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Human Capital and Finland's Economic Growth in 1910–2000

− Assessing Human Capital Accumulation by Education
Inside the National Accounts Framework

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– Assessing Human Capital Accumulation by Education inside the National Accounts Framework

Abstract

This paper examines whether the considerable input in education has had a connection to Finland's fast GDP per capita growth. For analysing empirically the impacts of investing in and accumulation of human capital on GDP and GDP per capita, human capital is assessed in the systematic framework of National Accounts. Final education consumption expenditures per year were separated from final consumption and treated as investments in intangible human capital in Finland in 1890–2000. Human capital stock was accumulated through invested monetary flows in education taking into account the obsolescence and renewing costs of the income generating capacity in the form of depreciation. As a result, investments in and the stock of human capital by formal education are valued in monetary terms as GDP and physical capital stock. The results of the analysis show that the direct impact of investments in education on current price GDP has varied between 1% and 5% in Finland in 1890–2000. The average growth of these investments in intangible human capital has been 3.8% a year, which is a higher average growth rate than that of investments in physical capital (3.3%). However, the level of annual investments in physical capital has been substantially higher compared to investments in education. According to the results, there has been a long run co-integration relation between the stock of human capital by education and real GDP per capita. The results showed a direction of causality from human capital by education to real GDP per capita in Finland in 1910–2000.

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1. Introduction

The role of human capital in economic growth, in national production of goods and services and in the incomes generated in the production process has been constantly discussed in economics and economic history, especially since the 1960s[1]. Briefly said, the importance of human capital in economic growth has been duly noted and approved in a variety of modern growth theory models.[2] Human capital is seen either as an input for production together with physical capital or as an enhancing factor for technical change and labour input.

However, in empirical studies no unambiguous agreement has been achieved on the role of increased education in explaining differences in economic growth across countries and time. Some of the cross-country empirical explorations document a positive and significant impact on schooling on real GDP per capita.[3] On the other hand, some find either non-significant or negative effect.[4] It has also been questioned whether other factors would drive the technical change, and would therefore be more important for growth than reproducible capital accumulation.[5] In the longitudinal aspect unequivocal empirical documentation of the relation between human capital accumulation and average income levels in the long run is missing as well.

The reason for the controversy could be that direct measuring of human capital is not an easy task. The proxies for human capital used are typically school enrolment ratio, average years of schooling and literacy rate. However, the empirical counterparts of the other core variables in the growth theories come from inside of the systematic National Accounts frame (GDP and physical capital stock) and are valued in monetary

[1] e.g. Schultz, Theodore W. (1961). Investment In Human Capital. *The American Review of Economics*, Vol. LI, March 1961, Number one, 1-17; Abramowitz, M. (1986). Catching Up, Forging Ahead, and Falling Behind. *Journal of Economic History*, Vol. 46, Issue 2, The Tasks of Economic History (Jun., 1986), 385-406; Lucas, Robert E. Jr. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*, 22, 1 (July), 3-42; Mankiw, N. Gregory & Romer, David & Weil, David N. (1992). A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics,* vol. 107, 1992:2, 407–37; Chaudhuri Kausik and Pushkar Maitra (2008). School Attainment, Completion, and Economic Development: A Cross-Country Analysis. *Review of Development Economics*, 12(1), 90-105

[2] Romer, Paul M. (1986). Increasing Returns and Long-Run Growth, *Journal of Political Economy*, vol. 94, 1986:5, 1002–37; Romer, Paul M. (1987). Growth Based on Increasing Returns Due to Specialization, *American Economic Review*, vol. 77, 1987:2, 56–62; Romer, Paul M. (1990). Endogenous Technological Change, *Journal of Political Economy*, vol. 98, 1990:5, pt. II, S71–S102; Galor Oded (2005). From Stagnation to Growth: Unified Growth Theory. In Aghion P., Steven N. Durlauf (Eds), *Handbook of Economic* Growth. Elsevier B.V. Amsterdam; Truong, Công N. and Binh Tran-Nam (2007). Endogenous Growth and Publicly Funded Knowledge Accumulation. *Review of Development Economics*, 11(2), 421-435

[3] e.g. Barro, R. J. (1991). Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics.* 106, 407-43; Levine, R. and D. Renelt (1992). A Sensitivity Analysis of Cross-Country Growth Regressions. *American Economic Review.* 82, 942-63; Barro, R. J. and X. Sala-i-Martin (1995) *Economic Growth*. New York, McGraw-Hill Inc.

[4] e.g. Lau, L. J., D.T. Jamison and F.F. Louat (1991). Education and Productivity in Developing Countries: An Aggregate Production Function Approach. Policy Research Working Paper # 612, World Bank; Islam, N. (1995) Growth Empirics: A Panel Data Approach. *Quarterly Journal of Ecomonics*, 110, 1127-70; Bosworth, Barry P. & Susan M. Collins (2003). The Empirics of Growth: An Update. *Brookings Papers on Economic Activity*, 2:2003

[5] e.g. Hall Robert E. and Charles I. Jones (1998). Why Do Some Countries Produce So Much More Output Per Worker Than Others? *The Quarterly Journal of Economics*, Vol. 114, No. 1, (Feb., 1999), pp. 83-116

terms. One of the problems with the proxies for human capital is that it is difficult to say whether these variables are comparable with investments in physical capital or with accumulated stock and services of physical capital. An obvious problem is that they do not have a logical connection to GDP as investments in physical capital.

The aim of this paper is to explore empirically the impacts of investing in and accumulation of human capital by formal education on Finland's fast GDP growth in the 20th century. Human capital is treated in the same National Accounts framework as the other variables examined in it, such as GDP, investments in physical capital and accumulation of physical capital stock. Education expenditure per year is separated from final consumption and treated as investments in human capital in Finland in 1890–2000. Human capital stock is accumulated through these monetary valued investments. As a result, investments in and stock of human capital are valued in monetary terms as GDP and physical capital.

Finland is one of the few examples of poor countries' absolute convergence in GDP per capita levels in the 20th century: One hundred years ago it was a poor agrarian country with a gross domestic product per capita less than half of that of the United Kingdom or the United States, world leaders at the time. In the 2000s it is an industrialized and services emphasised high technology country with a standard of living ranked among the top fifteen to twenty countries in the world. From late 19th century to the change of the millennium Finland has been one of the fastest growing countries among nowadays' OECD countries together with Japan and Norway.[6] In the same time frame Finland has converged to the average income levels of her leading neighbours, Sweden and the EU15.[7] This has happened in a low population density country with scarce natural resources. Industrialisation, investing early in physical capital especially in the paper and pulp industries, and the role of electrification and other technical innovations as enablers of productivity increase have been important.[8] In addition, as a part of the cultural climate of Scandinavia schooling has been seen important for bettering the living conditions in the future since early in the late 19th century. Nowadays Finland has often been considered an exemplary country of education[9]. The fundamental question of this study is: Have the substantial inputs in education played a role in this dramatic change of economic performance in Finland?

The rest of the paper is structured as follows: Section 2 focuses on accumulating human capital in the National Accounts. The section begins with a brief discussion of the underlying methodology and continues to empirics on how human capital by education was accumulated in this study. The section ends with analysing the development of the accumulated human capital stock together with GDP and GDP per capita. In section 3 the long run relation of the development of human capital by education and real GDP per capita in Finland in the 20th century will be explored. Section 4 concludes.

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[6] Cf. Jones, Charles I. (2002). *Introduction to Economic Growth.* University of California, Berkeley, 2nd edn., p. 65

[7] Cf. Kokkinen, Arto, Jalava, Jukka, Hjerppe, Riitta and Hannikainen, Matti (2007): Catching up in Europe: Finland's Convergence with Sweden and the EU15, *Scandinavian Economic History Review*, 55:2, 153 - 171.

[8] Jalava, Jukka, Electrifying and digitalising the Finnish manufacturing industry: Historical notes on diffusion and productivity, in *Explorations in Economic Growth. A Festschrift for Riitta Hjerppe on her 60th Birthday*, Ed. Sakari Heikkinen & Jan Luiten van Zanden. Amsterdam: Aksant Academic Publishers 2004, 227-244.

2. *Accumulating Human Capital Stock in the National Accounts Frame*

In this section the basic methodology of how human capital was included in the National Accounts Frame is summarised. The constructed series of long term final education expenditures, employed as investments in intangible human capital, will be introduced and the changes to the Finnish National Accounts[10] in this paper will be reviewed. Finally, the evolution of the formed empirical stock of human capital by education will be illustrated.

2.1 Methodology in brief

Two main well-known approaches on how to incorporate human capital measurement in the context of national accounting have been proposed – the retrospective (or resource-cost) method by John Kendrick in the late 1970s and the prospective (or present value) method by Dale Jorgenson and Barbara Fraumeni in the early 1980s[11].

In his seminal and comprehensive research Kendrick separates tangible and intangible human capital. He provides estimates of stocks and flows of both types inside National Accounts. Investment in tangible human capital is equal to the rearing cost of children up to the age of 14, including the full value of their consumption. Investment in intangible human capital includes, besides education and training, also health, mobility and research and development. Education and training include the costs of schools and the forgone earnings of students 14 years and over. Including the foregone earnings changed GDP a good amount in Kendrick's system, since it has not been an actual monetary flow tracked by the standard National Accounts.

In the approach of Jorgenson and Fraumeni human capital is seen as the present value of future labour incomes. In their profound and accurate system they define the investment in human capital in any year as the sum of lifetime incomes for all individuals born in that year and all immigrants plus the imputed labour compensation for formal schooling for all individuals enrolled in school. A system of National Accounts was introduced, where investment in human capital and consumption of non-market services, i.e. household work and leisure, were included in GDP. From the empirical point of view, for estimates of today's human capital this logical system requires forecasts of future labour incomes.

In the early 2000s Pirkko Aulin-Ahmavaara has made an important contribution by bringing these approaches comparably together with a representation of the production system in the System of National

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[9] e.g. OECD (2003). *Education at a glance 2003*. OECD, Paris. OECD (2007) PISA study 2006, www.pisa.oecd.org/

[10] Hjerppe, Riitta (1996). *Finland's Historical National Accounts 1860-1994: Calculation Methods and Statistical Tables.* University of Jyväskylä, Department of History, Suomen historian julkaisuja 24. Jyväskylä 1996; Statistics Finland, National Accounts, 2005

[11] Kendrick, John W. (1976). *The Formation and Stocks of Total Capital*, Columbia University Press for NBER, New York; Jorgenson, Dale W., Barbara M. Fraumeni, (1984). The Accumulation of Human and Nonhuman Capital. 1948-84. In R. E. Lipsey and H. S. Tice (eds.) The Measurement of Saving, Investment and Wealth, *Studies in Income and Wealth*, Vol. 52, University of Chicago, Chicago, IL

Accounts[12] (SNA93): Aulin-Ahmavaara analysed the underlying production systems of these methods in relation to the production system of the SNA93 and proposed a dynamic input-output representation of a complete production system that includes the production of human capital and human time.[13] In Appendix I Aulin-Ahmavaara's work is followed to compare the underlying production system in the empirical application of this work to the SNA93 production system.

This paper follows the core of ideas of the retrospective approach by Kendrick. From the point of view of long term empirical assessment the accumulated costs approach includes fewer variables that should be imputed (or forecasted) without actual data than in the sound and logical system by Jorgensson and Fraumeni, in which human capital is seen as the present value of future labour incomes.[14] In addition, practically all formal education services are produced by the general government in Finland and public sector services for individuals are valued in the national accounts through their costs.[15] These costs together with the taxes paid by households for the educational services are the monetary flows concerning investing in education in Finland.

The aim of this paper is to concentrate on the intangible human capital and thus the focus is on knowledge and skills accumulation achieved by the educational services. Therefore the rearing costs of children attached to tangible human capital in Kendrick's approach are not included here. In addition, the centre of attention is on the actual monetary flows paid for education in Finland, i.e. on the final education consumption expenditure. The foregone earnings of students are not included here, since they have not been actual monetary flows on macro level paid for the education services, as important as they are seen as opportunity costs at micro level when deciding whether to educate oneself more. Imputing the average forgone earnings would have immediate implications for the level and growth rate of measured GDP. Here the aim is to study whether investing in education has had a connection with the long run evolution of the standard GDP per capita.

Now, if final education consumption expenditures were to be treated as investments in human capital in National Accounts, what should be taken into account? Non-financial assets are in the SNA93 either produced assets or nonproduced assets. Following Aulin-Ahmavaara's comprehensive work, in order to treat

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[12] SNA93, ISWGNA (1993). The Inter-Secretariat Working Group on National Accounts, *System of National Accounts*, Commission of the European Communities-Eurostat, International Monetary Fund, OECD, United Nations, Brussels/Luxembourg, New York, Paris, Washington D.C;

[13] Aulin-Ahmavaara, Pirkko (2002): *Human Capital as a Produced Asset*. Session Paper Number 1, Session 6A, 27th General Conference of the International Association for Research in Income and Wealth, Stockholm, Sweden, August 18-24; Aulin-Ahmavaara, Pirkko (2003): Human Capital and National Accounts, *Tuottavuuskatsaus 2002*, (in Finnish), in Survey of Productivity, Statistics Finland, Helsinki; Aulin-Ahmavaara, Pirkko (2004): Moving Human Capital Inside the Production Boundary. *The Review of Income and Wealth*, series 50, number 2, 213-228.

[14] Cf. Jorgenson, Dale W., Barbara M. Fraumeni, (1984). The Accumulation of Human and Nonhuman Capital. 1948-84. In R. E. Lipsey and H. S. Tice (eds.) The Measurement of Saving, Investment and Wealth, *Studies in Income and Wealth*, Vol. 52, University of Chicago, Chicago, IL; see also Aulin-Ahmavaara, Pirkko (2002). *Human Capital as a Produced Asset*, where Aulin-Ahmavaara presents this method in accordance with the system of production of SNA93.

[15] The public sector services for individuals that are financed with tax revenues are not sold in free markets and thus we do not have market prices for them. The costs of providing these services are the only monetary flows paid for these services in the economy.

human capital as an asset it has to belong to either of these categories.[16] At the same time, learning new skills and knowledge requires inputs. And if producing of output resulting in this case in asset accumulation (or capital formation) requires inputs, there is a process of transforming inputs to output. It is not reasonable to consider human capital as in the origin no inputs demanding stock of assets as, for instance, natural resources. Thus, in Aulin-Ahmavaara's words, "If human capital is wanted to be seen as an asset, it has to be produced."[17] But production of human capital falls outside the production boundary of the SNA93. Therefore, including human capital inside of National Accounts necessitates moving its production inside the production system where output and other produced assets (e.g. physical capital) are produced.[18]

To describe concretely the monetary flows concerning education in National Accounts in Finland, let us begin the reasoning with sector accounts, which are used in the SNA to calculate how the institutional sectors have financed their production and investments. The household sector pays taxes to the general government sector. With these tax revenues the governmental sector organises the production of educational services that are given in return to households for the taxes paid. The first monetary flow between the sectors is taxes paid by households and received by the government. The second monetary flow between these sectors is realised in the education expenditures when the government has produced the services and gives them to households. The entries in each account are in accordance with the SNA93 and National Accounts in Finland. The taxes paid decrease the disposable income and financial position of households, whereas the education expenditures of the government are covered by tax revenues. On the other hand, households do not need to pay other money for education in Finland.

Now, with the tax revenues the governmental sector will first invest in school buildings and in teaching and learning equipment. These are included in the investments and the stock of physical capital. Secondly, the general government sector employs teachers to produce educational services each year in the industry of education. The production of these services also includes buying intermediate inputs from other producers (e.g. teaching materials).

In the National Accounts system of production in this paper (see Appendix I), students will produce and embody human capital in the learning process by using educational services as intermediate inputs. They will use their mental and physical capability to learn new knowledge and skills and accumulate their human capital, to be able to participate later in value added production in the economy. This requires time, rehearsal, reading and practising but without getting paid, i.e. no monetary transactions that are not already tracked in the SNA are taking place. The incentive for students is the possibility to use their abilities and generate incomes in the future: the trouble and bother for educating themselves are seen as an investment that will yield in time.

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[16] Aulin-Ahmavaara, Pirkko (2002). *Human Capital as a Produced Asset*
[17] Aulin-Ahmavaara, Pirkko (2002). *Human Capital as a Produced Asset*, p. 3
[18] It is worth clarifying that excluding human capital in the SNA93 is not an accident. It is a logical consequence of the definition of the production in the system. The issue of leaving human capital out is dealt in detail in the SNA93. Nevertheless, as economists have often requested to include human capital inside the system, one possibility would be an additional satellite account for further purposes of economic analysis.

In accordance with the above, the production system of National Accounts was modified as follows (see Appendix I for details): The monetary flow paid for the educational services (in Finland's case general government education expenditures) was subtracted from final consumption expenditure (here from general government final consumption) and added to intermediate uses. It was also added to the nation's output, since, by using the education services, human capital was produced and embodied by the students. Finally, this monetary flow for the education services was added to investments. These investments were used to accumulate the stock of human capital. Thus, human capital was treated as a produced asset following the internal logics of the System of National Accounts.

2.2 Investments in human capital

In this sub-section, first, the centre of attention is on the gathered long time series of education expenditures used as investments in human capital. Secondly, the changes to the original National Accounts[19] variables in the modified system in current and constant prices will be demonstrated.

The annual monetary flow that has been invested in education is included in National Accounts in every country following the SNA. In Finland's case this monetary flow is included in the general government expenditures. The main task was to separate the education expenditures from the general government expenditures in Historical National Accounts for the years before 1975, since nowadays' National Accounts have separated them from 1975 onwards. In addition, for forming stocks separately for primary and secondary education, vocational and university education, expenditures were separated further into these sub-classes for the whole time period. Education expenditures in these groups were gathered mainly by the state's total finances for different type of education institutions from Statistical yearbooks and from Documents of Parliament of government financial administration.[20]

Figure 2.2.1 displays the education expenditures at fixed prices collected for this study. According to these figures the fixed price education expenditures in Finland have grown to be 66 fold in 1890–2000 and in 1945–2000 14 fold, while GDP at fixed prices has grown 31 and 7.8 fold, respectively, and the volume of GDP per capita 14 and 5.7 fold, respectively. These annual figures of education expenditures were employed as investments in human capital in 1890–2000 (the missing observations between the first five years' figures were linearly interpolated).

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[19] Finland's Historical National Accounts, database: Hjerppe, Riitta, *Finland's Historical National Accounts 1860–1994: Calculation Methods and Statistical Tables.* Statistics Finland updates and chains these series to be in accordance with the nowadays' figures of Finland's National Accounts 1975 onwards.

[20] For a detailed analysis of all of the sources and how the education expenditures were formed and deflated see Kokkinen Arto (forthcoming 2008), Human Capital and Finland's Economic Growth in 1910–2000 – Assessing human capital accumulation by education inside the national accounts framework, *EUI – History and Civilisation Working Papers*. The main sources mentioned: Statistics Finland, *Statistical yearbooks*, published 1879 onwards; Suomen Eduskunta, *Valtiopäiväasiakirjat* (in Finnish) – Parliament of Finland, Parliamentary documents of government financial administration. Primary source for education expenses. A bound collection of the state's all financial documents each year, published annually, used from 1890 onwards.
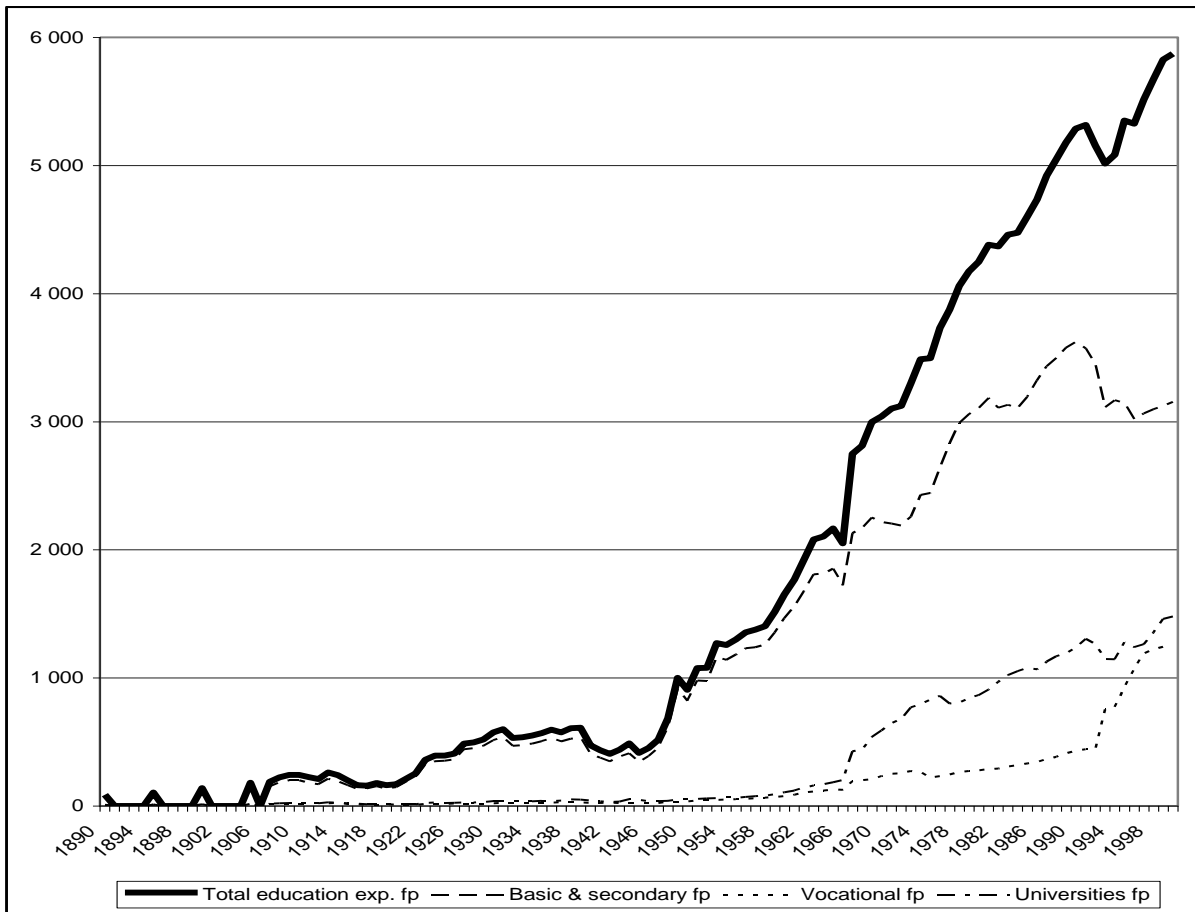
Figure 2.2.1 Finland's education expenditures and their division to sub-classes for the years 1890, 1895, 1900, 1905, 1907–2000, millions of euro, constant prices (reference year 2000).
Source: Own calculations, data from Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965, database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities, *Suomen taloushistoria 3. Historiallinen tilasto.* (1983) (in Finnish: Finland's economic history 3, Historical Statistics) (Ed.) Kaarina Vattula. Tammi, Helsinki 1983.

According to the classics[21] of National Accounting, one of the reasons not to include human capital inside of the System of National Accounts has been that it is difficult to decide what part of the substantial portion of the flows of goods and services to consumers should be treated as investments in human capital. For instance, if all health, social, education, cultural and re-creational services were classified as investments in human capital, the category of final consumption would diminish dramatically. In this paper the focus is on intangible human capital and on skills and knowledge accumulation by education that is believed here to be the core of human capital in economic analysis without regard to whether human capital is seen as an input in production or as a catalyst for technical change.

How much did the main aggregates of National Accounts change when the education expenditures above were employed as investments and the modifications to other variables were done respectively? The

analysis will be begun by viewing the most important changes to National Accounts current price variables in relation to GDP in Figure 2.2.2. Original general government expenditures' share of GDP (G/GDP) has varied between 6% and 25% in peace time Finland, the new general government expenditures (New G/GDP) between 5% and 20%, when the education expenditures have been subtracted. The difference between these variables' shares of GDP can be seen in investments in the human capital ratio of GDP (I hum/GDP) that has varied between 1% and 5% of GDP. The physical capital investments' ratio of GDP (I phys/GDP) has varied from 9% to 33% and the new physical plus human capital investments' ratio (New I/GDP) from 10% to 37% in relation to GDP. The new and old variables shares of GDP fluctuate in respect to each other. As a result in the modified system 1% to 5% more of monetary flows are treated as investments that reduce - with the same percentages - the general government expenditures in Finland's case. Therefore, the direct impact of investments in human capital by education on current price GDP has varied between 1% and 5%.
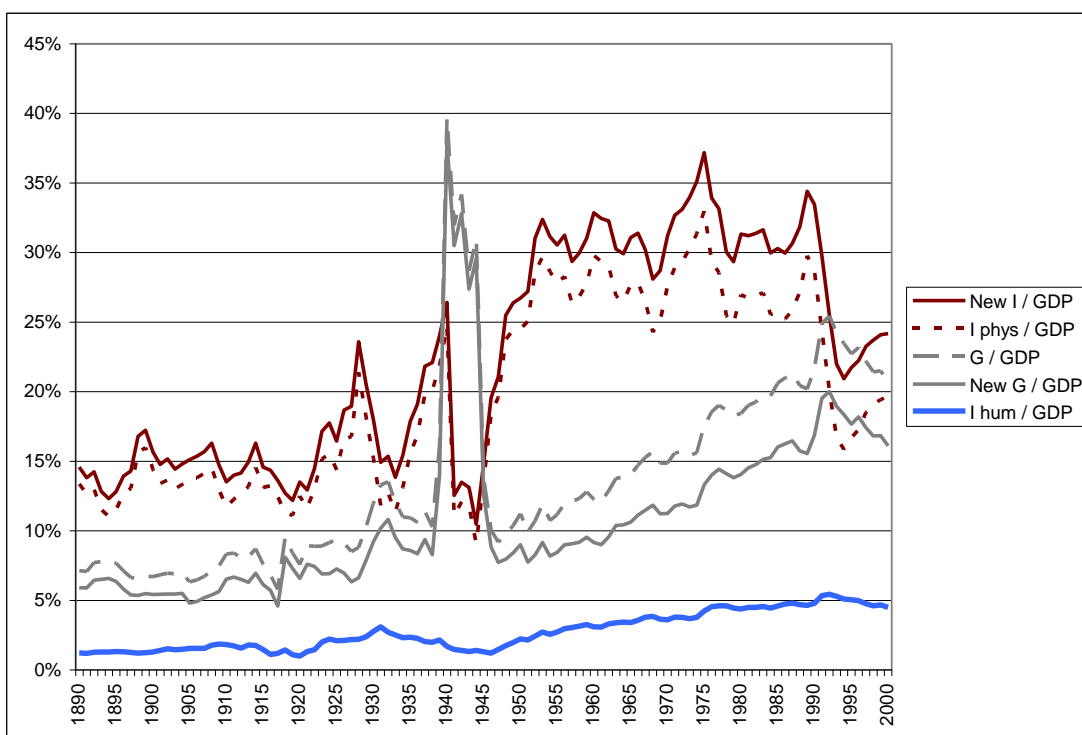

Figure 2.2.2 The original and changed National Accounts variables as a proportion of GDP at current prices in 1890–2000.
Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities, *Suomen taloushistoria 3. Historiallinen tilasto*. (1983).

What about constant price figures? Figure 2.2.3 presents the time series of constant price figures of GDP, old and new general government expenditures, investments in human capital and in physical capital as well as total investments in logarithmic form. (In Figure 1 in Appendix II, these main aggregates are expressed in non-logarithmic form.) The new and old variables' development follows each other, but the

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[21] Cf. Kuznets, Simon (1946). *National Income: A Summary of Findings*, New York: National Bureau of Economic

levels and the average relative growth rates have changed. Old general government expenditures (Gov exp. fp) grew on average by 3.51% a year in 1890–2000, new general government expenditures (New G) have grown at an average pace of 3.44%. Old investments grew (Inv. phys. cap.) on average by 3.25% a year and new total investments by 3.33% on average per year. The average growth of investments in human capital has been 3.82% a year, which is a higher average growth rate than that of physical capital investments. However, investments in physical capital formed 90% in the early years and in the late years still around 80% of the total investments and therefore the level of annual investments in physical capital has been substantially higher in the modified system. The direct impact of investments in human capital on constant price GDP has varied from 2% to 6%, whereas the direct impact of physical capital investments on constant price GDP has been from 10% to 35% in Finland. In the end, the changes to the system of production of National Accounts — when concentrating on actual monetary flows paid for education – were fairly modest.
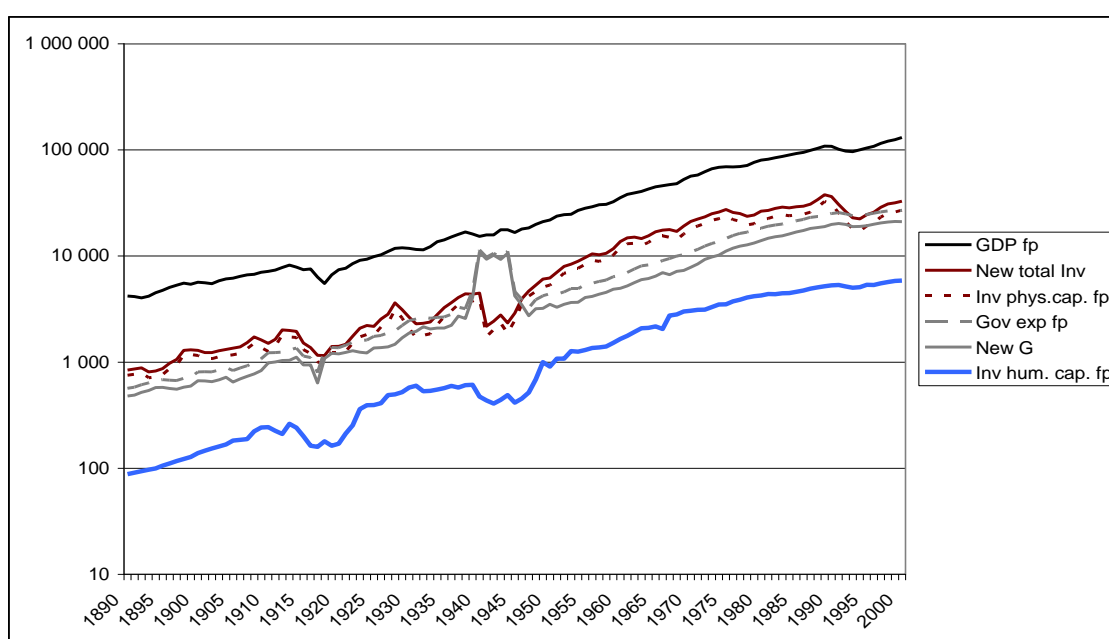

Figure 2.2.3 GDP, new total investments, investments in human capital by education and in physical capital, old and new general government expenditures, at constant prices in 1890–2000, logarithmic (LN) scale.

Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland, Parliamentary documents of government financial administration 1890–1975, Statistics Finland, Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–, Statistics of the financial statements of municipalities and joint municipal authorities; *Suomen taloushistoria 3. Historiallinen tilasto.* (1983).

2.2 The stock of Human capital by education

The stock of human capital by formal education was accumulated with the perpetual inventory method, where human capital, H, was accumulated with investments in human capital I_{Ht} along time. Without renewing the skills (by new education or learning by doing) old investments in human capital are considered

Research, p. 20; Aulin-Ahmavaara, Pirkko (2002). *Human Capital as a Produced Asset*, p. 3.

to diminish their income generating capacity along time. Therefore the stock is decreased by the rate of depreciation of human capital (also see Appendix I). The accumulation is done straight-forwardly in the sense that annual constant euro (or old Finnish Mark) expenditures are cumulated without regard to the time needed for completion of the education. This means that each year in education adds to human capital and income generating capacity. The accumulated stock – i.e. accumulated knowledge and skills – of the previous stages is used in the learning process in the next stages of education and ultimately in the labour markets for generating incomes.

The depreciation should be interpreted here both as costs of obsolescence of knowledge and skills by formal education and as renewing costs on the income generating capacity of formal education along time. The renewing costs mean that if a person has gone through basic & secondary education but has neither gone to work nor continued his/her studies, only stayed outside the labour force at home, he/she will begin to lose his/her ability to generate incomes with the invested education. This person is not renewing his/her capacity when the world and labour markets change in time. Instead, another person has either continued his/her studies or gone to work and can maintain and improve his/her income generating capacity. At work or in further education he/she is making further investments, in the first case by learning-by-doing (or in education provided by the employer), and in the latter by investing more in formal education. This helps the person to renew his/her incomes generating capacity when the working life and labour markets evolve. The need for maintaining and renewing of the skills needed in the labour markets comes quite obvious when considering a person with the 1970s education and no work experience trying to get a job in 2000.

On the other hand, individuals use actively different parts of all of knowledge in all of the subjects taught in general education later in the labour markets. In addition, individuals do have different levels of interest on different subjects already at the early stages of education in accordance with their preferences and abilities. At the later stages of the education they specialise in different fields. This means all of the taught knowledge is not in the active memory and cannot be used for income generation later without additional investments by re-education and rehearsing. Obsolescence of the knowledge and skills with regard to evolving labour markets from the beginning has to be taken into account as well. This is why the depreciation of investments in education has been placed to begin already at the same time with the early investments.

Geometric depreciation rates were used because they typically combine the age-price/age-efficiency and the retirement profile for a cohort of assets. As shown in OECD's manual for measuring capital[22], various age-efficiency profiles for individual assets, when combined with retirement profiles for entire cohorts, generate profiles that are more or less convex to the origin so that the geometric model can be used as an approximation to a combined age-efficiency/retirement pattern. In addition, an important computational feature is that the value of depreciation can be obtained directly by applying the rate of depreciation to the net capital stock (instead of computing it separately for every vintage). Furthermore, the productive capital

stock and the net capital stock coincide in the case of geometric depreciation rates because age-price and age-efficiency profiles coincide.

The depreciation rates for each type of education were approximated by using the declining balance method. In the late 1990s Hulten and Wykoff[23] made a suggestion for converting an average service life of a cohort, T^A, into a depreciation rate, with formula $\delta = R / T^A$, where R is the declining-balance rate. Under the double declining balance formula, R is set to equal 2, but generally it would be best to turn to empirical estimation results for the shape of the geometric depreciation pattern. Recently, Baldwin et al.[24] have reported econometric estimates of declining balance rates for traditional capital in the range between 2 and 3.

Here the long run retirement average was set to be at age 65.[25] The average age for completing the schooling from basic and secondary education was set to 17 (weighing the higher enrolment in basic education completing at age 16), from vocational education 18 and from university education 26, yielding the average service lives for each type of education 48, 47 and 38 years, respectively. Because of the lack of empirical estimates for the declining balance rate of human capital, the rough and rounded depreciation rates were set by calibrating with the declining balance formula: 5% depreciation for basic and secondary education, 6% for vocational and 7.5% for university education,[26] giving the respective declining balance rates 2.4 per cent, 2.82 per cent and 2.85 per cent falling in the range between 2 and 3. The decline rate in basic and secondary is assumed to be lower than in the two other types because of the basic knowledge and skills giving nature of this type of education. For vocational and university education the declining balance rate is assumed to be somewhat faster (and quite similar in respect to each other) firstly, because they include specialisation directed to the labour market at the time and the evolution of labour markets has been fast in connection with fast transformation of the society and rapid technological change in Finland. Secondly, these types of education have shorter service lives in the labour market.

Figure 2.2.4 shows the accumulated human capital stock by education together with constant price GDP and GDP per capita and Figure 2.2.5 the same variables and human capital stock per capita in logarithmic forms, respectively. In the first figure the exponential growth in all of the variables emerges very clearly. In addition, the accumulated human capital stock includes interesting fluctuation in respect to GDP series: For instance, there is a decrease in the stock in the early 1920s due to the civil war in the late 1910s, although the investments in human capital (or education expenditures cf. Figure 2.2.1) increased strongly in the early 1920s. Human capital stock began to grow faster only after the mid-1920s, growing swiftly all the way to

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[22] OECD (2007). Statistics Directorate, *Measuring Capital, Revised Manual,* (second draft), Working Party on National Accounts, Paris, 3-5 October 2007, available from Paul.Schreyer@oecd.org

[23] Hulten, Charles R. and Frank C. Wykoff (1996). "Issues in the Measurement of Economic Depreciation: Introductory Remarks". *Economic Inquiry* 34, pp 10-23

[24] Baldwin, John, Guy Gellatly, Marc Tanguay (2007). *The Cost of Capital Input: Calculation Methods*, revised version of a paper presented at the Capital Measurement Workshop, Ottawa, 22 May 2006

[25] In practice, of course, the age of retirement has varied by being lower because of lower life expectance in the first four to five decades since 1890, perhaps higher especially in primary production households some decades after WWII and around 65 on average in the last decades of the 20th century)

1939 when the Winter War began. Olle Krantz has considered this interwar period as the Finnish take-off period.[27] After WWII, a similar phenomenon can be observed: the stock of human capital started to grow substantially only after 1949 and especially from the 1950s onwards. GDP per capita at constant prices seems to begin its fastest growth after this. In particular GDP per capita appears to follow astonishingly similar movements to the estimated human capital stock by education.

The latter of the figures (Figure 2.2.5), with variables expressed in logarithms shows more inevitably the fact the accumulation of the stock has been initiated from zero in 1890. As can be observed the accumulation has taken approximately 20 years, i.e. until 1910, before the cumulated stock variable reaches its own fluctuation level. The fluctuations mentioned before and the growth in the interwar and postwar periods is even more discernible. The simultaneous and early timing of human capital stock growth in respect to GDP variables in the Golden Years of Finnish growth after the 1950s is striking. GDP per capita and human capital stock per capita seem to grow and fluctuate most closely together (the second highest GDP line and the dashed human capital line). This means that the more/less human capital there has been in proportion to population the more/less the average income levels have risen. This is a result that coincides with the theoretical considerations and with the modern growth theories.
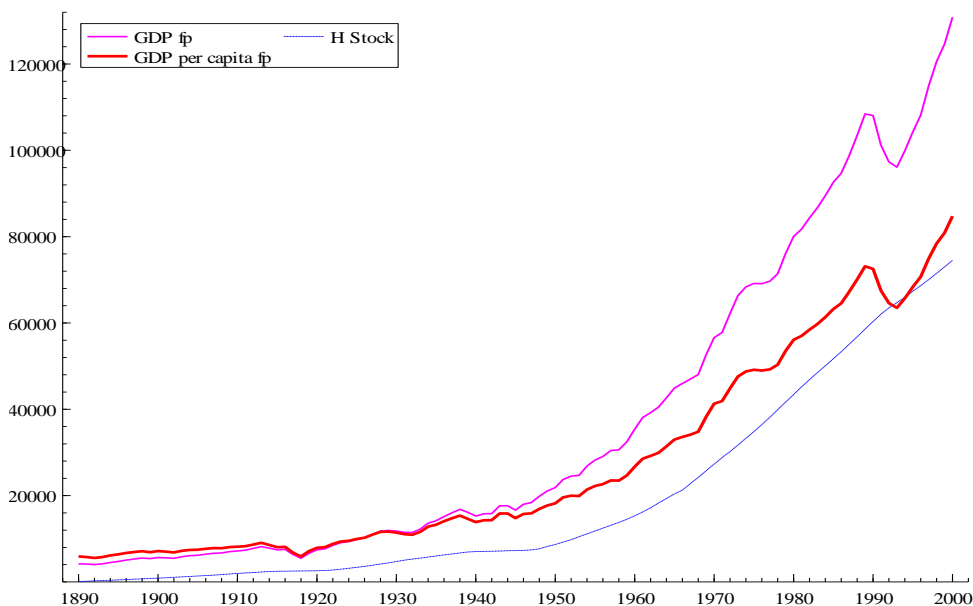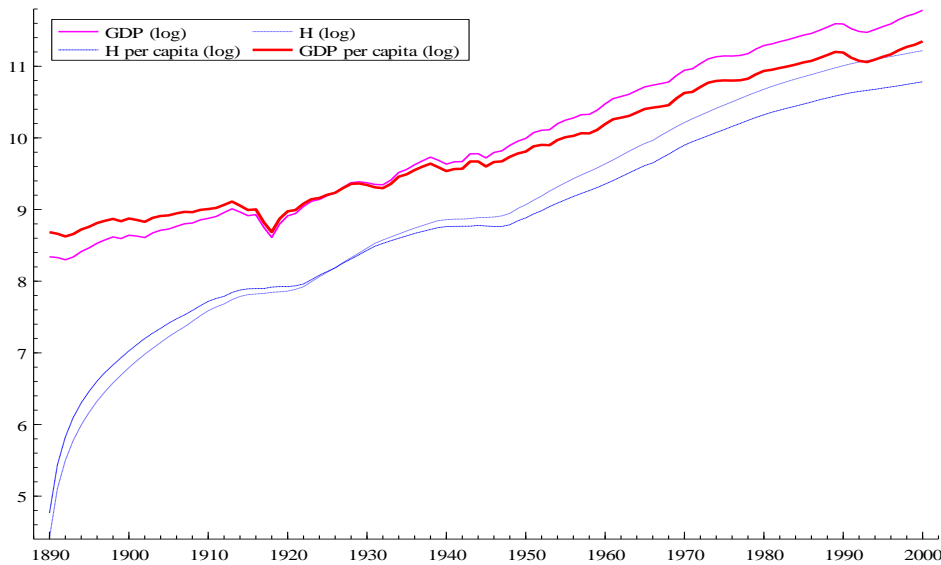

Figure 2.2.4 GDP (violet line, highest), GDP per capita (red thick line, second highest) and Human Capital Stock (dashed blue line, lowest) in constant prices in 1890–2000.
Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities; *Suomen taloushistoria 3. Historiallinen tilasto.* (1983).

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[26] Actually, with these geometric depreciation rates the basic and secondary education investment has lost 91% of its value in its average service life (48 years), vocational and university education investments 95% in their average service lives (47 and 38 years).
[27] Krantz, Olle (2001). Industrialisation in Three Nordic Countries: A Long-Term Quantitative View. In *Convergence? Industrialisation of Denmark, Finland and Sweden, 1870 -1940*. Ed. Hans Kryger Larsen. Helsinki: The Finnish Society of Sciences and Letters, 2001, 23 - 65

Figures 2.2.5 GDP (violet, highest line), GDP per capita (red thick line, second highest), Human Capital Stock (blue dotted line, second lowest) and Human Capital Stock per capita (blue dashed, lowest), constant prices in 1890–2000, logarithmic (LN) scale.

Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities, *Suomen taloushistoria 3. Historiallinen tilasto*. (1983).
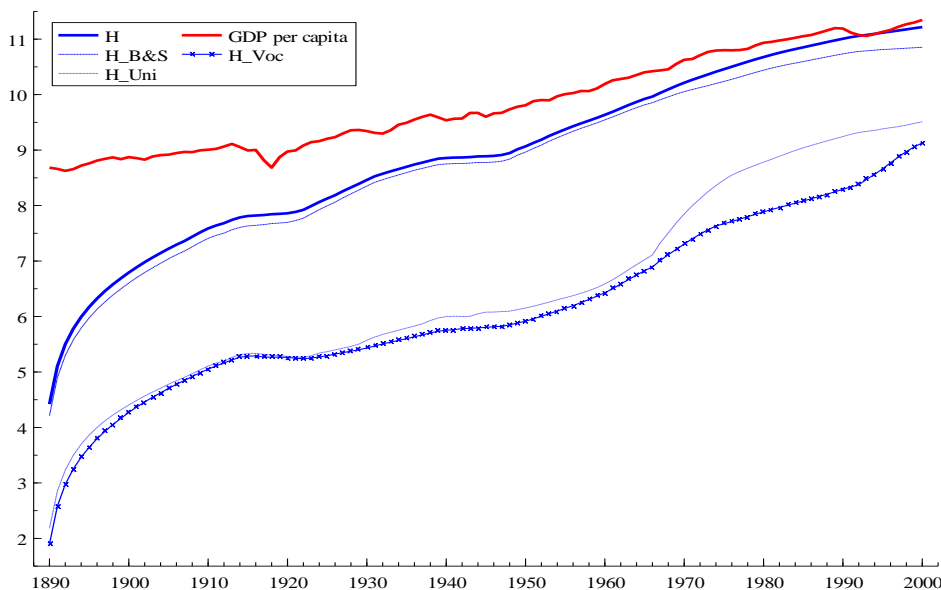
Figures 2.2.6 GDP per capita (red highest line), Human Capital Stock (blue, second highest line), basic and secondary education stock (blue dashed, third highest), university education stock (blue dotted, second lowest) and vocational education stock (the lowest), constant prices in 1890–2000, logarithmic (LN) scale.

Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities, *Suomen taloushistoria 3. Historiallinen tilasto*. (1983).

The stocks of the different education types can be seen in Figure 2.2.6 in logarithmic form together with GDP per capita. The level of basic and secondary education stock has been highest whereas the university and vocational education stocks have been at a lower level near each other. This is obvious and natural knowing a priori that enrolment in vocational and university education has been lower in the population.

Yet, the changes in each of the stocks and their contributions to the whole stock development compared with GDP fluctuations are of crucial importance. In the years from 1910 until the Civil War in 1918 all stocks increased at a high pace. The pause of the growth and even decline in the stocks during and after the Civil War is apparent. From 1920 to 1939 the basic and secondary and university education stocks already grew fast. The vocational stock recovered and began its increase as well, but more moderately in this Finland's take-off period. Because of WWII the growth of all stocks slowed again down until around 1950. At that time the vocational and basic and secondary stocks' growth recovered fastest, while the university education stock's growth began to speed up substantially around 1960 and especially after 1965. From 1965 to the late 1970s the university and vocational education stocks increased the most compared with the previous history. Interestingly enough, Finland did not catch-up the rapidly growing Sweden in 1945–1965, but only after 1965.[28] In the 1990s – during Finland's ICT revolution – the beginning and growth of polytechnic education has contributed mostly to the total stock, preventing in its part the growth of the total stock to cease with gradually declining generations.[29] However, the diminishing growth rate of the total stock is obvious, due to gradually retiring large generations combined with smaller new generations. The stock has still grown because new generations have educated themselves further. Nevertheless, a challenge for the stock of human capital in Finland around 2010 and after it will be the retiring of the very large generations born after the Second World War.

3. *The long run relation of GDP per capita and human capital by education*

The possible long run relation of human capital by education and GDP per capita is explored in this section by co-integration analysis. It is perhaps not reasonable to expect that education has an instant effect on GDP per capita. The students are not participating in the production of national income, i.e. they are not earning wages or salaries which are part of the incomes generated in the production and accounted to GDP.[30] Therefore, one would expect that in the long run the accumulated human capital and average income levels

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[28] Kokkinen, Arto, Jalava, Jukka, Hjerppe, Riitta and Hannikainen, Matti (2007): Catching up in Europe: Finland's Convergence with Sweden and the EU15, *Scandinavian Economic History Review*, 55:2, 153 - 171.

[29] Polytechnic education (established mainly from 1992 onwards in Finland) is included in the figure to the stock of vocational education. This is because schools in engineering and in other fields in nowadays' polytechnics have been originally part of vocational education from 1890 onwards. The aim here has been to build stocks comparable along different time points for longitudinal analysis with economic growth.

[30] The subsidies from the state (either a direct monetary subsidy or a subsidy for interests on study loans from the state) are social transfers from general government to the household sector in the sector accounts in the SNA. They are not included in production. Also see Appendix I.

would rather be candidates for having a relation with each other. The co-integration approach is used, because it is particularly designed for the analysis of interaction of the levels of the variables in the long run.

The economic variables are often non-stationary as are the variables in this analysis. When wishing to regress the levels of non-stationary time series, for avoiding spurious regression results, the co-integration of the variables has to be ensured. If two non-stationary variables do co-integrate, there is long run equilibrium between the variables. The variables share a common stochastic trend and they cannot depart from each other for a long time. When a shock occurs to one of the variables, the variables adjust in the following periods so that the equilibrium in their development is sustained. However, co-integration is a strong condition: The linear combination of non-stationary time series is non-stationary in general. Co-integration is defined as a special case where the linear combination of such series is stationary. This implies that there exists an error correction representation of how the equilibrium between the variables is sustained.

As a first part of the analysis co-integration between GDP per capita and human capital was tested using the Augmented Dickey-Fuller (ADF) test in 1910–2000.[31] The logarithmised GDP per capita was regressed on logarithmised human capital stock. The possible co-integration was tested using the residual of regression: if the residual of the regression does not contain a unit root, it is stationary, and the regression variables are co-integrated and have a long run dependence relation on each other.[32] Equation 3.1 shows the model for the conducted ADF test.

$$\Delta e_t = \beta_0 + \delta\, e_{t-1} + \gamma_1 \Delta e_{t-1} + \gamma_2 \Delta e_{t-2} + ... + \gamma_p \Delta e_{t-p} + u_t \qquad (3.1)$$

where
e_t = the residual of the original regression
u_t = the residual of the test model (supposed to be white noise)
δ = parameter for e_{t-1}, δ equals zero (one minus one) if e_t contains a unit root
$\gamma_1 ... \gamma_p$ = parameters for the lagged differenced e; $\Delta e_{t-1} ... \Delta e_{t-p}$, (lags of differenced e_t are used in the test
        model to ensure u_t to be white noise).

With the model the differenced residual, Δe_t, of the original regression was explained by the lagged non-differenced e_{t-1} and in order to ensure that the test model's u_t is really white noise by the lagged differenced Δes. The number of lags of differenced residual in the test model was determined by running the test model with an increasing number of lags. The test model with the lowest value of Akaike's Information Criteria (AIC) was chosen. The ADF test's H_0-hypothesis is that the residual of the original regression would contain a unit root (H_0: $\delta = 0$, H_1: $\delta < 0$).

[31] Dickey D. and Fuller W. (1979). Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association*, 74, 427-431, 1979. Harris R (1992) 'Testing for unit roots using the Augmented Dickey-Fuller test: Some issues relating to size, power and lag structure of the test', *Economics Letters*, 38, 381-386.
[32] This part of the procedure was carried out using PcGive 10.0.

Table 3.1 The ADF-CO-INTEGRATION TEST RESULTS
in 1910–2000 for GDP per capita and Human Capital stock, constant prices, logarithmised

ADF test results on residual of regression (T=88, constant, lags, 5%= - 3.17			
	Number of differenced	t-adf	AIC
Log GDP per capita on log Human cap. Stock	1	-5.346**	-6.311

The result in Table 3.1 shows that GDP per capita and human capital stock are co-integrated (with p-value < 0.01 H_0: $\delta = 0$ is rejected). This proves that these two variables do evolve together in the long run, and that there is a long-run equilibrium to be found between the two variables' co-integrated development.[33]

To corroborate the co-integration relation and elaborate the relation further, the error correction representation was estimated.[34] The co-integration relation within this approach is shown in Figure 3.1. The link between co-integration and error correction emphasises that co-integration is essentially a system property. A general formulation of the error-correction model consists of an equation for each variable. The two-variable case is shown below:

$$\Delta x_{1t} = \mu_1 + \Gamma_{11}\Delta x_{1t-1} + \Gamma_{12}\Delta x_{2t-1} + \alpha_1(x_{1t-1} - \beta x_{2t-1} - \delta) + \varepsilon_{1t} \qquad (3.2)$$

$$\Delta x_{2t} = \mu_2 + \Gamma_{21}\Delta x_{1t-1} + \Gamma_{22}\Delta x_{2t-1} + \alpha_2(x_{1t-1} - \beta x_{2t-1} - \delta) + \varepsilon_{2t} \qquad , \qquad (3.3)$$

where

$(x_{1t-1} - \beta x_{2t-1} - \delta)$ is the co-integration equation,

$\alpha_i(x_{1t-1} - \beta x_{2t-1} - \delta)$, i = 1,2 is the error correction term for each variable.

The parameters α_1 and α_2 are called adjustment parameters for telling how the system adjusts to the equilibrium. With them the direction of causality in the long run can be tested as well. For y_t to error correct it is required that $\alpha_1 < 0$, and for x_t to error correct $\alpha_2 > 0$. If both of them are statistically significant, both of the variables adjust. If one of them is not significant while the other is, the latter adjusts to the shocks of the other but not vice versa. The estimation of the system in equations 3.2 and 3.3 with GDP per capita and human capital stock was carried out[35]. (An impulse dummy was used for the civil war period 1917-19 and a

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[33] Co-integration was also found on GDP and the accumulated human capital stock as well as on GDP per capita and human capital stock per capita.

[34] Cf. Engle, R., Granger, C. (1987). Co-integration and Error Correction: Representation, Estimation and Testing. *Econometrica*, 55, 251-276. According to a representation theorem of Engle and Granger, two variables co-integrate only if there exists an error correction model for either of them or for both.

[35] This estimation was done in the context of the Johansen approach in EViews 6. Cf. Johansen, S. (1996). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, 2. edn*., Advanced Texts in Econometrics, Oxford University Press: Oxford; Juselius, K. (2006) *The Cointegrated VAR model: Econometric Methodology and Macroeconomic Applications*. Advanced Texts in Econometrics, Oxford University press: Oxford.

step dummy for the 1990-92 severe depression, however, the co-integration was tested without dummies as well.) The estimation results are shown below (t-values in brackets, the lag length was tested).

$$\Delta y_t = 0.01 + 0.36\Delta y_{t-1} + 0.19\Delta H_{t-1} - 0.157\ (y_{t-1} - 0.71H_{t-1} + 1.3) + \varepsilon_{1t}$$
$$\quad\ \ [1.19]\quad\ [4.7]\qquad\ [0.96]\qquad\ [-3.2]\qquad\ [-38.9]$$

$$\Delta H_t = 0.005 + 0.05\Delta y_{t-1} + 0.85\Delta H_{t-1} + 0.008\ (y_{t-1} - 0.71H_{t-1} + 1.3) + \varepsilon_{2t}\qquad ,$$
$$\quad\ \ [1.91]\quad\ [2.5]\qquad\ [15.9]\qquad\ [0.64]\qquad\ [-38.9]$$

where

y_t = log of GDP per capita

H_t = log of human capital stock.

The long run co-integration parameter β is highly significant in the error correction system, which ensures the previous results of the co-integration between GDP per capita and the accumulated human capital stock. The adjustment coefficients α_1 and α_2 have there expected signs for adjustment. The former of them is obviously statistically significant (t-value -3.2) and thus shows that GDP per capita is adjusting with a speed of 15.7% (parameter value -0.157) of a deviation of equilibrium every period. Instead, the adjusting coefficient for human capital is not significant (t-value 0.64) and the parameter value is very low (0.008). This can be further tested by setting a restriction $\alpha_2 = 0$ to the system.[36] Whether this restriction is binding can be tested by $\chi^2(1)$-distributed LR-test under the null α_2 being zero. The LR test statistic accepted this hypothesis with p-value 0.518. Therefore, only GDP per capita error corrects to maintain the equilibrium in the long run development of the variables and the long run causality runs from human capital to GDP per capita.

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[36] Johansen, S. (1995) Identifying restrictions of linear equations. With applications to simultaneous equations and cointegration. *Journal of Econometrics*, 69(1), 111-132
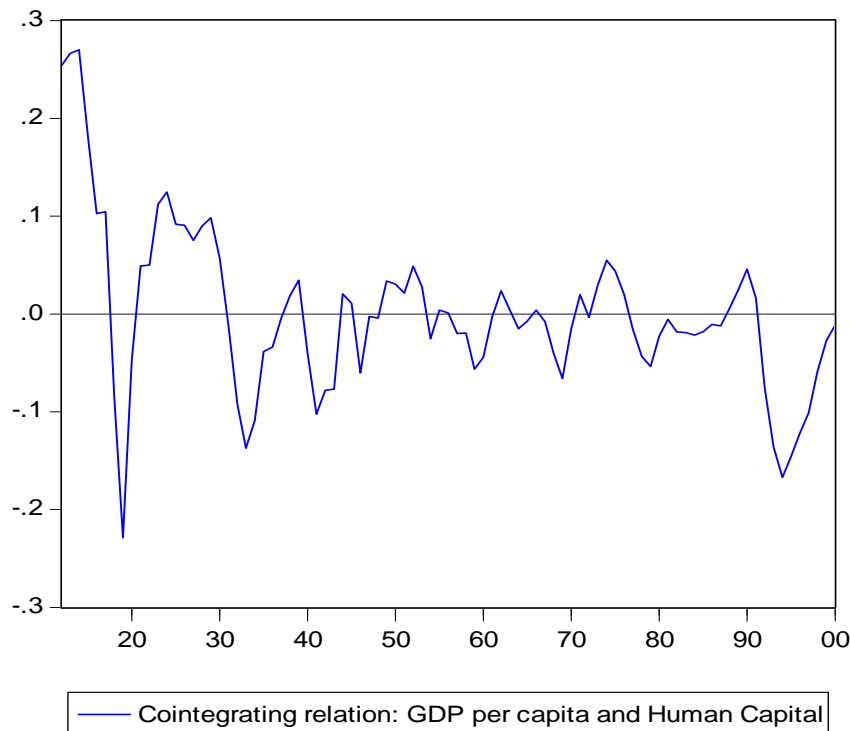
Figures 3.1 The co-integration relation of GDP per capita and Human Capital Stock in Finland in 1910–2000 (estimation by Johansen co-integration approach in EViews 6).
Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland; Parliamentary documents of government financial administration 1890–1975, Statistics Finland; Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–; Statistics of the financial statements of municipalities and joint municipal authorities, *Suomen taloushistoria 3. Historiallinen tilasto.* (1983).

4. Conclusions

The aim of this paper was to explore whether the considerable input in education has had a connection to the dramatically changed economic performance in Finland in 1910–2000.

In this paper the investment flow series of human capital by education in 1890–2000 and the stock of human capital by formal education were formed for Finland in 1910–2000 inside the systematic National Accounts frame. The advantage of this approach is that investments are valued in monetary terms as GDP and physical capital and they have a logical connection to GDP and to other variables in National Accounts. It is worth noticing as well that the empirical counterparts of the core variables in the growth theories (GDP, physical capital and hours worked) come from the National Accounts. However, this means changes to National Accounts, since human capital is not included inside the asset boundary in the international System of National Accounts 1993.

In the two most well-known earlier presented systems of this kind, also the level and evolution of GDP changed (partly due to broader concepts of human capital). In this paper, the focus was on the intangible

human capital by formal education and on the actual monetary flows paid for education. This enabled to introduce a system of production where human capital accumulation by education can be estimated inside the National Accounts without necessarily changing GDP, and to test the long run relation with accumulated inputs in education and the standard GDP per capita. In fact, the SNA93 (par 1.57) implies to a system of a kind as in this paper by stating *"The decision whether to classify certain types of expenditure by households or government, such as education or health services, as final consumption expenditures or gross fixed capital formation does not affect the size of GDP, as both are final expenditures."* Following this statement, the analysis could be broadened to cover health (and social etc.) expenditures as investments in human capital as well. The analysis here is done for Finland but following the same lines of thought, a similar approach could be done for any other country, since in the SNA93 all monetary flows in the economy should have already been traced – also the monetary flow invested in the education of citizens. Yet, more struggling with data is predicted when proceeding with countries where education services are not produced by the general government.

Inclusion of investments in human capital by formal education changed the National Accounts of Finland in this paper. Using the annual final education consumption expenditures as investments in education resulted in that they have varied from 1% to 5% of GDP at current prices in Finland in peace-time of 1890–2000. At constant prices the direct impact of investments on education has ranged from 2% to 6%. For comparison, the relation of investments in physical capital to GDP has varied at current prices between 9% and 33% and at constant prices between 10% and 35%, respectively. According to these calculations, Finland has invested more in total, and the new investment ratio (including physical and human capital investments) of GDP at current prices has ranged between 10% and 37% and at constant prices between 14% and 40%. Investments in physical capital have grown on average by 3.3% a year and investments in education at a higher 3.8% rate a year on average in 1890 to 2000. However, investments in physical capital formed 90% in the early years and in the late years still around 80% of the total investments and therefore the level of annual investments in physical capital has been substantially higher in the modified system.

The long run relation of human capital accumulation and economic performance in Finland after 1910 was tested with co-integration analysis. First, the co-integration between human capital stock and GDP per capita was tested using the Augmented Dickey-Fuller (ADF) test. The ADF test showed the variables are statistically highly significantly co-integrated. Secondly, an error correction representation (by Johansen, originally by Engel and Granger) was tested, on the one hand, to corroborate the co-integration and on the other hand, to analyse how the variables adjust to the long term equilibrium between them. It was found out that GDP per capita is adjusting to the deviations from the equilibrium in the development of the variables and the accumulated human capital is not. Therefore, the results showed a direction of causality from human capital to GDP per capita in Finland in 1910–2000.

In accordance with the above results this paper can be concluded with the conclusion that the substantial input in education has had a connection to the long run economic growth of Finland.

APPENDIX I: The modified production system of National Accounts with human capital by education

The system of production in the SNA93[37] and the revisions to the production system in this paper are shown below. The description of the SNA system of production (the basic equations 2.1 – 2.5a) and 2.6) is based on Aulin-Ahmavaara's representation.[38] The revisions to the production system are shown with the bolded variables and with equation 2.5b).

In the original system of production of SNA93 the first equation (2.1) defines the supply and demand in the economy in a time unit (in a year or in a quarter): Output (O) is the sales revenues producers get when selling the products they have produced. Imports (M) include the value of goods and services imported to the country. The use or demand of these products are tracked in the left side of the first equation (2.1): Part of these products has been re-used in the production of other producers as instant intermediate inputs (U) or as investments (typically e.g. machines and buildings that are used for more that one year in the production of the buyer-producer). A good part of them is used as private final consumption (C) or government final consumption (G). All of the variables are expressed in monetary terms, in current prices, or in fixed prices, where the price changes have been deflated.

The second equation (2.2) shows how GDP (or value added) can be calculated through output minus intermediate inputs or through net-demand, i.e. C + I + G + (E-M). The third equation (2.3) emphasises that the value of output can also be calculated through incomes generated in the production process, namely through intermediate inputs plus the compensations for labour (W) and capital (R, operating surplus of the producers). As a consequence, in the fourth equation (2.4) the same GDP can be tracked by the incomes generated in the production process as the sum of compensation for labour and for capital. The original fifth equation (2.5a) describes the accumulation of physical capital: investments in physical capital increase the accumulated stock and the depreciation (maintenance costs, etc.) decrease the value of the stock. The labour input (equation 2.6) is treated as an exogenous variable as households decide whether they are available in the labour market and how much they are willing to work.

In order to include human capital by education to produced assets the production system is revised in this paper (the bolded variables and equation 2.5.b). In equation 2.1, the education expenditures are deducted from general government expenditures and reclassified as intermediate inputs (used in the learning process of students). The new skills the students have embodied in a year are treated as produced human capital (O_H)

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[37] SNA93, ISWGNA (1993). The Inter-Secretariat Working Group on National Accounts, *System of National Accounts*, Commission of the European Communities-Eurostat, International Monetary Fund, OECD, United Nations, Brussels/Luxembourg, New York, Paris, Washington D.C

[38] Cf. Aulin-Ahmavaara, Pirkko (2002). *Human Capital as a Produced Asset.* Aulin-Ahmavaara has represented the SNA93's multipurpose system of production on a national level in accordance with the six equations 2.1 – 2.5a) and 2.6 without the revisions. The system is simplified in the sense that taxes and subsidies are ignored and a simple geometric rate of depreciation is assumed. She has also represented both Kendrick's and Jorgenson-Fraumeni's approaches compactly in the same context. Here her line of work is followed here when introducing the revised production system in this paper.

and as the nation's investments in human capital (I_H). The former is added to the nation's output and the latter is added together with physical capital investments (I_K). The produced human capital and the investments in human capital (to be used for more than a year in the production) are valued through the actual monetary flows paid in the economy, i.e. their value is equal to education expenditures. This means that the accounts are balanced and GDP does not change in the new equations 2.2 and 2.4 as the value of produced human capital (O_H) and investments in human capital (I_H) equals the value of education expenditure that is added to intermediate inputs and subtracted from general government expenditure.[39] It is worth noticing that in equations 2.3 and 2.4 the compensation for labour includes compensation for skills and knowledge by education (or human capital) used in the production. In a modern economy these should count for a bigger part than compensation for physical labour work.

2.1 *[O+O$_H$]+ M = [U + education expenditure] + C + [I$_K$ + I$_H$] + [G - education expenditure] + E*

2.2 *GDP = [O+O$_H$] - [U + education expenditure] = C+ [I$_K$ + I$_H$] + [G - education expenditure] + E - M*

2.3 *[O + O$_H$] = [U + education expenditure] + W + R*

2.4 *GDP = [O + I$_H$] - [U + education expenditure] = W + R*

2.5a) $\dfrac{dK}{dt} = I_{Kt} - \delta_K K_t$ 2.5b) $\dfrac{dH}{dt} = I_{Ht} - \delta_H H_t$

2.6 $L = \bar{L}$

Where
O = gross output, U = intermediate uses / intermediate inputs, C = private final consumption,
G = General government final consumption expenditure
I_K = gross physical capital formation, I_H = gross human capital formation
E = exports, M = imports
W = labour compensation, R = operating surplus (or mixed income)
K = physical capital stock, δ_K = rate of depreciation of physical capital
H = human capital stock, δ_H = rate of depreciation of human capital
L = labour input

In the new equation 2.5b, human capital, H, is accumulated with investments in human capital I_{Ht} along time with the perpetual inventory method. The accumulation is decreased by the rate of depreciation of human capital. Therefore, $H_t = H_{t-1}(1-\delta) + I_{Ht} = \sum_{\tau=0}^{\infty}(1-\delta)^{\tau} I_{H,\tau-t}$, with the assumption of geometric

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[39] The depreciation of human capital of the labour force is assumed to be included in their wages and salaries as part of the compensation for the skills accumulated and used in the labour market. The depreciation of human capital of pupils and students in education is assumed to be compensated in wages and salaries of their primary caretakers, who are responsible for their subsistence.

age-efficiency profiles. The broad capital accumulation in the revised system will include physical capital and human capital by formal education.

Human capital (or the accumulated knowledge and skills) is used when entering the next year in education and finally for the working ages in the labour market for participating in the production and income generation. The wages and salaries that are accounted in GDP (see above equation 2.4) are paid for people participating in the production. In a modern economy an increasing part of their income is compensation for their skills and knowledge. This does not imply in any way that the accumulated human capital – especially of people working in research and development – could not affect technical change separately. Rather, the reasoning here implies the existence of both channels on how human capital enhances economic growth.

APPENDIX II: The changes in National Accounts main aggregates in non-logarithmic form
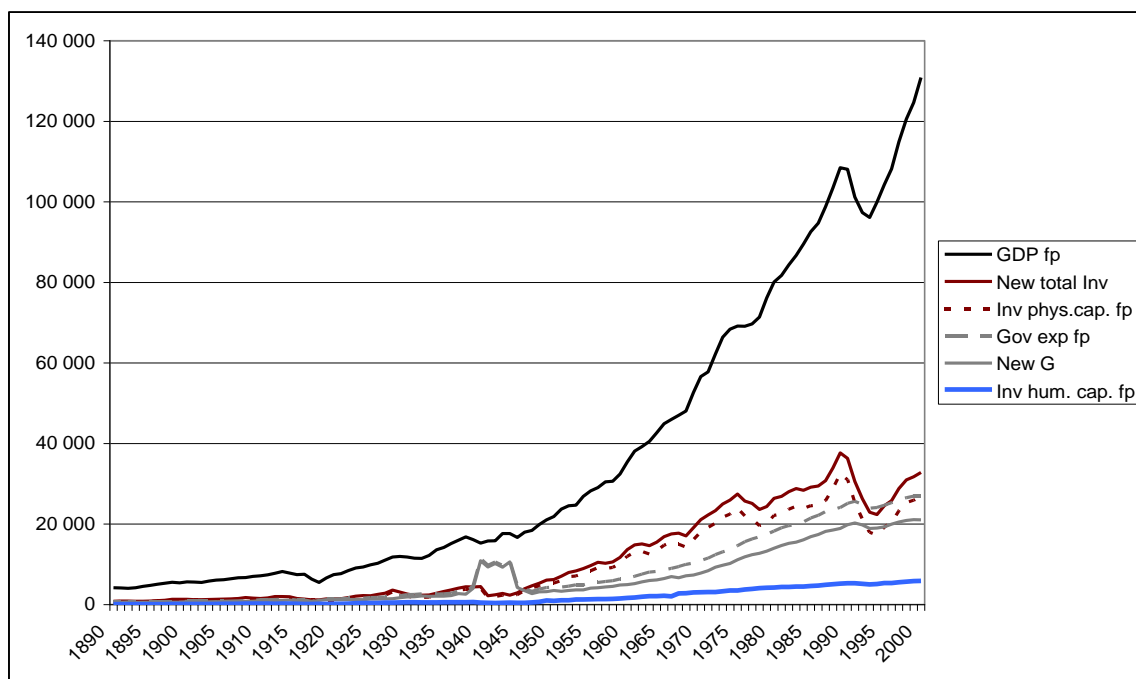

Figure 1: GDP, old and new general government expenditures, investments in human and physical capital, total investments, millions of euro, at constant prices in 1890–2000.
Source: Own calculations; data from Hjerppe, Finland's Historical National Accounts 1860–1994; Parliament of Finland, Parliamentary documents of government financial administration 1890–1975, Statistics Finland, Statistical yearbooks 1890–1975, National Accounts publications: 1948–1965 and database of Finland 1975–, Statistics of the financial statements of municipalities and joint municipal authorities; *Suomen taloushistoria 3. Historiallinen tilasto*. (1983).

Data Sources

Finland's Historical National Accounts, database: Hjerppe, Riitta, *Finland's Historical National Accounts 1860–1994: Calculation Methods and Statistical Tables.* Jyväskylä: Kopi-Jyvä Oy 1996; Statistics Finland
- 1860–1975 only general government expenditures, no break-down to industries like education
-→ Education expenditures by schooling type to be calculated and separated from general government expenditures 1890 – 2000

National Accounts data 1948–2000
- Statistics Finland, Finland's National Accounts for the years 1948–64 (in Finnish), Suomen kansantalouden tilinpito vuosina 1948–64, Tilastollisia tiedonantoja, N:o 43, Tilastollinen päätoimisto; *Suomen taloushistoria 3. Historiallinen tilasto.* (1983) (in Finnish: Finland's economic history 3, Historical Statistics) (Ed.) Kaarina Vattula. Tammi, Helsinki 1983
- 1975 –2000 (database with general government expenditures separated to industries, including education expenditures separated to central and local government, but not types of education)
- 1960 – 1975 (less detailed National Accounts publications, typically only general government expenditures published as a whole) some information on general government education expenditure)
- 1948 – 1964 (even less detailed publications, some information at least on education services' production value added)
- 1964–1975 (*Suomen taloushistoria 3. Historiallinen tilasto.* (1983) (in Finnish: Finland's economic history 3, Historical Statistics) (Ed.) Kaarina Vattula. Tammi, Helsinki 1983))

Education Expenditures of central government:
- 1890 – Suomen Eduskunta, *Valtiopäiväasiakirjat* (in Finnish) – Parliament of Finland, Parliamentary documents of government financial administration. Parliamentary documents of government financial administration; Parliament library Archives, A bound collection of the state's all financial documents each year, published annually, a primary source for education expenditures from 1890 onwards
- 1879 – Statistical yearbooks of Finland (data gathered and summarised of government financial administration from Parliamentary documents and financial statements of the state)
- 1890 – general government education expenditures by type of schooling (basic & secondary education, vocational education, university education)

Education Expenditures of municipalities and joint municipal authorities: The statistics of financial statements of municipalities and joint municipal authorities; Statistics Finland Archives
- 1910–1912 (Cities, boroughs and rural municipalities – each separately)
- 1925–1929 (Cities)
- 1930 – 1972 (Cities, boroughs and rural municipalities – each separately)
- 1959 – joint municipal authorities (new local authority type for providing health, social and   educational services by several municipalities together)
- 1973 – Statistics on financial statements of municipalities (Cities, boroughs and rural municipalities in the same publication)

Statistics on educational institutions in Finland (the number of schools or universities, the number of students, the number of teachers (and lecturers plus professors, expenditures); Statistics Finland library Archives
- 1900 – Secondary schools (old secondary schools beginning in the 5th grade – the end of high school); Statistical yearbooks
- 1884 – Vocational schools; Statistical yearbooks 1884 – (divided by type of schooling not summed up to national level)
- 1880 – Universities and other tertiary education institutions; Statistical yearbooks 1880–; Statistics on Universities and other tertiary education institutions 1917 – (source: Official Statistics of Finland; SVTXXXVIII 8-9, Statistics on Universities, 1979, includes data 1917 – 1979, similar statistics later, also from the Ministry of Education for the latest years)

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