FIRE AND FUELS
CO_2 AND SO_2 EMISSIONS IN THE FINNISH ECONOMY, 1800–2005

Jan Kunnas

From the beginning of the 19th century, Finland has gone through a transition from a wood based energy system to a fossil fuel based one. The article focuses on the environmental consequences of Finland's transition from a proto-industrial agricultural society to a "post-industrial" society, and it shows how historical methods can be used to test economic theory, and how useful quantitative methods are in historical research.

THE ENVIRONMENTAL CONSEQUENCES OF FINLAND'S ECONOMIC GROWTH

In this article, I will present the main findings of my Doctoral thesis, where I examined the environmental consequences of Finland's economic growth. The focus was on the transition from a wood based energy system to a fossil fuel based one, and the environmental consequences of this transition. Instead of the monograph format commonly used in historical sciences, my thesis consisted of an introductory review part, followed by five original research publications (The publications are referred to in the text by their roman numerals):

I) Jan Kunnas, "A Dense and Sickly Mist from Thousands of Bog Fires: An Attempt to Compare the Energy Consumption in Slash-and-Burn Cultivation and Burning Cultivation of Peatlands in Finland, 1820-1920," *Environment and History* 11, No. 4, 2005, 431–446.
II) Jan Kunnas, "Potash, Saltpetre and Tar: Production, Exports and Use of Wood in Finland in the 19th Century," *Scandinavian Journal of History* 32, No. 3, 2007, 281-311.
III) Jan Kunnas and Timo Myllyntaus, "The Environmental Kuznets Curve Hypothesis and Air Pollution in Finland," *Scandinavian Economic History Review* 55, No. 2, 2007, 101–127.
IV) Jan Kunnas and Timo Myllyntaus, "Anxiety and Technological Change – Explaining the Decline of Sulphur Dioxide Emissions in Finland since 1950," *Sustainable Growth and Resource Productivity – Economic and Global Policy Issues*. R. Bleischwitz, P. Welfens & Z. Zhang (eds.). Greenleaf Publisher, Sheffield 2009.
V) Jan Kunnas and Timo Myllyntaus, "Postponed Leap in Carbon Dioxide Emissions: Impacts of Energy Efficiency, Fuel Choices and Industrial Structure on the Finnish Energy Economy, 1800 – 2005," *Global Environment,* No. 3, 2009, pp. 154–189.

My theoretical starting point was the environmental Kuznets curve (EKC) hypothesis, which proposes that some pollution or measures of environmental degradation

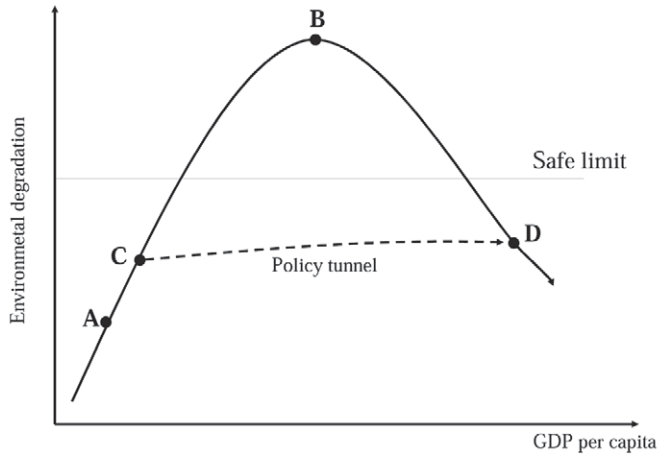


Figure 1.
The environmental Kuznets curve with a policy tunnel.

would follow an inverted U-curve related to incomes, increasing at low income levels and decreasing at high income levels.[1]

Figure 1 illustrates the assumed relationship between gross domestic product [per capita] and environmental degradation, pollution or resource depletion. Point A illustrates a pre-industrial economy with a low level of per capita income, where one might expect rather pristine environmental conditions relatively unaffected by economic activities. Along with industrialization and economic growth, increasing use of natural resources and emission of pollutants causes escalating environmental degradation. After a peak in environmental degradation (B), the declining part of the curve is finally reached. In the final stage complementary reasons, like growing ability and willingness to pay for a better environment, cleaner technologies and a shift to information and service-based activities are expected to result in reduced environmental degradation.

Mohan Munasinghe argues that developing countries could learn from past experiences of the industrialized world by adopting measures, which would permit them to "tunnel" through the EKC.[2] In Figure 1 above it means that developing countries could go through a policy tunnel from point C straight to point D, a society combining high per capita income with low levels of environmental degradation, without passing through point B associated with a high peak in environmental degradation. This new point should preferably be under some safe limit beyond which environmental damage could become irreversible.[3] Otherwise no amount of income growth will restore those losses.[4]

Using the EKC hypothesis this study has been divided into three major parts, as illustrated in Figure 2 below:

1) In order to get an insight to the starting phase of economic growth when environmental pressure is supposed to grow, I have investigated the fate of peasant livelihoods at the turn of industrialization.

2) The calculations done in the first part are then used in the construction of long time series for several measures of environmental pressures in order to examine the overall development from the beginning of industrialization to the present.

3) In cases where a development path according to the Environmental Kuznets curve hypothesis is found, a closer look at the actual turning point is taken in order to track what lies behind the turn. Correspondingly, if no turning point is found, this will also be explained.

Starting phase of economic growth

The first study compares the biomass consumption of slash-and-burn cultivation to that of burning cultivation of peatlands.

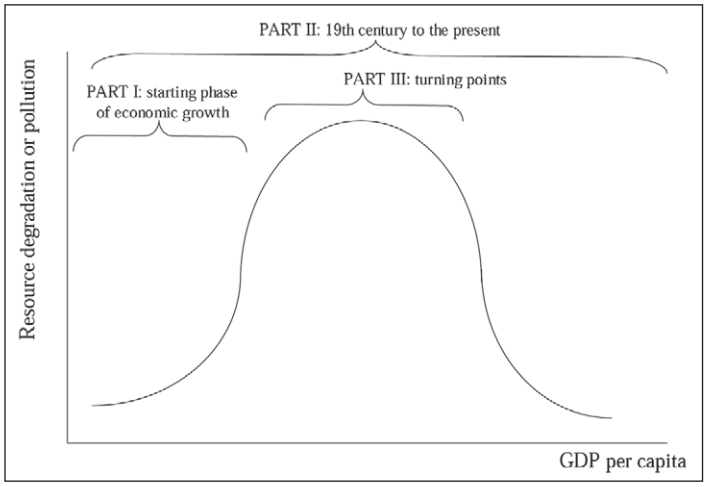


Figure 2.
The structure of the study

Finland has been chosen as a case study because it is one of the Western countries where the use of fire in agriculture lasted longest. In historical research about fire-clearance husbandry the focus has been on burning of forests, while swamps and other peatlands have been neglected.[5] I claim that this neglect is not acceptable, as according to my calculations, the amount of biomass measured by energy value burned on peatlands surpassed the amount burned in slash-and-burn cultivation after the mid-nineteenth century. A comparison with other sources of carbon dioxide (Figure 3) also shows that burning cultivation of peatlands was by far the greatest source of carbon dioxide in Finland during the entire nineteenth century and at the beginning of the twentieth century (I).

The remaining question is: To what degree can the results from Finland be generalized to other peat-rich countries? Burning cultivation of peatlands has been practiced all over Europe and North America, and was by no means a Finnish curiosity. In these and other peat-rich countries, the inclusion of the emissions from burning cultivation could substantially alter historical carbon dioxide emission estimates.

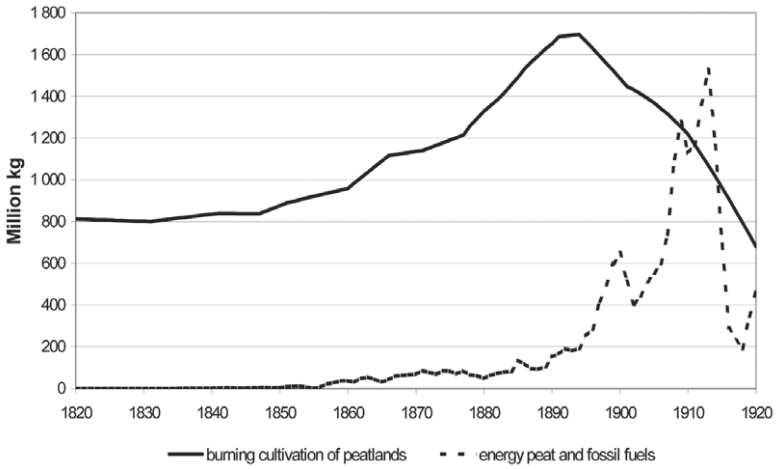


Figure 3.
Carbon dioxide emissions from burning cultivation of peatlands vs. emissions from energy peat and fossil fuels 1820 – 1920. Source: Kunnas, J., "A Dense and Sickly Mist from Thousands of Bog Fires." *Environment and History*, Vol. 11 No. 4, 2005, pp. 431–46.

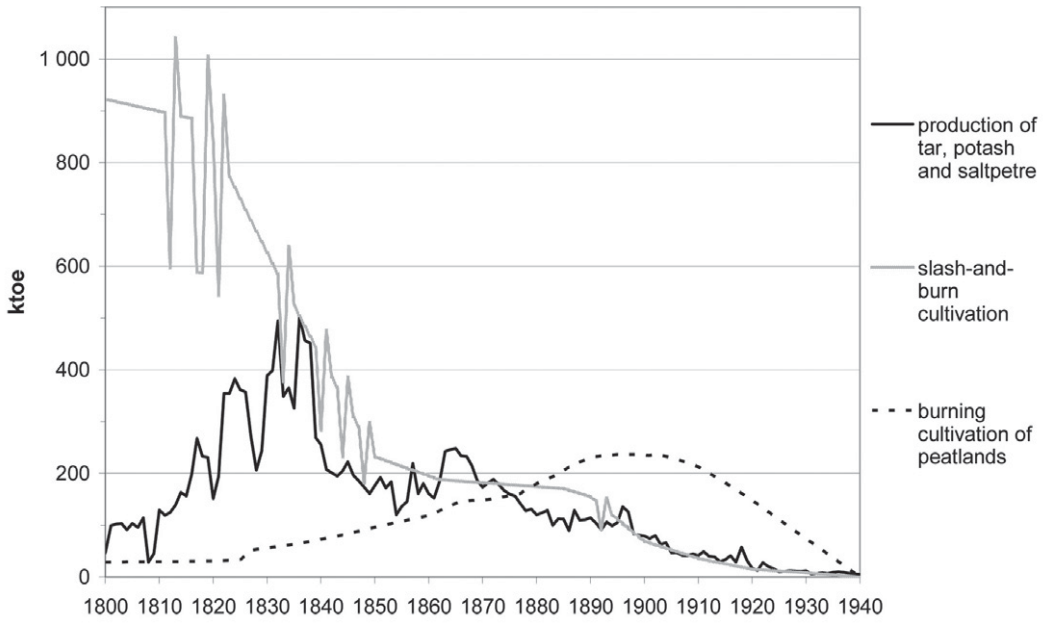
The second study compares the wood consumption in the production of potash, saltpetre and pine wood tar in 19th century Finland. This study also provides surprising results, as my calculations indicate that under its high period the production of potash might have consumed more wood than tar burning (Figure 4). Despite its short glory, it can thus not be neglected if we want to achieve a comprehensive picture of protoindustrial forest utilization. In the 19th century the cumulative wood consumption in the production of potash might have been higher or at least on the same level as in the production of tar. In the 1830s the combined wood consumption in the production of tar, potash and saltpetre reached the level of slash-and-burn cultivation (II).

From the 19th century to the present

The second part of the study examines the overall development of major air pollutants from industrialization to the present. The calculations done in the first part of the study are here used in the construction of long time series for several measures of environmental pressure in order to examine the overall development from industrialization to the present. Most notably, we have a 200-year long time series of carbon dioxide and sulphur dioxide emissions stretching from 1800 to the present.

I test whether the major energy related air pollution emissions follow an inverted U-curve related to income, as predicted by the

Figure 4. Energy consumption in the production of tar, potash and saltpetre compared to that in slash-and-burn cultivation and burning cultivation of peatlands 1800–1940 (ktoe is an amount of energy equivalent to 1000 tons of crude oil).
Source: Kunnas, J., "Potash, Saltpetre and Tar," *Scandinavian Journal of History*, Vol. 32, No. 3, 2007, pp. 281–311. & "A Dense and Sickly Mist from Thousands of Bog Fires." *Environment and History*, Vol. 11 No. 4, 2005, pp. 431–46.



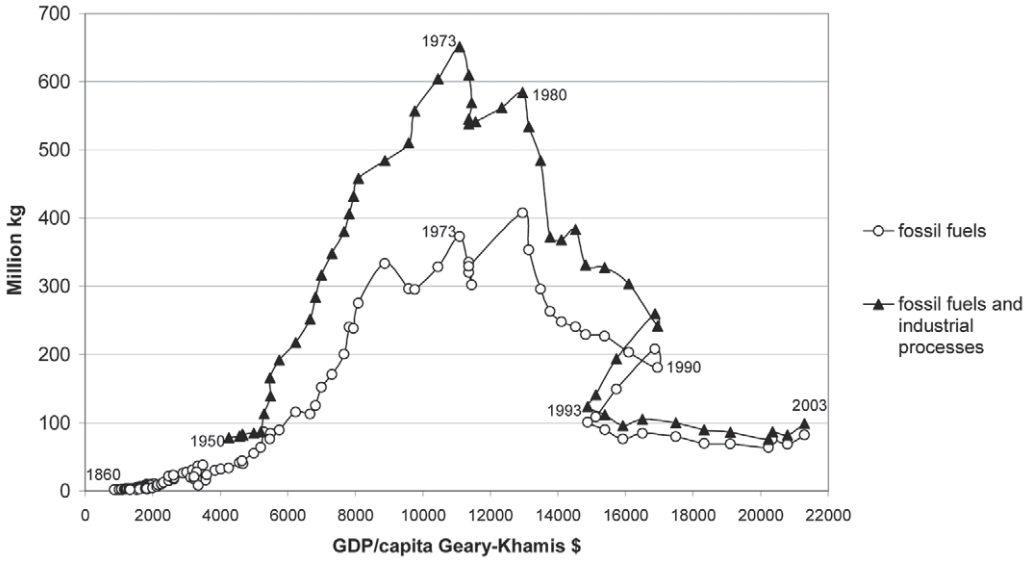


Figure 5. Relation between sulphur dioxide emissions and GDP in Finland, 1860–2003.
Sources: see Kunnas J. & Myllyntaus, T., "The Environmental Kuznets Curve Hypothesis and Air Pollution in Finland." Scandinavian Economic History Review, Vol. 55 No. 2, 2007, pp. 101–127.

'environmental Kuznets curve' hypothesis. The carbon dioxide emissions from Finnish energy production increased at the beginning of the period under study according to the EKC hypothesis, but a steady decline of these emissions at high income levels could not be found – only stagnation. Genuine support for the EKC hypothesis was only found for sulphur dioxide emissions and, with some reservations, for nitrogen oxides as well. A limitation of the reduced-form approach used is that it is unclear why the estimated relationship between pollution and income exists, a question that was studied in detail in the next part of the study (III).

Turning points?

The goal of part three of the study is to take a closer look at the reason between the divergent paths of carbon dioxide and sulphur dioxide emissions. Why did the emissions of sulphur dioxide start to decline in Finland and other industrialized countries in the 1970s, but emissions of carbon dioxide did not?

In the first study in this part the linkage between per capita GDP and sulphur dioxide emissions for one single country; in this case Finland is examined. The narrow approach together with a combination of a historical and economic approach enables to cut deeper into the controversial environmental Kuznets curve hypothesis. The main reasons for a downturn in sulphur emissions were found to be: technological development and anxiety about possible environmental damage and economic costs related to that. The role of economic growth creating a downturn was noticed being small or nonexistent (IV).

The decline of emissions in the 1970s was mainly a side-effect of changes in industrial processes rather than an outcome of a deliberate policy. Furthermore, anxiety about large and widespread damage to the forests was a major reason for active measures to decrease sulphur dioxide emissions since the mid-1980s. Thus the emissions themselves provoked their downturn. Although the risks facing Finnish forests might have been overestimated, without active measures the emissions would have

eventually reached a level in which the forests would have been seriously damaged. This again would have caused serious losses to the Finnish economy.

From an environmental point of view it does not matter whether the emission decline is a result of environmental considerations or a by-product of economically dictated technological change, or whether the engine of change is increased wealth or public reactions against emissions themselves. However, there is a big difference in the policy implications, for example, regarding carbon dioxide emissions. For future development of carbon dioxide emissions, the story of declining sulphur dioxide emissions in the 1970s inspires hope that reduction of emissions could be part of normal technological development. If again the environmental damage has to become severe enough to create pressure to reduce the emissions, then in the case of carbon dioxide the prospects are grim indeed. Another option is that, as in the case of sulphur dioxide, the anxiety about possible serious damage in the future can be enough to create the downturn in emissions.

The second study in this part examines the growth and composition of energy consumption in Finland in the 19th and 20th centuries, focusing on energy-related carbon dioxide emissions. This study argues that among European countries, Finland was an 'odd-man out' because it industrialized by means of renewable, indigenous energy sources. Only in the 1960s in the mature phase of industrialization, the country switched from indigenous energy sources, fuel wood, wood refuse and hydropower, to imported fossil fuels. The reasons for this late transition from an energy system based on indigenous energy sources to one largely depending on fossil fuels are Finland's large wood resources and reasonable hydropower potential, which made it possible to postpone the transition (V).

The switch to fossil fuels led to exceptionally fast growth of carbon dioxide emissions in the 1960s, as we can see from Figure 6. The growth of carbon dioxide emissions

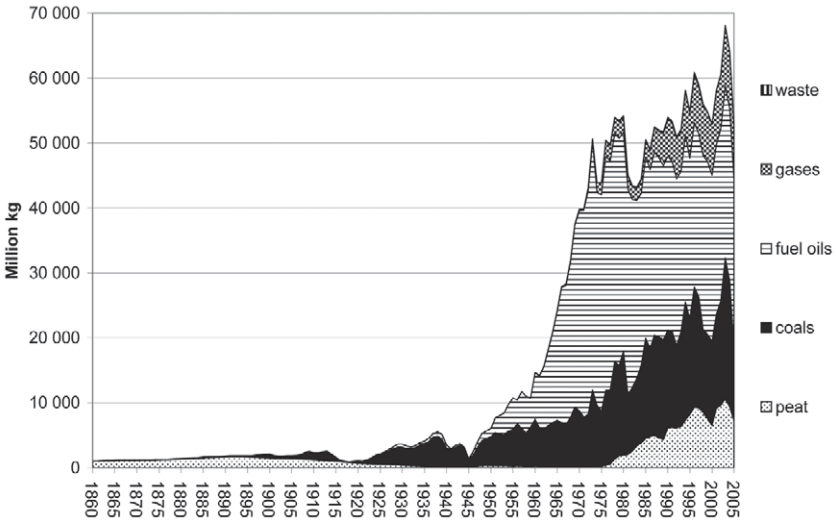


Figure 6. Carbon dioxide emissions from the use of fossil fuels in Finland, 1860–2005. Source: Kunnas, J. and Myllyntaus, T., "Postponed Leap in Carbon Dioxide Emissions: Impacts of Energy Efficiency, Fuel Choices and Industrial Structure on the Finnish Energy Economy, 1800–2005, *Global Environment*, No. 3, 2009, pp. 154–189.

slowed down, however, in the 1970s. The major reasons for this are a change in the industrial structure, an increased share of electricity import and nuclear power. Environmental considerations probably did not have any kind of role before the 1990s, although Gilbert Plass raised his concerns about the negative consequences of carbon dioxide emissions already in 1956. Despite this slowdown, Finland's carbon dioxide emissions have been almost seven-fold since Plass expressed his concerns.[6] Finland's present-day development concerning carbon dioxide emissions cannot thus act as an example for latecomers to follow.

Conclusions

Some proponents of economic growth go as far as claiming that economic growth is a necessary condition for proper protection of the environment and in the long run it is also probably a sufficient condition.[7] This thesis turns the argument around. I claim that the causal connection goes in an opposite direction: proper environmental standards and conservation comprise a necessary condition for economic growth in the long run (III, IV).

From a policy perspective Finland's industrialization in the 19th century without increasing its total use of energy and related carbon dioxide emissions is of particular interest (III, V). If the present-day developing countries could repeat Finland's "energy-less" growth which continued until the First World War, this could buy valuable time in the battle against climate change. If the developed countries would again use this time to lower their energy consumption and develop as environmentally friendly means as possible to provide the remaining needs for energy, there would be hopes to win this gigantic battle for the future of humankind. The accomplishment of this goal requires technology transfer to developing countries. This should, however, not focus on high-tech only; it should be remembered that Finland's initial energy-less growth was achieved by a technology which can be considered quite primitive from the present-day perspective, although it was revolutionary indeed at the time.[8]

I argue that quantitative calculations on the use of natural resources provide valuable tools, which can give new insights to old questions and raise new questions. The first two studies put forth the methodological question whether it is more misleading to leave matters uncalculated because of scarce sources to rely on or calculating despite this, suggesting that it can be the first one. Burning cultivation of peatlands, which has been neglected in historical research, was by far the greatest source of carbon dioxide in Finland during the whole of the nineteenth century and at the beginning of the twentieth century (I). Another neglected occupation, the production of potash might have consumed as much wood during the 19th century as the production of tar (II).

I also show how methods of historical research can be used to test economic theory (III, IV, V). So far, in my understanding, it has been mostly the other way round; economic tools have been used to provide answers to historical questions. Based on the historical approach used in this thesis, I add two new explanations for the existence of an Environmental Kuznets curve:

1) The severity of environmental degradation might itself create a turning point for the emissions, or in some cases fear of severe effects (III, IV).

2) What at a first glance seems to be an environmental improvement might just be a transformation of one environmental problem into another. What in an ahistori-

cal perspective seems to be one single environmental Kuznets curve are in fact several sequential curves (IV).

Jan Kunnas defended his doctoral thesis in History: "Fire and Fuels: CO2 and SO2 Emissions in the Finnish Economy, 1800–2005" [http://hdl.handle.net/1814/11753] 15th June 2009 at the European University Institute in Florence, Italy. Currently he is writing a book on the environmental history of Finland.
jan.kunnas@eui.eu

[1] Grossman &Krueger 1991; Shafik & Bandyopadhyay 1992. Selden & Song 1994; *World development report 1992;* Panayotou 1993.

[2] This argument resembles Alexander Gerschenkron's argument that backward countries could skip several (rostowian) stages of economic growth which advanced countries have gone through by adopting their advanced technology.

[3] Munasinghe 1999.

[4] Pearce 2005.

[5] Pyne, S. J. 1997; *Suomen maatalouden historia I–III* 2003–2004.

[6] Plass 1956.

[7] Beckerman 1995.

8 This idea is developed further in Kunnas & Myllyntaus 2008.

BIBLIOGRAPHY

BECKERMAN, W. *Small is stupid: Blowing the whistle on the greens*. Duckworth, London 1995.

GERSCHENKRON, A., *Economic Backwardness in Historical Perspective: A Book of Essays*. Belknap Press of Harvard University Press, Cambridge, MA 1962.

GROSSMAN, G. M., KRUEGER, A.B.,"Environmental Impacts of the North American Free Trade Agreement," *NBER. Working paper 3914*. Princeton 1991.

KUNNAS, J. & MYLLYNTAUS, T. "Forerunners and Policy Tunnels", *European Union Policies in the Making,* Leszek Jesień (ed.). Tischner European University, Kraków 2008, 249-263.

MUNASINGHE, "Is environmental degradation an inevitable consequence of economic growth." *Ecological Economics* 29, 1999, 89-109.

PANAYOTOU, T., *Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development*. Working Paper. International Labor Office, Technology and Environment Programme, Geneva 1993.

PEARCE, D. *Investing in Environmental Wealth for Poverty Reduction*. United Nations Development Programme, New York 2005.

PLASS, "Effect of Carbon Dioxide Variations on Climate." *American Journal of Physics* 24, 1956, 376-387.

PYNE, S. J. *Vestal Fire – An Environmental History, Told through Fire, of Europe and Europe´s Encounter with the World*. University of Washington Press, Seattle and London 1997.

SELDEN, T. M. and SONG, D. "Environmental quality and development: is there a Kuznets curve for air pollution estimates?" *Journal of Environmental Economics and Management* 27, 1994, 147–162.

SHAFIK, N. & BANDYOPADHYAY, S. *Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence*. World Bank, Washington D.C 1992.

Suomen maatalouden historia I-III. Suomalaisen Kirjallisuuden Seura, Helsinki 2003–2004.

World development report 1992. World Bank, Washington D.C. 1992, 39-41.