and their relationships.

Data shown in the Appendix are general and usually refer to more than one chapter of the text (indicated by ciphers). Charts, tables and figures important for particular sections of the text are shown in the text (indicated by roman numerals).

2. Human capital and its significance

During the last few decades, technological progress has dramatically changed the production of the developed-world. While, for centuries, work used to be mainly manual and very simple with respect to skills, now most production processes are computerized or automated and often no physical energy is required from the workers. On one hand, no human labor is required to complete the simplest tasks but on the other hand, there are many new sophisticated jobs and technologies, which require very skilled people.

This change, showing an important increase in the value of human capital, is clearly illustrated by the shift of main economic activities from heavy industry towards services in the developed world - a shift from physical capital intensive sectors to human capital intensive sectors[1]. (See figure I)

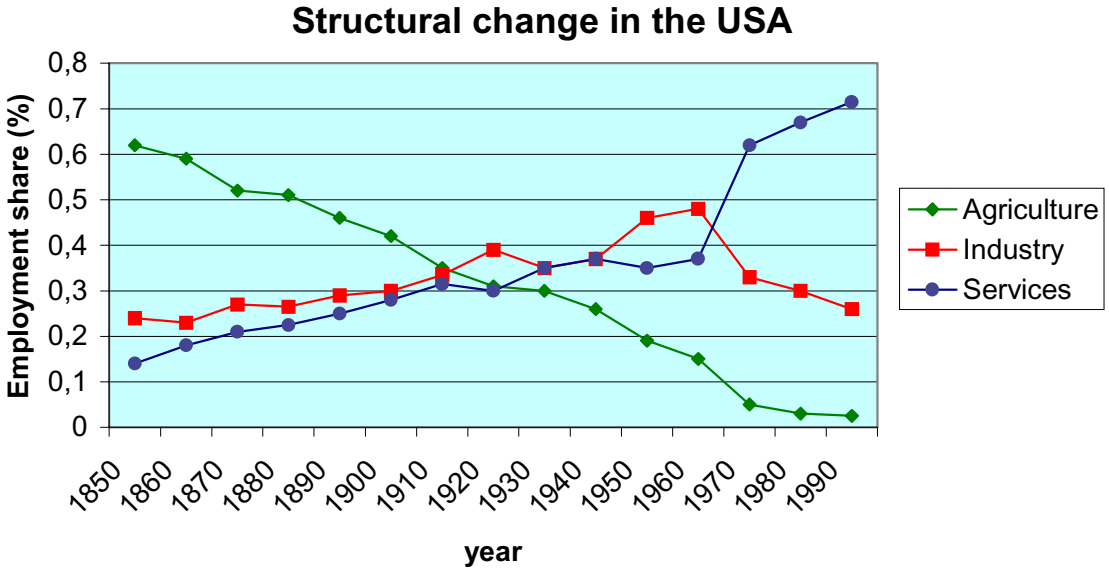
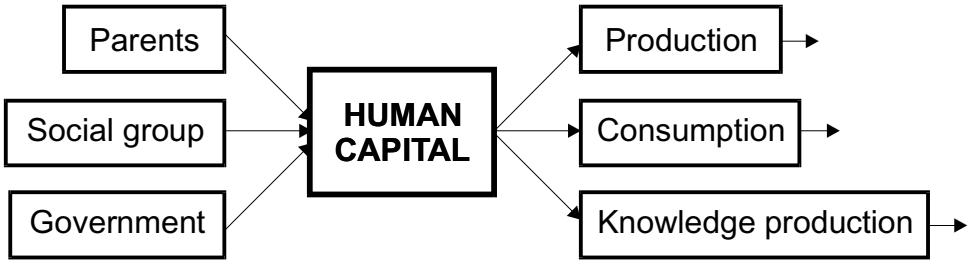


Figure I: Structural change in the USA from 1850 to 1990. (Klenow, Rodriguez-Clare (1997))

[1] In figure I, the services represent the most human capital intensive sector. Although services also include activities requiring little human capital (hairdressers, taxi-drivers etc.), the role of human capital intensive activities (computers and other high-tech services) has been substantially increasing since the 1960's. The importance of these services for the market is clearly illustrated by figure I.

In the last 10 years, the importance of human capital has been increasing in the Czech Republic as well. Since the fall of the centrally planned economic system in 1989, unemployment has been growing and demand for more qualified labor[2] (i.e. the number of more sophisticated jobs) has been increasing. In addition, the shift from heavy industry to services is also apparent in this country[3].

2.1 The meaning and the role of "human capital"



Human capital is a set of a person's capabilities, abilities, health and other features, which help the person in his or her economic and non-economic activities, increasing thus his or her income, improving life, increasing satisfaction etc. It would be extremely difficult to find a person of any age that has no human capital at all (except for newborn babies) but the individual level of acquired human capital may vary substantially across the population. The average level of human capital may also vary across nations according to their level of development etc.

The main difference between traditional physical capital and human capital is the transferability of the former[4].

[2] University educated workers now represent approx. 11 % of the work force in the Czech Republic (see table 1 in the Appendix), while in western countries this share is approx. twice as high. The share of university students aged 20-24 has increased from 16 % in 1991 to 24 % in 2000 and a further increase is expected. (Ministry of Education of the Czech Republic)

[3] The share of the service sector in the Czech Republic has grown rapidly, from less than 40 % in 1985 to 53 % in 1996. This is however less than in the EU (65 %) or in other developed countries. (Ministry of Labor and Social Affairs of the Czech Republic)

[4] Another important difference deals with the ownership of human capital. Unlike physical capital, which can be owned by companies, individuals or by other subjects, human capital can only be the property of individuals. This

Physical capital can be easily transferred from one economic agent to another. This is impossible with human capital. Once it is accrued no one can take it away from its owner and transfer it to someone else with the effect of decreasing the level of human capital of its original owner. It can be passed to another person (at a non-negative cost) but it remains the property of the former one. However, it can be leased to another economic agent. For example, workers are hired by companies for their human capital, their wages usually correspond to their human capital, etc. This leasing contract (i.e. job contract) has its own terms and conditions and in today's modern society where no slavery is possible, no one can force the workers, i.e. the owners of the human capital, to use it against their will. In addition, this type of contract does not imply a change of ownership - a change that occurs in case of physical capital.

The first and one of the most important sources of human capital is the family. Parents transfer their values, habits and traditions to their children. Parents invest in their children's human capital. They invest both time and money. This investment, of course, varies substantially across countries, nations, cultures and societies and it is not easy to measure its cost and value.

Human capital is created and increased during the person's life through many different activities. The main forms of increasing its level (i.e. of investment in human capital) are schooling, (on-the-job) training and health. But even the sole living has some influence on human capital (always at a certain cost, of course). Therefore, the level of one's human capital usually grows with age and experience.

All of the forms of investment are of a great importance. People without any formal education or training have to

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fact has important effects on the essential characteristics of human capital, i.e. its transferability. Companies have to hire their human capital (by means of a job contract).

struggle hard to find a job as their value in the labor market is fairly low.

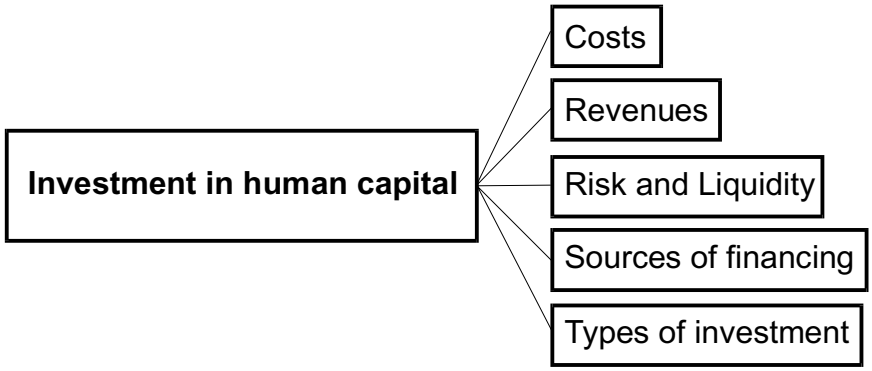
There are many economic activities that make use of human capital, e.g. production of goods & services, knowledge production and consumption. In effect, the main function of human capital is to increase the productivity of other factors. Human capital often accompanies the development of new technologies. The amount of human capital needed for production of new ideas is much higher than the amount needed for their usage (workers needn’t understand the technology but just the way they should use it). The production of new ideas, which is very human capital-intensive, may often result in massive production of goods that requires little human capital for their consumption or usage. This might lead to polarization of the society. (One sector of the economy would require very high levels of human capital, while all other sectors would require no or very low levels of human capital). However, it would be quite difficult to live in a modern society without adequate level of human capital. (The “adequate” level of human capital may of course be different for different parts of the world).

Human capital may help us explain some of the differences between western countries and developing or undeveloped countries in terms of per capita product and its growth. Productivity of labor grows with human capital, knowledge and skills acquired through education and training. As new technologies appear, the demand for skilled workers increases and in some countries, the supply may be insufficient.

There is one important aspect linked to the level of human capital and that is birth rate. A strong correlation has been observed between the number of children and the level of human capital. It can be shown that human capital per child

decreases with the number of children. On the other hand, an increase in human capital usually has, beside other effects, the effects of decreasing the average number of children per family. Countries with low levels of human capital may therefore find themselves in a vicious circle: they cannot increase their level of human capital unless they decrease the average number of children per family, but the average number of children per family will not decrease unless the level of human capital is higher.

2.2 Microeconomic factors affecting the demand for investment in human capital

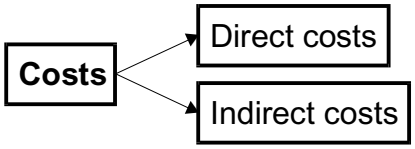


Dealing with investment in human capital, the first thing we have to realize is that investment in human capital is fairly similar to any other type of investment (such as investment in physical capital). People carry out decisions on investment in both physical and human capital according to the level of profitability, risk and liquidity of particular projects. If we expect people to be rational, net rate of return (gross revenues minus costs) on all investments should be the same[5]. Certain level of uncertainty is connected with both types of investment.

[5] When carrying out investment in human capital, people seem to rely less on analyses and available data than in the case of investment in physical capital, which is often the job of professionals and consultants in the field concerned. Investment in human capital usually relies on our “instincts” rather than on a “scientific” or “exact” reasoning. However, intuitively we do the same, we compare costs and revenues.

Therefore, speaking about investment in human capital, we should mention at least the following five factors: costs, revenues, risk & liquidity, sources of financing and types of investment.

2.2.1 Costs



What are the costs of investment in human capital? First, we need to note that the costs vary both across individuals and, in time. Like in the case of physical capital, there are two main types of costs:

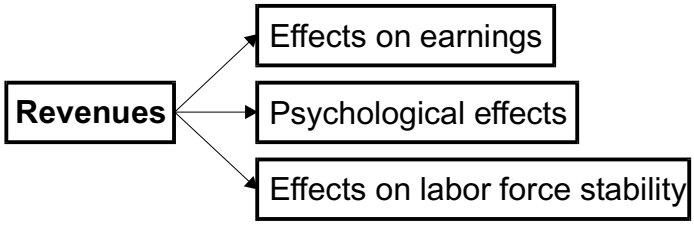
a) *Direct costs* = the amount of money the person pays for the capital. In case of human capital, these costs include tuition, study materials, supplies etc. The costs can be paid by the person whose human capital is to be increased or by someone else - parents, employer or others.

b) *Indirect costs* = opportunity costs. If a person attends a course or goes to school, university etc., he or she invests the time, which could otherwise be used to earn money at work. These costs are usually considered in case of training, or university studies, which are done at the age when the investor can already work, but they may be applied to any type of investment in human capital.

This implies that it is more common to invest in human capital when people are young. The indirect costs of investment in human capital are relatively low for young people, because the price of one’s time tends to grow with the number of years spent at work. Moreover, the direct costs (or at least their part) are often paid by someone else. We will agree that most people spend the first quarter of their life

investing in their human capital. In this period, most of the investment is paid by their parents or by the government.

2.2.2 Revenues



There are several types of returns to or motives for investment in human capital. They include:

a) *Effects on earnings*: Most investments in human capital result in higher future wages because they increase skills and productivity. Investment in training may result in a better position at work. Investment in schooling enables the person to choose from a wider range of jobs and improves his or her chances with the employer as he or she is then considered to have acquired more skills and knowledge. Employers who pay for the schooling of their employees often profit from such investment, because the productivity of their employees is higher. The returns to this increase in productivity are usually shared with the employee.

b) *Psychological effects*: Both the effects on position in a company and on salary have some positive effects on self-esteem and self-confidence (both personal and social). Achievements at school, university grades, etc. usually have similar effects. Psychological profit from some particular types of education and training may be very important and may exceed the monetary return to the investment.

c) *Effects on labor force stability*: As mentioned above, specific training usually helps to secure job to a person and employees to a company. This has an important influence on people’s state of mind because it increases their feeling of security.

Estimating the returns to an investment in human capital, we do basically the same as in the case of an investment in physical capital: we calculate the present value of net returns for each period, which equals the sum of returns (increases in earnings etc.) minus the sum of costs (including opportunity costs) in the period concerned, and then we calculate the total of these net returns for all periods.

Investments in human capital usually have long-lasting effects, which fact makes it more complicated to calculate the exact revenues from such investments. Sometimes (e.g. in case of training) it is also rather difficult to distinguish the period of investment and the period of profits from the investment. It may even be difficult to predict the length of training period. In addition, it is very complicated to calculate the psychological effects of these investments.

2.2.3 Risk and liquidity

Risk and Liquidity

One problem of investments in human capital is its very low (or even zero) liquidity. Its owner cannot sell it or use it as collateral[6] for loans, which affects the risk connected with such investments. This implies higher expected or required revenues from the investment because, if we apply classical rules for investing, the revenue should be equal to the risk-free asset revenue plus a risk premium (which is expected to be relatively high in case of human capital).

Factors increasing the risk of investments in human capital are for example:

[6] While for example a mortgage can be obtained for a future real-estate property with this future property used as collateral, this is impossible in case of human capital. In addition, the probability that a real-estate property is destroyed is much lower than in case of human capital. (The owner of human capital can come down with an illness or even die.) On the other hand, when banks certify a loan contract, they usually consider the applicant's "quality" including his or her level of human capital.

a) *uncertainty about the length of life*,

b) *uncertainty about abilities* and

c) *possibility of unpredictable events in one's life*.

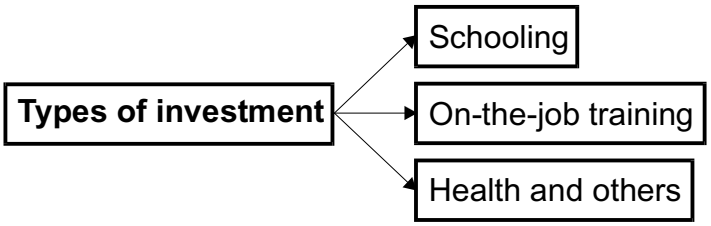
2.2.4 Sources of financing investment in human capital

Sources of financing

Where do we get funds for the investment? Comparisons of wage differences in some countries suggest that revenues from investment in human capital can be very high. The problem is that the investment is quite risky and most investors have nothing to offer as collateral for a loan (they cannot use their human capital that way either).

Nevertheless, it is important for people to invest when they are young because the longer they receive better earnings, the higher the returns to the investment are. (This implies a possible advantage of people from rich families.) It is costly to delay the investment in human capital unlike in the case of physical capital. It is therefore important for society to support investment and to create education funds (financed either by government with no or small contribution from students or by students themselves provided they can obtain loans).

2.2.5 Types of investment in human capital



There are several main types of investment in human capital. The most common types of investment, whose value can be expressed in money, are education and training. We are able

to study and analyze the effects of these two types. We can (probably) easily show the increase in salary after receiving secondary school education simply by comparing the average income of the uneducated with the income of secondary school graduates. Of course, we have to adjust the data according to different abilities and family background.

Other types of investment in human capital, whose microeconomic effects are measurable, include health, various information gathering and others.

Education may increase knowledge and skills of more-or-less general nature but this is usually not exactly what companies and employers need. Therefore there is a need for on-the-job training, which makes the knowledge more specific and more useful for the company. Moreover, education has one more positive side effect. An educated person is more likely to care more for his or her health and to enjoy a richer lifestyle concerning culture etc.

2.3 Implications of the factors affecting investment in human capital

The nature of costs, revenues, risk and liquidity of investment in human capital has (beside others) the following implications:

1) The investment is the more profitable, the greater increase in earnings it represents.
2) The investment is the more profitable, the longer its effects last.
3) The investment is the more profitable, the lower the opportunity costs during the investment period are.

Conclusion:

1) The probability of investment in human capital decreases with the age of the economic agent. The older a person is,

the shorter the period of receiving returns to the investment is. An old person would probably invest only if the costs were low and the effect on earnings very large.

2) People with high levels of human capital are unlikely to invest more, because the costs (opportunity costs) of the investment are very high (because of the effect of the high level of human capital), and yet higher returns would be required. Nevertheless, the psychological profits of further investment may be larger for this group of people, which might motivate them to invest.

3) People usually invest in human capital when they are young, because at that time, their opportunity costs are not so high and the period of profiting from the investment is expected to be long.

4) On the other hand, investment in human capital may reduce the direct costs of the investment. When a person’s human capital is high, it can be easier for him or her to invest more. This effect weakens the effect of higher opportunity costs.

In addition, we can apply usual economic laws:

1) A higher demand for a specific type of education or training leads to an increase in earnings.
2) An increase in the supply of a specific knowledge usually leads to a decrease in earnings (all other things equal).

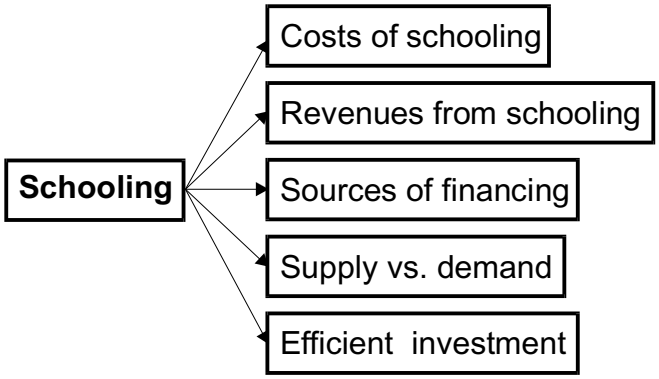
Profitability of investment in training tends to decrease with age. There are three reasons for such development:

i. The period of receiving revenues becomes shorter.
ii. The opportunity costs (value of time) increase over time.
iii. Personal learning costs increase with age.

In effect, investment in human capital usually follows the life cycle. Before and around the age of maturity investment in human capital is the highest. Then people tend to reduce this investment as their physical and mental abilities decrease. Nevertheless, individual profiles are very variable (except for their first and last periods).

2.4 A short description of the main types of investment in human capital

2.4.1 Schooling



Schooling is a process of educating people at institutions designed for this purpose, i.e. schools[7]. These institutions may be both very general and very specific (but they are usually not specific enough to satisfy the demands of a particular company). The level of specialization varies according to the level of school.

Formal education is usually provided by schools and institutions providing tertiary education.

- at the primary level, education is very general[8]
- at the secondary level, students can either continue pursuing the general education or start to pursue a specific education [9],[10]

[7] The average length of school attendance in different countries can be found in figure 1 in the Appendix.
[8] The share of children aged 6 - 14 attending primary or similar school in the Czech Republic is approx. 98,8 %. The EU average is 98 %, the OECD average is 97,6 %. (National Educational Fund (1999))

- at tertiary level[11] the choice and specialization is still broader

Primary schools provide education that is (in case of most countries) compulsory. At the secondary and higher levels, education is usually not compulsory.

The compulsory part of schooling is in case of many countries free of charge, financed by the government or community providing people with the minimum of skills they might need in their life.

To be able to compare the outcomes and to measure human capital, we will assume that educational systems regardless of their organization and structure provide knowledge in the most efficient way. Unfortunately, this is very limiting and not always realistic.

Often if demand for a specific skill obtained through on-the-job training increases, courses training for these skills become part of the curriculum at some schools (if the demand for some specialists increases, it is likely that schools preparing these people will soon start to appear.)

2.4.1.1 Costs of schooling

The definition of the costs of schooling is similar to the above-mentioned definition. There are, again, direct costs (tuition, school supplies, study materials, accommodation, transportation, etc.) and indirect costs (opportunity costs). Different methods of financing of schooling may be used. In

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[9] Approx. 72,2 % of the population of the Czech Republic aged 15 - 19 continued their education at any level of schooling in 1996. This figure is relatively low, the EU average is 80,1 % and the OECD average is 77,2 %. (National Educational Fund (1999))

[10] For the shares of specialized and general secondary education, see figure 2 (General vs. Specific education at higher secondary level in the Czech Republic and other countries) in the Appendix.

[11] In figure 3 in the Appendix, there is a comparison of participation of population aged 18 to 21 on tertiary schooling in selected countries in 1996.

some countries, schools (tuition) are free of charge[12]. In others, the tuition may be very high. The costs can be paid by the person whose human capital is to be extended, his or her parents, through loans or from some other sources.

In both situations, i.e. when the tuition is free as well as when the tuition is charged, there are certain opportunity costs. These costs are relatively important although in some countries the direct costs may be very high. Like with any investment in human capital, opportunity costs increase with age and the level of education of the investor. For very young people (under 15 years of age), these costs are represented by limited consumption of free time. For older people, these costs are reflected in the limited time for earning money at work etc.

2.4.1.2 Revenues from schooling

Economists maintain two different views of the effect of schooling, as a type of investment in human capital, on earnings. Some believe that schooling has just signaling effects (see for example Arrow (1983) and Spence (1974)), while others believe that schooling increases productivity and earnings through an increase in skills and knowledge. The truth is probably somewhere in between.

Schooling can have direct influence on the skills and knowledge of a person increasing thereby his or her productivity. This may directly increase the person's earnings[13]. Moreover, schooling represents a signal for

[12] "Free of charge" means that no direct payments for education are required. Of course, the government has to have money to pay for schooling, i.e. taxes have to be increased or money from other areas of public finance has to be taken. Therefore, "free education" is a form of social transfer, which can be more or less efficient.

[13] According to recent studies, an additional year of schooling increases the wage by approx. 8,3 % in average. (See tables 2 and 3 in the Appendix). In developed European countries, this increase is approx. 7 - 8 % while in the USA it is 10 %. (Institute for Information in Education database)

employers and has a positive effect on the investor's psyche. It may also improve his or her cachet in the society.

2.4.1.3 Sources of financing

There are two basic types of sources of financing schooling: private sources and public sources. The private sources include the investor, his parents, social communities, etc. Public sources are usually provided by the government or local authorities. Each of these sources has its specific advantages and disadvantages (see table I).

Education financing	*Costs*	*Direct advantages*	*Indirect advantages*
Public	Costs are paid by the government or local authorities, usually from tax revenues	Higher taxation in higher income groups, lower social transfers, higher employment of the more educated.	Healthier population, lower criminality, social solidarity
Private	Costs are paid from private sources.	Increased income diversification for lower taxation, better chance to find a job.	Better personal satisfaction, health, culture

Table I: Comparison of the main advantages for the two main types of financing education. Source: National Educational Fund (1999).

The sources may of course include various types of private institutions providing the investor with loans or other support. One problem linked to the investment in schooling is that differences between available financial sources are very large. This may have negative influence on marginal investors who cannot afford to invest as much as they wish to. These differences are in fact smaller in countries where students have to pay for tuition at schools. Here, if they are successful and have high abilities, they have a better chance to find cheaper funds for financing their education. If the system is good, nearly everyone has a chance to find some sources. They are not necessarily the cheapest, but they exist. In countries, where schools are free of charge, the supply, i.e. the number of available places at schools, is limited. In these countries, the differences between sources

of financing may be even infinite (students either pay zero (or very low) direct costs or they obtain no school education at all).

In both cases, the importance of fair admission, and entrance tests is high. These procedures affect individual opportunities. People who fail are utterly denied cheaper sources. They may still invest in their education, but only at higher costs (or much higher in case of “free schools”). A source may represent a rather strict budget constraint.

2.4.1.4 The relation between supply and demand for investments in schooling

Every person has his or her own demand for investment in human capital. This demand is influenced by many subjective and objective factors. Individual demand curves are confronted with the corresponding supply curve.

Becker (1993) lists three possible basic approaches to the relationship between supply of and demand for schooling:

1) Elite approach: Elite approach tells us that differences between the levels of human capital achieved by individuals are caused by the differences in their demand for investment in schooling. The supply conditions are equal for everyone. This implies that human capital differs according to individuals’ ability to profit from it.
2) Egalitarian approach: This approach expects that demand for investment in human capital is the same with all investors and only the supply conditions differ. Therefore, everyone could reach the same profit from the level of his or her human capital, if he or she had the same chance to invest. This chance depends on the area where the person lives, his or her family background and many other factors. This

approach is often addressed by those who support general availability of education.

3) The “non-extreme” approach: We can expect that both supply and demand conditions vary across people, regions and nations.

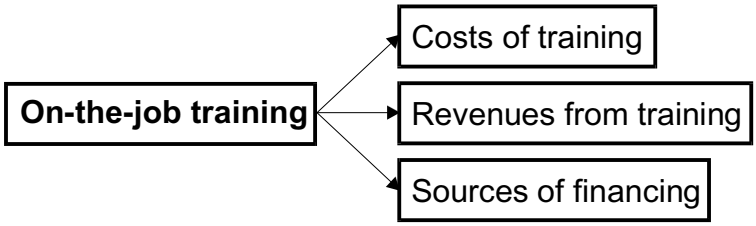
2.4.1.5 When is it efficient to invest in human capital through education?

As with any form of investment: it is efficient to invest in human capital when marginal revenues (MR) are larger than marginal costs (MC). The last efficient unit invested is the unit when MR and MC are equal. This is the classical economic definition of efficiency.

Investment is the higher the lower its costs are and the higher its revenues are. Therefore, its level may vary significantly across different regions. It will probably be higher in regions with low-cost or subsidized education (i.e. regions with higher net revenues) and in areas with higher demand for skilled employees (i.e. areas with higher revenues).

An important problem occurs when we attempt to estimate the efficient amount of this investment. How should we measure the indirect costs and revenues? There is no problem with the direct costs but we may underestimate the indirect factors and this may lead to serious inefficiencies in this form of investment. This problem applies to both micro- and macroeconomic level but at the macroeconomic level, one more problem occurs: the presence of externalities. Higher levels of education usually have a positive effect on health, criminality prevention and other desirable things, which are of course quite difficult to measure.

2.4.2 On-the-job training



Wage of an employee corresponds to his or her capital stock, i.e. to the level of completed education and to the amount of training. Wage increases correspond to the amount of undergone training.

J. Mincer (1993): “The educated have higher earnings, but the earnings are not fixed. They grow over the working life, albeit at a decelerating pace.”

On-the-job training[14] is a process of very specific education of employees at their work. This is necessary in most companies because the skills and knowledge their employees acquire at school are usually not specific enough to be used in practice. Training is needed to increase employees’ productivity and may vary from brief acquainting with the workplace and organizational structure to long-lasting processes of internal education preparing employees for the complicated tasks they have to fulfil[15].

In addition, the potential obsolescence of knowledge and skills increases the need for training. Personal information and knowledge in most fields become obsolete over time, thereby reducing the chance to utilize them effectively unless the employee is regularly trained for and educated in new technologies and processes.

[14] On-the-job training is a part of a broader concept of post-school education (or life-long education), which is encouraged by many modern theories of human behavior. Figure 5 in the Appendix illustrates the differences in participation in post-school education and figures 6 and 7 in the Appendix show a comparison of the shares of individual providers and sources of financing of post-school education in the Czech Republic and other selected countries.

[15] Figures 8a and 8b in the Appendix show the differences in the extent of and the participation in on-the-job training between the Czech Republic and other selected countries.

We can divide training into two groups according to the two basic types of knowledge and skills.

The training can be

a) *General:* This training increases the general productivity of a worker and is useful for more companies than just the one, where the training takes place.
b) *Specific:* This training is useful only for the company where it takes place because it improves very specific skills of its employees. These skills are usually of hardly any use to other companies. In the real world, no regular school can be specific enough to prepare people for a particular job. School education is always rather general.

2.4.2.1 Costs of training

The costs of on-the-job training are not neglectable[16]. These costs include the time the trainee would otherwise spend working and the time and/or the cost of the instructors. The total output is therefore bound to be lower throughout the period of training. Like in any other process of investment in human capital, there are two types of costs - direct and indirect. The definitions are similar to the definitions of direct and indirect costs of schooling.

2.4.2.2 Revenues from training

As training increases the productivity of a worker, it also increases his or her earnings, because earnings normally correspond to productivity. The system of allocating these earnings between the employer and the employee depends on various conditions - on the system of financing the training and on labor market conditions. In a monopsonic market,

[16] Total relative expenditures on on-the-job training in the Czech Republic are very low compared to other European countries. Comparison of these expenditures can be found in figure 9 in the Appendix.

employer’s share would probably be larger than in case of perfect competition.

Research on corporate behavior shows that further education at work has a strong influence on the total performance of a company and its competitiveness, especially when structural and technological changes are accompanied by this education. The efficiency of training depends on its form, i.e. the form of the training has to be adequate to workers’ abilities and knowledge. Only companies with consistent training and education of employees have a chance to be successful in the global market.

2.4.2.3 Financing the training

Who should pay the costs of on-the-job training?

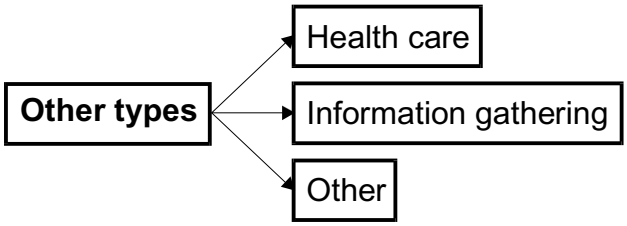
Should it be the company, whose production is increased thanks to the training, or the employee, who profits from the training in form of higher wage? As has been mentioned above, most companies require their employees to master specific skills necessary for particular tasks. If the company pays for the training, it faces the risk that the employee, in whom it invests (they invest in something they do not own and that they cannot control), leaves the company. This implies that the investment may be a waste. The employee also invests in the training - his or her time at least. Therefore, if he or she leaves the company after the training, he or she also suffers a certain loss. The more specific the acquired skills are, the less useful they are for both the employee who decides to leave that job and the new employer.

Training is therefore financed by that part of the job contract, for which it is more profitable. If the investment is very specific, it can be paid by the company, because the risk of quit is relatively low, whereas in case of more general investments, useful for many companies, the costs should be born by the employee.

Becker (1993) concludes that companies will only invest in general, widely usable training of their employees, when they do not pay the costs. A company financing general training can only reduce wages to cover the costs of it during the period of training. After training, employees are not willing to accept lower wages, they tend to leave the company for a new job and the investment is likely to be wasted (because in modern world companies cannot force their employees to remain with them). The worker is motivated to invest by future increases in his or her earnings (in any company, because the training is general).

Companies requiring specific training (e.g. those who have their own original information system etc.) can later deduct the costs of the training from the salary of their employees, because the threat of quit is relatively small compared to general training. Workers who decide to leave a company that has given them a specific training will suffer a loss since the value of the human capital acquired through that training is zero for other companies. This means that specific training is profitable for a company in one more way - it reduces the probability of quit of their workers by which it reduces fixed costs linked with labor (hiring costs etc.). This effect applies in fact to both sides - it also decreases the possibility that a worker will be fired because the company would lose its investment in his or her specific training and therefore it increases the value of the training for both sides of the contract. We can conclude that both costs of and returns to investment in specific training are shared between the worker and the company.

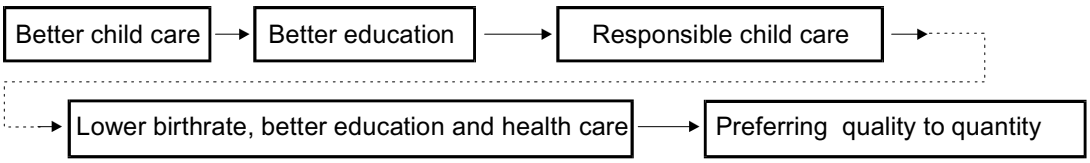
2.4.3 Other types of investment in human capital



Other types of investment in human capital include for example care for a person's health (both physical and mental). Healthier people spend more time on productive activities, live longer and feel better. Companies need healthy employees to maintain their production and profits. The costs, revenues and risk of this type of investment are similar to those mentioned previously. It is important that both workers and companies are motivated to invest in these factors.

In addition, health and nurture are extremely important in childhood when they have an important influence on creation of human capital and on the development of individual abilities. This is one of the points where the government can control and influence future economic situation of the country: through providing for better conditions for the upbringing of children, primary education and medical care. The government can thereby substantially improve the health of people during their life and increase life expectancy (by decreasing mortality and morbidity) which may have a positive effect on economic growth and stability. Longer life and improved health also represent a strong incentive to decrease birthrate, which allows for more investment in other types of human capital. (Of course, such policy should include promotion of decreased family size.)

The above mentioned progression can be defined as follows:



Becker (1993) lists other types of investment in human capital, i.e. activities that increase personal ability to

earn profit (monetary, psychological or other). These are for example gathering of information about prices of goods in available shops[17] (which decreases the costs of living), information about wages in different companies, areas and sectors (which may help find a better or a more earning job) and others. For all of these, the implications are very similar to those of schooling and training. Nevertheless, these activities are yet more difficult to measure, especially at the aggregate level and therefore they will not be mentioned in the next chapters.

2.5 A short description of the situation in the Czech Republic

It is worth to mention here a few facts about the level of and demand for education, on-the-job training and some other factors in the Czech Republic.

Figures 1 through 12 and tables 1 to 3 in the Appendix contain selected data on human capital in the Czech Republic and other selected countries.

Like in other developed countries, rate of literacy in the Czech Republic is very high (99 % - see table 8a). The participation in primary level education (which is compulsory) is of course also very high (almost 99 %, see table 1). Compulsory education in the Czech Republic is shorter than in most of the EU and OECD countries (only until the age of 15 compared to 16 in the EU; see table 1).

However, the share of participation in higher levels of education is markedly lower than in other developed countries. Only 72,2 % of people aged 15 - 19 still go to school while in the EU this share is 80,1 % (see table 1). In addition, at tertiary level (university education), the share of Czech population aged 20-29 is only 11,1 % compared to the EU

[17] In this case, there is a positive effect of human capital on consumption possibilities and availability.

average of 20,5 % (see table 1). The educational system is based on public schools with an increasing number of private schools at secondary level and only a very low share of private schools at tertiary level (these were allowed as late as in 1999). This led to a limited supply and consequently to larger excess demand in the recent past. Nevertheless, this situation should improve with the increasing choice of university and non-university tertiary-education institutions.

Data on "functional literacy"[18], i.e. ability to understand and use information, are dissatisfactory (Institute for Information in Education data). Nearly one third of Czech population falls into the lowest group (in other developed countries, the share is usually less than one fifth). The share of population with the highest level of "functional literacy" is also low (see figure 12). These data indicate that substantial change concerning the educational system in the Czech Republic is necessary.

The involvement in post-school education in the Czech Republic is also relatively low (approx. 32 % compared to nearly 65 % in the EU; see figure 5). The so much supported concept of life-long education has not been enforced here yet. The position of the Czech Republic is especially weak in the area of on-the-job training. Companies invest substantially less than in the EU countries (see figure 9), the involvement in and the extent of the training is lower (see figures 8a and 8b) and the companies are not fully aware of its importance. This is probably a transitional situation only. At the present time, training programs are underdeveloped and companies either have no funds to afford it or prefer investment in

[18] "Functional literacy" consists of three parts: literary literacy (ability to understand written texts of no informational contents), document literacy (ability to find requested data in a specified document) and numeric literacy (ability to work with numbers, to understand figures etc.) Functional Literacy enables us to categorize individuals in 4 groups reflecting different abilities to understand data and facts. Usually the 3rd and 4th groups are the most important for the economy.

other areas[19]. However, within a couple of years, companies are likely to realize that they need to have well trained and educated staff (with high levels of human capital) in order to be successful and competitive in the global market and not to serve as cheap labor force only.

On the earnings side, the position of the Czech Republic is better. The value of human capital (in this case of schooling) is increasing. While before 1989, an additional year of study would increase earnings by approx. 5 % only, now this increase makes up to 9 %. On the other hand, the value of work experience is decreasing (from approx. 4 % in 1988 to less than 3 % in 1996; see figure 4 and tables 2 and 3). The wage increase is not linear, it is more significant for higher levels of education than for the lower levels. These increases are still lower than in most western countries[20] but the trend is positive and consistent with the situation in Europe. The overall wage differentials in the Czech Republic are also increasing and reaching the OECD averages. The differentials are already larger than in the most socially-oriented West European countries and this should be an important incentive to increase investment in education in our country.

The positive effect of education on employment stability is also evident (see figure 10). The probability to become unemployed is significantly decreasing with the increasing level of acquired education. The only exception is the general secondary education, which does not provide the graduates with sufficient qualities for the labor market.

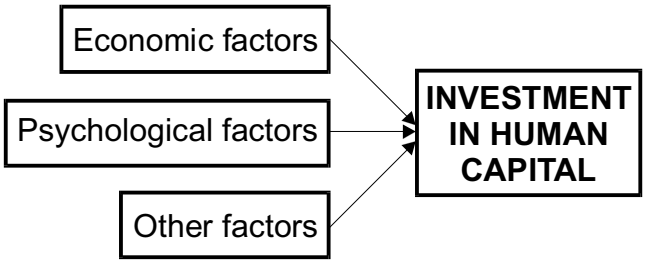
[19] Only 12 % of the Czech companies included on-the-job training in their human resource policy priorities in 1996. A survey carried out by the National Educational Fund in 1998 discovered that only 21 % of Czech companies had a comprehensive training program for their employees. The situation is worse in smaller and national companies. In companies owned by foreign investors, the situation is usually better. (National Educational Fund database)

[20] For example, an additional year of study in the USA increases average earnings by 10 %, but in the Western European countries by 7-8 % only. (Institute for Information in Education database)

The overall health and health care in the Czech Republic has been very good for long, therefore there are no major problems concerning this type of human capital (see table 4).

We can conclude that considerable effort and time will have to be devoted to the development of human capital sector in the Czech Republic. Although the situation is relatively good compared to the world average, we still have to meet the EU and OECD standards, related mainly to education and training, to become an equal member of these international organizations.

3. Demand for investment in human capital



The theory says that similarly to any other type of investment, an individual will invest in his or her human capital when the sum of revenues from the investment exceeds the sum of the costs. The costs and revenues of investment in human capital have been described in the previous chapter. This chapter will attempt to describe in short a simple model of investment in human capital. This model applies theoretically to any type of investment in human capital, although it is designed mainly for investment in education (i.e. schooling or on-the-job training).

3.1 A simple model of investment in human capital[21]

This model consists in maximization of lifetime earnings (utility) and wealth. For simplicity, this model omits indirect revenues (non-monetary revenues). Investment in compulsory education is fixed, therefore it enters the model as a constant.

A model of constrained optimization based on 3 functions:

1) Optimized function: The lifetime wealth is defined by the following equation:

$$W_t = \sum_{t=a}^{R} \left(y_t(h_t) - mS_t\right)(1-\delta)^{a-t}(1-tax), \text{ where}$$

W_t = future lifetime wealth calculated in period t

t = current period

a = current age of the person

[21] This model is based on a model by Ashton and Green (1996).

R = age when the person finishes his or her economic activities (retirement age)

$y_t(h_t)$ = income in period t with human capital at level h_t

m = unit costs of education (including opportunity costs)

S_t = amount of education received in period t, $S_t \geq 0$ in every period

δ = discount rate

tax = personal income tax rate

c = minimum of expenditures necessary to survive in every period

2) Constraint:

$(y_t - mS_t)(1 - tax) \geq c$ => an individual can invest in human capital only when he or she has enough funds to stay alive.

3) Function of human capital accumulation:

Human capital in every period depends on its previous level and current investment:

$h_t = \sum_{j=1}^{t-A} S_{t-j}(1+d)^{1-j} + h_A(1+d)^{A-t}$, where

A = age at the end of compulsory education

h_A = total human capital acquired during compulsory education

d = depreciation rate of skills

Assuming that individuals maximize their total lifetime earnings, we can express the investment in human capital in every period as a function of a number of parameters:

$S_t = f_t(a, c, d, \delta, h_A, m, R, tax, z)$[22], where

z = total effect of one unit of human capital on earnings.

[22] Differentiation of this function is described in Ashton, Green (1996).

We can expect that the following expressions well reflect the real life:

1) $\frac{\partial S_t}{\partial a} < 0$, period of future earnings is shorter for older people, the abilities to learn diminish with age, etc.

2) $\frac{\partial S_t}{\partial c} < 0$, less funds for investment in human capital are available if living costs increase.

3) $\frac{\partial S_t}{\partial d} \overset{?}{} 0$, changes in depreciation rate of investment in human capital may have complicated effects. With higher d the benefits of the investment diminish faster, therefore the investment is less efficient. On the other hand, one has to invest more to keep his or her level of human capital constant. The sign of this derivative depends on individual preferences.

4) $\frac{\partial S_t}{\partial \delta} < 0$, the discount rate makes it inefficient to invest in future wealth. An individual is likely to prefer consumption to investment in human capital if this discount rate increases.

5) $\frac{\partial S_t}{\partial h_A} < 0$, the higher the initial level of human capital, the smaller the incentive to invest in it later.

6) $\frac{\partial S_t}{\partial m} < 0$, the increasing cost of investment will lead to decreasing demand for it.

7) $\frac{\partial S_t}{\partial R} > 0$, a higher R means a longer period of wealth accumulation, therefore it supports investment in the future wealth. The higher the age of retirement, the longer the period of gains from the investment.

8) $\frac{\partial S_t}{\partial tax} < 0$, the higher the tax, the less can be saved, i.e. invested in human capital.

9) $\frac{\partial S_t}{\partial z} < 0$, if the effect of human capital on earnings decreases, the demand for investment in human capital decreases too.

This model is very simple and should help understanding the effects and influences of different parameters on investment in human capital. Its simplicity however leads to a number of inevitable disadvantages and imperfections:

a) We cannot predict the consequences of changes in every variable.
b) We have to assume that most parameters remain constant throughout one's life, which assumption is rather unrealistic.
c) There are many forms of investment in human capital, each of which may have different effects on earnings. To be able to describe these differences the model would have to be much more complicated.
d) The fact that every type of investment in human capital has different costs is not included in the model.
e) As mentioned above, the non-monetary gains are assumed to be zero, which is again unrealistic. To draw this model closer to reality, we have to ascribe the non-monetary benefits some value as well. Unfortunately, this value is likely to vary across the population, according to individual preferences.

3.2 General approach to investment in human capital[23]

(this approach applies especially to education and training)

To determine the demand for investment in a specific type of human capital (especially in a specific type of education) we can define a general function:

$d_h = d_h(c_h, r_h, t, D_h, IN, h_A, IP, MS, SA, PD, other)$. We can make the following statements about the influence of each variable:

a) *Costs (c_h):* The demand for any type of education is negatively sensitive to changes of the price of the education (like any other investment)

b) *Revenues (r_h):* The demand for any type of education is positively sensitive to changes of the revenues from the investment (like any other investment). For example, demand for specific education reflects the demand for the specialization concerned. However, we have to allow for a reasonable time lag.

c) *Time or age of the investor (t):* As mentioned in the previous chapter, the demand decreases with the age of the investor. This does not result only from the fact that younger people acquire new knowledge more easily and their potential lifetime revenues from the investment are higher. We can also expect younger and new workers to be more willing to undergo an educational process and to accept that older colleagues are more qualified and informed.

d) *The field, specialization (IN):* The demand for training depends on the type of the company and on its attitude towards technology. Training and education of employees is broadly accepted and required especially in fast developing industries (high-tech) which experience rapid development of new technologies and substantial changes of the structure of production.

[23] This model is based on Ashton, Green (1996) and Becker (1993).

e) *Initial level of education (h_a):* Demand for education can both increase and decrease with the initial level of particular type of education. We can expect more educated workers to accept new education more easily than the less educated ones. On the other hand, diminishing returns apply to human capital too. In addition, higher level of education implies higher opportunity costs of further education. Therefore, the effect of initial level of education is rather individual.

f) *Individual preferences (IP):* The level of specialization and single-field education depends on individual preferences concerning type of job and its stability. Job-hoppers usually prefer general education and lower post-school investments in their human capital. Individuals with strict career preferences and those who prefer stability usually have higher demand for specialization, which allows for career progress. Such people are also willing to invest more in their human capital, because it is efficient for them.

g) *Market structure (MS):* Education of employees can be larger in monopsonies and local monopolies, where labor mobility is limited and therefore higher specialization can be achieved. This applies also to larger companies, where labor force is stable and where it is efficient to employ highly specialized workers.

h) *Social attitude (SA):* The overall characteristics of a given society may also be of a great importance. Where high levels of education are appreciated, demand for investment in education is higher.

i) *Psychological determinants (PD):* There are many psychological determinants affecting investment in education. It is rather difficult to describe them in

economic terms; nevertheless, it will be useful to give at least an example from the econo-psychological area. This model assumes *exclusiveness* and *requisiteness* to play (at least) a small role in individual's decisions on the investment in human capital (education).

There are two factors affecting the choice of an individual:

1) His or her level of human capital (education), h_{e0}
2) Overall level of human capital (education) in the society where he or she lives, H_e

Then $D(h_e)=f(h_{e0},H_e)$, where $D(h_e)$ is an individual's demand for investment in education.

There are two opposite effects:

a) Individuals with high initial level of h_{e0} in a society with low average H_e, are usually in advantage. We may observe the effect of exclusiveness. If the person's specialization is important for the society, he or she can achieve very high profits from this specialization. These profits are considered a rent. Because of its above-standard returns, the specialization sooner or later becomes less scarce in the society and the advantage of the first individual will gradually diminish. In short, when a particular skill reaches a certain level in the society, the demand for that skill will most probably start decreasing - the effect of decreasing exclusiveness.

b) On the other hand, if the individual has little skill of a particular kind but the average level of this skill in the society is very high, it may become inevitable for the person to acquire this type of education too. The effect of requisiteness implies that demand for a particular skill is the

higher, the higher is the overall level of that skill in the society.

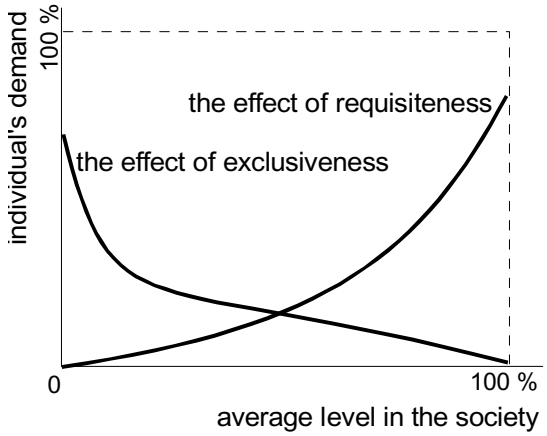


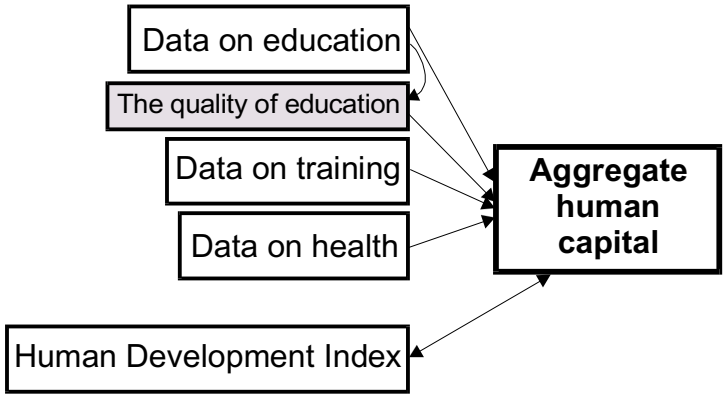
Figure II: The effects of exclusiveness and requisiteness

These effects are effective at different average levels of a skill in the society. Both of them are very individual and may have very different shapes. It is inadequate to expect the demand for a skill of an average person to reach 100 % at either end of the graph. As shown in figure II, the effect of requisiteness is expected to have a smoother slope than the effect of exclusiveness and to have a stronger effect on the demand. This may result from little individualism and prevailing risk-aversion in the society.

This example is here to illustrate one of the many influences that may affect the demand for education, a particular specialization or other types of human capital. Of course, as almost every model describing human behavior, also this one has its opponents.

We can conclude, that although some of the effects on the demand for education are clear, the entire demand is a very complex process that cannot be described by a single simple model.

4. Measuring aggregate human capital



Human capital has become an important part of many economic models in the last several decades. It has been included in a number of both microeconomic and macroeconomic[24] models. The previous chapters attempt to describe some of the features of human capital and to summarize how human capital is developed and accumulated.

Theoretical models seem to be capable of explaining problems linked to human capital. However, empirical studies involving human capital are an intricate task: how should we measure human capital? At the microeconomic level, we are able to examine and evaluate several indicators of personal level of human capital. Although it is not easy, it should be possible. At macroeconomic level, we face a more complicated task: how should we calculate the overall level of human capital in a country?

Many methods of measuring aggregate human capital have been proposed. Most of these are rather simplifying[25], including just a few (sometimes only one) types of human capital and therefore having a very low predicability. This chapter attempts to draft an overview of the approaches to measuring human capital. Some methods are described in more detail.

[24] The main problem of macroeconomic models is the aggregation of heterogeneous labor force.

[25] Without any doubt, simplifications are necessary because of the complexity of the human capital theory . It is impossible to include all possible economic, psychological and other attributes of human capital.

As far as economics (macroeconomics in particular) is concerned, data on human capital are most frequently employed in models of economic growth. Chapter 6 shows that there are many growth models with human capital. Most of them, however, do not introduce their own definition of human capital, or they use a very narrow one (such as average number of years of schooling). Empirical studies need data that are more accurate thence they employ huge sets of variables that should help them determine the input (i.e. human capital) and approximate the reality. In fact, behavior of growth models with human capital cannot be tested until a good measure of human capital is defined.

This problem stems from the complexity of the human capital concept. It is relatively difficult to take into account at least the three main types of investment in human capital:

1) Education
2) On-the-job training
3) Health

Most models involving human capital employ some indicators of the first category - education. A smaller number of models use also data on health. Very few models employ data on on-the-job training [26]. What is the reason for the situation to be so poor? Should all these types of investment in human capital be included in an index of aggregate human capital?

Estimating the real effect of human capital, we need to use an approach introducing a compromise between complexity and efficiency, i.e. a meaningful approach that does not underestimate the importance of human capital. The basic data on education are quite obviously more likely to be available than the data on other types of human capital. While it is

[26] This is due to the extreme difficulties related to the training measurement. The only data available (see figures 5 and 8a) are very limited and their reliability is relatively low.

probably not difficult to obtain data on average school attendance, data on the quality of education and on-the-job training are usually less accessible. Fortunately, data on health (at least some basic indicators) are available.

4.1 Data on education

As mentioned above, nearly every macroeconomic model with human capital involves some indicator of education. It is the simplest way to measure "human capital". A frequent indicator is for example the average school attendance (in years), literacy rate or enrollment rate at different levels of schooling (see tables 5 and 8a). The main advantage of these data is their availability. On the other hand, the predictability of these data is not perfect. The main problem is that these indices usually assume that the quality of education remains constant over time[27]. Unfortunately, it is very difficult to compare the quality of education rather than its mere extent[28].

It is undoubtedly reasonable to include data on education in an index of human capital because the general level of education is a good measure of the quality of population in any country. Nevertheless, the measure we use should be precise enough to enable us to compare different countries and it should therefore correspond to the real differences[29].

Basic data on education can be found in many studies published by the World Bank (www.worldbank.org), OECD, UN (www.undp.org) and other organizations.

[27] These studies usually make no difference between 8 years of schooling in an EU country and 8 years of schooling in for example Botswana. They give both the same rating.
[28] Some methods of measuring the quality of education is described in the following subchapter.
[29] Different indicators have to be used for different panel studies. (For example, it makes no sense to include literacy rate in a study of EU countries.)

4.1.1 The quality of education

Many studies such as Barro and Lee (1993) use the average number of years of schooling to estimate the level of human capital. Mulligan and Sala-i-Martin (1995) list four main disadvantages of this approach:

1) The assumption of perfect substitution of workers from one education category for workers from any other category is unrealistic.
2) The assumption that productivity differentials are proportional to the number of years of schooling (i.e. a worker with 15 years of schooling is three times more productive than a worker with 5 years of schooling) is also unrealistic.
3) It is too simplifying to expect the elasticity of substitution across workers of different groups to be constant always and everywhere.
4) Different educational systems are expected to be of the same quality, i.e. one year of schooling is expected to increase skills always and everywhere by the same amount.

Drawing on this reassessment of the simplest method, Mulligan and Sala-i-Martin (1995) have designed an index of labor income[30]. Although this method has solved many of the problems listed above, one of them remained - we have to expect zero-skilled worker to have the same productivity all over the world. In addition, this model neglects the changes in wages caused by changes in other factors than productivity and mistakes them for changes in productivity instead.

There are many other ways of employing the quality (and not only the quantity) of education in economic models. One

[30] Assuming that wages reflect individual's productivity (i.e. they express the market value of each specialization), the model takes into account the

option is to use the “functional literacy” data (see figure 12). “Functional literacy” - as mentioned in short in previous chapters - evaluates individual’s abilities to understand and interpret data. Thence it can be used as a simple proxy for the “marketable” qualities of labor force[31]. The limited use of data on “functional literacy” is apparent - they are not available for all countries but only for a small sample. On the other hand, since these data are available for OECD countries, they can be used for small selections of these countries, where the differences in the average length of school attendance are only small and where the quality of education may play a crucial part.

There are also other methods of measuring the quality of education. Some of them include IQ testing (which can be more individual and yet less available), others - like Mulligan and Sala-i-Martin (1995) - use economic variables such as wage differentials. Another frequent method is based on comparison of countries according to the score in internationally comparable math and science tests. Every single method has its own advantages and disadvantages but their suitable combination could help to define a more powerful model.

4.2 Data on on-the-job training

Data on on-the-job training are least available of all data. There are hardly any complex and complete studies on training. The OECD (1999) has published a couple of studies but these are of a very small extent and cover only selected parts of the world. We must non forget that training is primarily a microeconomic factor and the demand for it is largely diversified across companies and individuals. On the

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weighted average of individual wages weighted by their ratio to zero-skill wage.

[31] This draws on the assumption that modern technologies require workers who are able to understand and use data and information that are more complicated compared to old-fashioned technologies. This of course does not apply to every situation.

other hand, training can have an enormous influence on corporate productivity and competitiveness. Therefore, if data are available, it is useful to include them in indicators of human capital.

4.3 Data on health

The use of data on health is less frequent in macroeconomic models. This is often considered a result of the relatively equal health conditions in selected groups of countries (such as in European Union or in central African countries). Yet, if we want to make a model explaining differences between the most rapidly developing countries and countries whose development is rather slow, or to draft a very broad comparison of very distant countries, we should employ at least a general indicator of health conditions in order to capture the vast differences in mortality, morbidity and availability of medical care in different parts of the world.

Data on health can be obtained for example from the World Health Organization (www.who.org), CDC (www.cdc.gov) or from other sources. The most common indicators are: mortality, life expectancy, mortality of newborn babies, number of doctors per 100.000 people, availability of clean water and uncontaminated food, etc. (for some of these data see tables 4 and 9a). Including such data into a study of a heterogeneous sample of countries could have a strong influence on the accuracy of the study[32].

[32] Per capita GDP is accepted as a good measure of living standard in a country. Health conditions and availability of health care are of course an inseparable part of living standard and it is apparent that in all rich countries health care is more accessible than in poorer countries (see tables 4 and 9a).

[33] Growth studies obviously should not employ indicators in which growth is already included (HDI). Some of these indices however do not contain data on GDP and may therefore be used without any problems.

4.4 The Human Development Index

It is worth to mention here one yet broader indicator of human capital. The United Nations Organization has developed a set of indicators evaluating human development in different countries. These indicators include the Human Development Index (HDI, see table 6), Human Poverty Index (HPI) and other indices. These indices can be useful for comparative studies due to their complexity and availability for a great number of countries. They all include variables involving health conditions (life expectancy, etc.), knowledge (literacy rate, enrollment ratio, etc.) and the standard of living (poverty ratio, per capita income, etc.)[33].

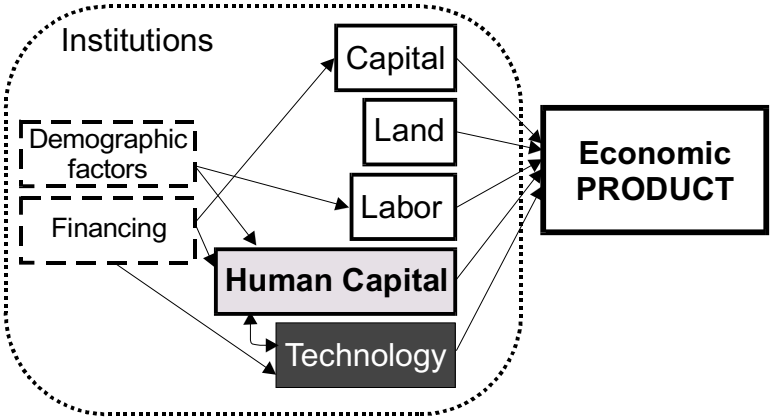
Human Development Indicators can show important differences in living standard between countries with the same GDP. These indicators are annually published in the Human Development Report (UN, http://www.undp.org/hdro). Besides these indicators, this report contains a variety of data on economic situation[34], gender-related differences, living standard and many other important factors. Figures 14, 15 and 16 in the Appendix show some interesting findings linked to the HDI index. These figures clearly illustrate that the same level of HDI does not necessarily imply the same level of per capita GDP and vice versa.

[34] These economic data are provided by the World Bank.

5. The role of human capital at macroeconomic level

Why should human capital be included
in models of (macro-)economic growth?

J. MINCER (1993): *"I think it is fair to conclude that even if substantial levels of human capital may not be a prerequisite for an acceleration of economic growth at a certain time and place, the concurrent growth and diffusion of human capital appear to be necessary to ensure sustained economic development."*



The classical growth theory involves three essential inputs: land, capital and labor.

Physical capital enters the model in the form of its real value whereas both land and labor are represented only by their "raw" quantities, which leads to considerable difficulties. Moreover, for a long time land used to be regarded as a fixed input.

However, such perception of the contribution of land towards product proved to be false. Land quality and "productivity" may vary across regions and in time very much and can be significantly influenced by human activity. Revenues per unit of land have substantially increased in developed countries over the past centuries (this increase is of course not boundless).

Similar features apply to labor. It is too simplifying to expect homogenous labor force. Human abilities are very different and everyone's contribution to domestic product is rather different too. Just like at the microeconomic level: the wage generally corresponds to the productivity of a worker[35]. Considering that wage differences can be so huge, why should then all workers be regarded as equal at the macroeconomic level[36]? Employing productivity of an average worker may be fine with a single-country model but considerable problems may arise in a model comparing more countries.

Traditional, i.e. neo-classical, theory of economic growth was successful in predicting and calculating the economic growth in the period around the first word war, prior the 1930's. Later studies (such as Walters (1968)) showed that although the predictions for the period before the depression drawing on neo-classical ideas had seemed to be very accurate, computed coefficients of individual inputs had been substantially disproportional in later periods. (Labor coefficient exceeded the share of wages in the total output, etc.) Following several studies of this kind, a new trend has appeared: a struggle to identify and analyze the sources of growth. One of the major impetuses was a study of Abramovitz (1956) showing that 80 to 90 percent of the per capita output growth in the USA over the 1870 - 1953 period could not be attributed to increases in (physical) capital per head. The results of Solow's study (1957) brought similar results for US non-farm sector in the 1919-1957 period.

Most production function analyses show that the contribution of labor accumulation (with special attention to human capital) to the growth of output cannot be ignored. For example, the World Bank's estimation (1991) of this

[35] Labor market economists will probably disagree with the statement that wage corresponds to the productivity but we will see that such simplification is useful in this case.

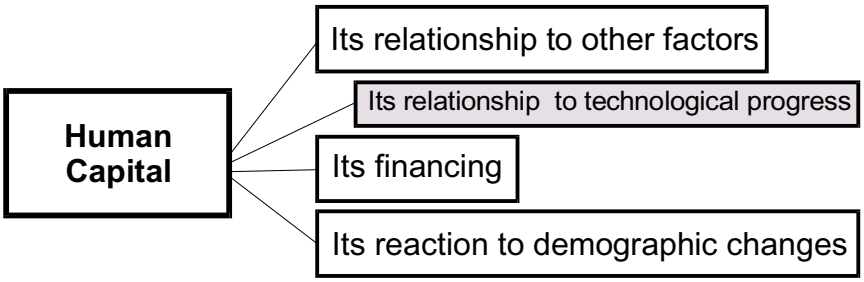
contribution is 23 per cent and some studies quote an even higher figure.

There is no doubt about the legitimacy of the inclusion of labor force in models of economic growth. However, it is inappropriate to measure labor input simply by calculating the total number of hours devoted to work (i.e. to “count hands”). To make the analysis of economic growth meaningful, we have to take into account at least two important factors closely related to the quality of labor:

1) differences in skills and
2) health of the labor force.

Reflecting these two factors will enable us to measure the contribution of labor to growth in a more appropriate manner. Without these factors, the residual in the production function would be too high as a result of the wide gap between the productivity of a healthy and skilled worker and that of an ill and unskilled one.

5.1 Human capital and its relationship to other economic factors



Human capital is an important factor of economic growth. However, to bring forth considerable growth, human capital needs to be accompanied by an adequate amount of physical capital and other factors. Human capital without interaction with other factors is less productive and vice versa.

[36] See table 3 in the Appendix.

Lim (1995) uses this argument to explain the success of Marshall plan as opposed to a much smaller success of foreign aid to developing countries: “Europe had available the industrial and commercial organization, and the skilled people required for modern industry; what it lacked was precisely physical capital which was largely destroyed or obsolete. The problem of less developed countries was different: they lacked virtually everything necessary for a higher standard of economic productivity, and the injection of only one element (physical capital) was found to be both wasteful and disappointing.[37]”

This comment approves an important conclusion: One of the main, and for economic policy most important, differences between physical and human capital is its flexibility. Though it cannot be changed immediately at any time (for which reason we cannot regard it as variable capital), the stock of physical capital can be increased or modified relatively easily. To do so we only need either money or other sources. On the other hand, it is much more complicated to increase or modify human capital: If a country (or - at microeconomic level - a company) cannot hire skilled workers from other parts of the world it is very time consuming to raise their own skilled labor force. Though changes at microeconomic level may be easy to implement, some countries will find it necessary to improve their level of education and change some of their traditions in order to increase the aggregate level of human capital and to achieve faster economic growth. It of course takes a much longer time to increase the aggregate level of human capital than to complete the construction of a factory or power plant.

If we agree that human capital increases economic growth through increased productivity of physical capital and better

[37] This statement can be supported by the Uzawa-Lucas growth model described later in chapter 6.

utilization of available technology (and though the development of new technologies), human capital may imply endogenous growth: an increase in human capital leads to an increase in the productivity of physical capital. This implies an increase in the demand for physical capital and subsequently also an increase of total product. In addition, higher amount of physical capital leads to higher productivity of human capital, which further increases the level of human capital. (This implication holds if human capital is considered a complement of physical capital and if this relationship is stronger than the relationship between physical capital and labor (i.e. the unskilled and homogenous factor)).

$$HK \uparrow \Rightarrow MP_K \uparrow \Rightarrow K \uparrow \Rightarrow Y \uparrow \text{ and}$$
$$\Downarrow \Rightarrow MP_{HK} \uparrow \Rightarrow w \uparrow \Rightarrow HK \uparrow \text{ and so on.}$$ [38]

This has also one side effect: differences in unemployment between skilled and unskilled workers. (This differential has been experienced in several countries with long-term economic growth). The complementary relationship between physical and human capital is well demonstrated by the fact that unemployment of skilled workers remains stable throughout the cycle. (This is due to the specific training that makes layoffs inefficient as described in section 2.3.2: *on-the-job training*).

5.1.1 Human capital and technological progress

Some theories assume that new knowledge spreads very fast, because ideas need not overcome any obstacles[39]. Therefore, the growth in terms of technological progress should be

[38] HK = human capital, K = physical capital, MP_K = marginal product of physical capital, MP_{HK} = marginal product of human capital, Y = product, w = wages.

[39] The assumption that ideas spread with an infinite speed is contradicted by the existence of laws protecting intellectual property. Yet, for

approximately the same for every part of the world. However, even a short edge over and earlier launch of a new technology can cause huge or at least important differences between countries.

A country is only able to adopt and make some use of new technologies, if there are enough skilled and qualified specialists who can

1) implement and use the technologies and
2) teach other workers how to use it. (This is one of the very important roles of “human capital” - reproduction.)

If a country wants to have a modern and up-to-date technological park, it is not enough to have or to hire some foreign specialists. It is impossible to upgrade the overall level of knowledge or to impose new technologies on a nation that lacks some essential skills, e.g. is largely illiterate. As shown in table 8a, the share of literate citizens varies from 99 per cent in the most developed countries to 21 per cent in the least developed ones. For the countries at the bottom of the list introduction of any new technology may represent a serious problem.

5.2 Financing investment in human capital

For reasons described in previous chapters, it is not easy to find funds for financing investment in human capital. We expect that product growth (= income growth) usually leads to an increase of human capital, because it brings in more sources available for investments in human capital. This means that economic growth goes hand-in-hand with investment in human capital, because national product is divided between consumption, investment in physical capital, investment in human capital, etc. Nevertheless, this can be a serious problem for poor countries since they do not have enough of

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simplicity, we shall expect this assumption to apply to the essential

their own financial sources and it is difficult to borrow money from other countries.

Under normal conditions, the law of supply & demand applies to the quantity of investment in human capital like to any other commodity. Therefore, the amount of this investment is bound to reach its optimum in every country (although in some countries the optimum can be too low to ensure sufficient levels of growth).

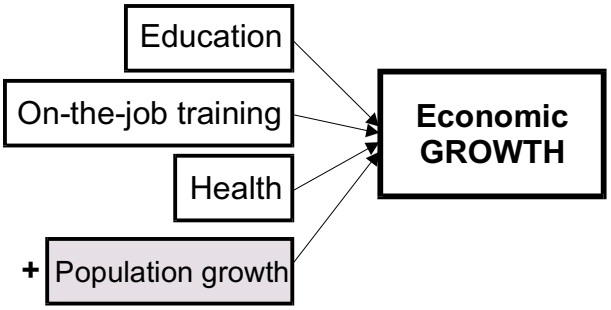
5.3 Human capital and demographic factors

A substantial increase of the overall level of human capital, i.e. an increase in the share of population with higher education would not have been possible without a decrease in mortality and morbidity. Up to the 19. century the probability for a newborn baby to survive was relatively low. This led to a high number of families with many low-educated children. The progress in medicine[40] and especially in epidemiology has brought forth a decrease in the size of an average family, because financial resources available to each family have not been sufficient to bring up more than a certain low number of children. This trend of decreasing fertility has been followed by the trend of increasing average level of education. The “educational budget” has been shared by a smaller number of children. Consequently, more education per unit has been available. This was the main reason why quality started to be preferred to quantity.

technologies necessary for developing countries.

[40] As shown in table 4 in the Appendix, life expectancy has been systematically increasing over the last 25 years, infant mortality has been decreasing and the overall health quality has been improving in many countries including the Czech Republic.

5.4 Effects of individual determinants of human capital on the economy:



To be able to draft a complete summary of the influence of the most important determinants of human capital on economic growth and prosperity we had to add one more determinant: the population growth. This determinant is not considered an internal part of human capital but it is closely linked to human capital at macroeconomic level through its effects on per capita wealth and on the availability of resources.

5.4.1 The role of education at macroeconomic level

One of the main indicators of the level of development of a country is its general level of education. This is because education has both direct and indirect effects on economic growth and on the overall economic and intellectual prosperity.

The main positive effects of education are summarized in the following short list:

1) Education increases skills and general abilities and thereby also the quality and productivity of labor force.
2) Education increases abilities to learn new methods and principles supporting thereby modernization and technological progress.
3) Education increases mobility of labor force and encourages differentiation of labor.
4) Education of particular kind increases managerial abilities and their efficiency.

5) Education of particular kind improves organizational skills and planning.

Many empirical studies support the assertion of the importance of education. For example, a study published by the Asian Development Bank (1989) shows a strong positive correlation between average years of schooling and economic growth in 13 Asian countries in the period from 1965 to 1986.[41]

Table 8a shows data on education and literacy for selected countries[42]. Correlation[43] of the data is shown in table 8b. The positive correlation between per capita GDP (especially log (per capita GDP)) and education indices is apparent.

Tables 10a and 10b show the regression coefficients calculated for per capita GDP growth and several indicators of education. The coefficients for male education are positive. However, for female education they are negative (table 10a). The reason for this is the predominant positive effect of female education on fertility, which makes the effect of female education on economic growth itself negative.

All these studies support the idea that it is very desirable for governments to support education and to motivate investment in it.

[41] The regression equation was Y = 1,16 + 0,93 X, where Y = yearly change in GDP per capita, X = average years of schooling. The coefficient for X proved statistically significant.

[42] Education in the Czech Republic has been described in short in previous chapters. In addition to that, table 5 drafts a small comparison of the situation in the Czech Republic, Slovakia, USA and Germany. Although the expenses on education in the Czech Republic are the highest from the sample, we have the lowest total school enrolment (74 %) and the lowest number of scientists. (United Nations (1999))

[43] Correlation need not necessarily imply causality. However, we can expect variables with high correlation levels to be substantially interconnected. For example, it is apparent that high levels of GDP (i.e. “rich countries”)

5.4.1.1 A few remarks on the possibilities to support education:

Private investment in education can be encouraged for example by tax allowances. In case of a complete lack of resources, some economists advise to transfer sources from other sectors (e.g. defense) to schooling, where it is supposed to be more effective. If no new resources may be found, than it is advisable to use at least the existing ones with maximum efficiency.

The supply side in the sector of education should always reflect the potential of the society and the requirements of the country. A poorly organized education may lead to undesired income differentiation and to unnecessary shifts in unemployment and its structure. In an over-educated society, for example, jobs requiring little qualification are performed by overqualified people and the education funds are wasted.

There is little doubt that increased education funds alone do not guarantee the optimal, growth-supporting structure of knowledge supply. The structure of supply has to correspond to demand and to the needs of the given economy.

Especially countries where most or all schools are public (like the Czech Republic) should evaluate future qualification requirements and the structure of demand for individual professions very carefully and with a great deal of responsibility. Uncoordinated and totally unorganized system of education is likely to lead to unnecessary unemployment in some professions and lack of specialists in others.

Countries where most or all education is provided by private institutions usually do not face the above-mentioned problem (or at least not in the long run) because of the law of supply and demand. Nevertheless, problems could still occur in the short run, because decisions carried out by individuals are rational only to a limited degree and they are usually

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are usually reached in countries with higher levels of education. Tables 10a and 10b support this statement.

based on past experience and historical data rather than on professional predictions of future demand (such predictions could be provided by the government).

The government can of course affect the demand for individual professions. This is rather easy in the system with prevailing public education - the government can easily adjust the supply side. System with prevailing private education may be affected through tax allowances and privileged loans or grants in desirable fields of study. However, such policy can only be successful if the government uses sophisticated analyses able to predict the optimal and efficient structure, which may not always be the case.

Demand for education changes over time. One century ago, completed primary education was usually enough to guarantee the person a job and respectable social status, whereas today, the same level of schooling is an essential requirement guaranteeing neither job nor perspective. This shift is an inevitable implication of technological progress. The process of globalization and economic integration has positive effects on the demand for and the use of education too.

5.4.2 The role of on-the-job training at macroeconomic level

This chapter will also briefly describe the role of on-the-job training. On-the-job training has positive effects (in terms of economic growth and prosperity) similar to those of education. The areas positively affected by training are for example:

1) Productivity of labor-force
2) Managerial qualities and organizational and planning skills
3) Abilities to operate new technologies and methods, etc.

While education usually affects the overall general knowledge of the population, training is usually very particular and often very specific. Higher levels of training

often require substantial prior education, which requirement implies that training and education are (from a certain point of view) closely linked. As mentioned in chapter 4, it is rather difficult to find an appropriate measure of the amount and quality of training. This problem accounts for little applicability of training for studies comparing different countries.

5.4.3 Health and its effects on macroeconomic level

Another important factor affecting the value of human capital in a country is the health of its population. There is no doubt that the healthier a nation is (i.e. the fewer people are ill) the higher productivity it can achieve[44]. Healthier people usually live longer and, being productive for a longer time, they are able to create more output. They can also invest more in other forms of their human capital because they expect to be obtaining the returns to this investment over a longer period.

It is apparent that the lowest values of per capita GDP and total GDP are in countries where health conditions are the worst. Tables 9a and 9b show the positive correlation between health indicators and per capita GDP and its growth. The correlation between per capita GDP indicators and infant mortality rate is also very strong. This is because GDP has a significant influence on the average size of a family and therefore also on the average investment in the children's human capital. Table 10a clearly illustrates the positive effect of increased life expectancy on economic growth. It shows that life expectancy is highly significant and that a

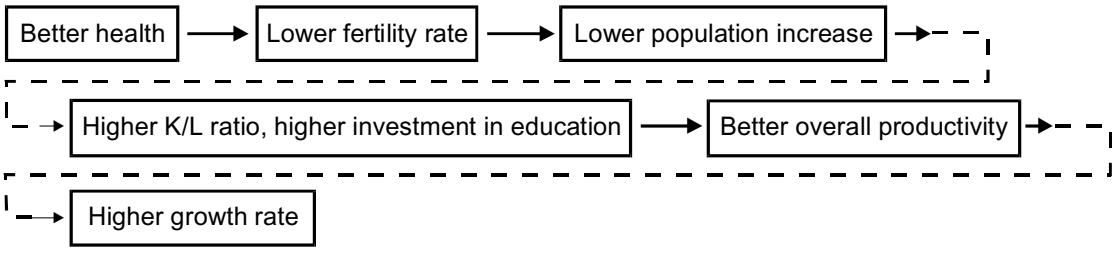
[44] According to table 4 in the Appendix, we can conclude that the health situation in the Czech Republic is relatively good. Though it is worse than the situation of western economies, it has been improving. Life expectancy in the Czech Republic is rather low (73,9 years) compared to developed countries (USA: 76,7 years), but this is due to different (we must admit that worse) life style (including nutrition, physical activities etc.). Various medical reports also point out higher heart attack rate, etc. (United Nations 1999)

one-standard-deviation increase in it (for the data one standard deviation equals approx. 13 years) is estimated to raise the growth by 1,4 percentage point per year[45]. Similarly, Table 10b illustrates the negative relationship between fertility and economic growth.

Various studies (e.g. World Bank 1991) have confirmed that there is a strong relationship between the overall health of the population and economic growth. Another important finding is that improvements to aggregate health lead to improvements to productivity and labor organization and to a more efficient utilization of other resources.

Various medical studies suggest that improvements to health lead to better education of children. This is because healthy children are less absent and their cognitive and comprehension abilities are better. Better health results in fewer interruptions of school attendance (later work attendance), improving thereby the overall productivity.

The interconnection between individual human capital factors and economic growth can be summarized by the following diagram:



In addition, improvements to health systems are usually followed by improvements to prevention, which may have strong positive effect on the economy due to lower future expenditures on health care (smaller number of the unnecessarily ill). Of course, higher expenditures on prevention require sufficient funds that are usually available only in developed countries with higher levels of economic

[45] See Barro, Sala-i-Martin (1999).

growth. The trap of poverty applies to both health services and prevention.

5.4.4 The influences of population growth on wealth, economic growth and output

Classical models of production function expect that population growth, i.e. an increase in labor force, has (with a certain time lag) positive effects on the GDP growth: since more workers are involved in the production process, more goods are produced. In addition, economies of scale are expected to apply to this case.

We can write the production function as follows:

Y = f(K,L,A)

$\dot{Y}-\dot{L}=\alpha(\dot{K}-\dot{L})+\dot{A}$, where

Y = output, $\dot{Y}$ = growth of output

K = capital, $\dot{K}$ = growth of capital

L = labor, $\dot{L}$ = growth of labor force

A = technology, $\dot{A}$ = growth of technology.

Suppose $\dot{A}$ = 0, then if $\dot{L}$ increases, $\dot{K}$ has to increase too to keep the optimal capital/labor ratio constant. However, if the growth of technology, $\dot{A}$, is positive, L can grow faster than K, due to the positive effect of improved technology resulting in higher productivity.

This model allows for a common assumption: that increases in L are positive. Moreover, population growth does not only affect economic growth but it also encourages technological progress (technologies must improve in order to be able to “feed” and “sustain” the increased population, to increase available resources and to increase productivity, therefore we often use the term “technological progress of necessity”).

Another positive implication of increased population growth is the increased share of young people in the population, which may be a strong impetus for modernization and improvements make production more efficient and profitable. This implication draws on the hypothesis of lifetime profile of investment in human capital, which expects older people to have lower motivation to invest as their costs of investment are higher and the period of obtaining the returns to such investment is shorter. On the other hand, many economists prefer the growth of per capita GDP to simple GDP growth, because it is supposed to be a more appropriate indicator of the changes in living standard. This approach points out the negative effects of population growth on the growth of per capita GDP. One of the main negative aspects is the decrease of investment and available capital per unit of labor. More resources are required to replace the physical capital and less money can therefore be spent on investment in human capital and other important factors.

For example, Coale and Hoover (1958) show that fast population growth is negative in terms of economic growth. They show that a decrease in fertility leads to an increase in per capita growth due to the following reasons:

1) with less children, consumption is smaller and more money is saved and can be invested in all forms of capital

2) with more per capita capital, the productivity of labor is higher.

Some studies show that countries with faster population growth have higher growth rates of per capita output. They point out that periods of economic growth are usually preceded by periods of population growth. The World Bank has published a study showing that a moderate rate of population growth is positive as it supports economic growth through increased aggregate demand, stimulation of innovations, etc. The desirable rate is estimated to fall in the interval from 0 to

1,5 per cent[46]. Higher rates lead to a decrease in private savings, and to insufficient investment in physical capital. This results in lack of per capita stock of physical capital, and subsequently in a decrease in economic growth. Per capita investment in human capital is also likely to decrease.

These statements can be easily demonstrated on real data. Table 7a shows the comparison of population growth, GDP growth and per capita GDP growth for a random selection of 30 countries from all over the world. The index of correlation (table 7b) between population growth and GDP growth in the period from 1975 to 1997 was 0,2643, while the correlation between population growth and per capita GDP growth in the same period was -0,5659.

5.4.4.1 A few remarks on the possibilities to support decreases in population growth:

The above assumptions and findings have led to an endeavor to draft out a set of recommendations for countries to increase their economic growth. The recommendations aimed especially at decreasing the fertility rate and subsequently also the population growth in developing countries. Such decrease would allow for an increase in investment in physical and human capital and would make these countries more competitive and successful.

A comprehensive list of economic methods decreasing fertility has been composed[48].

[46] Table 4 in the Appendix provides a small comparison of fertility rate and average annual population growth in four countries including the Czech Republic and Slovakia. It is apparent that population growth in the Czech Republic has been very low (lower than EU average!). Further decrease is expected to occur in the following 25 years (-0,1 %). Czech fertility rate is also very low. (United Nations (1999))

[48] These recommendations are based on works studies by Nerlove (1974) and Cochrane (1975).

The main principles are:

a) promotion of smaller families with less children
b) effort to decrease demand for children (increase the costs and decrease the benefits of having children)

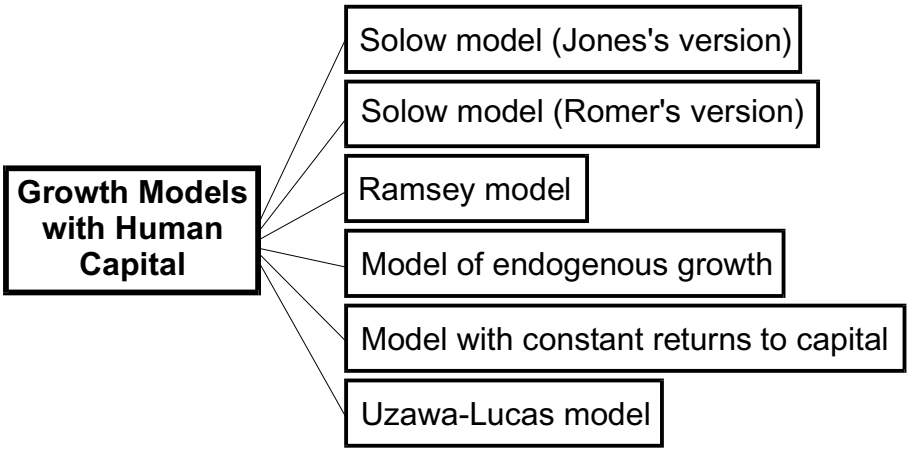
The recommendations suggest, for example:

1) to support employment of women (make women start preferring career to family life)
2) to improve social welfare system for aged and retired people (avoid the dependency of old people on their children)
3) to improve health (better health care, nutrition, etc.) in order to reduce children mortality
4) to limit children employment (the possibility to earn money) for example by establishing compulsory school education, etc.
5) to support education of women (higher average education is expected to decrease the fertility rate - children's quality will be preferred to their quantity).

6. Human capital in models of economic growth

There are many models of economic growth. Although most of them do not involve human capital, there is a considerable number of those which do. This chapter will attempt to draft a short description of some of these models and to compare their approach to human capital.

6.1 Models of economic growth involving human capital



6.1.1 Solow model with human capital according to Jones[49]

It is useful to start with the simple Solow model (with human capital). This model is largely popular since it is relatively simple and yet powerful enough to describe and explain the main principles of economic growth.

Assumptions:

a) countries produce a single homogenous product = output
b) there is no international trade (=>I=S)
c) technology is exogenous (firms don not affect their technology)
d) marginal propensity to save is exogenous

These assumptions are very strict and many of them are relaxed in other models. Nevertheless, they allow for the afore mentioned combination of simplicity and reliability.

[49] For details see Jones (1997)

In order to explain growth differentials between countries and the Solow residual (i.e. the part of national product that cannot be attributed to traditional inputs), it is necessary to incorporate human capital into the Solow model. To do this, Mankiw, Romer and Weil (1992) and Jones (1997) replaced labor (L) with "skilled labor" (H).

The basic Solow model with human capital consists of three equations:

1) Production function (we usually use a Cobb Douglas production function, i.e. a function with constant returns to scale):

$Y = f(K, AH) = K^{\alpha}(AH)^{1-\alpha}$, where

Y = product,

K = physical capital (increased by investment, decreased by depreciation),

H = human capital = skilled labor (growing at rate n),

A = technology (exogenous, growing at a constant rate g),

α = share of capital in the production function, $0 \leq \alpha \leq 1$.

2) Physical capital accumulation function

$\dot{K} = s_K Y - (n + g + d)K$, where

$\dot{K}$ = change in physical capital,

d = depreciation rate and

s_K = savings rate for investment in physical capital

3) Human capital accumulation function[50]

$H = hL = e^{\psi u}L$ [51], where

[50] See figure 14 in the Appendix comparing the level of development of selected countries (HDI) with their per capita GDP. Positive correlation of these two indicators is apparent here. The Czech Republic is below the trend line, which implies that further economic growth may be expected in the future.

[51] This equation corresponds to the observation that every additional year of schooling increases productivity of labor (and subsequently wages) by approximately 10 %. (National Educational Fund database)

L = labor force (unskilled)

u = share of an individual's time spent on accumulation of human capital (in this model, this share is assumed to be exogenous and constant; in other models it is usually represented by the average number of years spent in schools) and

ψ = efficiency of human capital accumulation (a positive constant).

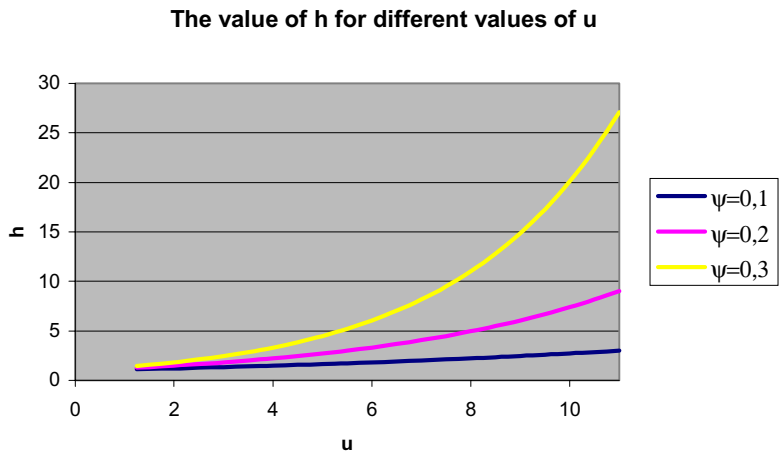


Figure III: Relationship between h, ψ and u.

Hall, Jones (1998) have suggested a slightly different human capital accumulation function. Their solution employs acquired human capital in a more straightforward way but it is less general:

$H_i = e^{\phi(Ei)} Li$, where $\phi(E_i)$ is the efficiency of labor with E_i years of schooling relative to that with $E_i=0$ ($\phi(0)=0$). $\phi'(E_i)$ is the return to schooling estimated by means of a Mincerian wage regression[52]. In the following text, however, the original definition ($H = hL = e^{\psi u} L$) will be used.

[52] i.e. regression coefficients have been estimated from equations defined in Mincer (1993).

A simple rearrangement of the above equations yields the expressions for physical capital and output per unit of labor. Then $h = e^{\psi u}$ and

$k = \frac{K}{hLA} = \frac{K}{HA}$, $y = \frac{Y}{HA}$, $y = k^{\alpha}$ and $\dot{k} = s_K y - (n + d + g)k$.

This model is in equilibrium (i.e. in steady state) when $s_K y = (n + d + g)k$.

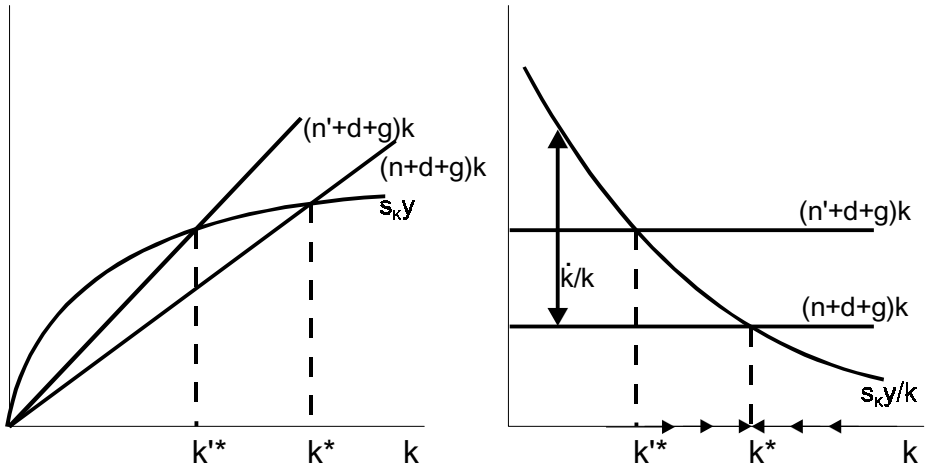


Figure IV: The growth rate of capital stock ($\dot{k}/k$) is determined by the difference between $s_K y/k$ and (n+d+g)k. The economy converges to its steady state. Each level of n corresponds to a different equilibrium level. (For n’ > n, there is a new steady state at k’*).

The following equation holds in steady state:

$$y^*(t) = hA(t)\left(\frac{s_K}{n + g + d}\right)^{\frac{\alpha}{1-\alpha}}.$$

This means that steady state output per worker at various points in time depends on technology, which is assumed exogenous (and on human capital per worker, which is constant).

The simple Solow model with human capital shows that the only source of per capita economic growth in steady state is technological progress (in this case, per capita output grows

at rate g). If g is held zero, per capita output (and per capita physical capital) is constant in steady state.

In steady state, the properties of this model are almost the same as those of the original Solow model: the economy grows at rate g.

Comparative static:

Changes in s_K: Changes in s_K account for rotation of the investment curve ($s_K y$) in figure IV. An increase in s_K leads to an increase in both k and y and economy moves to a new steady state. Growth rate is temporarily higher over the period of transition to the new steady state, but thereafter it returns to its original level remaining unaffected in the long term.

Changes in n: If n increases, more has to be invested in capital to keep the K/AL ratio constant. An increase in n is therefore followed by an increase in k and a decrease in y.

One of the most important implications of the Solow model is that changes in n, s_K and d have only a level effect (they shift the path of y), but no long-term growth effects (the growth rate of y remains unaffected).

In order to increase its wealth, a country should:

- maintain a low population growth n
- maintain a high savings rate s_K (i.e. high investment rate)
- invest enough in human capital
- have advanced technology

Inter-country differences in output and its growth are usually attributed only to:

- different savings rate and population growth (these variables determine the steady state[53]), i.e. to differences in transition dynamics, and to

[53] 1) Many countries will often find themselves out of their steady state,

- different rate of technological progress g (or different ability of a particular country to absorb and use new technologies).

Finally, if the Solow model with human capital has nearly the same conclusions and results as the original one, what is the advantage of introducing human capital in this model? Originally, Solow analyzed the so-called "growth accounting", i.e. the measure of contribution of individual growth factors to total economic growth. These rates were calculated from the following function:

$$\frac{\dot{Y}}{Y} = \alpha \frac{\dot{K}}{K} + (1-\alpha)\frac{\dot{L}}{L} + \frac{\dot{A}}{A},$$

where A is a residual, which cannot be attributed to other factors included in the model (K and L). In Solow's studies, this residual component amounts up to 40 per cent. The residual component may be attributed to technological progress, but the figure seems too high to result from technological progress itself and therefore it is necessary to look for another explanation. Such explanations are rather numerous: increases in the prices of inputs (for example after the oil shocks in the 1970's), sectoral changes, mass spread of computers, changes in composition of labor force or in human capital, changes in education, etc. Since human capital can be at least approximately measured, such studies encourage us to include it in the model.

We expect (and empirical studies by Jones (1997) and others confirm it) that the Solow model with human capital yields better predictions and inter-country comparisons of economic growth than its original version. The main reason for this assumption is the addition of labor quality indicator allowing for better determination of labor force contribution

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2) there is no reason for the steady states of all countries to be the same.

to economic growth[54]. However, since the main principles are the same as those in the original model, predictions related to the convergence of countries are very similar.

6.1.2 Solow model with human capital according to Romer[55]

Romer uses slightly different assumptions about and approach to human capital. In his model, human capital is not only a redefinition of labor (i.e. skilled labor) but it is described as a new form of capital besides labor and physical capital. His production function is defined as:

$$Y = K(t)^{\alpha} H(t)^{\beta} [A(t)L(t)]^{1-\alpha-\beta} = K^{\alpha} \left(\frac{H}{AL} \right)^{\beta} (AL)^{1-\alpha}$$, where

$\alpha > 0$, $\beta > 0$, $\alpha + \beta < 1$,

H is the stock of human capital

L is labor force (number of workers)

$\dot{K}(t) = s_K Y(t)$, $\dot{H}(t) = s_H Y(t)$, $\dot{L}(t) = nL(t)$ and $\dot{A}(t) = gA(t)$ where

s_K and s_H are savings rates for physical and human capital respectively, n is population growth and g is technological progress. If we define: $k = \frac{K}{AL}$, $h = \frac{H}{AL}$ and $y = \frac{Y}{AL}$, then

$$y(t) = k(t)^{\alpha} h(t)^{\beta}$$.

The main difference between Romer's and Jones's models is the definition of human capital and its formation. While in Jones's model, human capital was represented by a constant h multiplying L, in Romer's model human capital is an independent form of capital interacting with physical capital, labor and technology thus creating output.

This difference implies substantial modifications of our analysis. In this model, it is not only physical capital that converges to its steady state but also human capital. Steady

[54] and therefore for lower values of the Solow residual.
[55] This model is fully explained in Romer (1996), chapter 3.9.

state is therefore a combination of particular values of both these inputs.

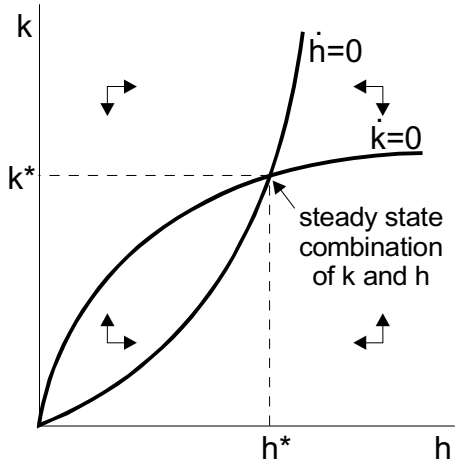

Figure V: Steady state in Romer's modification of the Solow model

Nevertheless, the implications for economic growth in steady state are the same as in the original Solow model: Y, K and H grow at rate n + g and Y/L, K/L and H/L grow at rate g, which is exogenous by assumption. The main difference is the extent of transition in case of changes of n or s. The fact that in this model, both physical and human capital have to accommodate, results in a more extensive transition than that in the model where only physical capital has to accommodate.[56]

We may conclude that the main difference between these two models is related to the expected behavior of human capital. In Jones's model, human capital may only grow hand in hand with population (it is represented by population multiplied by the human capital constant). In Romer's model, human capital is independent of population being a function of savings and other constants. Human capital influences GDP in both cases, but its influence on product growth is limited only to the period of transition to a new steady state.

[56] $\dot{k}(t) = s_K k(t)^{\alpha} h(t)^{\beta} - (n+g)k(t)$ and $\dot{h}(t) = s_H k(t)^{\alpha} h(t)^{\beta} - (n+g)h(t)$.

6.1.3 Model of open economy, finite horizons and adjustment costs involving human capital *(based on the Ramsey model)*[57]

This model should serve as an example of a different type of growth model. The key assumption of the model is that physical capital flows to countries (regions, industries, sectors), where it obtains the highest revenues.

Assumptions:

- m = number of countries, i=1,..,m,
- r = world interest rate,
- a_i = assets per capita in country i,
- k_i = capital per worker in country i,
- $d_i = k_i - a_i$ = country's net per capita debt to foreigners,
- The budget constraint of a household in country i, $\dot{a}_i = w_i + (r - n_i)a_i - c_i$, where
- c_i = per capita consumption in country i, w_i = average wage in country i

This model without human capital leads to the following situation:

According to time preferences of individual countries all countries except for the most patient one will tend to have no wealth (i.e. to owe everything) and to have consumption growth asymptotically approaching 0. Consumption growth of the patient country will equal the growth of world output[58]. The convergency to this equilibrium is a result of capital flowing towards higher revenues. The speed of this convergency is infinite.

[57] This model is explained in Barro, Sala-i-Martin (1999), chapter 3.2.

[58] Every impatient country borrows to increase consumption as soon as possible but this is paid by lower (finally zero) consumption growth (and of course zero domestic product growth). The country becomes a debtor and in the end it owns no capital at all and only keeps borrowing money against the present value of wages.

However, if we include “human capital”[59] in this model, we obtain different results. Following assumptions have to be added:

Every country has two types of capital. The first one, physical capital, can be used as collateral for international loans, while the other one, “human capital”, cannot. In other words, d_i is limited by k_i, i.e. no country can borrow against their labor. This means that foreigners may only own *physical* capital of another country.

Output and assets per unit of effective labor: $\tilde{y} = f(\tilde{k}, \tilde{h}) = A\tilde{k}^{\alpha}\tilde{h}^{\beta}$, $\tilde{a} = \tilde{k} + \tilde{h} - \tilde{d}$ respectively. Such economy becomes open only partly and will have diminishing returns to human capital accumulation. In this version of the model, the speed of convergency is no more infinite, but it is still relatively fast.

The description of this model was rather short, as it was intended merely as an example of a model called “involving human capital” where “human capital” has no real importance in terms of the human capital concept. In this model, “human capital” serves as a technical tool only. It represents a special form of capital that cannot be used as collateral for foreign loans. That means that there is no link between this concept and the “quality of labor force” or other previously mentioned concepts[60].

[59] The reasons for quotes used with human capital will be described later.

[60] There is no doubt that human capital can well illustrate a type of capital that cannot be used as collateral for international loans (though arguments against this statement could be found too). However, there are other examples of such capital and therefore it is not quite correct to call a model of this type “a model with human capital”.

6.1.4 Model of endogenous growth involving human capital[61] (AK model)

Unlike the Solow model, the AK model is based on non-diminishing returns to capital. The main assumptions of this model are:

- s = savings rate (exogenous)
- Y = AK, A is the level of technology (A>0), K is physical capital and Y is output.
- y = Ak, where k is per capita physical capital and y is per capita output.

$\frac{\dot{k}}{k} = sA - (n+d)$, it is shown in the following figure as the vertical difference between sA and n+d.

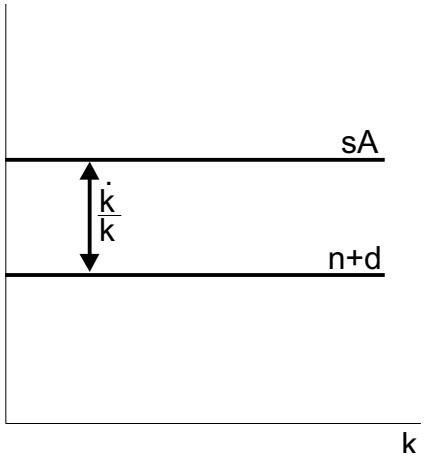

Figure VI: Graphical definition of $\frac{\dot{k}}{k}$.

In steady state, $\frac{\dot{k}}{k}$ is constant ($\frac{\dot{k}}{k} = s\frac{f(k)}{k} - n - d$).

The main idea behind this model is that economy can sustain economic growth in the long-term even if there is no exogenous technological progress (in such case, growth depends on savings rate, population growth and depreciation rate). However, no economic convergence is predicted in this model.

If we employ human capital in the model, we obtain the following production function: Y = f(K,H)[62], Y = K f(H/K),

[61] For a complete explanation of this model see Barro, Sala-i-Martin (1999),

f′(H/K) > 0. The depreciation rate of physical and human capital is d_K and d_H respectively. Several rearrangements of the above expressions yield an equation[63] confirming that the H/K ratio is constant in steady state. If we define A = f(H/K), we can rewrite the production function to obtain: Y = AK, which is the original AK model. Then, in steady state, C, K, H and Y grow at the same, constant rate.

This model distinguishes between physical and human capital in order to support the assumption of asymptotically constant returns to capital (i.e. a broader approach to capital). This may again result into regarding human capital as a mere technical tool. However, in this model human capital is also used together with K to define the A term.

6.1.5 Model with constant returns to capital, non-negative investment and human capital[64]

In this model, we expect a one-sector economy where K and H are produced by the same technology. This means that output can be used in three ways:

a) for consumption,

b) for investment in physical capital and

c) for investment in human capital.

To obtain constant returns to capital (i.e. to K and H) we use the production function $Y = AK^{\alpha}H^{1-\alpha}$, where 0 ≤ α ≤ 1 and H = hL, where h = human capital per worker. This means that quality can be replaced by quantity, i.e. the main features of human capital are not reflected. In this model, L is fixed.

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chapter 4.2.

[62] We assume f to exhibit constant returns to scale in K and H.

[63] Drawing on assumption that real interest rates on all investments are equal, we get the following equation: $f\left(\frac{H}{K}\right) - f'\left(\frac{H}{K}\right)\left(1+\frac{H}{K}\right) = d_K - d_H$.

[64] This model is explained in Barro, Sala-i-Martin (1999), chapter 5.1.

$\dot{K}$ = I_K - δK, $\dot{H}$ = I_H - δH, where I_K, I_H is the gross investment in physical and human capital respectively and δ is the depreciation rate.

Following some substitutions we may rewrite the production function as: $Y = AK\left(\frac{1-\alpha}{\alpha}\right)^{1-\alpha}$. This implies that the K/H ratio in steady state equals $\frac{\alpha}{1-\alpha}$, i.e. it is constant.

If K and H in period one are given by a ratio different from the $\frac{\alpha}{1-\alpha}$, H and K have to be adjusted to meet the proper combination allowing for steady state.

However, this model expects non-negative investment. This means that if, for example, H is abundant, the country cannot have negative investment in H. Therefore H can only be changed (i.e. decreased) at rate -δH, when gross investment is zero. In such case, K will grow at the rate of net investment and H will diminish at the depreciation rate until $\frac{K}{H} = \frac{\alpha}{1-\alpha}$. This adjustment is done in finite time.

In steady state both H and K grow at the same optimal rate of g_K=g_H. Moreover, constant returns to capital may, in steady state, make economic growth possible even if no exogenous technological progress occurs.

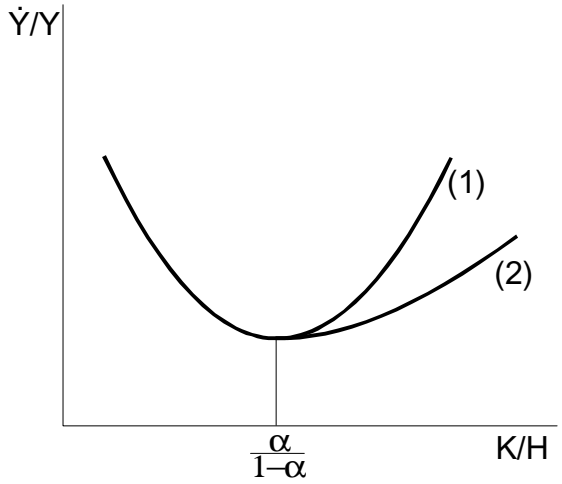


Figure VII: Relationship between product growth and K/H ratio. Any deviation from the optimum leads to changes in growth. Curve (1) shows the situation when changes in H and K can be done at the same speed. Curve (2) shows the more realistic situation when it is cheaper (easier) to modify the stock of K than the stock of H. This model demonstrates the complementary relationship between human and physical capital.

6.1.6 The Uzawa-Lucas model[65] (as a special case of the two-sector model with human capital)

The two-sector model reflects the assumption that physical (K) and human capital (H) are produced by different technologies. We also assume non-negative investment. The production functions are defined as follows:

$Y = A(vK)^{\alpha}(uH)^{1-\alpha}$ and $\dot{H} + \delta H = B[(1-v)K]^{\eta}[(1-u)H]^{1-\eta}$, where

A, B = technologies used in the sector of production of K and H respectively.

α, η = share of K in individual sectors (production and human capital production), $\alpha \neq \eta$, $0 \leq \alpha \leq 1$, $0 \leq \eta \leq 1$.

v,u = share of K and H in the production sector, $0 \leq v \leq 1$, $0 \leq u \leq 1$.

$I_K = \dot{K} + \delta K$, Y = C + I_K, i.e. product is divided between consumption and investment in physical capital.

Q = Y + p($\dot{H}+\delta H$), i.e. Q is the total product and p is a hypothetical price of human capital calculated in units of goods.

It is reasonable to assume that $\alpha > \eta$ i.e. the human capital intensity in the sector producing human capital is higher than the physical capital intensity in the sector producing goods.

The Uzawa-Lucas model allows for the following simplification: $\eta=0$, i.e. no physical capital is needed in human capital production sector and therefore v=1. This leads to a substantial simplification of the whole model, because the production functions are then defined as follows:

$Y = AK^{\alpha}(uH)^{1-\alpha}$ and $\dot{H}+\delta H = B(1-u)H$. Figure VIII describes the behavior of this model in terms of the K/H ratio:

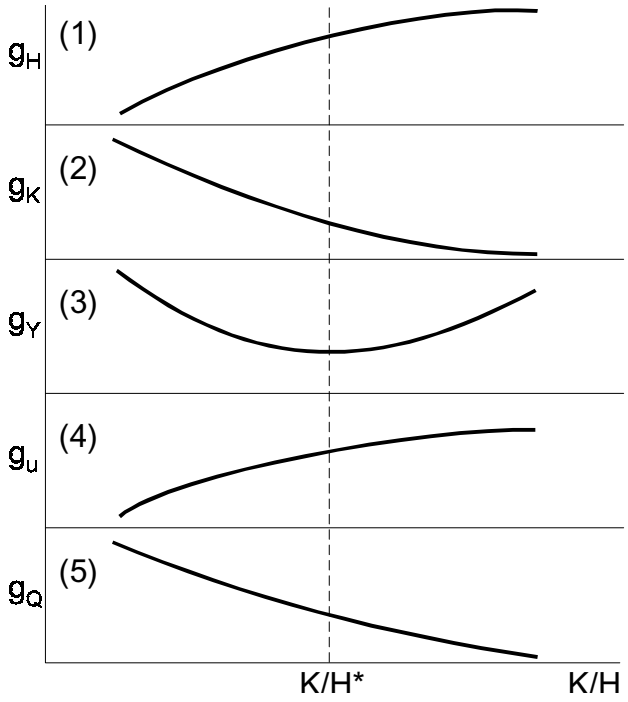


Figure VIII: The behavior of individual growth rates depends on the K/H ratio (disproportion between K and H). For example in case of K/H > K/H*:

65 For details, see Barro, Sala-i-Martin (1999), chapter 5.2.

(1) As mentioned above, the two-sector model is more realistic due to its approach to individual sectors as it allows for higher human capital intensity in the H-production sector. In case of K/H > K/H*, i.e. when H is relatively scarce, the marginal productivity of H is high in both sectors, which results in higher growth of H-production.

(2) The behavior of g_K is analogous but reversed compared to human capital.

(3) The behavior of Y is similar to that in the previous model (one-sector model with human capital).

(4) An increase of the productivity of H in the production sector leads to higher demand for H in the production sector. An increase in the costs of H (i.e. wages), caused by increased demand for H, leads to flows of H from the H-production sector, which is more H-intensive, to the production sector (less H-intensive), where it is cheaper.

(5) Growth of Q is decreasing in K/H ratio due to the influence of increasing u in the H-production sector. (Q = Y + net I_H).

We may conclude that, similarly to other models with endogenous growth, the restrictive assumption of non-negative investment results in a disproportion effect (disproportion between K/H and K/H*) leading to increased growth rate. This model perfectly illustrates the “after war” situation described in chapter 5.1. Unlike the one-sector model with human capital, where the disproportion effect may increase product growth both when K/H > K/H* and when K/H < K/H*, in the Uzawa-Lucas model the product growth[66] increases only when K/H < K/H*. In the opposite case, growth is suppressed.

[66] We have to employ Q instead of Y since Y does not reflect changes in H-production sector, which is an integrate part of the economy.

6.2 Comparison and evaluation of models involving human capital

6.2.1 Comparison of the models' approach to human capital

6.2.1.1 Simple Solow model with human capital (Jones):

In this model, the parameter defining human capital (h) is exogenous and constant. H grows at rate n, which is very limiting. This approach implying that human capital corresponds to the number of workers and their average number of years spent at school is a simple one but at least a little realistic. Unfortunately, this version of the model is unable to reflect any other types of human capital apart from school education. To make the education index comparable, the average number of years of schooling should be weighted by its quality (this can be included in ψ). To use this model for a cross-country comparison, we need to produce a very good estimation of ψ.

An apparent advantage of this model is the possibility to redefine the h parameter in order to include more forms of human capital and to involve the factor of different quality of human capital in different countries, thereby making the approach to human capital very complex. On the other hand, an evident disadvantage of this model is the assumption of constant h. This precondition is limiting for the impossibility to include per capita growth of human capital. Therefore, economic growth may only increase by means of human capital if there is an increase in labor force, which does not comply with the assumptions about the influence of population increase on output growth.

The consequences of the exogenous growth assumption are the same for all versions of the Solow model, therefore they will not be commented on in detail.

6.2.1.2 Simple Solow model with human capital (Romer):

Romer's view of this model has an indisputable advantage. Its definition of human capital comprises all forms of this input. Being defined as an autonomous form of capital, human capital is no more constant but converging to its steady state value. In addition, this model suggests that only a specific H/K ratio is optimal for the economy, i.e. that H and K are complementary factors.

Nevertheless, this change to the model does not affect the traditional properties of the Solow model in steady state. The only differences in its behavior may be observed during the period of transition to a new steady state.

6.2.1.3 Model of open economy, finite horizons and adjustment cost involving human capital (Ramsey model with human capital):

In this model, human capital definition is very broad, potentially including all forms mentioned in the previous chapters. However, the main purpose of employing "human capital" in this model is to illustrate a form of capital that cannot be used as collateral for international loans.

In the original version, "human capital" represented the value of productivity or quality of labor force, i.e. it corresponded to wages. However broad or complex the definition of "human capital" might be, it wouldn't account for any changes to the model, since "human capital" is regarded here as a mere technical tool representing a different type of capital.

6.2.1.4 Model of endogenous growth involving human capital:

This model uses human capital to support its assumption of constant returns to capital, i.e. to extend the definition of capital to allow for such assumption. Human capital is acquired through investment (as a portion of savings) and

could be useful for growth accounting. Although human capital enters this model only in the form of education, it is possible to set up a very complex definition that would allow for the inclusion of all possible forms, leaving the model's predictions about steady state and economic growth in the long run unaffected. The assumption of depreciation of human capital is realistic.

6.2.1.5 Model with constant returns to capital, non-negative investment and human capital:

For some of its properties, this model lies somewhere between the Romer's version of the Solow model with human capital and the AK model. The formation of human capital is similar to that in the Romer's model, while the nature of steady state is similar to the Romer's model and the AK model with human capital[67]. There are several reasons to include human capital in this model (and its definition can be very complex without any but measurement or estimation problems). First, like in every growth model, it is useful for growth accounting to decrease the residual part. Second, it is useful to show the complementary relationship between physical and human capital. This model can illustrate the different costs in the production of human and physical capital. Then, if the costs of human capital adjustment are higher, which usually is the case, it is easier for an economy to adjust physical capital than to adjust human capital. Third, disproportion between human and physical capital has positive effects on economic growth leading the economy to its steady state. As mentioned in the previous sentences, a relative excess of human capital over physical capital can lead to increased productivity of and growing investment in physical capital, which in turn leads to an increase economic growth. Relative excess of physical capital can make the adjustment of H more

[67] Because of the assumption of constant K/H ratio in steady state.

difficult and long lasting, and therefore it has a smaller effect on economic growth.

6.2.1.6 The Uzawa-Lucas model involving human capital:

Of all models with endogeneous growth, the Uzawa-Lucas model offers the best (the most realistic) approach to human capital. Its main advantage is distinguishing between production function for production of human capital and production function for production of final output. Its overall approach to production of human capital allows for a broad definition employing technology, (physical capital[68]) and previously produced human capital. This assumption allows for different capital- and human-capital intensities in individual sectors. In addition, the assumption of human capital depreciation is realistic.

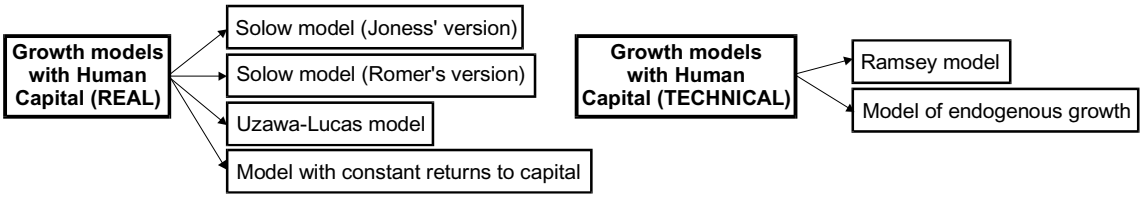
Distinguishing two different production functions in this model also leads to a broader definition of final output Q, i.e. regards human capital as a special form of output of the economy, which is realistic but hard to measure in practice. The properties of economic growth implied by the disproportion effects of the K/H ratio are similar to those described by the previous model. Again, the complementary relationship between both forms of capital is crucial here.

Other forms of human capital, besides education or training, should be possible to include in this model.

6.2.1.7 Summary of the approaches to human capital

We can conclude that there are two basic approaches to human capital[69]:

1) Many models involve human capital as a technical tool only. The definition of human capital in these models is of little importance, because it does not affect the principle of the model. Authors of these models usually do not offer any precise definitions of H. However, for comparisons and cross-country studies, the broader the definition is, the better. This applies also to these models.
2) In other models, the term "human capital" has a real economic meaning in terms of the human capital theory. Some of these models (such as the Jones's version of the Solow model with human capital) define this form of capital in a very limited way.



6.2.2 Evaluation of models involving human capital

There has been a lot of struggle to explain differences in per capita product growth among countries. These differences (based on the Solow model) can be attributed to:

a) differences in physical capital accumulation
b) differences in human capital
c) differences in the Solow residual

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[68] In the general model, physical capital is used in sector producing human capital.

[69] In most cases, the distinction is not completely explicit and those models should lie somewhere between those categories. However, usually one attribute is prevailing.

Many empirical studies and theoretical models support the role of human capital. On the other hand, some empirical studies[70] also show that the two first factors account for only a small part of the difference. These studies suggest that the largest part of the difference may be attributed to the differences in the Solow residual[71].

The most serious problem linked to human capital, which most models of economic growth are faced with, is the problem of the indicator of human capital. As described in the previous chapters, it is very difficult, or nearly impossible, to obtain high-quality data on human capital for a broader selection of countries.

A complex measure of human capital would be very troublesome for most models. Substantial simplifications are necessary to keep a model simple and efficient[72]. Nevertheless, these simplifications are the main cause of the lower reliability and accuracy of these models.

There is one more problem related to the more complex and reliable models: it is not easy to collect the data. Moreover, if the data are successfully collected, serious problems with their consistency and accuracy may arise. Serious measurement errors may occur especially in the less developed countries.

It is clear that the accumulation of human or physical capital is not the one and only driving force of economic growth. Nevertheless, a sizable part of the residual may indeed be attributed to the complementary relationship and to interactions between human and physical capital.

[70] See for example Levine (1992).
[71] Here, the Solow residual does not include the modeled human capital like in traditional models without human capital.
[72] For example: human capital per worker is expressed only by the average number of years of schooling. However, this approach does not consider the differences in the quality of schooling and other properties of human capital.

7. Conclusion

This thesis was aimed to provide a short description of the human capital concept. As this concept describing a specific type of human behavior and abilities is very broad, it is impossible, in a text of this length, to detail every single aspect of this subject. However, the main principles have been covered. It has been shown that human capital plays an important role in the economy as it affects many different human activities.

In the first three chapters, we have shown the structure and the extent of the human capital concept. We have drafted a brief description of the types of investment in human capital and their determinants. We have seen that the number of things that may have some influence over the amount of investment into one's human capital is very large as the whole concept of human capital is very complex.

The complexity of this subject has many advantages but also a number of disadvantages. In chapter 4, we have explained the main problems related to the measuring of human capital. It is difficult to encompass all aspects of human capital in a quantitative model that would allow for a comprehensive cross-country comparison. Nevertheless, we have proposed a few solutions of this problem.

A specific method of measuring the national level of human capital is the Human Development Index. This approach promises a rational solution of this problem, which is also suitable for cross-country comparisons. Using this concept, it is possible to show that the situation in the Czech Republic is relatively good. Our country is at the 36^{th} place in the HDI ranking. Nevertheless, there are still many things to improve.

In chapter 5, we have summarized the importance of human capital at the macroeconomic level. We have seen that the situation in the Czech Republic is fairly good and that the country has good prospects of improving its welfare, because

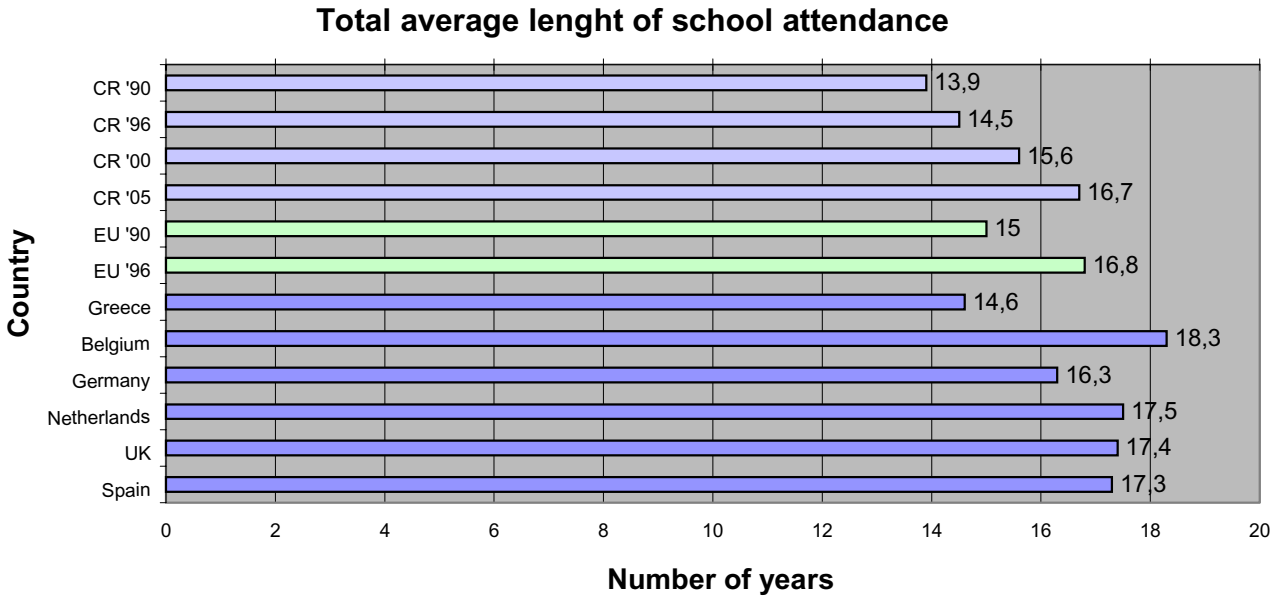
the indicators of human capital are relatively high compared to output and its growth. This is undoubtedly a positive signal for the future of our country.

The brief comparison of growth models with human capital in chapter 6 has illustrated the diversity of approaches to human capital. The problem related to the measuring of human capital has shown itself quite clearly in this comparison. Models and empirical studies dealing with economic growth require a comprehensive indicator of human capital capable of reflecting its real importance. Chapter 6 has also shown that the phrase “human capital” in the name of a model does not necessarily mean that the model really involves human capital. The phrase “human capital” is sometimes used as a mere technical tool.

We have to admit that the human capital concept is still incomplete and contains certain imperfections. Nevertheless, it may substantially contribute to the quality and reliability of many economic models and may facilitate the process of introducing new methods into the science called economics.

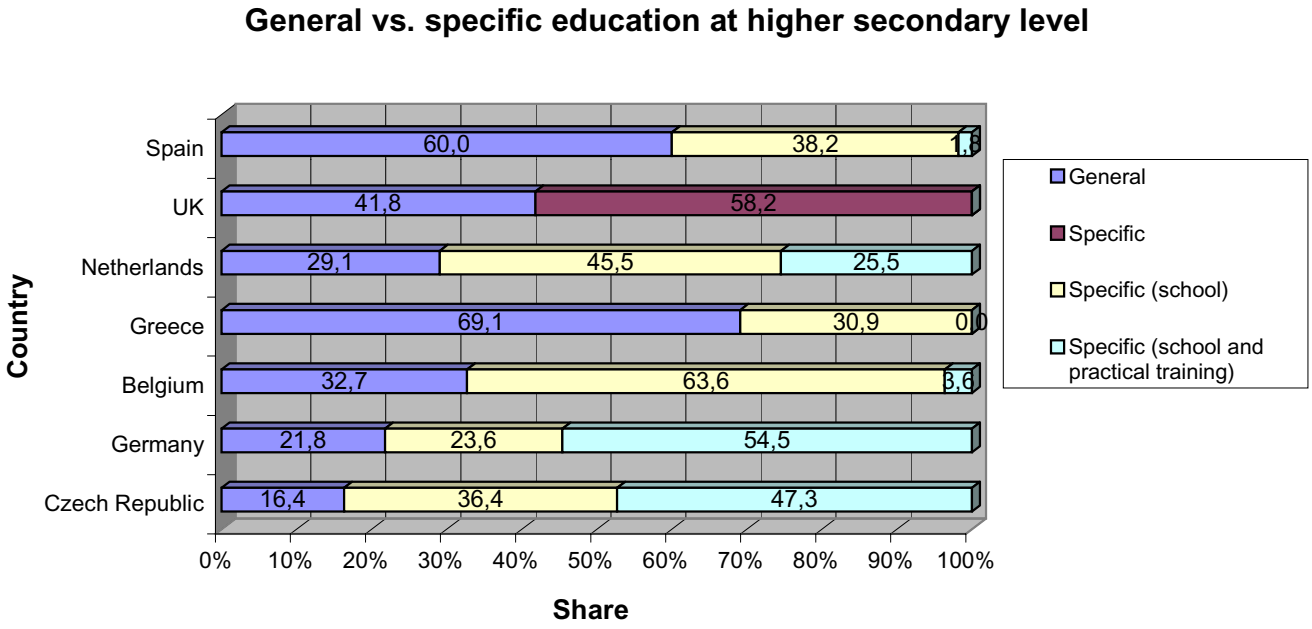
Appendix: Figures, tables and data views

Figure 1: Comparison of the average length of school attendance in selected countries. The Czech Republic has lower average school attendance than the EU countries, but a converging trend may be observed.



Note: Data where no year is stated are from 1996.
Source: Institute for Information in Education, OECD.

Figure 2: Comparison of the share of general and specific education at higher secondary level in the Czech Republic and in selected EU countries in 1996.



Note: The last category (specific training, both theoretical and practical) applies to most higher secondary schools in the Czech Republic where both school attendance and practical training is required (i.e. the so-called "Vyšší střední škola"). The share of general education at higher secondary

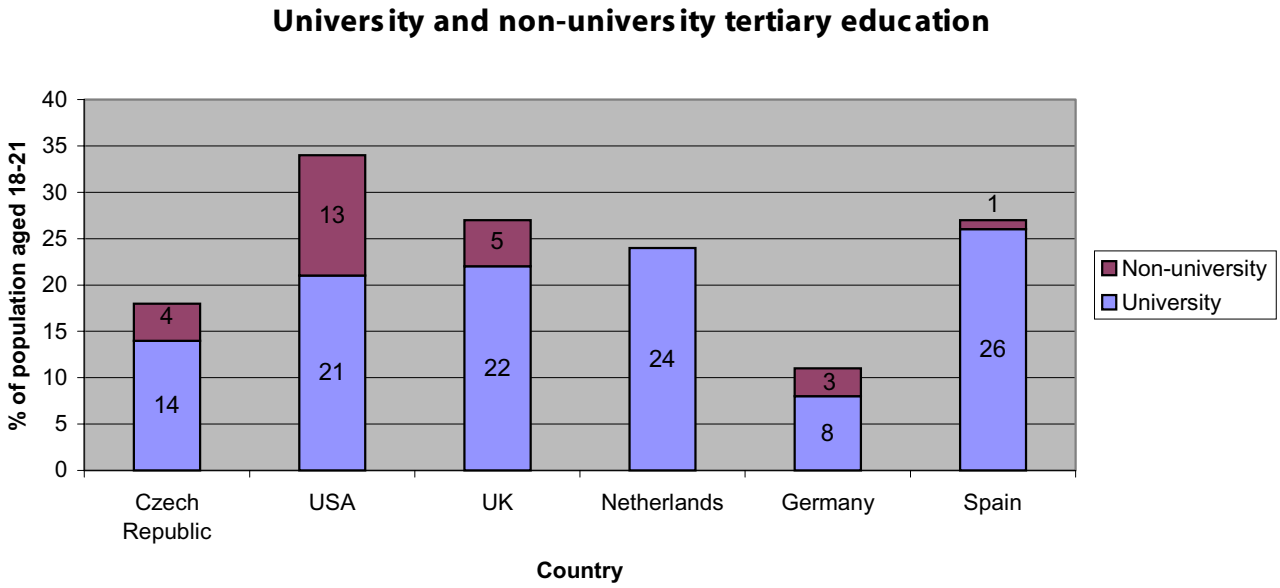
level in the Czech Republic is clearly lower than in the EU countries. In the UK, schools at this level are not divided into the two groups, therefore there is a special category for this country.
Source: National Educational Fund (1999)

Table 1: Participation of different age groups in education (1996 data)

Country	*Compulsory education ends at the age of*	*Share of 5-14 year old population at school (%)*	*Share of 15-19 year old population at school (%)*	*Share of 20-29 year old population at school (%)*
Czech Republic	15	98,8	72,2	11,1
EU average	16	98,0	80,1	20,5
Netherlands	18	99,2	88,5	23,7
UK	16	98,8	72,1	17,5
Spain	16	98,4	73,8	21,8
Germany	18	96,5	87,9	20,5

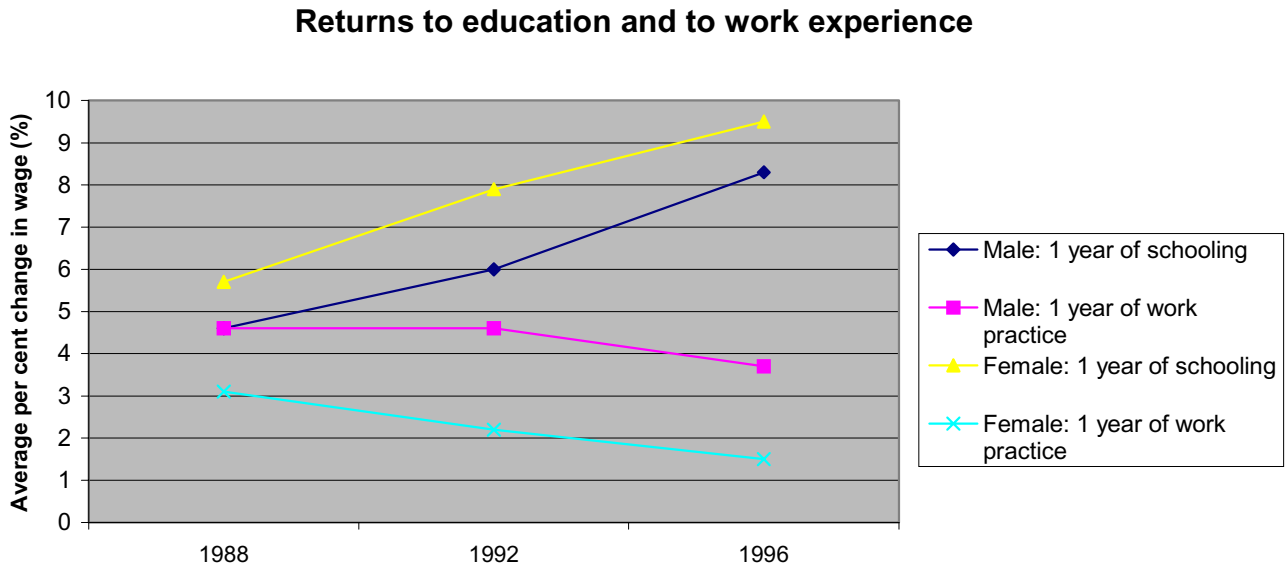
Source: National Educational Fund (1999)

Figure 3: Participation in tertiary education in selected countries in 1996.



Note: The main cause of the low tertiary education participation in the Czech Republic is the limited supply in this sector. According to the Ministry of Education, the demand for university education was approx. twice as high as the supply throughout the 1990s. The situation may soon start improving since private non-university education is available from the academic year 1999 - 2000. However, the total supply is still low.
Source: National Educational Fund (1999)

Figure 4: Evolution of returns to education and to work experience in the Czech Republic from 1988 to 1996.



Source: Czech Statistic Institute (1996).

Table 2: Evolution of returns to education, work experience and to different levels of completed education in the Czech Republic from of 1988 to 1996.

	Type of education	*1988*	*1992*	*1996*
Male	1 year of schooling	4,6	6,0	8,3
	1 year of work experience	4,6	4,6	3,7
	Vocational school	5,0	9,0	16,6
	Secondary school	13,5	24,9	39,1
	University	34,4	50,9	73,2
Female	1 year of schooling	5,7	7,9	9,5
	1 year of work experience	3,1	2,2	1,5
	Vocational school	6,7	8,8	10,7
	Secondary school	21,6	36,2	42,1
	University	50,4	63,2	75,7

Note: The shift in favor of higher education between 1988 and 1996 is apparent. The wage differentiation has been increasing since the introduction of market economy. However, the level of differentiation is still lower than in many western countries (see table 3).
Source: Czech Statistic Institute (1996)

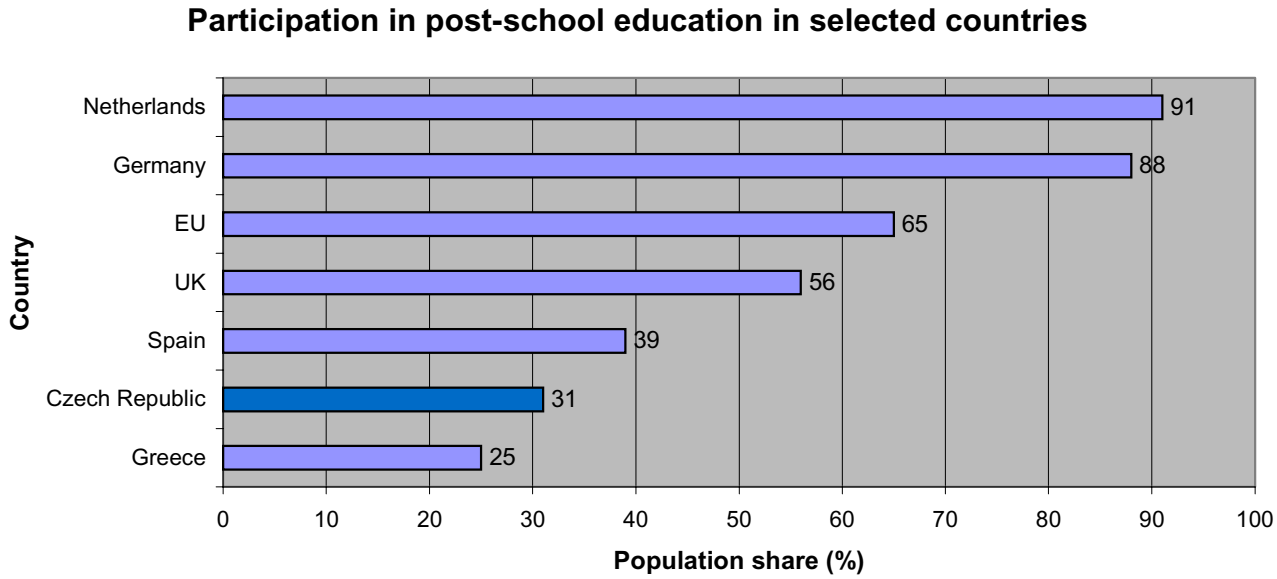
Table 3: Comparison of wage differentiation according to received education level in selected OECD countries in 1995-6.

(100 % = average wage of a worker with secondary level education)

Country	*Lower education*	*University education*	*Lower/university ratio*
Czech Republic	78	151	1,94
Germany	76	158	2,08
USA	67	183	2,73
UK	74	181	2,44
Netherlands	86	137	1,59

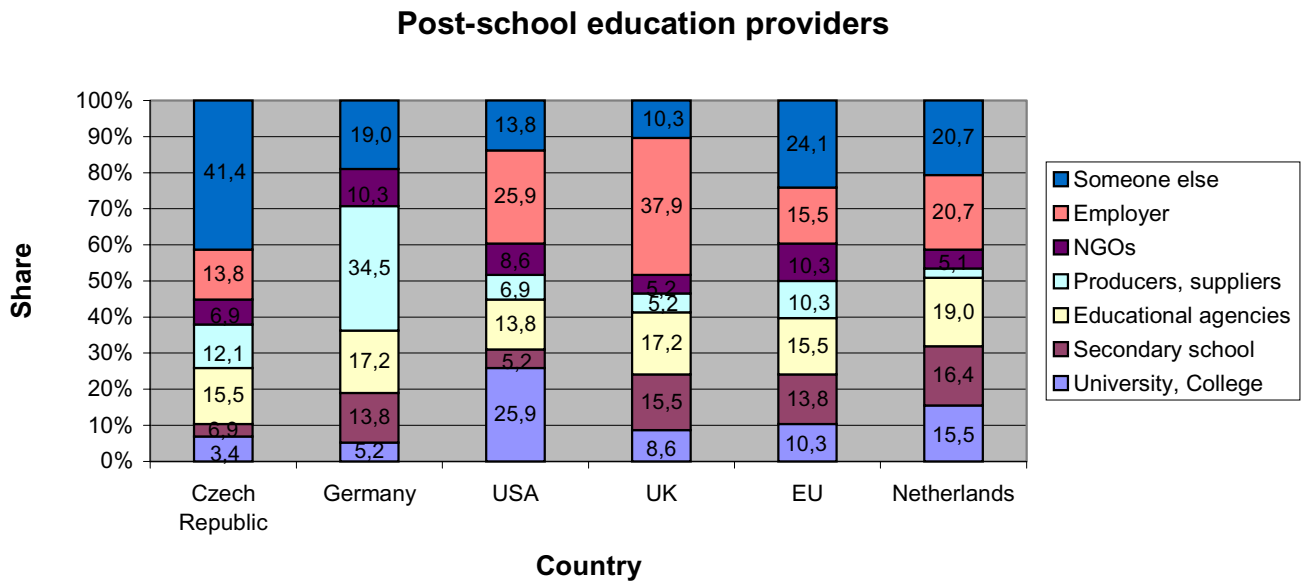
Source: Czech Statistic Institute (1996), OECD (1996).

Figure 5: Comparison of participation in further education in selected countries in 1996.



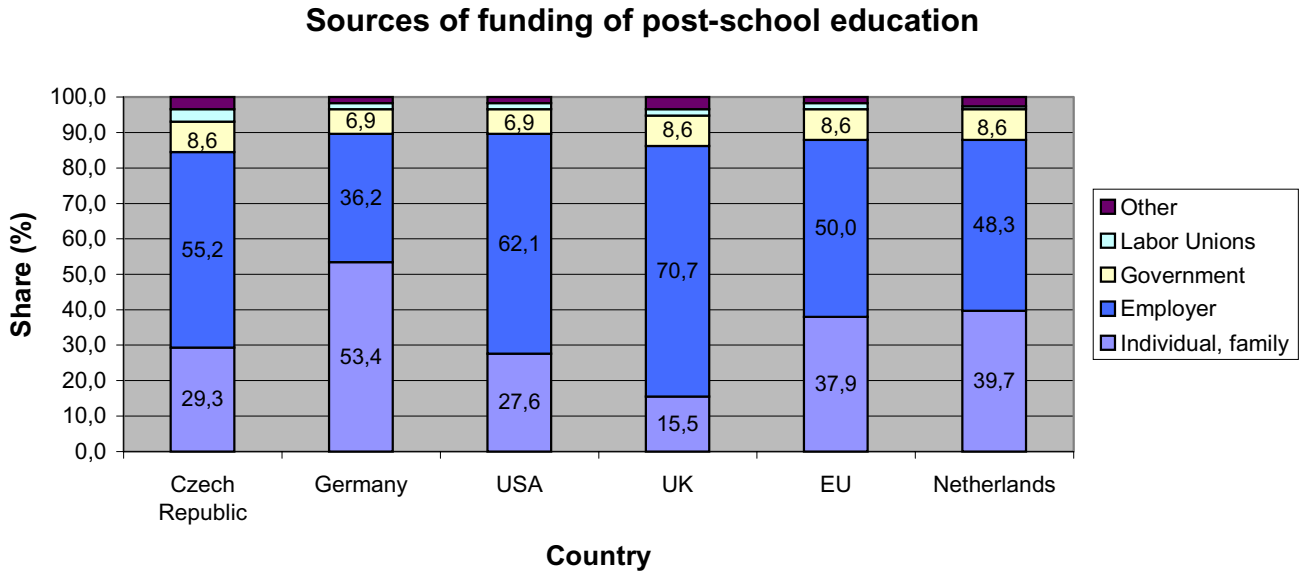
Source: National Educational Fund (1999).

Figure 6: Comparison of shares of individual providers of further education in selected countries in 1998.



Note: This type of education includes on-the-job training, requalification and other education. The share of employer's supply of further education in the Czech Republic is relatively low (13,8 % compared to the EU average of 15,5 %). The largest share of further education is provided by other subjects (for example by individual employees themselves).
Source: National Educational Fund (1999).

Figure 7: Comparison of shares of individual sources of financing of further education in selected countries in 1998.



Note: The employers in the Czech Republic bear an important part of the total costs. The role of the government is similar to other developed countries.
Source: National Educational Fund (1999).

Figure 8a: The extent of and participation in on-the-job training in hours per year per employee in selected countries in 1994-5.

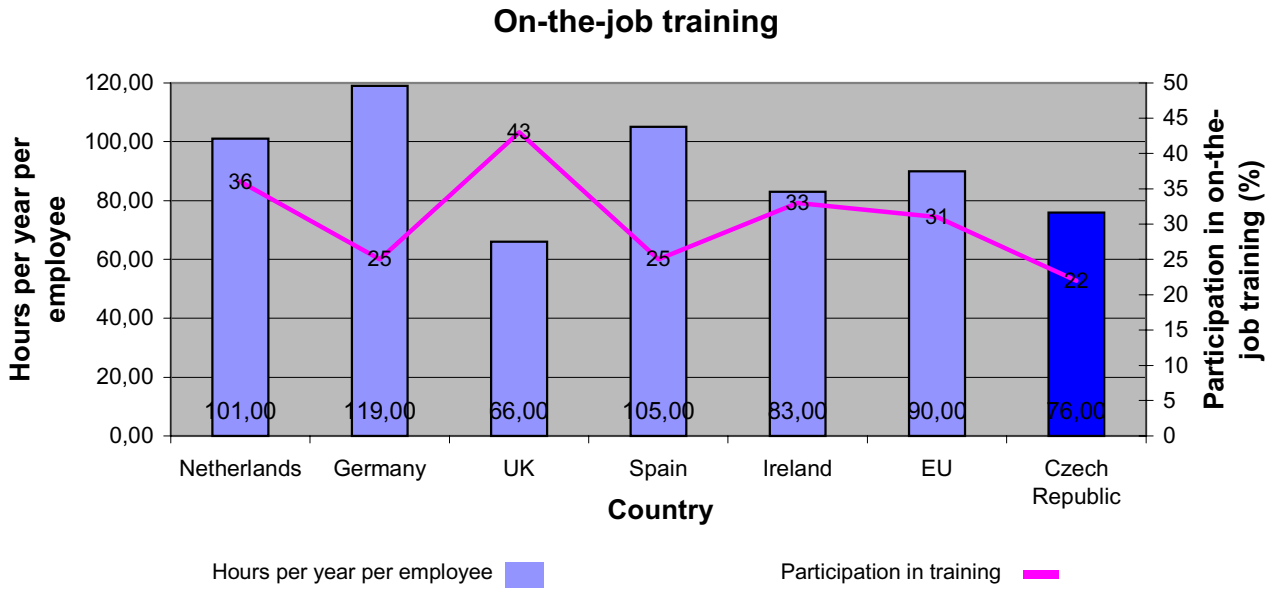
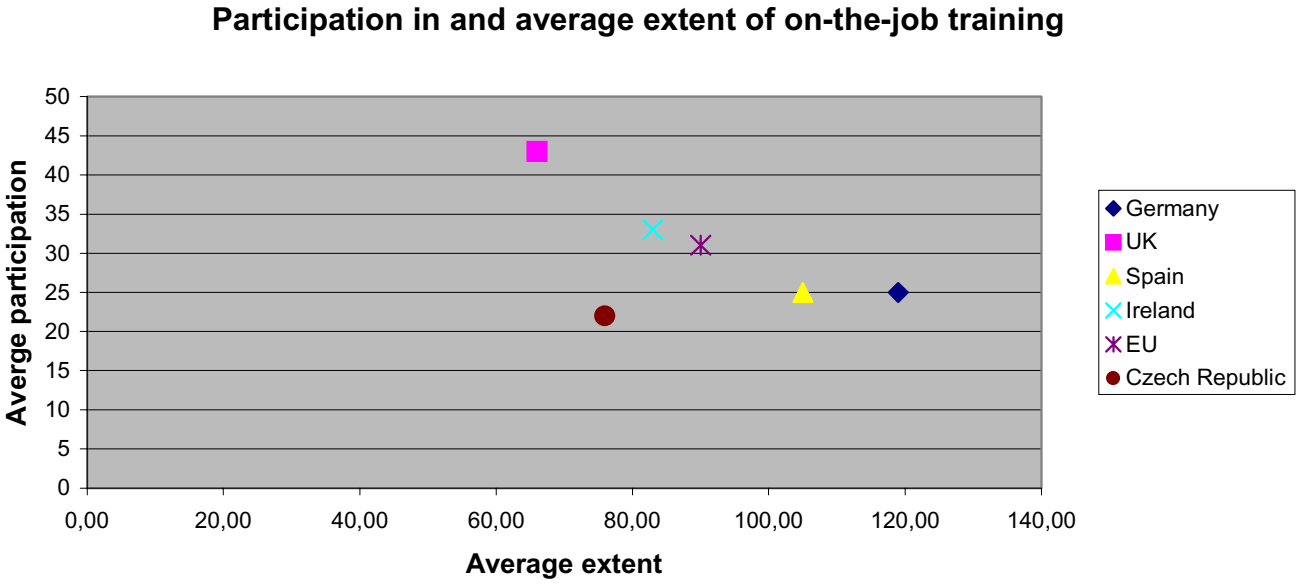
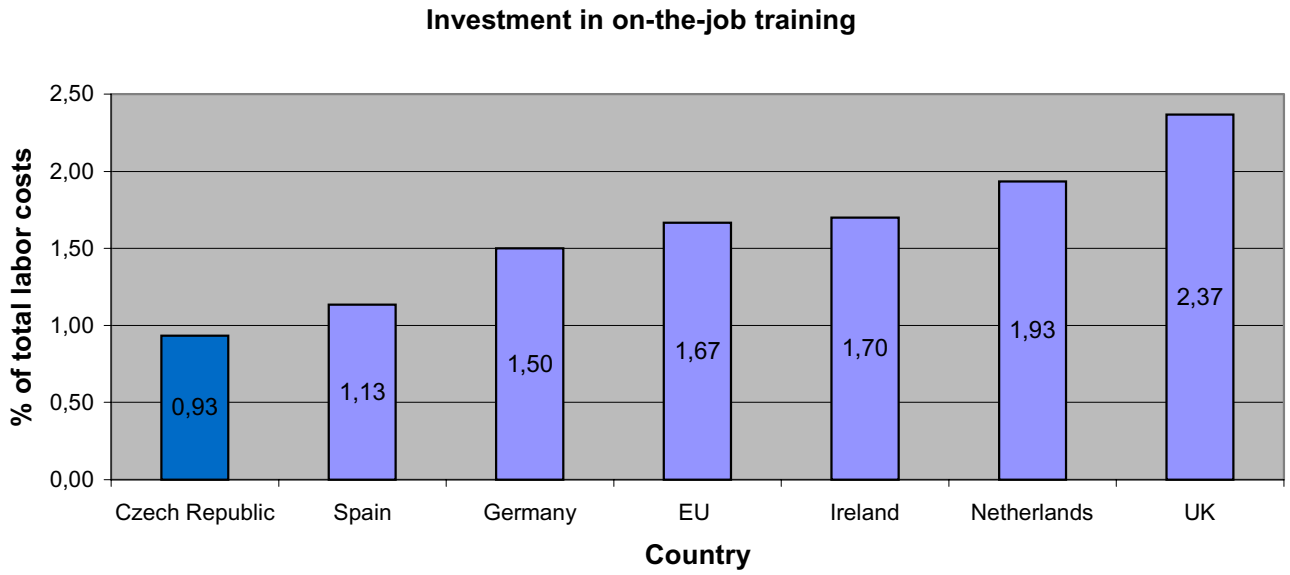


Figure 8b: The extent of and participation in on-the-job training in hours per year per employee in selected countries in 1994-5. (Scatter plot)



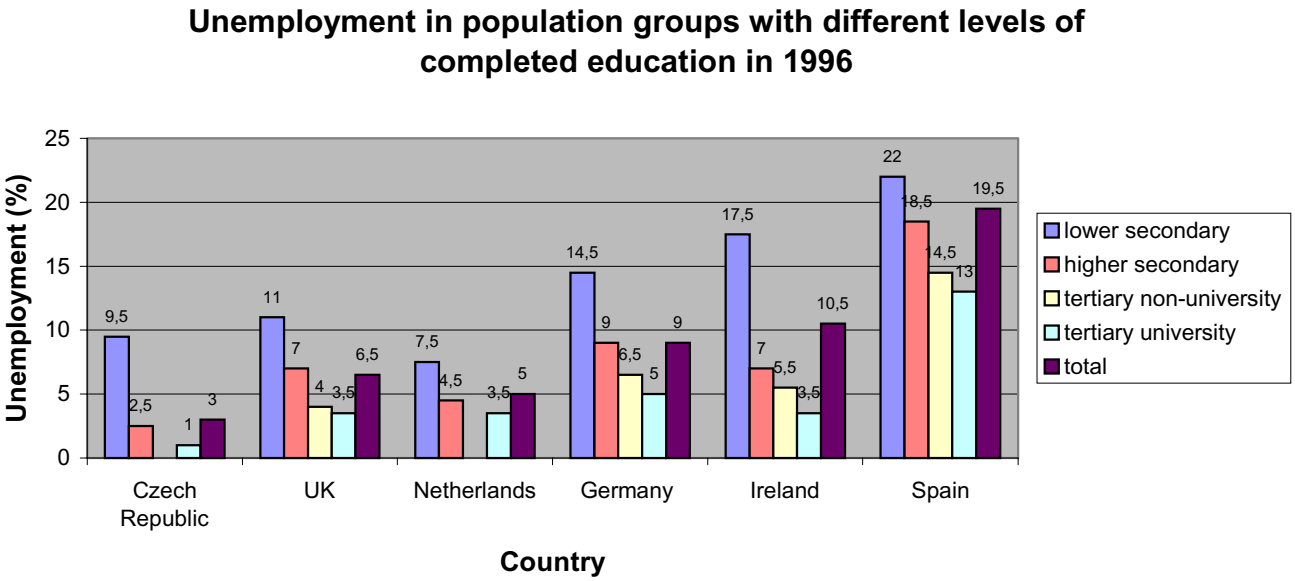
Note: It is apparent that in the Czech Republic, both participation in and the extent of on-the-job training are low. This should probably improve during the transition to market economy. Only 12 % of companies consider on-the-job training an important part of their human resource management (1996 data). According to National Educational Fund data only 21% of all companies have a complete program of training. Czech companies (like companies in other post-communist countries) invest little money in their employees' education (approx. 0,9 % of total labor costs in 1995, while the EU average amounts to 1,6 % - see chart 9).
Source: National Educational Fund (1999).

Figure 9: Investment in on-the-job training in different European countries (as percentage of total labor costs)



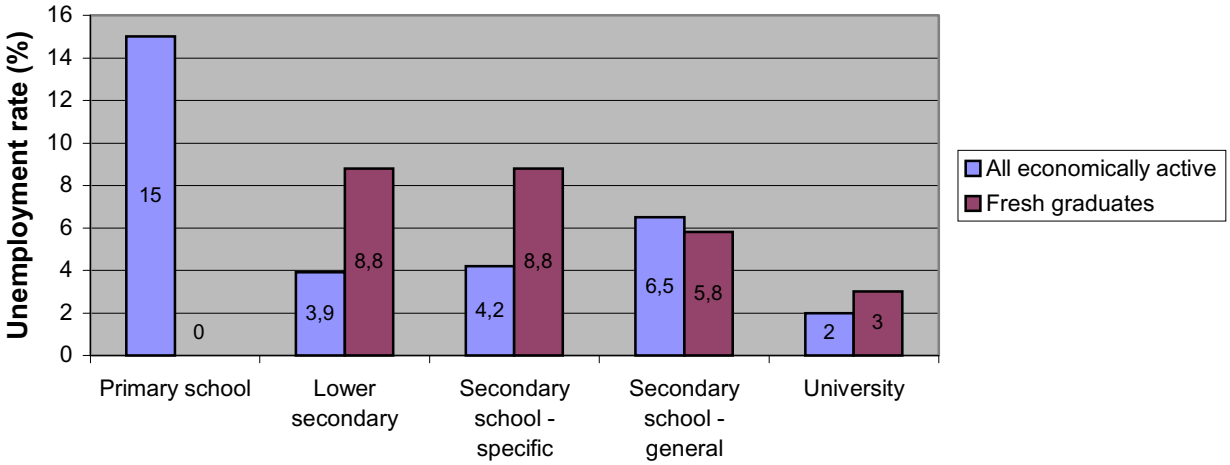
Note: Total expenditures on on-the-job training in the Czech Republic are the lowest compared to the EU countries. This may result from the worsening economic situation in the Czech economy after 1995. However, low training investment may lead to lower productivity and such development may result in a vicious circle.
Source: National Educational Fund (1999).

Figure 10: Effects of higher levels of completed education on the probability of unemployment in selected European countries.



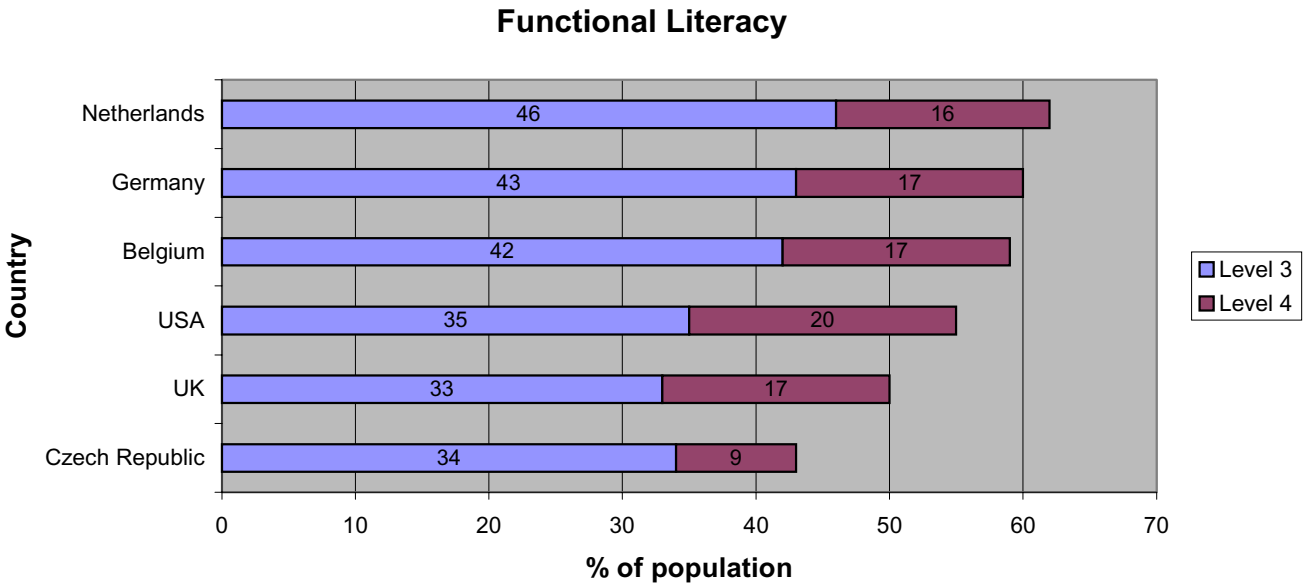
Note: One of the important advantages of completing higher education is the positive effect on employment stability. In all countries, the higher the educational level of an employee, the lower the probability to become unemployed. There were no non-university tertiary level educational institutions in the Czech Republic and Netherlands in 1996.
Source: Ministry of Labor and Social Affairs of the Czech Republic (1999).

Figure 11: Unemployment in groups with different levels of education in the Czech Republic in 1998.



Note: In most categories, fresh graduates face a higher risk of unemployment, but this figure is lower for higher levels of education. General secondary school education has a weaker effect on unemployment than the specific one.
Source: Ministry of Labor and Social Affairs of the Czech Republic (1999).

Figure 12: Functional literacy in the Czech Republic and in other selected countries - share of population at levels 3 and 4.



Note: The alarmingly low value of functional literacy in the Czech Republic should compel the designers of the system of education to reorganize it so that the methods and required abilities would better correspond to the needs and principles of modern society.
Source: Institute for Information in Education data.

Table 4: Health indicators in selected countries (data without other specification are from 1997)

Indicator:	Czech republic	Slovakia	USA	Germany
Life expectancy (years)	73,90	73,00	76,70	77,20
Life expectancy index	0,81	0,80	0,86	0,87
People expected to die before the age of 60 (%)	14,20	16,40	12,60	10,70
Life expectancy (1970) (years)	69,90	70,20	70,70	70,80
Infant mortality rate (‰)	6,00	10,00	7,00	5,00
Infant mortality rate (1970) (‰)	21,00	25,00	20,00	22,00
Doctors per 100 000 inhabitants	293,00	325,00	245,00	319,00
Public health expenditures (% GDP)	6,90	6,10	6,50	8,10
Fertility rate	1,20	1,40	2,00	1,30
Annual population growth 1975-1997	0,10	0,10	1,00	0,20

Source: United Nations (1999).

Table 5: Education and science indicators in selected countries (data without other specification are from 1997)

Indicator:	Czech republic	Slovakia	USA	Germany
Adult literacy rate (%)	99,00	99,00	99,00	99,00
Primary + Secondary + Tertiary enrollment rate (%)	0,74	0,75	0,94	0,88
Index of education	0,91	0,91	0,97	0,95
Primary school enrollment (%)	99,90	n.a.	99,90	99,90
Secondary school enrollment (%)	99,90	n.a.	96,30	95,30
R&D scientist per 1000 inhabitants	1,90	2,60	3,60	4,30
Education expenditures (% GDP)	5,40	4,90	5,40	4,80

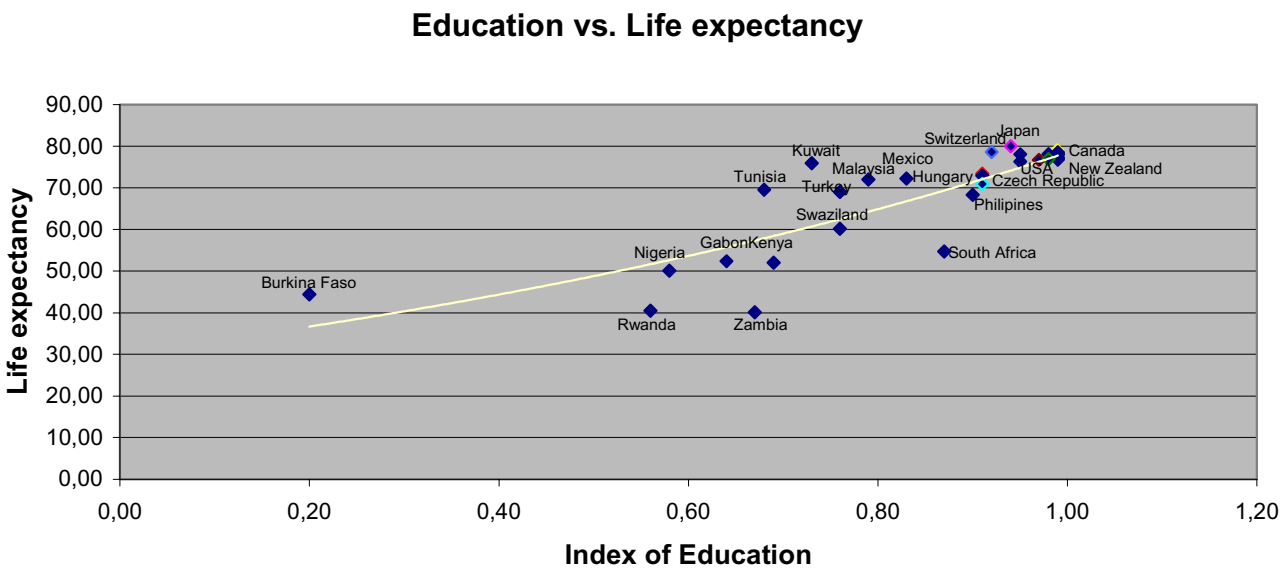
Source: United Nations (1999).

Table 6: Indicators related to national wealth in selected countries (data without other specification are from 1997)

Indicator:	*Czech republic*	*Slovakia*	*USA*	*Germany*
Real per capita GDP (PPP$)	10510,00	7910,00	29010,00	21260,00
Per capita GDP (US$)	3329,00	3432,00	21541,00	n.a.
GDP index	0,78	0,73	0,95	0,89
Human development index	0,83	0,81	0,93	0,91
Long term unemployment (%)	1,20	n.a.	0,50	6,40
Real per capita GDP of the poorest 20 %	4426,00	3344,00	5800,00	6594,00
Real per capita GDP of the richest 20 %	15764,00	8823,00	51705,00	37682,00
Poorest/richest ratio	3,60	2,60	8,90	5,80
GNP per capita (US$)	5240,00	3680,00	29080,00	28280,00
Average inflation (1989-1996) (%)	11,50	8,90	3,20	n.a.
GDP (US$ billions)	52,00	19,50	7834,00	2092,30
Consumption (% GDP)	51,00	49,00	69,00	58,00
Government expenditures (% GDP)	20,00	22,00	16,00	20,00
Gross domestic investment (% GDP)	34,00	35,00	18,00	21,00
Gross domestic savings (% GDP)	28,00	28,00	16,00	22,00
Tax revenues (% GDP)	33,00	n.a.	20,00	27,00
Urban population (%)	65,70	59,70	76,60	86,90
Unemployment rate (%)	4,70	11,60	5,00	9,80

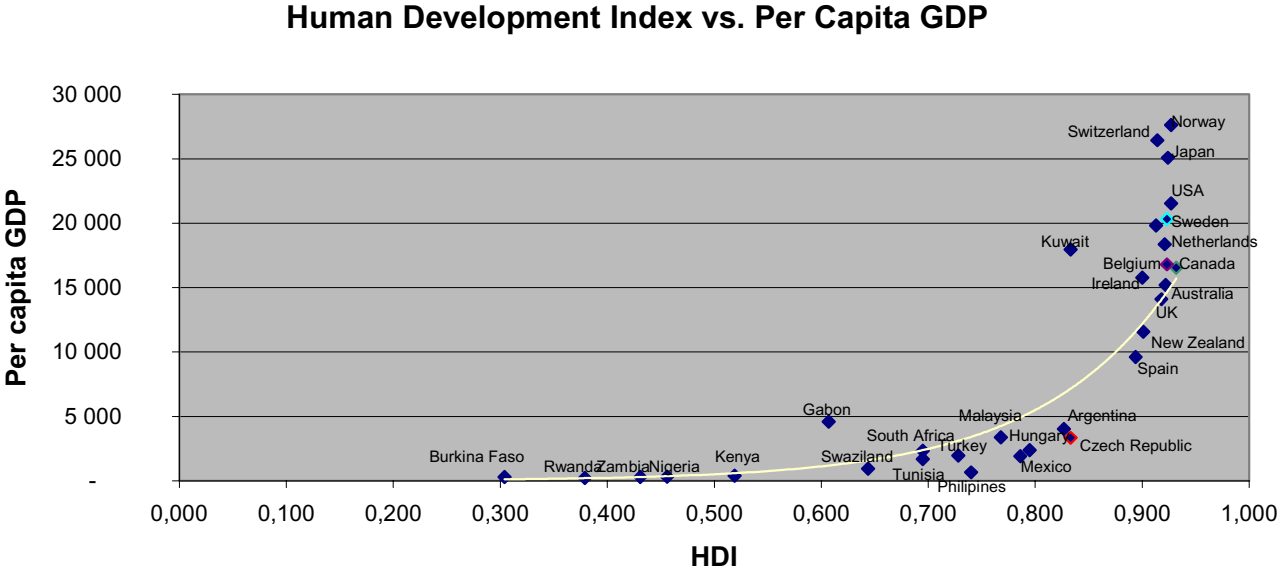
Source: United Nations (1999).

Chart 13: The relationship between education and life expectancy (for a panel of 30 countries). Data are from 1997.



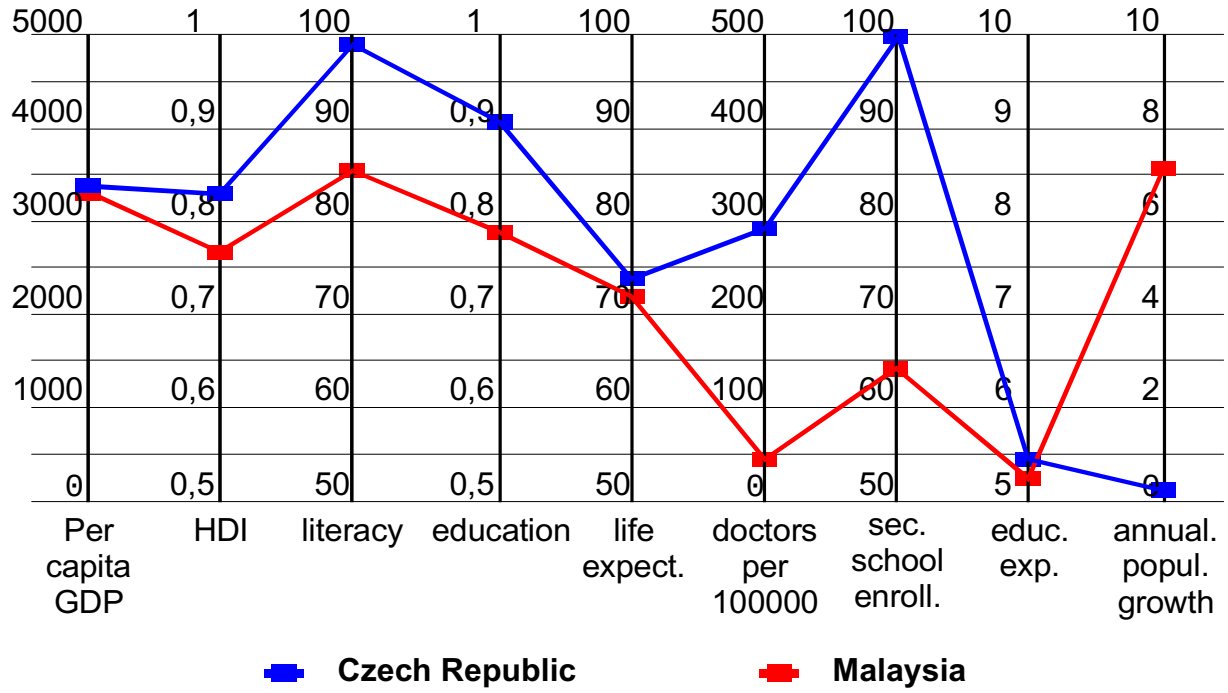
Note: The index of education consists of data on literacy, enrollment rates and other indicators of education. We can see that the countries with higher levels of education tend to pursue a healthier life style and better health care and therefore their life expectancy is higher. The trend line is exponential.
Source: United Nations (1999).

Figure 14: Per capita GDP and the level of development in 30 selected countries (data from 1997).



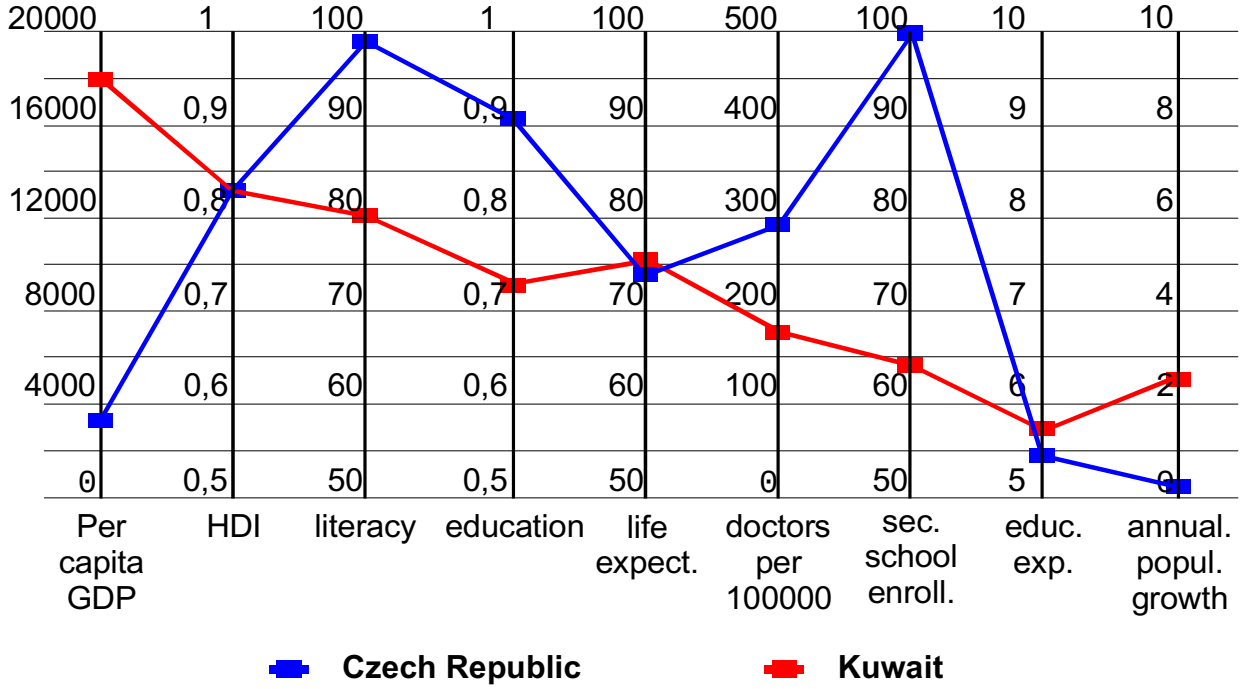
Note: The trend line is exponential. It is apparent that the level of development of the Czech Republic slightly exceeds its per capita GDP.
Source: United Nations (1999).

Figure 15: The differences in several indicators of human development in the Czech Republic and Malaysia. We can see that countries with nearly the same level of per capita GDP can have substantially different values of other indicators describing their development.



Source: United Nations (1999)

Figure 16: The differences in several indicators of human development in the Czech Republic and Kuwait (countries with the same HDI)



Source: United Nations (1999)

Table 7a: Comparison of population growth, GDP growth and growth of per capita GDP in 30 selected countries from all over the world. Countries are ordered by per capita GDP.

Country name	*Per Capita GDP (US$)*	*Growth of per capita GDP*	*GDP growth*	*Population Growth*
Norway	27 620	3,3	2,9	0,4
Switzerland	26 441	1,5	1,1	0,6
Japan	25 084	3,5	2,9	0,6
U.S.A.	21 541	2,5	1,5	1,0
Sweden	20 309	1,2	0,8	0,4
Finland	19 816	1,9	1,5	0,4
Netherlands	18 369	2,3	1,7	0,6
Kuwait	17 991	1,3	-1,0	2,5
Belgium	16 809	2,0	1,9	0,2
Canada	16 525	2,7	1,4	1,2
Ireland	15 779	3,7	3,0	0,6
Australia	15 186	2,9	1,6	1,3
U.K.	14 096	2,0	1,8	0,2
New Zealand	11 565	1,4	0,6	0,9
Spain	9 591	2,2	1,7	0,5
Gabon	4 575	0,2	-2,9	3,0
Argentina	4 021	1,4	-0,1	1,4
Czech Republic	3 329	n.a.	n.a.	0,1
Hungary	2 372	0,9	1,1	-0,2
South Africa	2 336	1,7	-0,6	2,1
Turkey	1 940	3,9	1,7	2,1
Mexico	1 910	2,8	0,6	2,1
Tunisia	1 670	4,3	1,9	2,2
Swaziland	947	5,1	1,8	3,0
Philippines	652	3,0	0,5	2,3
Kenya	372	4,0	0,5	3,4
Nigeria	315	2,5	-0,6	2,8
Zambia	300	0,8	-2,2	2,6
Burkina Faso	290	3,7	1,3	2,7
Rwanda	222	1,4	-0,5	1,4

Table 7b: Correlation matrix for the data in table 7a

Correlation	*Population growth*	*GDP growth*	*Growth of per capita GDP*
Population growth	1,00	0,26	-0,57
GDP growth	0,26	1,00	0,64
Growth of per capita GDP	-0,57	0,64	1,00

Source: United Nations (1999) and author's calculations

Table 8a: Comparison of education and literacy indicators, GDP growth and growth of per capita GDP in 30 selected countries from all over the world. Countries are ordered by literacy rate.

Country	Literacy rate (%)	Index of education	Per cap. GDP (US$)	Prim. Sch. Enroll rate (%)	Sec. Sch. Enroll rate (%)	Educ. expendit. %GDP	GDP growth rate (%)	Pcap.GDP growth rate (%)
Finland	99,0	0,99	19 816	99,9	95,4	7,6	1,9	1,5
Belgium	99,0	0,99	16 809	99,9	99,9	3,2	2,0	1,9
Ireland	99,0	0,95	15 779	99,9	99,9	5,8	3,7	3,0
Norway	99,0	0,98	27 620	99,9	97,6	7,5	3,3	2,9
New Zealand	99,0	0,98	11 565	99,9	92,9	7,3	1,4	0,6
U.S.A.	99,0	0,97	21 541	99,9	96,3	5,4	2,5	1,5
Canada	99,0	0,99	16 525	99,9	95,2	7,0	2,7	1,4
Switzerland	99,0	0,92	26 441	99,9	83,7	5,3	1,5	1,1
Netherlands	99,0	0,99	18 369	99,9	99,9	5,2	2,3	1,7
Hungary	99,0	0,91	2 372	97,5	96,9	4,7	0,9	1,1
Sweden	99,0	0,99	20 309	99,9	99,9	8,3	1,2	0,8
Australia	99,0	0,99	15 186	99,9	96,0	5,6	2,9	1,6
U.K.	99,0	0,99	14 096	99,9	91,8	5,4	2,0	1,8
Japan	99,0	0,94	25 084	99,9	99,9	3,6	3,5	2,9
Czech Republic	99,0	0,91	3 329	99,9	99,9	5,4	n.a.	n.a.
Spain	97,2	0,95	9 591	99,9	91,9	4,9	2,2	1,7
Argentina	96,5	0,91	4 021	99,9	76,9	3,5	1,4	-0,1
Philippines	94,6	0,90	652	99,9	77,8	2,2	3,0	0,5
Mexico	90,1	0,83	1 910	99,9	66,1	4,9	2,8	0,6
South Africa	84,0	0,87	2 336	99,9	94,9	7,9	1,7	-0,6
Turkey	83,2	0,76	1 940	99,9	58,4	2,2	3,9	1,7
Kuwait	80,4	0,73	17 971	65,2	63,2	5,7	1,3	-1,0
Kenya	79,3	0,69	372	65,0	61,1	6,6	4,0	0,5
Swaziland	77,5	0,76	947	94,6	81,5	7,3	5,1	1,8
Zambia	75,1	0,67	300	72,4	42,2	2,2	0,8	-2,2
Tunisia	67,0	0,68	1 670	99,9	74,3	6,7	4,3	1,9
Gabon	66,2	0,64	4 575	n.a.	n.a.	2,8	0,2	-2,9
Rwanda	63,0	0,56	222	78,3	n.a.	n.a.	1,4	-0,5
Nigeria	59,5	0,58	315	n.a.	n.a.	0,9	2,5	-0,6
Burkina Faso	20,7	0,20	290	32,3	12,8	3,6	3,7	1,3

Table 8b: Correlation matrix for the data in table 8a

Correlation	*GDP growth*	*GDP per. Cap. growth*	*GDP per. Cap.*	*Log (GDP p.cap.)*
Literacy rate	-0,17	0,40	0,61	0,73
Index of education	-0,15	0,44	0,64	0,78
Prim. Sch. Enroll rate	-0,07	0,39	0,36	0,57
Sec. Sch. Enroll rate	0,45	-0,19	0,59	0,76
Education expenses	0,12	0,33	0,39	0,43

Source: United Nations (1999) and author's calculations

Table 9a: Comparison of health indicators, GDP growth and growth of per capita GDP in 30 selected countries from all over the world. Countries are ordered by GDP per capita.

Country:	Life expectancy (years)	Per Capita GDP (US$)	Infant mortality rate (‰)	Doctors per 100000	GDP growth rate (%)	Per cap. GDP growth (%)
Canada	79,00	16 525	6	221	2,7	1,4
Norway	78,10	27 620	4	n.a.	3,3	2,9
U.S.A.	76,70	21 541	7	245	2,5	1,5
Japan	80,00	25 084	4	177	3,5	2,9
Belgium	77,20	16 809	6	365	2,0	1,9
Sweden	78,50	20 309	4	299	1,2	0,8
Australia	78,20	15 186	5	n.a.	2,9	1,6
Netherlands	77,90	18 369	5	n.a.	2,3	1,7
U.K.	77,20	14 096	6	164	2,0	1,8
Switzerland	78,60	26 441	5	301	1,5	1,1
Finland	76,80	19 816	4	269	1,9	1,5
New Zealand	76,90	11 565	7	210	1,4	0,6
Ireland	76,30	15 779	6	167	3,7	3,0
Spain	78,00	9 591	5	400	2,2	1,7
Kuwait	75,90	17 971	12	178	1,3	-1,0
Czech Republic	73,40	3 329	6	293	n.a.	n.a.
Argentina	72,90	4 021	21	268	1,4	-0,1
Hungary	70,90	2 372	10	337	0,9	1,1
Mexico	72,20	1 910	29	107	2,8	0,6
Philippines	68,30	652	32	11	3,0	0,5
Turkey	69,00	1 940	40	103	3,9	1,7
South Africa	54,70	2 336	49	59	1,7	-0,6
Tunisia	69,50	1 670	27	67	4,3	1,9
Swaziland	60,20	947	66	n.a.	5,1	1,8
Gabon	52,40	4 575	85	19	0,2	-2,9
Kenya	52,00	372	57	15	4,0	0,5
Nigeria	50,10	315	112	21	2,5	-0,6
Zambia	40,10	300	112	n.a.	0,8	-2,2
Rwanda	40,50	222	105	n.a.	1,4	-0,5
Burkina Faso	44,40	290	110	n.a.	3,7	1,3

Table 9b: Correlation matrix for the data in table 9a

Correlation	*GDP growth*	*GDP per. Cap. growth*	*GDP per. Cap.*	*Log (GDP p.cap.)*
Life expectancy	0,05	0,63	0,74	0,88
Infant mortality rate	-0,01	-0,61	-0,72	-0,86
Doctors per 100000	-0,38	0,41	0,58	0,57

Source: United Nations (1999) and author's calculations

Table 10a: Regressions for growth rate of real per capita GDP. These regressions have been calculated for a panel of 87 countries for the period 1965-75. The indicators in this table represent only a narrow selection of indicators included in original study.

Indicator	*Regression coefficient*	*Standard error*
log(per.cap.GDP)	-0,261	0,0031
male sec. educ.	0,013	0,0056
female sec. educ.	-0,055	0,0068
male higher educ.	0,055	0,0290
female higher educ.	-0,085	0,0390
log (life expectancy)	0,058	0,0130
log (GDP*HK)	-0,315	0,0970

Source: Barro, Sala-I-Martin (1999).

Table 10b: Regressions of the growth rate of real per capita GDP. These regressions have been calculated for a panel of 87 countries for years 1965-87. The indicators in this table represent only a narrow selection of indicators included in the original study.

Indicator	Regression coefficient	Standard error
log(per.cap.GDP)	0,1240	0,0270
years of schooling	0,0072	0,0017
log(fertility rate)	-0,0251	0,0047
democracy index	0,0540	0,0290

Source: Barro (1998).

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