Convergence: An Analysis of European Union (EU) Health Care Systems - 1960-95

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Abstract

The academic study of convergence within the context of the neo-classical growth model is well established and has been widely applied to macro-economic areas such as GDP income and growth rates. This thesis has investigated the presence, or otherwise, of convergence in the health care systems of the European Union over the period 1960-95. The hypothesis investigated is that membership of the EU encourages countries to converge under the influence of a range of economic, social and political factors. These include the free movement of the factors of production, the opening up of EU markets to competition, EU legislation, and common social and economic influences and goals. Convergence analyses are developed and then applied to a framework of variables for each EU country, which include health care expenditure, health outcomes, health care resources, and utilisation rates. The results confirm that convergence has occurred in most areas of the framework and reveal which countries have contributed most The results also reveal differences according to the way in which health care is financed and organised in the EU. Regression analyses were applied to determine significant associations to develop a conceptual model for the study of health care convergence in the EU. The model confirms the predictions of the neo-classical growth model in terms of income convergence, which leads to health care expenditure convergence which, along with environmental and lifestyle variables, is found to be a determinant of the observed health outcome convergence. When convergence analyses were applied to a control group of non-EU OECD countries, which share similar economic and health care characteristics, convergence was also found to be present but to a lesser degree. The thesis concludes by identifying the policy implications of the results and the areas in need of attention that, if addressed by member-state governments, will lead to greater convergence throughout the EU.

Acknowledgements

Is it not, indeed, a pleasure to acquire knowledge and to exercise oneself therein?

(Confucius, the *Analects*)

I have come to the realisation over the period of my PhD studies that such an undertaking requires a tremendous amount of effort, determination and stamina, and cannot be successfully achieved without the support and encouragement of others. In this respect I have been extremely fortunate. Firstly, having a good supervisor is paramount if the experience of PhD study is to be fulfilling and enjoyable. In having Dr. Theo Hitiris as my principal academic supervisor I have been extremely grateful as he has been a tremendous source of inspiration and encouragement, as well as collaborating and advising with publications related to my thesis. I also express my sincere thanks to Professor Andrew Jones for supervising the latter stages of my study, and to Professor Jos Kleijnen and Professor David Mayston for being on my Thesis Advisory Group. Their valuable guidance and advice has resulted in many improvements and refinements to the work and for this I am most appreciative. I also acknowledge the revisions suggested by Professors Maynard and Whynes, and Dr. Mossialos. Finally, achieving any form of success in life is an empty experience without the recognition and appreciation of one's family and friends. In this regard I wish to acknowledge the encouragement and interest of all my close family members; my dear parents Alan and Veronica, my children Lisa, Philip and Christopher, my sisters Valerie and Barbara, my brother David, my dedicated and loving partner, Yumi, and my good friends and colleagues Francis Pang, Urpo Kiiskenen, Jimmy Christie and Julie Glanville.

Dedication

I dedicate this thesis to my son *Christopher Michael Nixon,* and to my mother *Veronica Nixon.*

Declaration

Throughout my period of PhD study I have been grateful for the advice and guidance I have received from my Academic Supervisors, Dr. Hitiris, Professor Jones, and the members of my Thesis Advisory Group; Dr. Alan Duncan, Professor Jos Kleijnen and Professor David Mayston. Any remaining errors or omissions that may remain in this thesis are my sole responsibility.

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List of Abbreviations

A = Austria.

AIDS = Acquired Immunosuppressant Deficiency Syndrome.

ANOVA = Analysis of Variance.

B = Belgium.

CABG = Coronary Artery Bypass Grafting.

CHD = Coronary Heart Disease.

CODES = Collège des Economistes de la Santé.

COM = European Commission.

CRS = Constant Returns to Scale.

c.v. = Coefficient of Variation.

D = Germany.

DALY = Disability Avoided Life Year.

DARE = Database of Abstracts of Reviews of Effectiveness.

DK = Denmark.

E = Spain.

EEC = European Economic Community.

ECJ = European Court of Justice.

EC = Economic Community.

ECSC = European Coal and Steel Community.

EIB = European Investment Bank.

EGM = Endogenous growth models.

EMU = Economic Monetary Union.

EMU = Economic Monetary Union.

ERDF = European Regional Development Fund.

EU = European Union.

Eureka = The European Research Co-ordination Agency.

GDP = Gross Domestic Product.

GP = General Practitioner.

HTA = Health Technology Assessment.

GR = Greece.

I = Italy.

INSERM = Institut National de la Santé de la recherch médicale.

INHATA = International Network of Agencies for Health Technology Assessment.

IRL = Ireland.

JRC = Joint Research Centre.

L = Luxembourg.

LI = Low Income.

NHS = National Health Service.

NHS CRD = NHS Centre for Reviews and Dissemination.

NICE = National Institute of Clinical Excellence.

NHS EED = NHS Economic Evaluation Database.

NL = The Netherlands.

NS = Non-significant.

OHE = Office of Health Economics.

OECD = Organisation for Economic Co-operation and Development.

P = Portugal.

PPP = Purchasing Power Parity.

QALY = Quality Adjusted Life Year.

S = Sweden.

SEA = Single European Act.

s.d. - standard deviation.

SI = Social Insurance.

PTCA = Percutaneous Transliminal Coronary Angioplasty.

TEN = Trans-European networks.

TEU = Treaty on European Union.

UK = United Kingdom.

USA = United States of America.

Chapter One

Introduction

1.1. Background

Economic, political and social integration within the countries of the European Union (EU) is a subject which is attracting much attention of late (Leidl, 1998). The Maastricht Treaty in particular has laid the foundation for this to occur and specific, high profile initiatives such as European Monetary Union (EMU) (Grahl, 1997), which has its own convergence criteria[1], and the Social Chapter are in train and will undoubtedly create opportunities for the fifteen countries of the EU to reduce social welfare differentials between them.

With this background in mind the aim of this thesis is to investigate the existence, or otherwise, of convergence in the health care systems of the present EU countries over the period 1960-95. This has been achieved by adopting and developing suitable statistical tools to empirically test a number of variables from the OECD Health Data set (OECD/CREDES, 1997; OECD/CREDES 2000). The present 15 countries (and date of joining) of the EU are: A=Austria (1995), B=Belgium (1957), D=Germany (1957), DK=Denmark (1973), E=Spain (1986), F=France (1957), FIN=Finland (1995), GR=Greece (1981), I=Italy (1957), IRL=Ireland (1973), L=Luxembourg (1957), NL=Netherlands (1957), P=Portugal (1986), S=Sweden (1995), UK=United Kingdom (1973) (Hitiris ,

[1] Laid down in the Maastricht Treaty: To qualify for the EMU countries must (1) have achieved sustained price stability, (2) avoid excessive budget deficits, (3) have avoided severe exchange-rate tensions in the European Monetary System (EMS) for the previous two years, (4) have kept its long-term interest rates down to no more than 2% higher than the countries where prices are most stable. Article 109j of the European Community Treaty refers.

1998). Along with the findings of the analyses. the thesis seeks to explain the reasons for any observed convergence or divergence over this period.

In fact national health care differs between member states of the EU both in terms of quality and quantity demanded and supplied, and is related to the different economic structures and health care delivery systems employed (Mossialos and Le Grand, 1999; Hitiris, 1997; Abel-Smith *et al.*, 1995). The developing influence of European law and its provision of the 'four freedoms' of movement of goods, services, persons and capital also have implications for the provision of health care (McKee *et al*, 1996). A question therefore arises as to the need for health care delivery within the EU to move towards a more or less common experience as the prospect of citizen mobility becomes an increasing phenomenon.

The thesis is therefore an in-depth study of convergence, which, in sociological terms, is defined as:

> *The result of a process in which the structures of different industrial societies come increasingly to resemble each other.* (Jary and Jary, 1991, p.121)

A prominent theme in much recent macroeconomic literature, economic convergence implies a 'long-run tendency towards the equalisation of *per capita* income or product levels' (Abramovitz (1986). The motivation for undertaking this thesis lies in the tenets of health economics within the framework of social policy, which can be regarded as the study of differences or inequalities in society. The attraction of the study of convergence to the author is that it offers a means of determining if differences are diminishing over time as a way of judging progression towards common levels of health care provision within the EU.

This introductory chapter starts by specifying the study hypothesis and listing the research questions and then identifies the variables that have been selected for analysis. Following this an explanation is given regarding the various reasons as to why convergence is a realistic expectation in the EU. The theoretical foundation of the thesis, the neo-classical growth model, is then summarised along with the chosen statistical techniques that are considered to be appropriate for the empirical work. A summary of the health care systems operated by the member states of the EU and the extent of common policies on health in the EU are then given, before finally providing an outline of the remaining chapters of the thesis.

1.2. Study hypothesis and research questions

Having presented relevant background the thesis hypothesis investigated can be specified as follows:

Membership of the EU leads to convergence in member states' health care systems

In order to investigate this, the following research questions lay down the coherent approach used in this study and are divided into six discrete areas as follows:

1. What current variations exist between the member states of the EU in terms of health care?
2. What degree of convergence has occurred over the period of analysis in relation to a reliable point of reference?
3. What are the relevant factors that explain any observed convergence?
4. What economic, social and political influences exist to encourage convergence?
5. Can a generic model be developed for the study of health care convergence?
6. Is there evidence of convergence in other non-EU OECD countries?

1.3. Framework for the empirical analysis

In order to address these questions a framework of representative health-related variables has been chosen which provides a means of testing for the existence of convergence. To this end four specific areas are used: **expenditure** on health care, **health outcomes**, **health care resources** and **utilisation rates** associated with each member state. Throughout the analyses, associations are sought in relation to the health care typology adopted under the generic systems of Social Insurance (SI) and National Health Systems (NHS), as outlined in detail later in this introduction.

1.4. Benefits of the research

The principal benefit of the thesis is to inform policy makers and other researchers regarding the degree of convergence that has occurred in recent decades in the health care systems of the EU, to identify areas that need further attention if differences are to be reduced, and thus clarify the picture regarding how greater convergence could be achieved. As such the thesis raises issues of equity, standardization, universality and expectations of health care throughout the EU. The methods developed throughout the thesis are also anticipated to be applicable to other areas of economics, health economics and social policy.

1.5. Literature surveys

Due to the wide range of statistical techniques and concepts studied in this thesis a dedicated chapter for reporting a literature survey has not been created. Rather, within each chapter the relevant literature has been reviewed using a systematic approach, and used to inform the content of each chapter. The strategy adopted has been to use the electronic databases BIDS and EconLit to search on key words over the period 1990-97 (using various combinations of the following words/phrases: *convergence, economic convergence, European Union, EU, European Union (EU) health care systems, health care expenditure, determinants of health, cluster analysis*).

The bibliographies of retrieved papers and books were then hand searched to locate further publications of interest. However, it was considered important to gain an understanding of the findings of previous empirical studies of economic convergence, and to accommodate this a literature review and summary of key studies, both within and outside the EU, has been compiled and is reported in Appendix A of the thesis.

To take account of studies that have been published in the area of convergence in health care expenditure and social welfare during the writing of this thesis, an update of recent work is provided in Chapter Seven.

1.6. Factors influencing convergence

It can undoubtedly be argued that the general process of globalisation and the opening up of markets will create forces for convergence among specific groups of countries around the world. However, in acknowledging this point of view, the thesis puts forward the argument that additional forces for convergence exist within the member states of the EU. The following sub-sections provide a brief overview of these influences. These will be examined in more detail within the main chapters of the thesis, and summarised in the discussion and conclusions of Chapter Seven.

1.6.1 Increasing demand and health care reforms

One of the most likely factors influencing convergence has been brought about by the escalating demand for health care, which is largely due to demographic changes in the populations of the EU countries and advances in medical technology (Hitiris, 1997).

In terms of the ageing population in developed countries such as those forming the EU, cost analyses reveal the impact of this social phenomenon on health care costs. For example the costs for a 70-year-old have been found to be 50 percent higher than those of a 60-year-old, who costs twice as much as a 40-year-old (Denton and Spencer, 1975). Spending for the average person over 85 has also been found to be more than 5.2 times the average spending for 35-44 year olds (Cutler and Meara, 1997). These figures thus illustrate the policy challenges that emerge as a result.

In relation to health care technologies, countless new drugs and surgical interventions are now available that were not a few decades ago. For example, patients with coronary heart disease (CHD) are now able to benefit from a range of interventions such as improved medical management and advanced surgical procedures (Koon, 1998). These include lipid lowering treatment (cholesterol reduction) in primary as well as secondary prevention of coronary artery disease, coronary artery bypass grafting (CABG), intracoronary stenting - a high technology innovation in which a balloon-expandable, stainless steel tube is implanted at the site of a coronary lesion to treat acute or threatened vessel closure after coronary angioplasty, and percutaneous transliminal coronary angioplasty (PTCA) which is a less invasive alternative to CABG aimed at clearing blocked arteries supplying the heart as opposed to bypassing them. These procedures are all relatively new and aim at improving both the life expectancy and quality of life for these patients. However, they are invariably associated with increased costs for the health care sector and attract increased demand due to the high prevalence of CHD in European populations, further enhanced through the increased awareness of such procedures on behalf of patients. Although some new interventions are both more effective and less costly, examples can be cited in almost any area of modern medicine in relation to the availability of new treatments and initiatives such as mass screening for major and preventable diseases. Under such pressures, health-related costs are rising at a far higher rate than national income.

All countries in the EU are therefore experiencing economic pressures in relation to increased health care demand and have been seeking ways of increasing efficiency and limiting expenditure on health care (Ham, 1997). However, the responses to these pressures vary according to the political make-up of governments, culture, history, economic wealth and the way in which health care provision is organised by member states.

In the United Kingdom, for example, the introduction of a quasi internal market within the NHS through the *NHS Reform Act of 1990* reflected an attempt to introduce the benefits of the free market into the system in order to maximise technical and allocative efficiency, whilst retaining the advantages of universal health care provided from public money[2]. The centralisation of the UK system meant that the policies of public expenditure cuts could produce the desired outcome but the drawback has been recurrent underfunding and lengthier queues.

In France, reimbursements from the Government have been limited as costs rise and more emphasis placed on the private element of health insurance (*mutuelle*). As France, for example, spends considerably more as a percentage of GDP on health care (9.9% compared with 6.9% for the UK[3]), the French Government is being forced to consider other measures in order to limit demand, some of which have the characteristics associated with NHS

[2] The internal market, since the election of a Labour government in 1997, has come under new reforms which are aimed at eliminating the division created by the former Conservative government between purchasers and providers and money flows between them. This indicates that responses to health care provision are conditioned by political factors.

[3] See OECD Health Data (OECD/CREDES, 1997). Figures provided are for 1995.

modalities such as the GP as gatekeeper principle, although this action would appear to be culturally unacceptable to the French people with their belief in the rights of the citizen and the value they place on the principles of liberal access (Nixon, 1995). In France, discussions have also focused on the costly fragmentation of the health care system which is not conducive to controlling increasing health care expenditure, a theoretical point of focus in the analyses of the thesis.

In Italy, reforms introduced at the end of 1993 have been aimed at reducing the chronic problems of deficits and the mounting inefficiencies whilst in Germany, where the main problem has been oversupply of services with few incentives for efficient use of resources, the reforms have aimed at deep structural changes of the system.

In terms of the wider objectives of the reforms the OECD Project on the Reforms of Health Care Systems (OECD, 1994) identified a number of key issues and characteristics which, if rigorously pursued by EU member states, will have an increasing impact on the possibility of convergence. It examined reforms throughout the 80s and 90s and identified the following health policy objectives:

- Adequate services for all
- Equity of access
- Protection of income
- Macroeconomic efficiency (cost containment)
- Microeconomic efficiency (health outcome maximisation, patient satisfaction maximisation and cost containment)
- Consumer choice
- Provider autonomy

However, member states may implement policies at the lowest and most appropriate level. and in reality health indicators such as infant mortality, life expectancy and death rates may be the main thrust in terms of achieving convergence.

With these influences and concepts in mind, the following statement by the EU Commission implicitly identifies forces for convergence based perhaps on what might be described as commonality of experience and shared knowledge in matters relating to health care provision:

> *In the last fifteen years, Member States have implemented a number of reforms, in order to adapt their systems to crisis constraints...as member states become aware of the strong links which exist between them and as information about what is going on in other countries is improved (for example competition/market forces), it is reasonable to believe that they will seek long-term solutions in similar directions.* (Commission of the European Communities, 1994, p.40)

Therefore it is evident from the above that a number of demographic and technological influences exist within the EU that tend to drive up demand for health care, which places pressure on health care budgets. This common experience has tended to generate policy responses and reforms which may have an equalising effect in encouraging the process of health-related convergence.

1.6.2 GDP Income

Another important and influential driver of health care convergence is the *per capita* GDP income of a country, which has been shown to be the most important determinant of health care expenditure (Newhouse, 1977). Moreover, convergence of GDP income has been observed by means of empirical research among groups of homogenous countries, specifically the OECD countries as well as the states of the United States, the prefectures of

Japan and also among the regions of seven European countries (for example Barro and Sala-i-Martin, 1991; 1992a; 1992b). The point perhaps to focus on from these and similar analyses of economic convergence (see Appendix A), is that convergence most often occurs among the members and sub-groups of the OECD 'club' (a key expression in this field of study) and convergence disappears when the sample is widened to include Eastern Europe and the developing countries.

These findings therefore provide encouragement from an economic point of view that it should be a reasonable expectation, given the link between health care expenditure and *per capita* income and the empirical evidence for *per capita* income convergence among open economies trading in goods, services and factors of production, that convergence in health care expenditure among the countries of the EU will be occurring.

It should also be borne in mind that within the EU specific policies and mechanisms are in place that redistribute wealth by targeting deprived areas in need of extra investment[4]. As such, GDP income will tend to equalise throughout the EU and act as a further driver of convergence in health care expenditure and provision.

In considering the make-up of the EU it has to be recognised that an argument may also be put forward that within the present 15 countries a degree of heterogeneity exists. However, the member states of the EU do 'aspire' to achieve greater homogeneity through their collective bodies and policies and have had to meet certain criteria to join the EU. To take account of these factors, the thesis will attempt to reveal any links between income convergence, health care expenditure convergence and the other elements of the chosen framework of analysis (health outcomes, resources and utilisation rates).

[4] Two prominent mechanisms exist: The European Regional Development Fund (ERDF) which provides grants for development projects in poorer regions. It has the expressed aim of reducing imbalances between regions of the EU (and therefore a force for convergence). The second is the European Social Fund which provides financial assistance for vocational training, retraining and job-creation schemes (Hitiris, 1998).

1.6.3 *Theoretical issues*

As the theoretical tools and approaches to the measurement of convergence generally fall under two different schools, the following sections summarise the important theoretical foundations of convergence analysis in income and growth rates. It is considered important to have a grasp of these issues as the approaches applied in this thesis to examine the chosen health care framework will need a degree of explanation and justification.

1.6.3.1 The neo-classical growth model

Of particular relevance to the EU, the neo-classical growth model provides a theoretical reference for much of the empirical work on convergence as it predicts this phenomenon in terms of income and growth rates.

The model is based on Solow's (1956) and Swan's (1956) seminal papers. Its main prediction, supported by the refinements of Cass (1965) and Koopmans (1965), is that economies which are similar in terms of technologies and preferences are expected to converge to the same level of *per capita* income. The key point is that if technologies exhibit constant returns to scale and declining capital productivity, the *per capita* growth rate tends to be inversely related to the starting level of output or income *per capita*. The predicted result is that an initially poor economy with a lower starting value of the capital/labour ratio tends to grow faster in *per capita* terms than a rich one. Therefore countries are predicted to converge with one another, regardless of their initial conditions.

Bertola (1999) provides a useful review of the theoretical considerations of the neo-classical growth model, which are summarised below:

Let country i's output over time t, $Y_i(t)$, be produced with (accumulated) capital K and (non-accumulated) other factors L according to:

$$Y_i(t) = F_i(K_i(t), L_i(t)), \tag{1}$$

and let $Y_i(t)$ be allocated to consumption and capital accumulation according to:

$$Y_i(t) = C_i(t) + I_i(t), \quad K_i(t) = I_i(t) - \delta K_i(t). \tag{2}$$

Where C = consumption, I = investment and $\delta K(t)$ = capital depreciation.

If technology is the same for all i and offers constant returns to K and L together.

$$F(\lambda K, \lambda L) = \lambda F(K, L) \text{ for all } \lambda \text{ (constant) and for } \lambda > 1.$$

$$F(\lambda K, L) < F(\lambda K, \lambda L) \tag{3}$$

as long as the non-accumulated factors indexed by L have positive productivity: an increase in the accumulated factor K encounters *decreasing returns* if it is not accompanied by a proportional increase in L. This implies that the production function in intensive form is convex:

$$f(k) \equiv \frac{F(K,L)}{L} = F\left(\frac{K}{L}, 1\right) \Rightarrow f''(k) \langle 0, \tag{4}$$

and that accumulation should find it difficult (if not impossible) to sustain long-run growth. To see this, it is possible write the proportional growth rate of output as:

$$\frac{\dot{Y}}{Y} = f'\left(\frac{K}{L}\right) + \frac{\dot{K}}{Y} + \frac{\dot{L}}{L}\left(1 - f'\left(\frac{K}{L}\right)\frac{K}{Y}\right): \tag{5}$$

in a closed economy, where $K = Y - C - \delta K$ as in (2), the net saving rate K/Y is bounded above by unity; with $f''(\cdot)\langle 0,$ its weight as the driving force of growth declines as capital intensity increases. If:

$$\lim_{k\to\infty} f'(k) = 0 \tag{6}$$

unbounded capital intensity would tend to annihilate the first term on the right-hand side of (5), and before that happens the economy must settle in a steady state where *K L, K/Y* and $f'(\cdot)$ are constant. In the long run, income growth is exogenous and determined by the rate of increase $\dot{L}/L$ of non-accumulated factors, in the second term on the right-hand side of (5).

A further crucial step brings neo-classical transitional dynamics to bear on cross-sectional findings of *per capita* income (non-) convergence: the non-accumulated factor L is identified with labour and proportional to population (N); further, if $L_i = N_i A_i$ for N_i country *i's* population N_i and A_i an index of its productive efficiency, A_i is given a technological interpretation and, like $F(\cdot,\cdot)$, is taken to be the same for all i. Then, *per capita* income:

$$y_i(t) \equiv \frac{Y_i(t)}{N_i(t)} = f(k_i(t))A(t) \tag{7}$$

may differ across countries only to the extent that k_i does - *and poor countries should grow faster than richer ones.*

The process will also be reinforced by open economy features such as factors flows and free trade (available, as outlined earlier, within the EU), which contribute to factor price equalisation. It should be noted that the Solow-Swan model explains growth in an isolated economy, but in combination with other aspects of neo-classical theories such as the Hecksher-Ohiln theorem of factor price equalisation, it leads to convergence in income levels among countries (Capolupo, 1998).

1.6.3.2 Absolute and conditional convergence

A key element in convergence analysis is the distinction between 'unconditional' (sometimes referred to as 'absolute') and 'conditional' convergence (Barro and Sala-i-Martin, 1991).

The first concept is that: absolute or unconditional convergence is displayed when poor economies grow faster than rich ones. The important implication of this concept is that *all economies should eventually converge to the same per-capita income*. Regressions that do not control for other growth factors are referred to as unconditional convergence regressions (Capolupo, 1998). Typically these regressions (of growth rate against level of GDP in a base year) yield positive slope in a broad sample showing that, contrary to expectation by some, there is a tendency for the initially richer countries to grow faster. However, this point should be taken in context, as outlined earlier, and is not the case for more homogenous countries.

In order to accommodate the theory with empirical observations, conditional convergence has been defined involving the running of conditional regressions. This concept, which is now very familiar in the literature, has come to indicate that an economy grows faster the further it is below its own steady state. From an empirical perspective, in order to test for conditional convergence it is necessary to hold constant the steady state. This can be done by estimating a regression which includes a vector of variables that proxy for the steady state. In order to test for conditional convergence Barro-type regressions are employed. A typical example (Capolupo, 1998, p.515) would be:

$$\frac{1}{T}\ln y_{i,t_0+T} / y_{i,t_0} = \alpha + \left(\frac{1-e^{\beta T}}{T}\right)\ln(y_{i,t_0}) + \gamma X_{i,t} + u_{i,t} \qquad (8)$$

where T is the time period being analysed, α is the constant. The average growth rate is thus a function of initial income and a vector, X, of conditioning variables, and u_{ij} is a disturbance term. The vector, X, can include investment ratio, population growth, primary and secondary school enrolment rates, and other fiscal and monetary variables. These variables are designed to control for differences in preferences and technology and hence the steady states achieved. The test for convergence consists of running regressions with the growth rate as the dependent variable and the initial level of income as the explanatory one. If the coefficient of initial income exhibits the expected negative sign for β, when the vector of new variables is held constant, then there is conditional convergence and the neo-classical model is not rejected in its predictions. The negative correlation is thus interpreted as evidence of convergence in terms of both income levels and growth rates ($-\beta$ is the change in the growth rates (i.e. diminishing) over time).

It is important, however, to recognise that conditional convergence does not imply a tendency towards equalisations of *per capita* incomes. *Each country converges to its own steady state*, which can differ permanently from the steady state level of other countries. To discriminate between conditional or unconditional convergence it is not sufficient to observe the sign of the coefficient of initial income but there is a need to test the hypothesis that long run income levels are the same for all countries of the sample.

1.6.3.3 σ and β-convergence

The concepts of convergence analysis according to the neo-classical approach are encapsulated in two commonly used measures of convergence (Quah, 1993a; Barro and Sala-i-Martin, 1992a), namely β-*convergence* and σ-*convergence*. The former, as described above, occurs when countries which initially start out with below average incomes grow at a faster rate than those countries with initially above average incomes, resulting in a tendency to 'catch up.'

σ-convergence, on the other hand, occurs if the standard deviation (usually its log) or coefficient of variation can be shown to be declining over time. More precisely, data show *σ-convergence* if $\sigma_{i,t+T} < \sigma_{i,t}$ for time period, T, and group of countries denoted by subscript, *i*, and initial year denoted by *t*.

Capolupo (1998) points out that in general the process of *β-convergence* tends to generate *σ-convergence* but the former does not necessarily imply the latter. It might be the case, in fact, that the distributional dynamics are such that σ is invariant or increasing even if a country is converging towards the sample mean. In fact some debate exists in the literature concerning the links between these two instruments in the measurement of convergence (Barro and Sala-i-Martin, 1991; 1992a; 1995; Quah, 1995; Sala-i-Martin, 1995). Both of these instruments are employed within the chapters of this thesis in the empirical analyses.

Although much of the empirical studies on convergence has been directed towards GDP income and growth rates (see Appendix A), recent studies have begun to emerge in the area of social welfare in the European Union. For example, Alonso *et al.* (1998) applied both σ and *β-convergence* analyses to examine *per capita* social benefits across the 12 countries (in 1992) of the EU. Their results support the hypothesis of convergence during various periods between 1966 and 1992. Consistent with the philosophy of this thesis, their findings support the concept that convergence in social benefit protection can contribute to facilitate labour mobility within the EU which may have important implications for the speed of growth both within individual EU countries and the EU at large (Razin and Yuen, 1996). This point of view clearly extends to other elements of social welfare, such as health care.

1.6.3.4 Endogenous growth models (EGMs)

One of the criticisms of the neo-classical growth model is that empirical evidence reveals diversity in growth over long time periods and in large samples of countries, including the less developed ones (Capolupo, 1998). Endogenous growth models (EGMs) have recently been developed which question the dynamics of the traditional model and its convergence property. Unlike the neo-classical growth model, EGMs are capable of generating sustained growth without recourse to exogenous technological progress. In fact, in contrast with the neo-classical growth predictions, EGMs anticipate divergence in income levels and growth rates. The theory suggests that if the rate of technological progress is determined endogenously by private decisions to invest in human or physical capital, permanent differences in growth rates across countries can arise as a result of different rates of accumulation or differences in factor endowments. Moreover, even when the rate of technological change is not endogenous, if the marginal productivity of capital does not decline with increasing GDP *per capita*, convergence does not necessarily take place and the accumulation of capital can sustain growth indefinitely.

In EGMs the determinants of growth include physical and human capital accumulation (King and Rebelo, 1990; Lucas, 1988; Rebelo, 1991), private externalities (Romer, 1986), public externalities (Barro, 1990), R&D (Aghion and Howitt, 1992; Grossman and Helpman, 1992; Romer, 1987; 1990), trade and technological transfers (Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991).

1.6.3.5 Endogenous vs exogenous growth theories

Bertola (1999) explains that interest in cross-country income convergence is motivated by the question of whether it might be technologically feasible for individual economic units to sustain their own growth indefinitely and independently of other similar units' growth behaviour. In other words, is an individual economy's long-run growth experience *endogenous* to its own saving and investment rates and their determinants? In theoretical models, endogeneity of long-run growth largely depends on the character of technology and market interactions. In this respect a lack of convergence is unfavourable evidence for Salow's (1956) neo-classical growth model, where complete competitive markets under a constant return (CRS) technology offer decreasing return to investment and, for realistic specifications, yield slowing and eventually ceasing growth.

However, in spite of this diversity of opinion regarding the theoretical issues surrounding convergence analysis, a point of focus for this thesis is that the neo-classical growth model does acknowledge that if countries do not share the same (or similar) technology then convergence will not occur. That is, lack of convergence does not mean that the neo-classical growth model can be rejected in favour of the endogenous growth theory. Moreover, although homogeneity in terms of technology is not absolute in the countries of the EU, all countries belong to the developed world and therefore fall within the expectations of convergence according to the tenets of the neo-classical theory of convergence.

1.6.4 Technology diffusion by assessment and dissemination

As outlined above, the main prediction of the neo-classical growth model is that economies which are similar in terms of technologies and preferences are expected to converge to the same level of *per capita* income. Therefore convergence must be conditional on the ownership of common information that allows optimal solutions to be adopted by member states. In this regard this section briefly flags up the process of technology diffusion through the assessment and dissemination of health technologies.

Assessment of health technologies at a micro level. taking into account both the clinical effectiveness and cost of treatment, is conducted by means of economic evaluations (Drummond *et al.*, 1997). In order to qualify as a full economic evaluation a study must explicitly examine both costs and outcomes for at least one intervention and one comparator (usually the traditional method of delivering care in a given area of medicine). Under the pressures outlined earlier, namely demographic changes towards an elderly population and new and more expensive health technologies, countries within the EU are facing increasing demands for health care. Whilst macro-economic policies may seek to control demand through supply-side mechanisms such as global budgets, limiting the supply of new health care professionals, co-payments, limiting reimbursements and capping of health care financing, micro-economic mechanisms such as economic evaluations seek, by quantifying the cost-consequences of alternatives, to ensure value for money is achieved within the principles of welfare economics.

An example of how economic evaluations may influence choices can be observed in comparisons between minimally-invasive and open surgical procedures. The results of a study (Cerveira *et al.*, 1999) of minimal incision (MINI) repair of abdominal aortic aneurysms in comparison with Laparoscopic-assisted repair (LAP) and standard open surgery, showed that MINI is associated with quicker recovery for the patient, and significant reductions in hospital charges (primarily due to lengths of in-patient stay being one third of that of LAP and open procedures). The example illustrated here shows a case where dominance is demonstrated (the intervention being both more effective and less costly) which would be the ideal outcome of an economic evaluation for the policy maker. There are, however, nine possible outcome permutations associated with economic evaluations (Nixon *et al.*, 2001) and although it is not pertinent to the thesis research questions to expand further, they offer the decision maker with a means of assessing the need, or otherwise, for additional funding to acquire the benefits of the technology being evaluated.

Finally in this section, making such information available to others as a driver for convergence relies on a process of dissemination, which is a function carried by various groups and institutions within the EU. The 'Information Society', for example, established under the EC Treaty, has as part of its objectives 'the securing of equal opportunities in competition and access to new technology' (Weidenfeld and Wessels, 1997, p.160). In the area of health technology assessment (HTA), collaborations such as the Cochrane Library offer information on the clinical effectiveness and cost-effectiveness of health technologies which are derived and/or supplemented by organisations such as the UK's NHS Centre for Reviews and Dissemination[5] which provide publicly accessible databases on systematic reviews of clinical effectiveness[6] and cost-effectiveness[7]. By making such information widely available throughout the EU, health care systems may determine optimal health care interventions which make the best use of available resources[8] and therefore encourage convergence at the micro-level (through technical efficiency) which feed back to expenditure trends (and therefore convergence) at the macro-level.

Although the above-described factors are relevant in terms of facilitating convergence in health care systems such as those operating within the EU, they will not be formally assessed in this thesis as collecting empirical evidence on their impact is not feasible at this stage. Their influence, however, may reasonably form the subject of future research.

[5] University of York, UK.

[6] DARE (Database of Abstracts on Reviews of Effectiveness).

[7] NHS EED (NHS Economic Evaluation Database). See Nixon *et al.* (2000a) and Nixon *et al.* (2000b).

[8] In the UK, for example, this task is being taken over by NICE (National Institute of Clinical Excellence).

1.6.5 Organisation of health care system

Within the EU there are a number of models evident in terms of social protection (*c.f.* Esping-Andersen, 1990; Cochrane, 1993; Hoffmeyer and McCarthy, 1997; Hurst, 1992) but health care for the residents of the member states is the concern of the countries themselves. Although health care coverage against medical costs (medical care, ambulatory care, and medical goods) is largely universal in every EU country, the systems they employ differ in organisation, financing, resources and delivery.

The EU countries operate two different health care systems, namely National Health Service (NHS - the Beveridge model) or SI (the Bismark model), with varying additional levels of private insurance and private medical systems. Both types of system assign an important role to the government for reasons of equity and efficiency but otherwise they differ markedly in many respects.

The NHS system is characterised by universal coverage and financing and public provision of services in state-run or state-supported institutions, where the government:

- directly controls the organisation and financing of health service;
- directly pays the providers;
- owns most of the facilities;
- guarantees equal access to the general public;
- allows some private care for patients willing to pay their own expenses.

The main feature of the SI system is that usually it is compulsory and financed by employer and employee contributions. Under this system, the government:

- indirectly controls the organisation and financing (mainly by social insurance) of health services;

- owns some of the facilities;
- regulates payments to providers;
- guarantees equal access to the general population;
- allows private care for patients willing to pay their own expenses.

The private insurance model, associated more with countries outside the EU such as the United States, is characterised by employer-based or individual purchase of private health insurance coverage financed by individual and/or employment contributions, and private providers.

Of the 15 EU member states, nine operate the NHS system: Denmark, Greece, Spain, Italy, Ireland, Finland, Sweden, Portugal and the United Kingdom; and six the SI system: Austria, Belgium, Germany, France, Luxembourg, and the Netherlands.

Using recently published data it is possible to break these classifications down further (EUROSTAT, 1996). Table 1 shows the classification of health care systems according to *type, provider* and *payment* method (for those who deliver primary health care).

The ways in which systems are operated depends largely on historical, political, cultural and economic influences within member states of the EU. These variations have an impact on issues such as equity-efficiency-cost, and access arrangements experienced by users of those systems. For example users of the French Health Care System (SI model) are able to make direct appointments - on a fee-for-service/reimbursement basis- with a doctor or specialist of their choice, whereas in Britain (NHS model) users must always consult their GP, who acts as a gatekeeper for further access to secondary health care. Additionally, waiting lists in NHS countries are generally shown to be much longer than SI models (Royal College of Practitioners, 1993; Nixon, 1995) due to factors such as a higher ratio of doctors per head of population and more in-patient beds[9]. However, in terms of universality, NHS modes of delivery may have an advantage over systems relying on social and private insurance which can produce gaps in health care provision and reliance, for those without insurance, on charity. For example the delay between GP referral and specialist appointment for medical and surgical appointments for the UK (NHS) and France (SI) was 34 days versus 7 days, and 38 days versus 4 days, respectively (Royal College of Practitioners, 1993).

In terms of broad classifications the thesis adopts the two generic groupings of NHS and SI such that these may be investigated empirically throughout the thesis. From Table 1.1 it is evident, however, that homogeneity within these sub-divisions is questionable. Indeed, one could examine other sub-divisions such as the degree of centralisation exercised by NHS countries in the EU, or, in relation to SI countries the variations in terms of benefits in kind or benefits in cash, based on income levels for patients of those systems (for example the Netherlands). However, analyses at the macro level have to accept a trade-off between sensitivity to sub-classifications and the need to choose global categories. Without such a trade-off analyses such as those being pursued in this thesis would become too problematic to deal with.

This limitation, however, applies to many other areas of the thesis framework and will be discussed more fully in the discussions of Chapter Seven.

[9] For example the delay between GP referral and specialist appointment for medical and surgical appointments for the UK was 34 days versus 7 days, and 38 versus 4 days, respectively (Royal College of Practioners, 1993).

Table 1.1 Organisation of health care systems in the EU

Country	Main type of coverage	Main type of providers	Type of payment of primary health doctors
A	social insurance	ambulatory mainly private; hospitals mainly public	fee-for-service, capitation
B	social insurance + government subsidies	ambulatory private; hospitals partly public	fee-for-service
D	social insurance	ambulatory private; hospitals partly public	fee-for-service
DK	national health service	mainly public	28% capitation, 63% fee-for-service, 9% other
E	mixed: national health service with contributions	mainly public	salary, capitation
F	social insurance	ambulatory private; hospitals partly public	fee-for-service
FIN	national health service	mainly public	salary, some capitation
GR	mixed: national health service with contributions	mainly public	salary
I	mixed: national health service with contributions	mainly public	capitation
IRL	public financed system	mainly private	fee-for-service if high income, capitation if lower income
L	social insurance	mainly private	fee-for-service
NL	social insurance	mainly private	fee-for-service if high income, capitation if lower income
P	national health service	mainly public	salary
S	national health service	mainly public	salary
UK	national health service	mainly public	capitation

Source: Statistical Data on Health Care Systems in the European Union (1980-1993) *Statistics in Focus - Population and Social Conditions,* EUROSTAT (1996).

1.6.6 Economic integration and public health policies in the EU

The forces of convergence acting on health care systems within the EU are also derived from economic integration and public health policies, as summarised in the following sections (Hitiris and Nixon, 2000).

A brief analysis of the history of the member states of the EU shows that they have already gone through three stages of economic integration: the customs union, 1958-85; the common market, 1985-92; and the economic union since 1992, in an attempt to achieve the 'essential objective of their efforts, the constant improvement of the living and working conditions of their people' (EEC Treaty, Preamble).

However, as integration advances from the markets for commodities and services to the markets for factors of production, certain allocative disadvantages may arise from different national provisions of the member states. Health care is a sector where both the supply of health care services and the regulations governing health care markets differ across the EU member states in both quantity and quality. There is nothing, for example, in the treaties establishing the EU about aiming at a common market in health care. In spite of this, progressive integration may give rise to certain allocative disadvantages associated with different national organisations and regulations of health care markets which could become more prominent.

For example, it is possible that in the course of establishing a single European market the interstate migration of labour would be influenced not only by purely economic reasons but also by the quality and quantity of national and regional health care provisions, causing suboptimalities in the intra-union allocation of resources. Similarly, the interstate patient flows in search of better or cheaper medical treatment in countries well endowed with social and medical services may intensify through unhindered 'cross-border shopping' (expanded on in Chapter Seven). Such eventualities confirm that national health care policy has economic and social spillover effects which have positive and negative repercussions or 'externalities' beyond the confines of a member state. As in the case of other policies, in an attempt to establish compatibility between their national health care provisions the members of the economic union 'internalise these externalities' by adopting co-operation, harmonisation or, in some cases, unification of certain aspects of their health-related policies.

As the date for completing the internal market (1992) was approaching the above-described consequences of liberalisation in terms of factor mobility within the Community became more pressing. It was postulated, therefore, that an explicit common approach to public health policy might be necessary. Thus, before the 1990 European Council in Rome that led to two intergovernmental conferences to consider how the EC would move towards European Union (EU), a French/German initiative for a European Social Space included proposals to extend the competence of the Community to the area of public health. The Rome Council finally led to the Treaty on European Union (TEU) which set 'the raising of the standard of living and quality of life' as a target and with the insertion of a 'Public Health' Title affirmed explicitly that 'the activities of the Community include ... a contribution to the attainment of a high level of health protection'. However, since most power in this sector remained in the hands of the member states, the Community's role in health matters was subsidiary, limited to encouraging co-operation between the member states and lending support to actions taken nationally, 'excluding any harmonisation of the laws and regulations of the member states' (TEU, Article 129).

Since 1993, the Commission has identified eight areas for action relating to public health in which co-ordination and harmonisation is expected to be advantageous: (i) Health promotion, education and training; (ii) Health data and indicators, and monitoring and surveillance of disease; (iii) Cancer; (iv) Drugs; (v) AIDS and other communicable diseases; (vi) Intentional and unintentional accidents and injuries; (vii) Pollution-related diseases; and (viii) Rare diseases.

In addition, emphasis was also placed on the dissemination of information and evaluation of these policies, especially regarding their effectiveness. Subsequently, Community activity in the field of public health has taken three forms: (1) promoting health and safety in the workplace; (2) improving living and working conditions, e.g. by increasing controls over environmental pollution; and (3) co-ordinating medical and health research and funding public awareness campaigns of diseases (such as 'Europe against AIDs' (1991-3) and 'Europe against Cancer' (1993-4)).

Under the influence of these developments and the shortcomings of the previous legislation and administrative arrangements, the new Treaty of Amsterdam (1997), which extended and ratified the TEU, changed radically the EU's health provisions by stating explicitly:

> *1. A high level of human health shall be ensured in the definition and implementation of all Community policies and activities. Community action, which shall complement national policies, shall be directed towards improving public health, preventing human illness and diseases, and obviating sources of danger to human health. Such action shall cover the fight against the major health scourges, by promotional research into their causes, the transmission and their prevention, as well as health information and education. ....*
>
> *5. Community action in the filed of public health shall fully respect the responsibilities of the Member States for the organisation and delivery of health services and medical care....".* (Amsterdam Treaty, Article 152).

In contrast with earlier provisions, the Community can now adopt measures aimed at ensuring (rather than contributing to) 'a high level of human health protection' not only by 'the prevention of disease' but also by 'improving public health'. Consequently, the new Article 152 lists among the areas of co-operation between member states not only diseases and major health scourges but also, more generally, all causes of danger to human health, as well as the general objectives of improving health.

Community measures thus focus on horizontal initiatives providing information, education, surveillance and training in the field of health, the drafting by the European Commission of reports on the state of health in the EU and the integration of health protection requirements into Community policies.

Community action has also assumed other forms, for example in the fields of transmissible diseases, cross country epidemics, environmental issues and the health consequences of the free movement of persons and goods, including pharmaceuticals. Veterinary and plant-health measures directly aimed at protecting public health also come under the competence of the Community. Two EU-level advisory groups were set up within the Directorate General V (Employment and Social affairs) to co-ordinate the national and Community responsibilities on health matters: (1) the High Level Committee on Health, which comprises officials from the member states, and its function is to advise the Commission on policy developments; and (2) the Inter-service Group on Health, which includes among its tasks the promotion of awareness of the health impact and the integration of health protection in other Community policies. The Community intends to develop public health policy on the basis of the following action:

- Improving information for the development of public policy;
- Developing a rapid reaction capability to respond rapidly to threats to public health;
- Combating lifestyle-related diseases by joint efforts in health promotion and prevention

(COM, 98, 230).

All these actions refer to *public* health policy which in countries progressing towards economic integration is considered as one of the sectors that require co-ordination. Otherwise, harmonisation was specifically excluded and health care remained in the exclusive competence of the national authorities of the member stares.

It is therefore reasonable to expect that increasing economic integration and EU-wide co-operation in public health policies will result in a greater commonality of experience in health and health care throughout the EU. The direction as a consequence of such solutions, however, is open to opinion and indeed some argue that the common trend will be a downward one towards the lowest common denominator (Hitiris, 1997). Irrespective of this latter point, these two influences should act as forces for greater convergence in the EU although they can only be dealt with in a theoretical manner as their influences cannot be empirically tested.

1.7. Thesis layout

The thesis is divided into seven chapters which seek to investigate and answer the posed research questions within the defined framework. A summary of chapters Two to Seven of the thesis is provided below:

1.7.1 Chapter Two

In Chapter Two a means of identifying the level of 'achieved' convergence is presented, which is aimed at answering the first research question of the thesis. The methodology adopted to investigate the existence of groups in the EU is hierarchical cluster analysis, which is applied to the chosen framework of variables. The chapter also explores associations between the cluster country-membership and the health care mode of organisation (SI or NHS). Statistical analyses are also performed where differences between countries are dependent on health care system typology. The findings of this chapter illustrate the way in which countries form clusters according to their mode of delivery and their geographical location. The findings provide an overview of EU member states' health care systems and identify areas of difference which, if addressed by policy and practice, could lead to greater convergence.

1.7.2 Chapter Three

The aim of Chapter Three is to develop and explain suitable statistical tests to apply to the chosen framework of variables. The chapter starts from the perspective that convergence analysis in economics has largely been confined to macro-indicators such as GDP income and applied within identifiable regions of the world or between developing and developed countries. The chapter explains the rationale for the adopted techniques, *σ-convergence* and *β-convergence,* which the literature confirms are appropriate for use within the neo-classical basis of the thesis. The techniques are then applied to the area of health care expenditure in the countries of the EU, with explanations being given to account for any observed convergence. The chapter therefore establishes the chosen methodology and illustrates how it can be applied to meet the aims and objectives of the thesis. Finally in Chapter Three, the impact of health care reforms, introduced over the 1980s and 1990s, is described in relation to the countries which have had the greatest influence on the results.

1.7.3 Chapter Four

In Chapter Four the methods developed in Chapter Three are applied to the second area of the thesis, health outcomes, as measured by infant mortality and life expectancy. The aim is to test the hypothesis that despite variations in health outcomes throughout the EU, as identified by the cluster analysis of Chapter Two, convergence is occurring. Using OECD health data, both σ and β-*convergence* analyses are applied over the periods 1960-95 and 1980-95, respectively. Again, in addition to presenting the results of the statistical tests, graphical representations allow individual trends for countries to be identified and explained within the context of the various hypotheses and scenarios possibly within the overall study of convergence.

1.7.4 Chapter Five

An alternative approach to evaluating health care systems is to examine levels of resources and utilisation by patients. Chapter Five takes these elements of the thesis framework and applies both σ-*convergence* and β-*convergence* analyses over the chosen periods of analysis. The specific variables tested are the number of physicians *per capita*, number of beds *per capita*, average length of in-patient stay and in-patient admission rates. Analyses to explain the observed convergence or divergence reveal which countries have contributed to the observed trends and associations with health care system typology. Prominent in the findings are that policies adopted by some countries to achieve efficiency at the micro level in terms of reducing length of stay and increasing throughput are shown to be having an impact.

1.7.5 Chapter Six

The aim of Chapter Six is to bring the thesis to a coherent conclusion by exploring causal links between the neo-classical growth model, convergence in GDP income, convergence in health care expenditure, resources and utilisation rates, and health outcomes. In other words, to take into account the findings of each chapter in the context of the theoretical basis of the thesis. Using each of the health outcome variables in turn as dependent variables, the thesis variables are augmented by other environmental and lifestyle variables which are known to be determinants of health. A distinction is drawn between individual-level data and macro-level data in the formulation of a suitable health production function production that can be applied to the data to explore significant associations. In particular, the aim of the analyses reported is to determine if health care expenditure is a significant determinant of health, which, according to many previous empirical studies, is not strongly established. Three regression equations using infant mortality, life expectancy (females) and life expectancy (males), are developed using the range of explanatory variables that are available.

From the findings of these regressions, which utilise two key methodological approaches to analysing and dealing with fixed effects in cross-sectional time-series panel data, a conceptual model is drawn up which encapsulates the philosophy of the thesis in terms of the study of health and health care convergence in the EU. The model not only ties the various strands of the thesis together, but offers a framework for future convergence analysis in the EU, and perhaps beyond.

To address the question of whether or nor membership of the EU is a primary driver of convergence, a control group of non-EU OECD countries (comprising Australia, New Zealand, Canada, Norway, Iceland Switzerland and Japan) is taken and tested for convergence in the principal areas of the developed conceptual model. In order to determine a sample wich is similar in socio-economic terms to the EU, two of the non-EU OECD countries are removed (the U.S.A. and Turkey). This enables the influence of membership of the EU to be assessed in relation to the observed results.

1.7.6 Chapter Seven

In this chapter the findings of each chapter are summarised and discussed in the context of the observed convergence or divergence. In particular, the various influences impacting on convergence are addressed in the light of the most recent findings or observations reported in the literature.

This chapter also sets out and discusses the various limitations and caveats of the thesis findings. These include an appraisal of the reliability of the OECD Health Database and differences in data definitions, the rationale for the various methodological choices and approaches made, the economic and political influences that affect the results, and comments on how future studies of convergence can be improved.

The chapter then looks at a number of developing influences, not examined empirically in the thesis, that will enhance the potential for further convergence in the future.

In the final part of this chapter the policy implications of the thesis findings are presented, which are aimed at informing EU-wide and country-specific health policy makers regarding how greater convergence, if considered to be a desirable goal, can be achieved. Finally, the overall conclusions and recommendations of the thesis are presented.

1.8. Summary

The thesis aims to test the hypothesis that convergence has been taking place in the member states' health care systems of the EU, and that membership of the EU is significant in this process, by empirical analyses of a representative framework of variables. The reasons as to why convergence in health care within the EU is expected can are derived from economic, social and political influences, and these have been introduced and discussed in this first chapter.

The majority of work on convergence has been applied to macro economics indicators and empirical studies have shown that convergence in income and growth rates within homogenous countries such as the states of the United States and OECD countries, including those of the EU, has occurred. Furthermore, numerous studies on health care expenditure have established a strong correlation between this and GDP income and therefore it is reasonable to anticipate convergence in EU health care expenditure.

Recent trends have shown an increasing demand for health care under the dual pressures of new technologies and demographic changes in the population have led governments to introduce health care reforms to gain control of health expenditure increases which have been over and above GDP growth rates in recent decades. The European Commission, in recognising the principles of subsidiarity, anticipates that in facing the same problems EU countries will seek similar long term solutions in the provision of health care. Health care reforms adopted by EU member states, however, often reflect the system used to organise health care and the political foundations of EU governments.

The theoretical foundation of the thesis, which predicts convergence for groups of homogenous countries such as the EU, comes from the neo-classical growth model. Other growth models, particularly EGMs, tend to predict divergence in large samples but the tenets of the neo-classical growth model are adopted in this thesis, which offer specific statistical tests as developed by prominent researchers in the field of economic convergence, in order to test the empirical framework of the thesis.

From a political point of view it should be noted that although no specific policies exist in the EU to guarantee convergence, a number of legislative mechanisms are in place to encourage the free flow of trade and inter-state movement of the factors of production. The principle of freedom of movement in citizens throughout the states of the EU, it is argued, requires a degree of convergence in social welfare provision in order to facilitate this policy. At the public health level and in terms of combating specific diseases a large degree of co-operation also exists, which is enhanced by common research initiatives and projects.

From a social point of view convergence in health care is anticipated due to cross-country employment opportunities and the free movement of EU citizens between member states, redistribution of wealth (and therefore income) through the EU's regional development mechanisms, convergence in the use of the English language in scientific research, economic evaluations of health care technologies, and the availability and dissemination of information on health care systems and technologies.

This chapter has thus revealed the many factors that enable one to anticipate convergence in the chosen health care framework. The following chapter explores the first step in this investigation by analysing the existence of groups of countries within the EU to identify the degree of convergence that has been achieved and potential future convergence.

Chapter Two

Cluster Analysis of EU Health Care Systems

2.1. Introduction

The aim of this chapter is to undertake static, cross-sectional analysis to determine the level of convergence that has occurred in the health care systems of the EU and to gain an overview of groupings that exist regarding relevant associations. The methods have been applied by the author in a review of EU health care systems in order to assess the position of the UK NHS in comparison with its EU partners, and are reported elsewhere (Nixon, 2000a).

In determining a suitable method to undertake this task some of the more conventional methods used to classify health care systems have been considered.

Previous comparative studies have often addressed issues such as system typology (Culyer *et al.*, 1988; Wall, 1996; Wagstaff and van Doorslaer, 1992), expenditure as a percentage of GDP and the factors affecting expenditure (Hitiris, 1996; 1997) or a combination of these methods (EUROSTAT, 1996; Hoffmeyer and McCarthy, 1994). Others have considered reforms of health care systems and cost containment issues (Culyer, 1989; OECD, 1992; OECD, 1994; OECD, 1995a; Ham, 1997). Others still have undertaken analyses of the problems facing further integration of health care policies and systems in the European Union (EU) (Abel-Smith *et al.*, 1995; Hitiris, 1997; Mckee *et al.*, 1996).

However, a more statistically relevant method of classifying and analysing health care systems has been sought in order to evaluate the result of past and potential future convergence. Moreover, in order to be of practical use to policy makers, a means of presenting the results of any analysis in a way that could be easily assimilated was considered to be a key issue in analysing the thesis framework of variables.

The specific questions addressed, therefore, are:

1. How are health care systems in the EU grouped in terms of expenditure, health outcomes, resources and utilisation rates?
2. Do any associations exist between identified groupings and system typology and/or geographical location within the EU?

As other methods of statistical inquiry have some limitations in terms of the number of variables that can meaningfully and simultaneously be analysed, it was decided to employ **hierarchical cluster analysis** (Everitt, 1993; Norusis, 1994) as this multivariate method is able to deal with a large number of variables in determining the clustering of 'similar' cases, and is particularly useful in formulating hypotheses and identifying associations. The solutions provided by this method place countries in groups according to the chosen cluster criteria.

The chapter therefore begins with an overview of the theory of hierarchical cluster analysis and explains some key issues that need to be taken into account when conducting this form of analysis. This is followed by an overview of the methods used, the results of the analysis and finally the discussion and conclusions.

2.2. Theory of hierarchical cluster analysis

In this section a summary of the theory of hierarchical cluster analysis is given whilst the specific issues and methodology relating to its use are addressed more fully in the study methods section. The following outline is taken principally from Everitt (1993) and Norusis (1994).

In general terms, cluster analysis is a technique that allows the analyst to group cases according to their degree of *similarity*. It is a method utilised within many disciplines. For example in biology it is used to classify animals and plants, known as numerical taxonomy. In medicine, cluster analysis is used to identify diseases and their stages, and in marketing it can be used to identify people with similar buying habits. The principal goal of cluster analysis, therefore, is to identify homogenous groups or clusters which, in the case of this chapter, will be used to establish a platform for the thesis concerning the degree of achieved and potential future convergence in the health care systems of the EU.

As a starting point in this summary, hierarchical clustering techniques can be subdivided into *agglomerative* methods which proceed by a series of successive fusions of the *n* variables in the sample into groups, or *divisive* methods, which separate the *n* individuals of the sample successively into finer groupings. These hierarchical classifications may be represented by a two-dimensional diagram known as a *dendrogram* which illustrates the fusions or divisions that occur at each successive stage of the analysis. This process is illustrated and fully explained in the study methods in conjunction with Figure 2.3.

In this study *agglomerative* methods are used which means that variables relating to the health care systems of the fifteen countries of the EU are successively fused from 15 separate cases into a single cluster containing all 15 cases. This can be summarised by the following procedure which provides an outline of hierarchical clustering procedures (Everitt, 1993, p.57):

START: Clusters C_1, C_2 .....,C_n each containing a single individual.

1. Find the nearest pair of distinct clusters, say C_i and C_j, merge C_i and C_j, delete C_j and decrement the number of clusters by one.

   If number of clusters equal one then stop, else return to 1.

2.2.1 Linkage methods

A number of techniques are available which can be used to link clusters within the agglomerative process. The simplest is the *single linkage*, otherwise known as the *nearest neighbour technique*. Within the agglomerative process the distance between two clusters used to determine new combined clusters is the distance between their two closest points. Therefore, the distances of other members of either cluster is not taken into account but only the two cases (one from either cluster) which are closest.

A second commonly used technique is that of *complete linkage*, or *furthest neighbour*. In this method, the distance between two clusters is calculated as the distance between their two furthest points (again, one case from either cluster).

Again, another commonly used method is the *group-average linkage* technique. In this process the average distance between two clusters is calculated which forms the basis of new fusions. Thus, taking an example from Everitt (1993, p.61) if cluster A has two cases

(1 and 2) and cluster B has three cases (3, 4 and 5) then the average distance, d, between cluster A and B would be:

$$d_{AB} = (d_{13}+d_{14}+d_{15}+d_{23}+d_{24}+d_{25})/6.$$

Other methods include the *centroid* technique which takes the mean score of all members of each cluster as the point of reference, *median clustering*, and *Ward's method*. The latter uses an error sum-of-squares criterion, ESS, to minimise information loss in the fusion process.

Much discussion exists in the literature as to the relative merits of each method, although it is beyond the scope and purpose of this to chapter to discuss the specifics of this debate and indeed several other less widely used techniques are also available (see Everitt, 1993 p.66-89).

2.2.2 Distance measures

A number of distance measures exist in determining the above-described linkages which provide their own *weighting* to the data. The most commonly used method is the *squared Euclidean distance* in which the distance between two items is the sum of the squared differences between the values for the items (based, therefore, on Pythagoras' theorem):

$$\text{Distance (A,B)} = \sum_i (A_i - B_i)^2$$

Sometimes simply the *Euclidean distance* is adopted, which is the square root of the sum of the squared differences between the values for the items:

$$\text{Distance (A,B)} = \sqrt{\sum_i (A_i - B_i)^2}$$

Other measures include the *Chebychev distance metric* in which the distance between two items is the maximum absolute difference between the values for the items, the *City-block* or *Manhattan distance,* which measures the distance between two items as the sum of the absolute differences between the values for the items, and the *Minkowski* method in which the distance between two items is the *p*th root of the sum of the absolute differences to the *p*th power between the values for the items. The method is also able to deal with *binary* data, incorporating *chi-square and Phi-square measures* amongst others based on the familiar measures of association for contingency tables.

The above provide a sample of the commonly adopted distance measures but the reader is referred to the literature (for example Everitt,1993; Norusis, 1994) for a more in-depth analysis.

2.2.3 Data standardization

Before embarking on hierarchical cluster analysis it is necessary to consider the relative scaling of the data to be included as any distance measure will reflect primarily the contributions made by variables with the largest units. This issue is fully explained in the methods section and illustrated throughout the paper. Suffice it to say that a number of approaches can be taken, which should be considered before carrying out the hierarchical cluster analysis. The options include converting, for example, all data to *z scores*, to *a mean of 1*, to a *maximum of 1*, to *binary* values above/below a certain threshold, amongst others. See Romesburg (1984) or Anderberg (1973) for a wider explanation.

Having provided this brief overview of the theoretical issues relating to the application of hierarchical cluster analysis it is now possible to proceed to the study methods which explain the rationale behind the choice of the techniques adopted in this chapter. The discussion addresses some of the key issues and limitations relating to the application of these techniques.

2.3. Study Methods

Using OECD Health data (OECD/CREDES, 1997), a number of key variables consistent with the chosen framework, shown in Table 2.1, were chosen as the basis for the hierarchical cluster analysis.

The analysis broadly divides the data describing each country's health system into **four** categories as shown below (numbers in brackets here relate to variables in Table 2.1):

a. **Expenditure** variables which measure the level of financial commitment each member state of the EU has towards spending on health care. The raw data collected were **percentage of GDP spent on health care, X^y (1) and** ***per capita*** **public spending on health care in Purchasing Power Parities (PPP$)[1], X^h (2).**

b. **Health Outcome** variables which provide measures of the health of the relevant population. The raw data collected were used to determine **infant mortality per 100 live births, im (3), life expectancy at birth (females), LEF (4),** and **life expectancy at birth (males), LEM (5).**

c. **Resource** variables which include the **number of physicians per 10,000 head of population, DOC (6),** and **number of beds per 1,000 of population, BED (7).**

d. **Utilisation** variables which include average in-patient **length of stay, LOS (8)** and in-patient **admission rate (%), AR (9).**

[1] PPP$ are used to adjust for differences in cost of living across countries by comparing prices for a fixed basket of goods. The basket of goods and services used in this case is broad-based and not derived from health sources.

These data were entered into the chosen software package[2] such that the analysis could be undertaken.

2.3.1 Clustering Strategy

Having collected the data it was considered beneficial to examine each pair of variables from each of the first four categories above using scatter plots to obtain an overall picture, but use the results of the cluster analysis to form each group. To test the clustering of the **composite solution** it was not possible to produce a scatter plot as all nine variables were used in the cluster analysis. In summary, the method adopted is described in detail as follows:

i. Select, in turn, two variables from each classification. For each pair of variables conduct hierarchical cluster analysis.

iii. Determine, from the dendrogram, the optimal groupings (based on the point at which the re-scaled distances become 'large').

iv. Construct a scatter plot based on the number of groups in (iii), using the hierarchical cluster analysis grouping variable (this is done automatically by SPSS).

v. Conduct cluster analysis on all nine variables to derive a composite solution which provides an inclusive dendrogram output.

The distance measure employed was the **squared Euclidean distance** as it was cited in the literature as being the most commonly used approach and was suitable for the chosen variables as they are all continuous by classification.

[2] SPSS version 6.1 for Windows.

In order to ensure that the scale for each variable did not unduly distort or create bias in the results, the question of standardisation needed to be addressed.

2.3.2 Data Standardisation

One common problem associated with cluster analysis, as identified in the theory section above, is the disproportionate influence some variables can have on the final solution due to differences in scale. For example if we consider **infant mortality** in its raw form as a low fraction per 100 live births and compare it with **number of beds**, which is given in units per 1000 of population, then clearly the latter will have more influence than the former if clustering is determined by a distance measure (Norusis, 1994). For this reason, before cluster analysis was performed, the data were standardised to either a **mean of 1** or to their relevant **z scores** as they were all continuous in nature.

To illustrate the principles of standardisation the process of calculating the z score for each variable is described below using, to begin with, the following formula: $z = \frac{x - \mu}{\sigma}$.

Thus, for a sample mean $\mu = 100$, standard deviation $\sigma = 10$ and observation $x = 105$, the standardisation gives $z = \frac{105 - 100}{10} = \frac{5}{10} = 0.5$. In other words 105 is one half standard deviations to the right of the mean value.

Values below the sample mean will result in a negative value representing the number of standard deviations they are below the sample mean. As the squared Euclidean distance is taken the absolute values only are used. To illustrate how this is calculated consider two variables, x and y. Taking two z scores for each x_i, y_i the squared Euclidean distance for two observations is given by: $(zx_1 - zx_2)^2 + (zy_1 - zy_2)^2$. By applying this process to the data set it was possible to ensure that all variables contributed evenly to the analysis.

Similarly, in the case of standardisation using a mean of 1, the mean value for each population was calculated and set equal to 1, with other values being converted to proportional scores by dividing by the original mean. This method has the advantage of not distorting the proportionality in the data, unlike the case of z scores.[3]

Results were obtained using both **z scores** and a **mean of 1** and compared during the analysis phase. However, the final solutions are based on a mean of 1 as this method gave good results and is consistent with the convergence analysis in the remaining chapters of the thesis.

2.3.3 Data Grouping

In order to combine the benefits of scatter plots and hierarchical cluster analysis it was decided to cluster into groups based on the dendrogram outputs of the cluster analysis. The dendrogram shows the rescaled squared Euclidean distances (coefficients) and the process of combining cases (countries) and as such provides a good indication as to the appropriate number of clusters to choose. The issue of how many clusters to employ is contentious but guidance suggests that an appropriate number will be achieved once the squared Euclidean distances start becoming 'large' and more distinguishable (Norusis, 1994). In this study the dendrogram outputs enable a suitable number of clusters to be chosen and also facilitate easy analysis of smaller numbers of clusters, particularly two group solutions which are of special interest in determining if classifications exist around homogeneity according to health care typology. If greater convergence of health and health care provision is to be a

[3] For a wider discussion on the subject see Sneath and Sokal, 1973.

future aim of the EU, the question of whether to converge up or down could be considered in relation to the discrete groups produced here.

Table 2.1 Health related variables - EU countries (1995)

	1	2	3	4	5	6	7	8	9
	X^y	X^h	im	LEF	LEM	DOC	BED	LOS	AR
A	7.9	1634	0.54	80.1	73.5	26.6	9.3	10.9	24.7
B	8.0	1665	0.7	80	73.3	37.4	7.6	11.5	19.8
D	10.4	2134	0.53	79.5	73	33.6	9.7	14.2	20.7
DK	6.4	1368	0.55	77.8	72.5	29	4.9	7.5	20.4
E	7.6	1075	0.55	81.2	73.2	41	4	11	10
F	9.9	1972	0.5	81.9	73.9	29.4	8.9	11.2	22.7
FIN	7.7	1373	0.4	80.2	72.8	27.7	9.3	11.8	25.4
GR	5.8	703	0.81	80.3	75.1	38.8	5	8.2	13.6
I	7.7	1507	0.62	80.8	74.4	17	6.4	10.5	16
IRL	6.4	1106	0.63	78.5	72.9	17.2	5	7.2	15.5
L	7.0	2206	0.5	79.5	72.5	22.3	11.1	15.3	19.4
NL	8.8	1728	0.55	80.4	74.6	25.2	11.3	32.8	11.1
P	8.2	1035	0.74	78.6	71.5	29.9	4.1	9.8	11.3
S	7.2	1360	0.41	81.5	76.2	30.7	6.3	7.8	18.5
UK	6.9	1246	0.6	79.7	74.3	15.6	4.7	9.9	23

Source: OECD/CREDES (1997) OECD Health Data 97 – A software for the Comparative Analysis of 27 Health Systems, Paris, OECD/CREDES.

Notes: X^y health expenditure as a share of GDP, X^h = health expenditure per capita, im = infant mortality, LEF = female life expectancy, LEM = male life expectancy, DOC = number of physicians per capita, BED = number of in-patient beds *per capita*, LOS = average in-patient length of stay, AR = in-patient admission rate. See full definitions at 2.3.

2.3.4 *Linkage method*

As outlined above, the data were clustered using **squared Euclidean measures** and the chosen linkage method, after referring to the literature and in the light of pilot testing, was the **average linkage within groups** criterion. There is a wide range of clustering methods available, some of which were tested on the data. However, some limitations exist in, for example, the single linkage method, otherwise known as 'nearest neighbour' as described in the theory section. The chosen strategy has the advantage of taking into account all possible pairs of cases in the resulting clusters. The method combines clusters so that the 'average distance between all cases in the resulting cluster is as small as possible' (Norusis, 1994, p.98) and is therefore considered to be a more reliable and inclusive approach to adopt.

Thus, by utilising a progressive method of initially using scatter plots for two selected variables within each data classification and using cluster analysis to remove the subjectivity of grouping countries, followed by cluster analysis using all nine variables, it was possible to gain confidence in the methods such that the results obtained had an intuitive as well as a statistically relevant means of obtaining groups.

2.4. Results

The results are presented firstly by indicating the initial clustering using the selected outputs of the cluster analysis, based on the two selected variables under each category of health expenditure, health outcomes, health resources and health care utilisation, followed by the composite cluster analysis using all nine variables.

For the first results that are presented, health expenditure, all cluster analysis outputs are provided for clarification as to their purpose and usefulness, namely the agglomeration schedule, the icicle plot and the dendrogram, but for subsequent analyses only the dendrogram and scatter plot are provided as these provide the best means of understanding, in an inclusive way, the process of grouping countries according to the re-scaled (Euclidean squared) distances. For the composite solution, only the dendrogram is provided as scatter plots are not possible on more than two variables at a time.

2.4.1 Health expenditure inputs

The results of the cluster analysis are shown in the agglomeration schedule, icicle plot and dendrogram of Figure 2.1, Figure 2.2 and Figure 2.3 respectively whilst the scatter plot of health expenditure is shown in Figure 2.4. Examination of the dendrogram confirms that a four cluster solution is optimal at a rescaled distance of approximately 10. The resulting groups, as shown in Figure 2.4, are:

Group 1 Austria, Belgium, Italy and the Netherlands.

Group 2 France, Germany.

Group 3 Denmark, Finland, Greece, Ireland, Portugal, Spain, Sweden and the UK.

Group 4 Luxembourg.

Each of the outputs, which reveal how the clusters are derived, is explained in detail below before going on to discuss the specific results.

As outlined in the theory section, the principle of (agglomerative) hierarchical cluster analysis is to start with all fifteen cases as separate entities and at each subsequent stage to fuse cases according to the chosen distance measure between them until only one group exists.

If we examine Figure 2.1 in detail it is possible to see how cases are combined at one of 14 stages as determined by the distances, or coefficients, between cases or one case within its own cluster. In stage 1, the smallest coefficient exists between case 1 (A) and case 2 (B) and so these are joined to form the first cluster. This can be seen in the icicle plot of Figure 2.2, when 1 (A) and 2 (B) are fused to become a single black horizontal line.

Figure 2.1 Agglomeration schedule for health expenditure

	Clusters Combined			Stage Cluster 1st Appears		Next
Stage	Cluster 1	Cluster 2	Coefficient	Cluster 1	Cluster 2	Stage
1	1	2	.000610	0	0	4
2	7	14	.004265	0	0	5
3	5	13	.006766	0	0	10
4	1	9	.007232	1	0	7
5	7	15	.009965	2	0	6
6	4	7	.013333	0	5	9
7	1	12	.015770	4	0	12
8	3	6	.016264	0	0	13
9	4	10	.022632	6	0	10
10	4	5	.036039	9	3	11
11	4	8	.070241	10	0	14
12	1	11	.080265	7	0	13
13	1	3	.117706	12	8	14
14	1	4	.218213	13	11	0

In the dendrogram, this is shown by a vertical line joining cases 1 (A) and 2 (B). On the right-hand column on the agglomeration schedule it is possible to see the next stage at which case 1 is fused to another cluster, in this case stage 4. Again, from the agglomeration schedule, in stage 2, cases 7 (S) and 14 (FIN) are joined, represented in the same way as stage 1 within the icicle plot and the dendrogram.

In a similar manner, the process continues until all cases are fused to form a single group. To complete the explanation, when small clusters are formed and then joined to another cluster, one case within each cluster is selected to represent all the cases within its own cluster. This can be illustrated in Figure 2.1, for example, in stage 7 when 1 (A) (representing 1 (A), 2 (B) and 9 (I)) is fused with 12 (NL) to form a new and larger cluster.

This is similarly represented in the icicle plot at the 8 + point (when 8 clusters exist) with cases 1, 2, 9 and 12 being located at the right-hand side of the diagram.

In the case of the icicle plot, shown in Figure 2.2, the 15 cases are shown as vertical black lines, separated by broader white columns, which begin from the bottom and work their way up to the top, eventually becoming one horizontal black line at which point all cases are clustered into a single group.

The dendrogram, shown in Figure 2.3, provides an alternative to the icicle plot in representing the clustering process graphically. In this method the process begins at the left-hand side of the diagram when all cases are shown as 15 separate horizontal lines. The re-scaled distances grid line indicates at which point the cases are fused together to form clusters. Eventually, all fifteen cases are joined to form a single group at the right-hand side of the dendrogram, and all intervening stages of fusion are indicated within the horizontal extremities of the diagram. The whole process is determined by the (squared Euclidean) distances between each of the cases or clusters, which are revealed in detail in the agglomeration schedule, shown in Figure 2.1.

Having now fully explained how the outputs should be interpreted, it is possible to analyse the results they provide by focusing on the scatter plot of Figure 2.4. The clustering produced for *health expenditure* variables shows that there are still wide variations between EU countries in terms of the amount spent on health care.

In summarising these results we can see that group 2 countries spend more in terms of health expenditure as a percentage of GDP and, with the exception of Luxembourg in Group 4, spend more *per capita* on their citizens. Group 2 achieves fairly similar spending levels in terms of percentage of GDP, but *per capita* spending achieved is somewhat higher than group 3 countries. It is interesting to note that apart from Italy, group 1 and group 2 have SI models of health care provision. Group 3. on the other hand, is made up of countries with NHS systems. The dendrogram shows that if a five group solution were taken, Greece would form a group on its own as it allocates the lowest percentage of GDP and also achieves the lowest levels of *per capita* spending. It is also interesting to note that a number of countries spend very similar amounts in terms of percentage of GDP. but due to the level of their GDP and the size of their populations, achieve a wide variation in terms of *per capita* spending, with, for example, Portugal spending 8.2% of its GDP on health care but only achieving $1035 *per capita*, whereas Denmark spends 6.4% as a percentage of GDP but achieves $1368 in terms of *per capita* expenditure.

Figure 2.2 Icicle plot for health expenditure

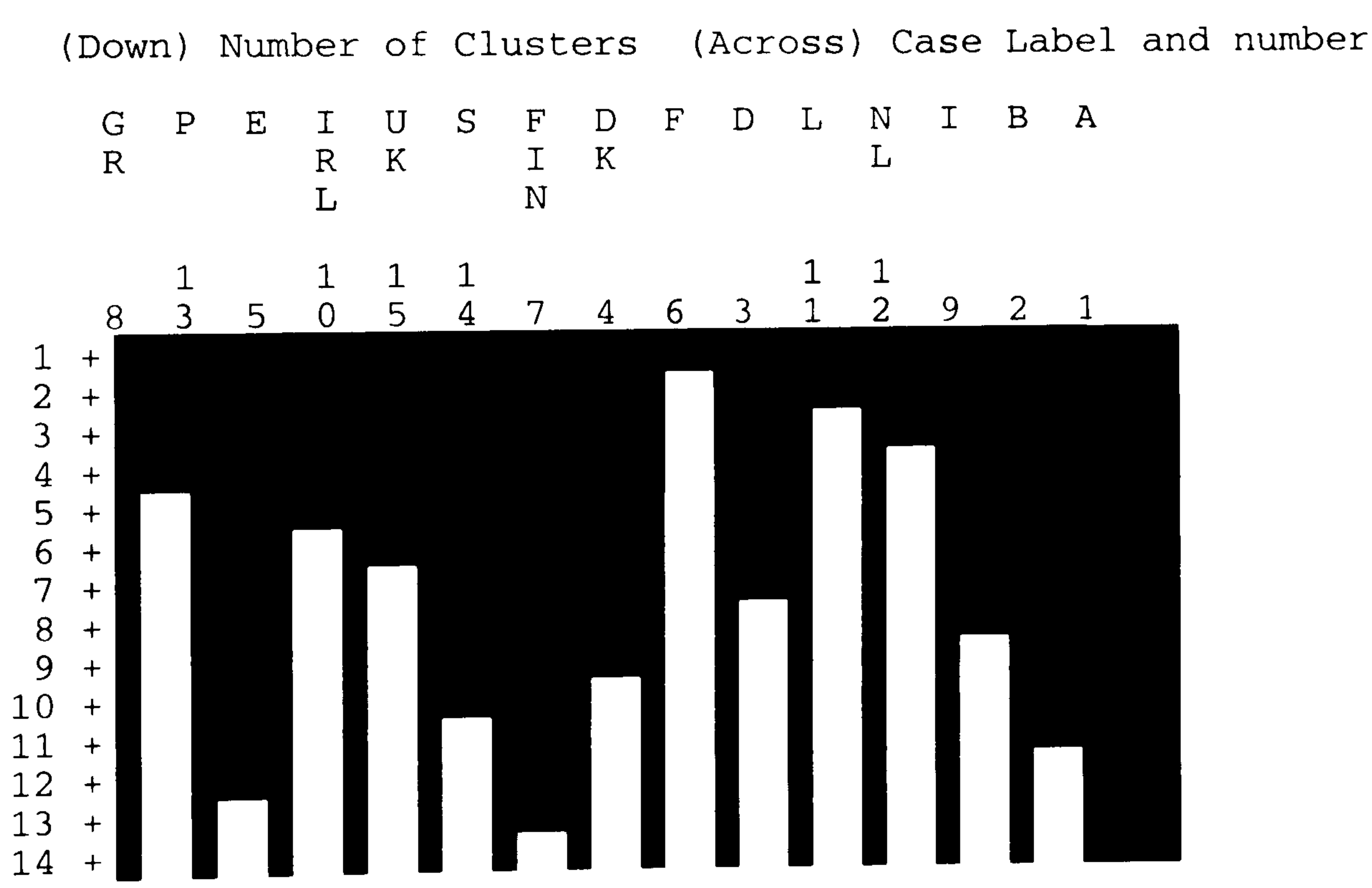
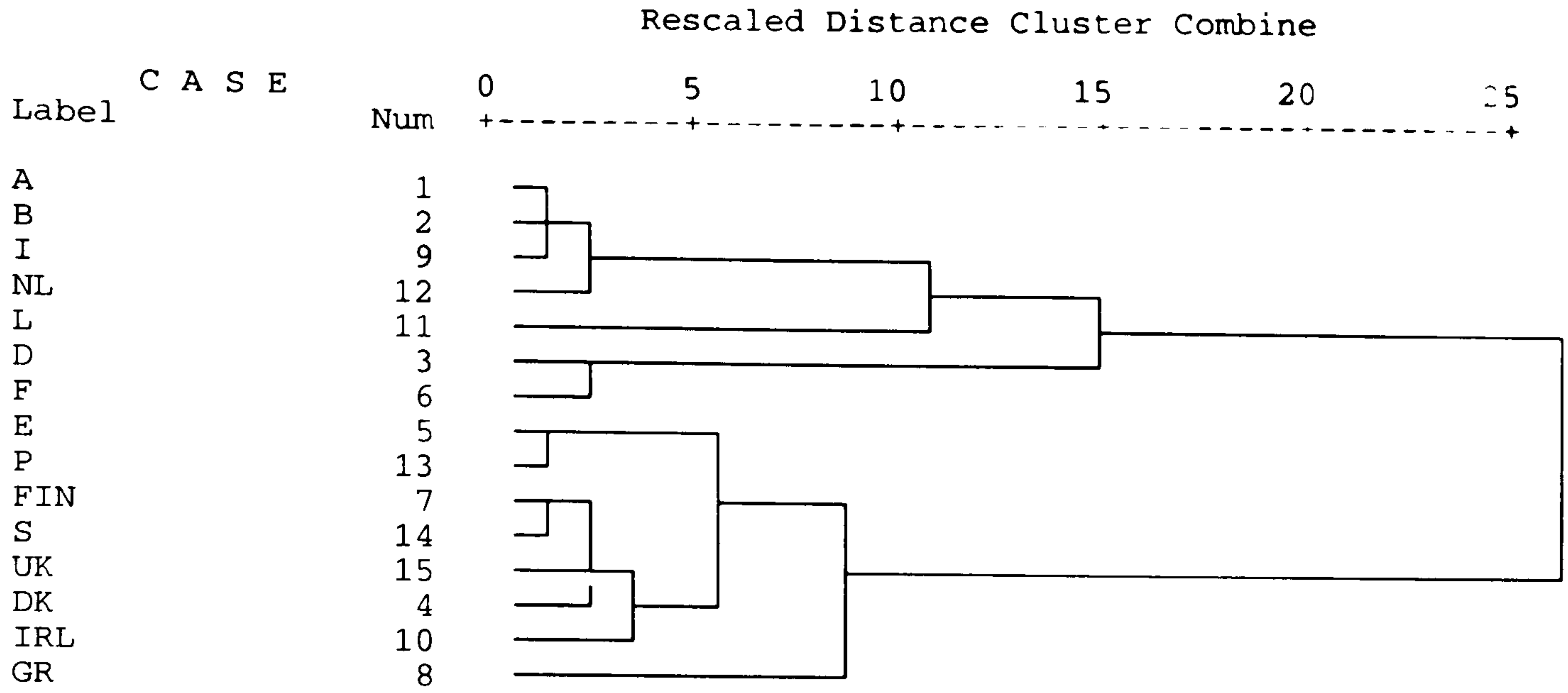
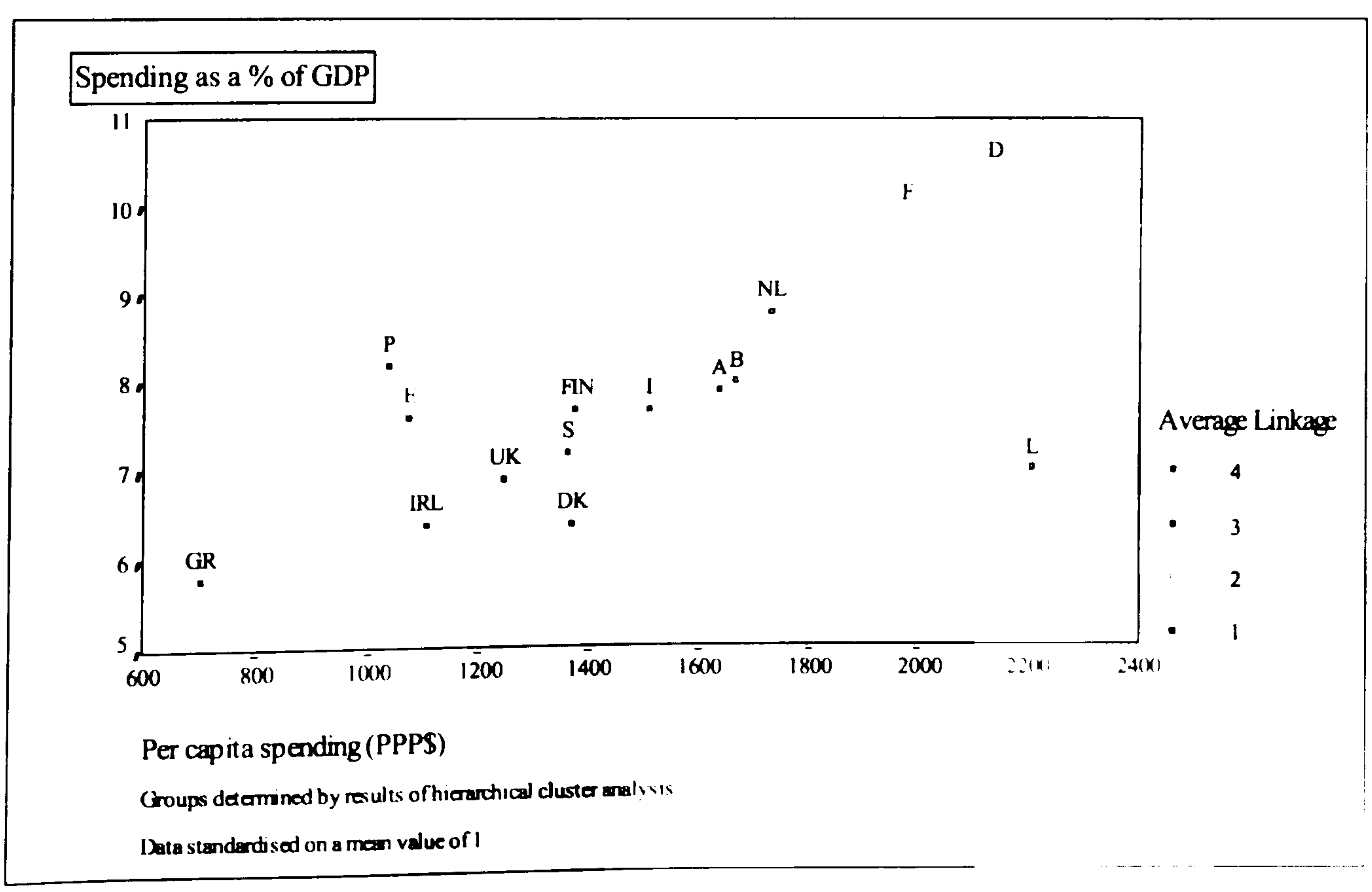


Figure 2.3 Dendrogram for health expenditure



All countries in group 3 have NHS systems, with Ireland being somewhat of an exception in that it is classified as being publicly financed but with private provision (EUROSTAT, 1996).

Figure 2.4 Scatter plot for % of GDP and per capita health expenditure - 1995



Luxembourg is the only member of group 4 as it spends the fourth lowest amount as a percentage of GDP, but achieves an extremely high value *per capita* of $2206, which is in fact the highest in the EU.

The results show that in general those countries with SI models tend to spend more on their health care systems and citizens, whereas less is spent by countries with NHS typologies[4]. This is likely to be due to the fact that NHS models are much more centralised and, therefore, they may benefit from exploiting economies of scale and are able to exercise more controls over spending when compared with de-centralised and often more liberal SI models of operation. However, in spite of countries spending similar percentages on health care within the four groupings, wide variations exist in relation to *per capita* spending which is a reflection of the purchasing power and strengths of currencies, preferences in health care expenditure, and national wealth in GDP terms within respective countries, Luxembourg providing the most striking example of this feature as described above.

In terms of future convergence, Greece is of particular concern as it spends the least (using both measures) of all EU countries on health care but an interesting link is made in relation to life expectancy (males) as Greece has the second highest level in the EU (see Figure 2.6), although it also has the highest rate of infant mortality in the EU. Therefore, if health spending is related to health outcomes (explored statistically in Chapter Six), Greece achieves a relatively much better outcome in terms of how long Greek people live. Notwithstanding the analysis undertaken in Chapter Six on this topic, two possible factors may explain this situation.

First of all diet may play an important role as it is generally acknowledged that the low saturated fat and high fibre levels in Mediterranean diets are associated with lower levels of

[4] Shown to be a statistically significant difference in convergence analysis (see Chapter Three; Nixon, 1999)

chronic illnesses such as coronary heart disease when compared with northern European diets. A second factor is that some Greek citizens with sufficient financial resources or private insurance make use of health care systems in other countries within the EU, particularly for specialist treatments (McKee *et al.*, 1996). This form of cross-border trade and augmentation in health care is becoming perhaps an increasing feature within the EU as evidence suggests that this is occurring between other countries. Starmans and Leidl (1994), for example, have examined in detail the movement of patients between the Netherlands, Belgium and Germany, although this only amounted to 2% of cases and many patients were living in the host country because of employment reasons. Lewalle and Lona (1991), on the other hand, have shown that 90 per cent of movements of this nature occur between Belgium, France, Italy and Germany. The topic of cross-border health care in the EU is addressed and discussed further in Chapter Seven.

Finally it is worth noting that if a two group solution is taken at a rescaled Euclidean distance of 15 as shown in the dendrogram of Figure 2.3, Luxembourg, France and Germany (SI countries) are joined with the predominantly SI group and the remaining group is made up of NHS countries, further re-enforcing the NHS/SI divide in health care expenditure.

2.4.2 Health Outcomes

The results of the cluster analysis for health outcomes (infant mortality and female life expectancy) are shown in the dendrogram of Figure 2.5 and the scatter plot of Figure 2.6. Infant mortality against life expectancy (males) are similarly shown in the dendrogram and scatter plot of Figures 2.7 and 2.8, respectively.

Examination of the two dendrograms reveals that a four cluster solution is optimal at a rescaled distance of approximately 9 and 7, respectively. The resulting groups in both cases are:

Group 1	Austria, Denmark, France, Germany, Italy, Ireland, Luxembourg, the Netherlands, the UK and Spain.
Group 2	Belgium and Portugal
Group 3	Finland and Sweden.
Group 4	Greece

Interesting variations are also observed in relation to these groupings. Group 1 is made up of the vast majority of countries (10) with no strong association with the type of health care system employed by members of this group. The cluster analysis for group 1 has selected countries with low to medium levels of infant mortality, but a fairly wide range of female life expectancies with France at the top of this group (approximately 82 years for French women) and Denmark at the bottom (approximately 78 years).

Group 2 is made up of only two countries, Belgium and Portugal, with higher rates of infant mortality and life expectancy at a little over 80 for Belgium and a little under 79 for Portugal.

Group 3 is made up of two Scandinavian countries, Sweden and Finland, with very low levels of infant mortality and life expectancies among the highest in the EU (especially Sweden in second place).

Group 4 is made up of Greece on its own, largely due to the fact that its infant mortality rate is the highest in the EU, although life expectancy for Greek women is about average for the EU as a whole.

Figure 2.5 Dendrogram for health outcomes

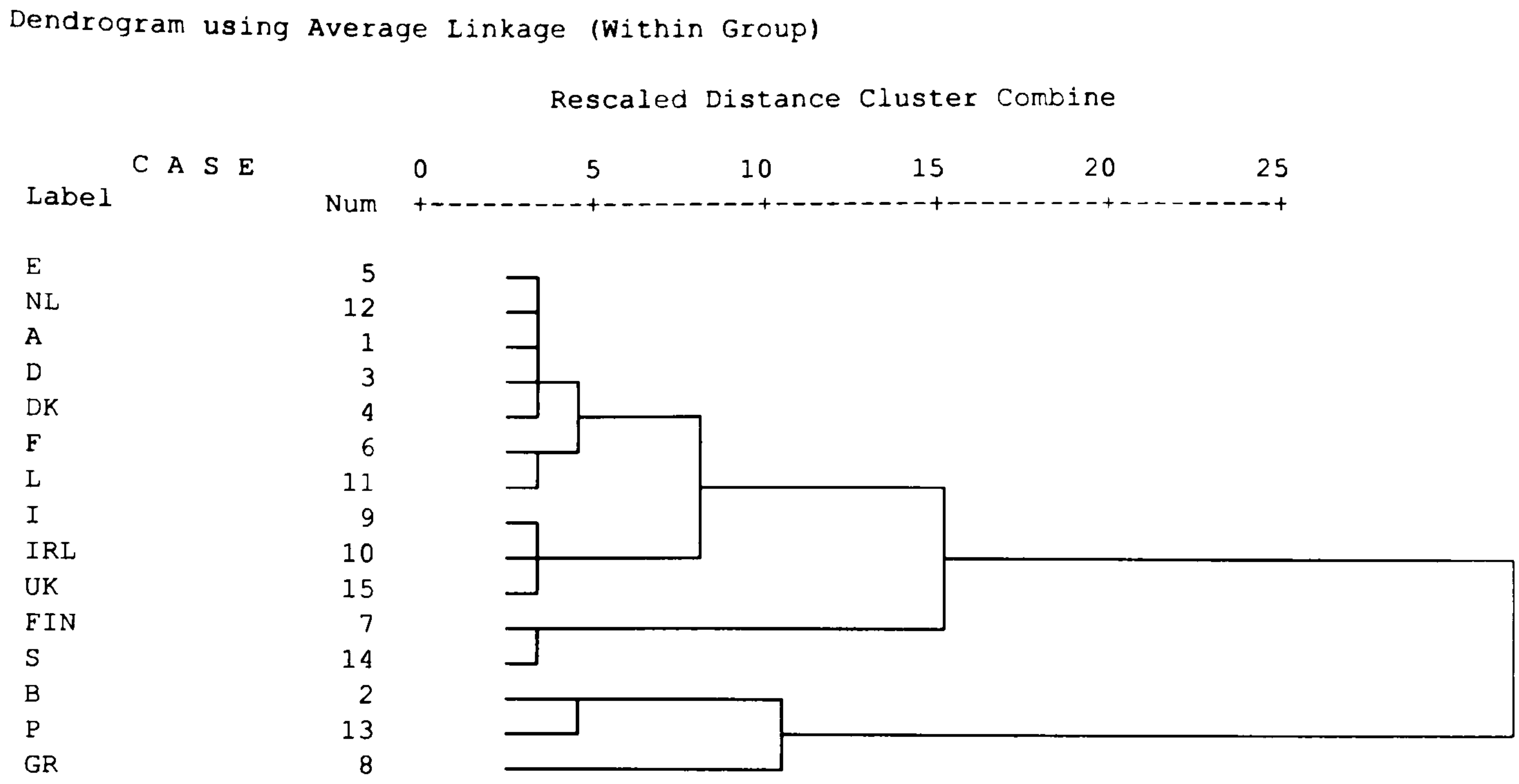
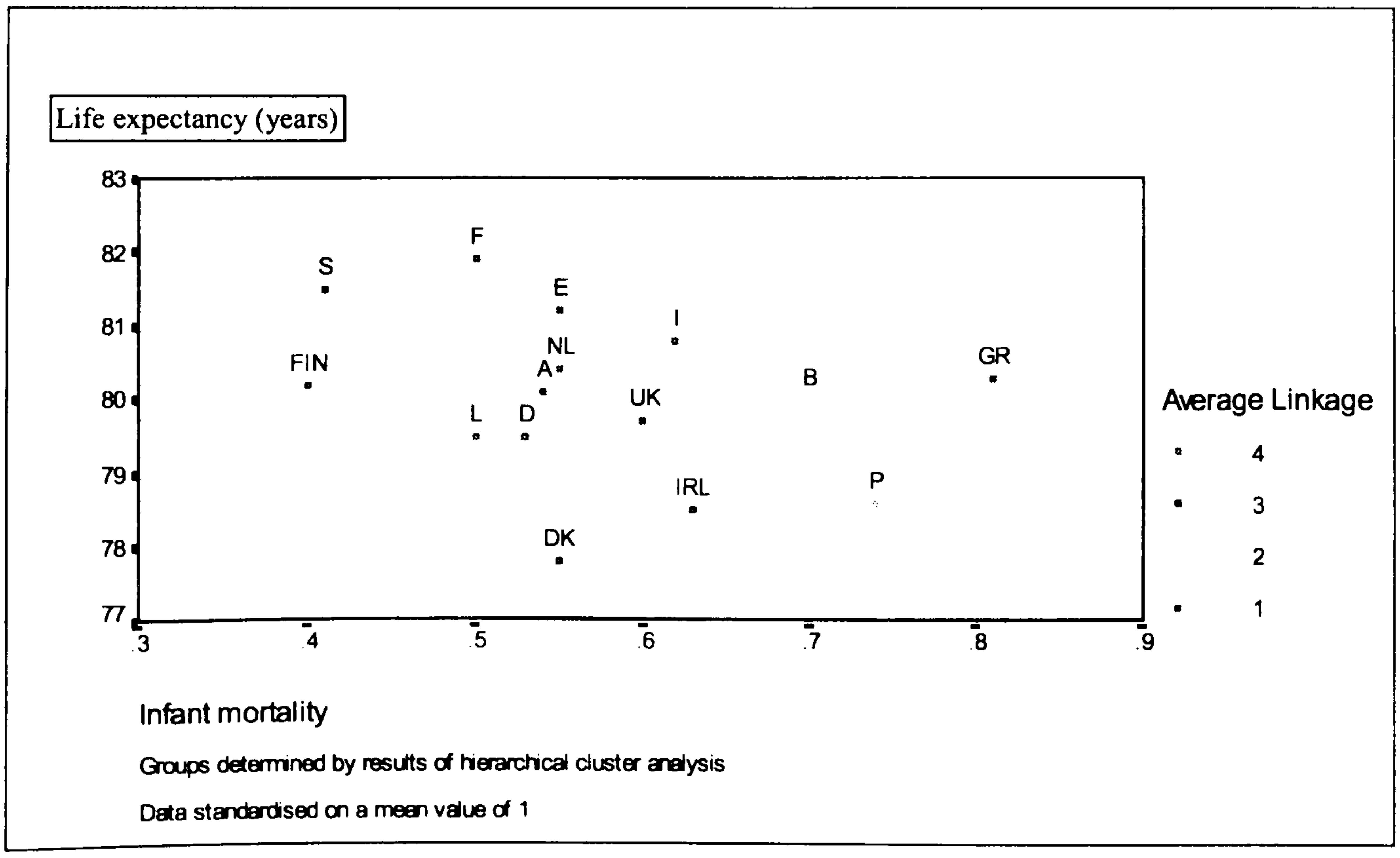


Figure 2.6 Scatter plot for infant mortality and life expectancy (females) - 1995



Note: Infant mortality is given per 100 live births. Life expectancy is at birth.

The picture is repeated for infant mortality and life expectancy (males) in terms of the groups identified by the cluster analysis, although life expectancies differ somewhat in a number of countries when comparing males with females as shown in Figures 2.7 and 2.8.

For example, although French females live the longest in the EU, French males appear down the scale at an age close to the EU mean. Greek males, on the other hand, live longer compared with the remainder of the EU (second place) in comparison with Greek females. Swedish males live longer than males in any other country by a long way, but Finnish males, although in the same health outcomes group as Sweden, have a life expectancy somewhat below the EU mean.

Figure 2.7 Dendrogram for infant mortality and life expectancy (males)

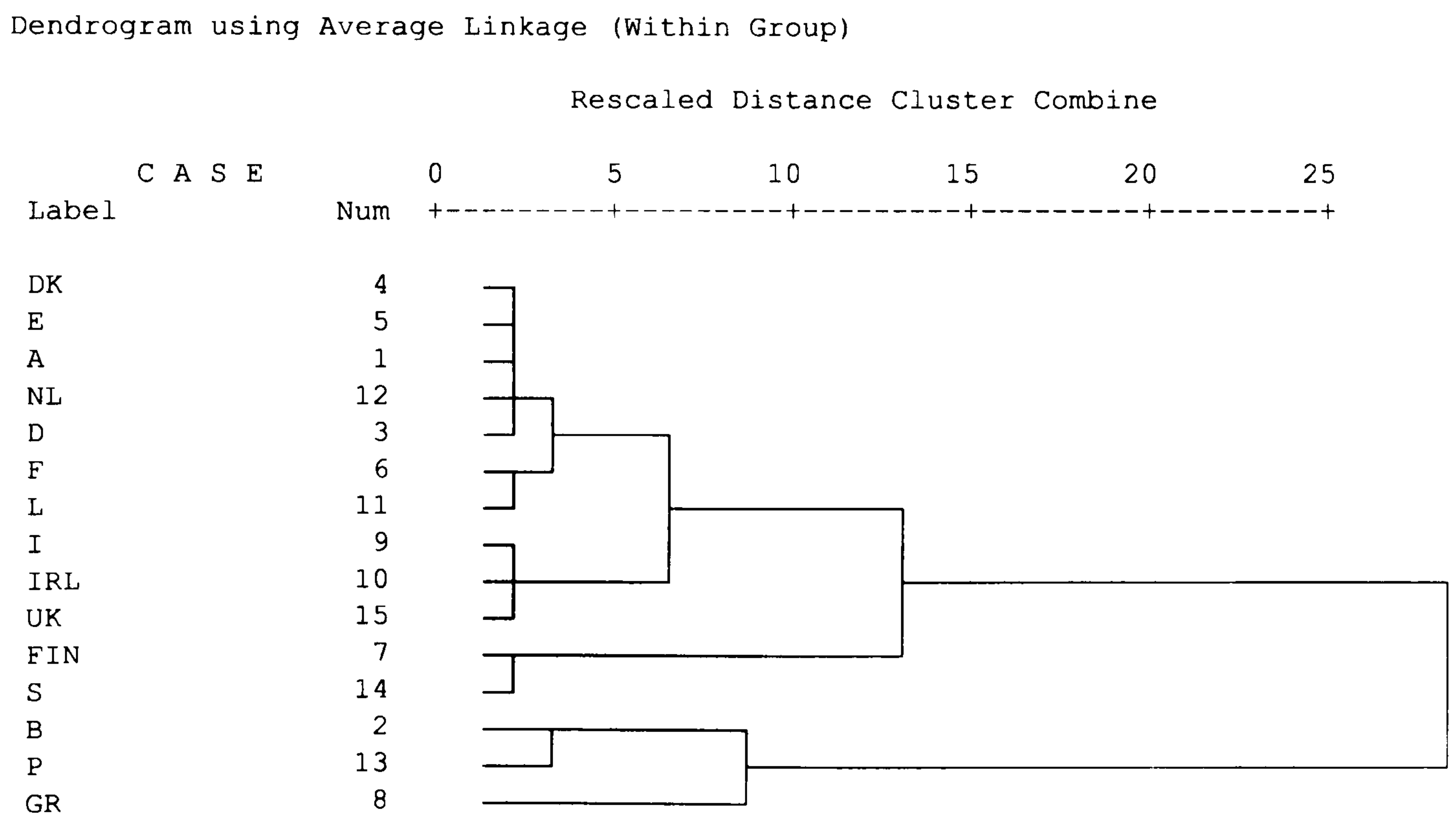
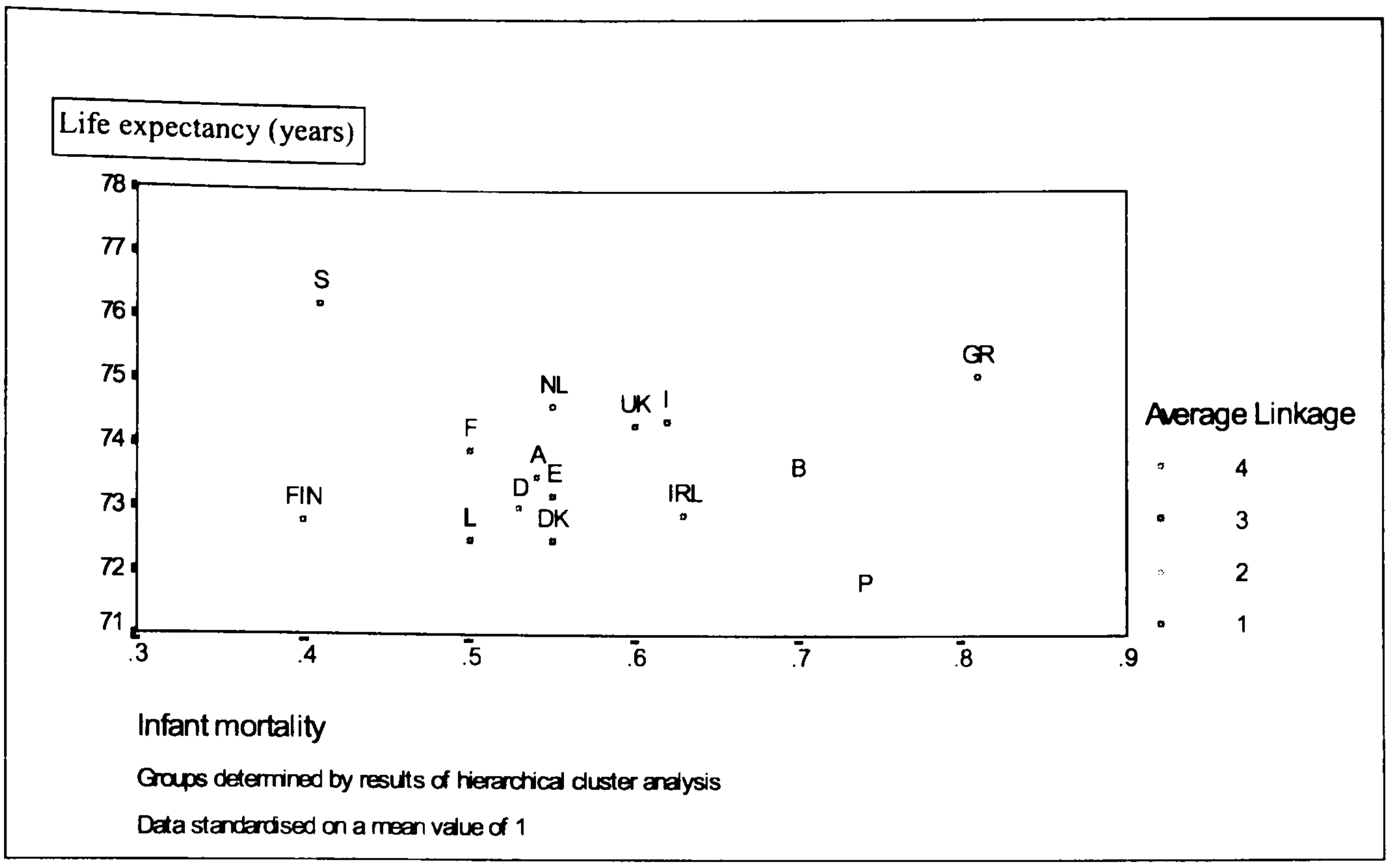


Figure 2.8 Scatter plot for infant mortality and life expectancy (males) - 1995



Note: Infant mortality is given per 100 live births. Life expectancy is at birth.

The dendrograms of Figures 2.5 and 2.7 show that if a three group solution were to be taken, Greece would be joined to group 2 with Belgium and Portugal. The main dividing factor in these analyses is that of infant mortality, which has wide variations across the EU. In particular, Finland and Sweden (approximately 0.4) have values half that of Greece (0.8), with Portugal and Belgium not far behind this (approximately 0.75 and 0.7, respectively). Due to the data standardisation undertaken, it can be seen that the figure for infant mortality in Greece is 100% higher than that of Sweden, whereas life expectancies have differences of approximately 5% across the minimum and maximum values in the EU. In other words the variation in infant mortality is much higher than the variation of life expectancy.

2.4.3 Resources

The results for health care resources are shown in the dendrogram and scatter plot of Figures 2.9 and 2.10 respectively. Examination of the dendrogram reveals that a four cluster solution is optimal at a rescaled distance of approximately 9. The resulting groups are:

Group 1	Austria, Belgium, France, Finland and Germany.
Group 2	Denmark, Greece, Portugal, Spain and Sweden.
Group 3	Italy, Ireland and the UK.
Group 4	Luxembourg and the Netherlands.

When considering these results some interesting findings are evident. For example, although a four group solution has been selected, the dendrogram shows that the two group solution selects all countries in the bottom half of the dendrogram which have NHS systems, and all the top half countries are, with the exception of Finland, SI systems. The dividing factor here is the number of beds which is lower, Finland aside, in the NHS countries. In the case of Portugal and Spain, for example, the number of beds is approximately one quarter of the Netherlands and Luxembourg, which make up group 4 in the cluster analysis. The NHS countries are divided, however, by the number of physicians, with countries of group 3, namely Italy, Ireland and the UK, having values well below half of other NHS countries such as Greece and Spain. Other SI countries and Finland in group 1 have middle to high numbers of beds and middle range numbers of physicians. Luxembourg and the Netherlands also have middle range numbers of physicians.

Figure 2.9 Dendrogram for number of physicians and number of beds

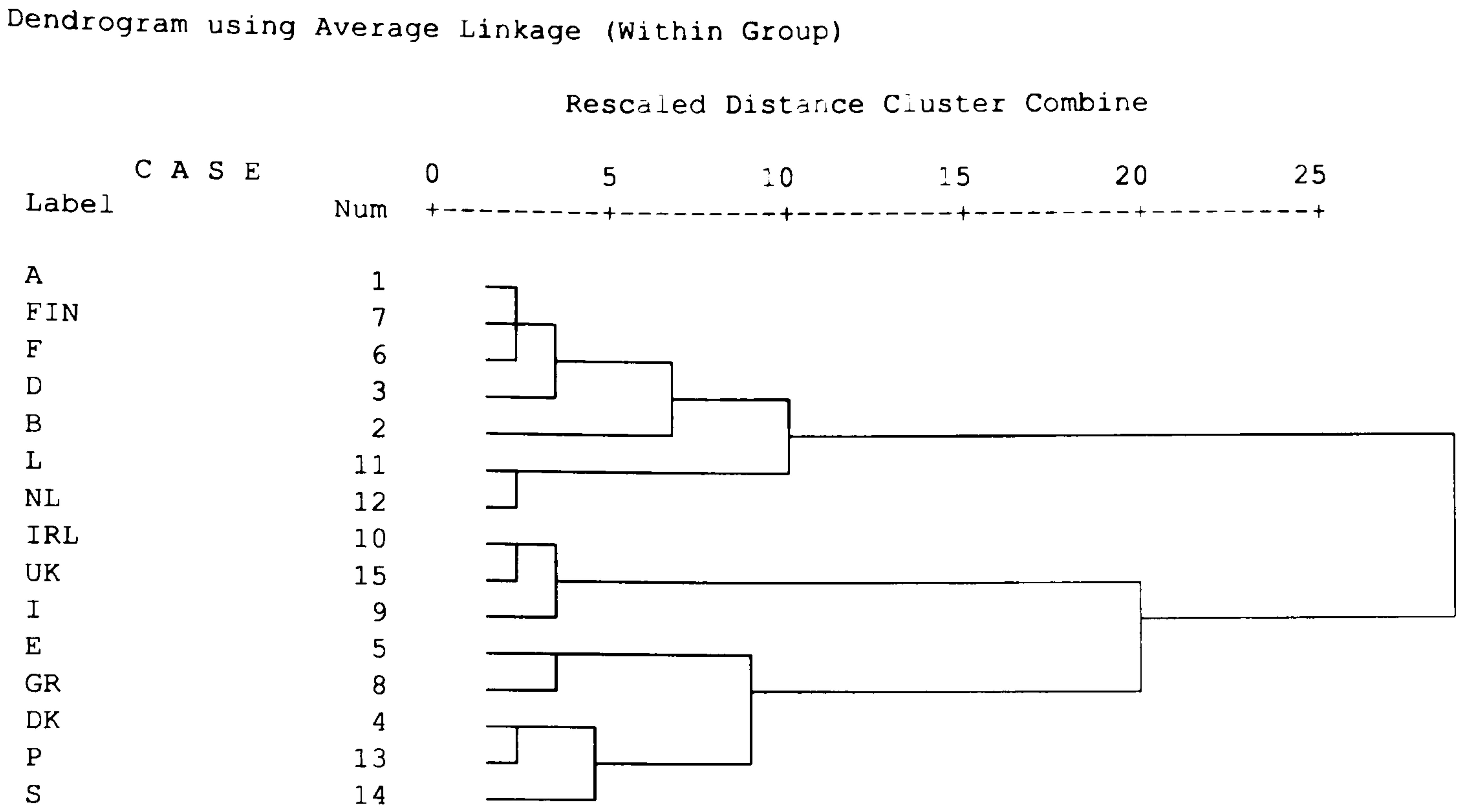
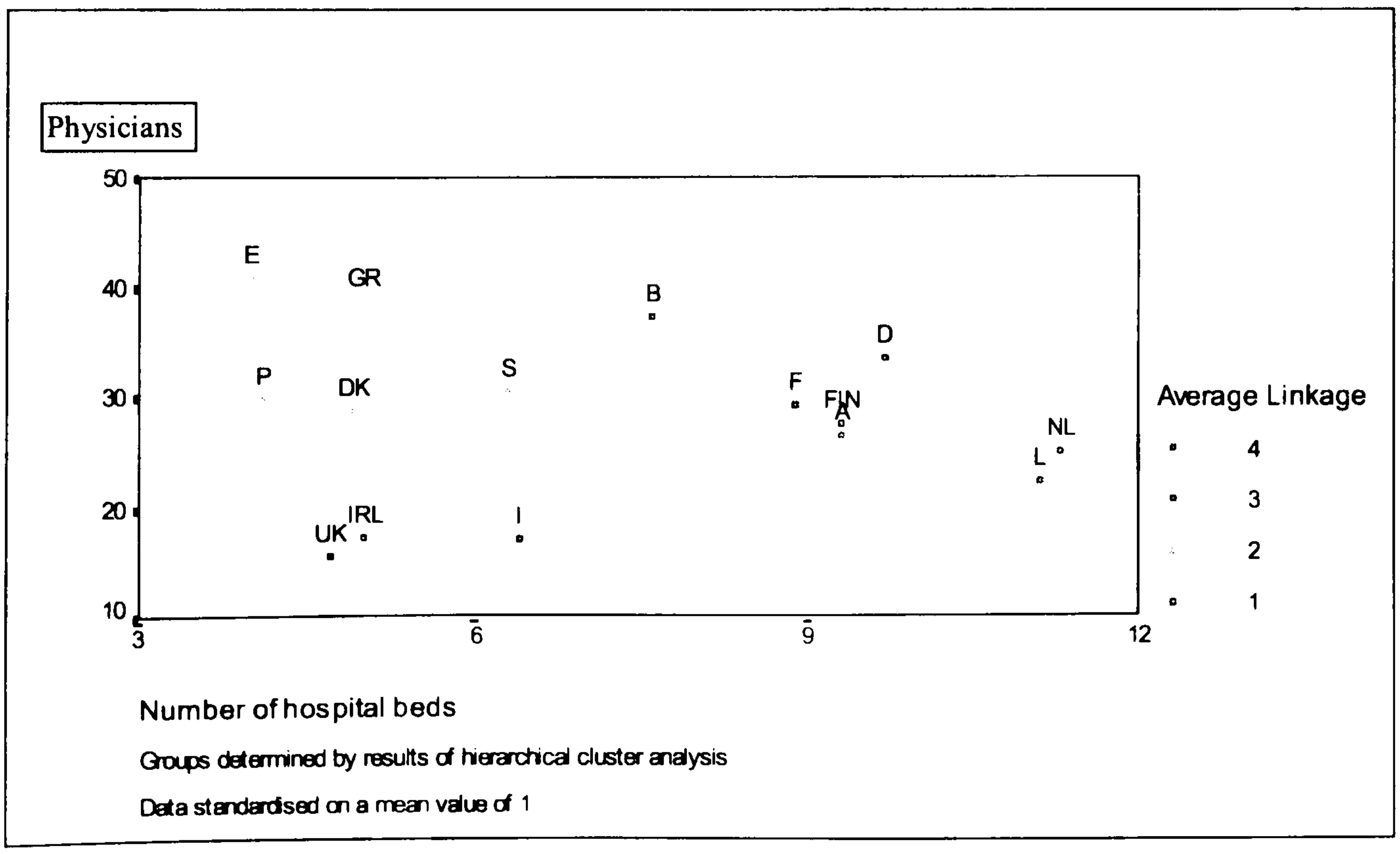


Figure 2.10 Scatter plot for number of physicians and number of beds - 1995



Note: Physicians per 10,000 of population. Number of beds per 1000 of population.

2.4.4 Utilisation

The results for utilisation levels are shown in the dendrogram and scatter plot in Figures 2.11 and 2.12, respectively. Examination of the dendrogram reveals that a three cluster solution is optimal at a rescaled distance of approximately 7. The resulting groups are:

Group 1	Austria, Belgium, Finland, France, Germany, Luxembourg and the UK.
Group 2	Denmark, Greece, Ireland, Italy, Spain, Portugal and Sweden.
Group 3	The Netherlands.

In terms of *utilisation* levels the scatter plot of Figure 2.12 shows that Group 1 is made up of a majority of SI countries, with the UK and Finland from the NHS countries. Interestingly, group 2 is homogenous as it contains all the remaining NHS countries, which are characterised by lower admission rates and shorter lengths of stay, although Denmark and Sweden as Scandinavian countries have much higher admission rates than the southern countries of Spain, Portugal and Greece.

The situation of the Netherlands, in a group entirely on its own, seems to suggest that the way in which data for average length of stay are collected from the Netherlands is somewhat different from the rest of the EU. With a very low admission rate of 11.1% (the second lowest in the EU), it has a length of stay, at 32.8 days, equal to three times the EU mean for this variable. This can be explained by possible inconsistencies in the way in which an episode of in-patient care is defined across the EU, with the Netherlands including groups such as the elderly in some forms of nursing care.

Figure 2.11 Dendrogram for average length of stay and admission rate

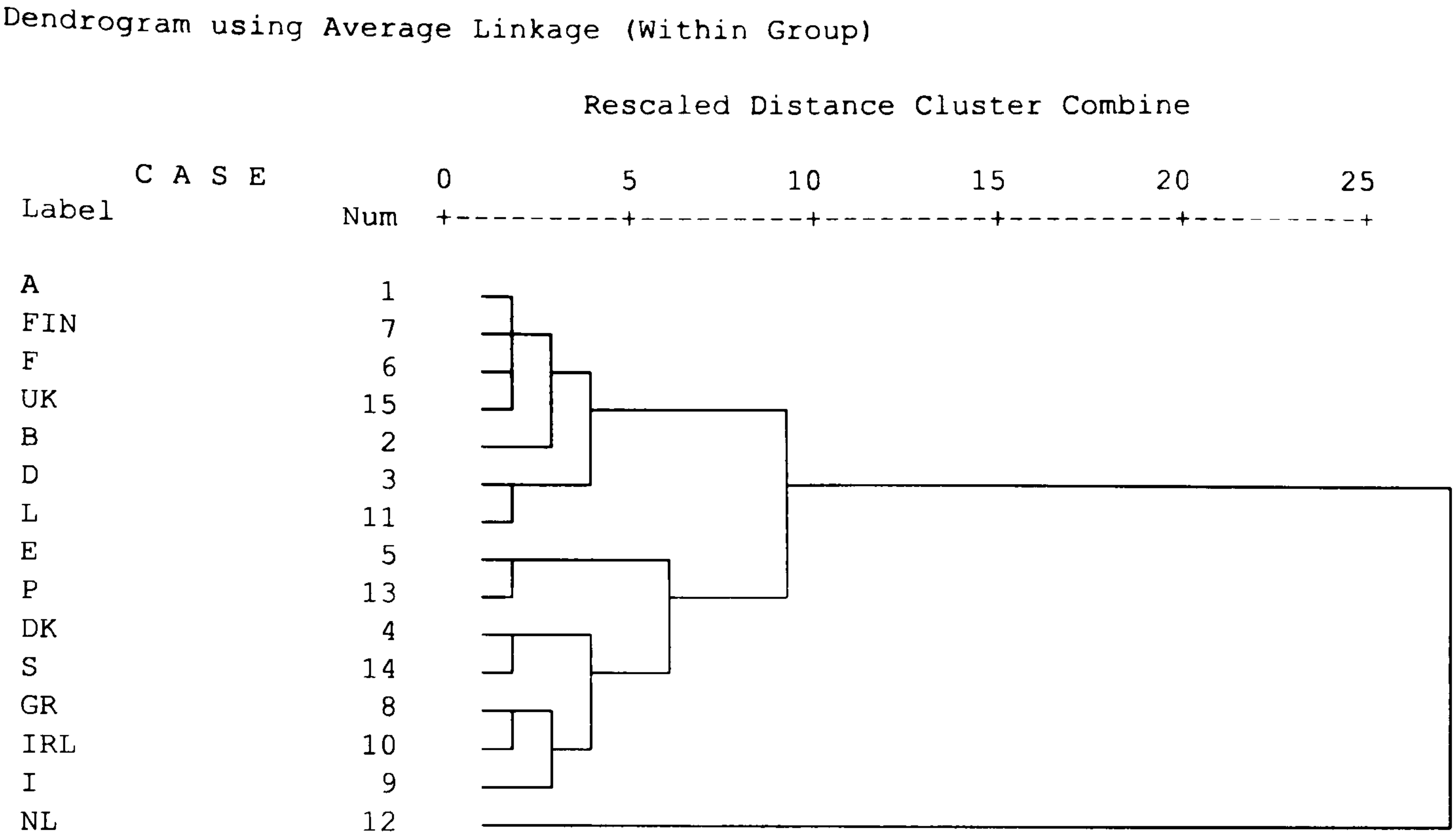
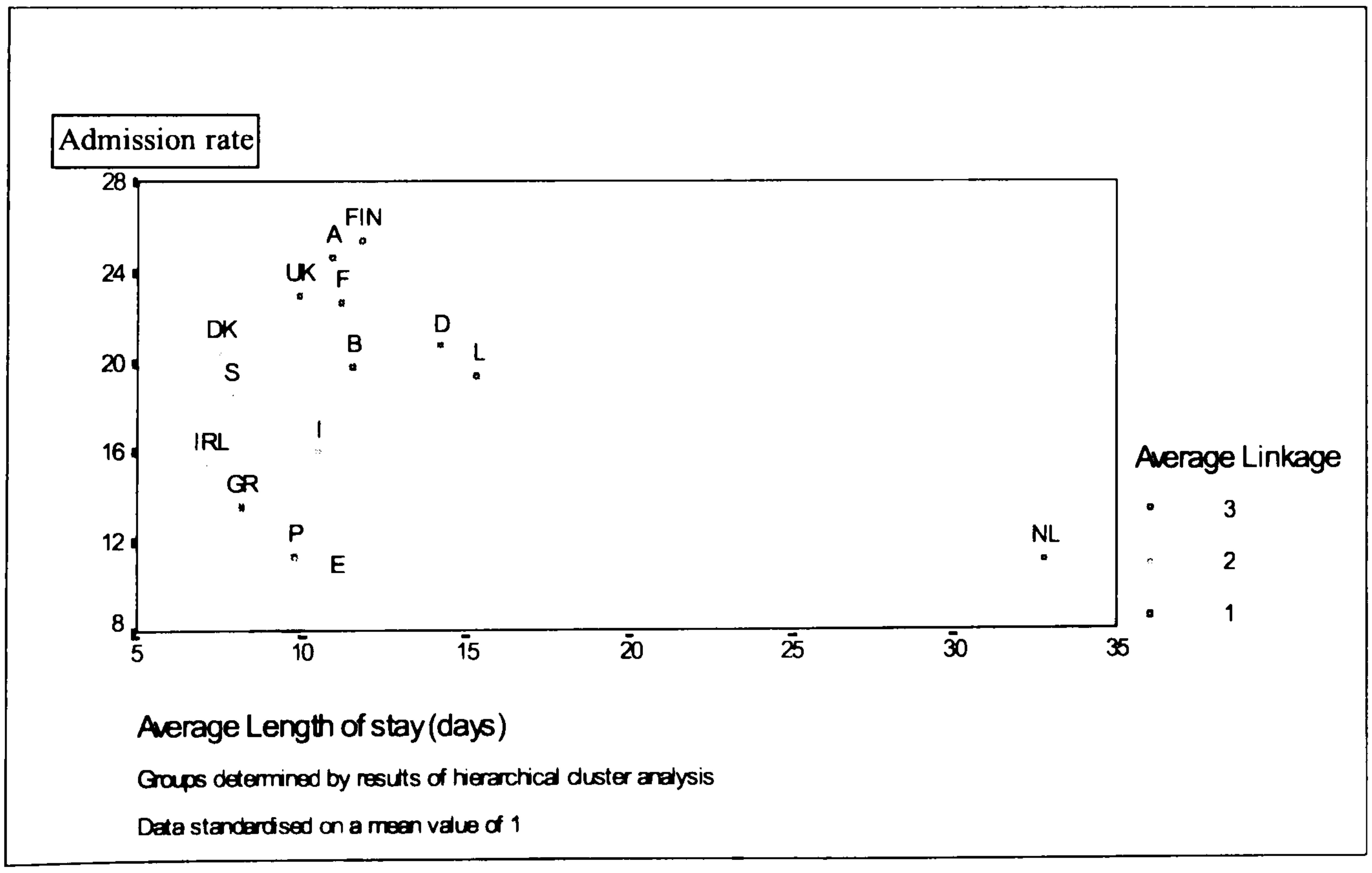


Figure 2.12 Scatter plot for utilisation rates in the countries of the EU - 1995



Note: Admission rate (%). Average in-patient length of stay in days.

With the exception of the Netherlands, therefore, it is possible to state that, in general, SI models of health care are associated with higher admission rates and longer lengths of stay.

2.4.5 Composite solution

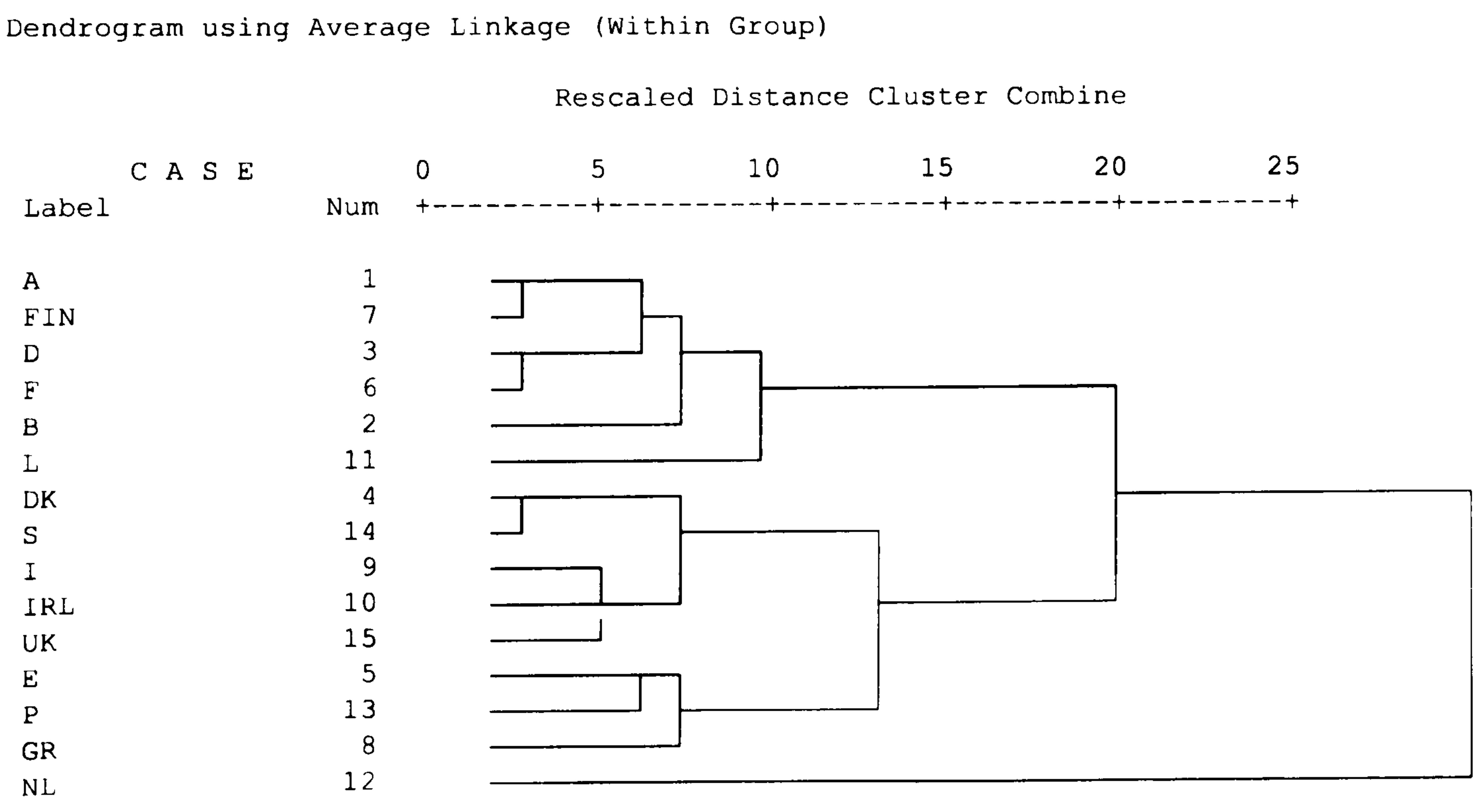
The results of the cluster analysis containing all 9 variables are shown in the dendrogram of Figure 2.13. Examination reveals that a three cluster solution is optimal at a rescaled distance of approximately 15. The resulting groups are:

Group 1 Austria, Belgium, Finland, France, Germany, Luxembourg.

Group 2 Denmark, Greece, Italy, Ireland, Portugal, Spain, Sweden and the UK.

Group 3 The Netherlands

Figure 2.13 Dendrogram for composite solution



The *composite solution* provides a summary cluster analysis taking into account all nine variables. The results show a clear association with the typology of the health care systems employed by each country, and perhaps of equal interest, countries are often fused at the earlier stages of the cluster analysis according to geographical location.

Group 1, apart from the Netherlands, contains all the countries in the EU with SI models of delivery, plus Finland. As the previous analyses have confirmed, Finland has many of the characteristics of SI countries even though it has an NHS system.

Group 2 is, with the exception of Finland, made up of all the NHS countries of the EU. Particularly within this group it can be observed that the initial fusions are based on geographical location, with, for example, Denmark and Sweden being clustered at an early stage, the UK, Ireland (and Italy) being fused slightly later but joined with Sweden and Denmark at the same distance at which Spain, Portugal and Greece are clustered. Before this latter fusion occurs, Spain and Portugal are clustered into a single group.

The Netherlands appears in a group of its own, perhaps influenced by the variables *number of beds* and *average length of stay* which were found to be two to three times higher than the EU mean. For this reason, further analysis will be needed to confirm the reliability and consistency of the data although it is likely, given the analyses presented here, that the Netherlands would be placed within the SI countries.

2.5. Discussion and conclusions

This chapter has reported on the utilisation of hierarchical cluster analysis as a means of placing the health care systems of the EU into different groups using economic, health outcome, and resource and utilisation variables. A composite solution, using all variables, has provided an overall assessment of the systems in terms of their clustering. Using two methods to standardise the data it has been possible to ensure that the scaling problems of the data have been minimised. The results show the degree of achieved convergence in the health care systems of the EU.

Perhaps the first observation emerging from this study is that cluster analysis can be a useful statistical method that produces groupings based on similar characteristics and is particularly useful in generating hypotheses. The particular conclusions of the chapter that could formulate hypotheses for further testing are:

1. Health expenditure in SI countries of the EU is higher than that of NHS countries.
2. There is no association between the method of health care delivery and health outcomes.
3. There is greater variation in infant mortality than life expectancy across countries of the EU.
4. NHS countries have lower levels of resources in terms of number of in-patient beds than SI countries.
5. Average length of in-patient stay and in-patient admission rate are lower in NHS countries than those of SI countries.

When considering the strengths and weaknesses of hierarchical cluster analysis it was found that the approach used to create clusters was rather sensitive to the method of standardisation and the method of clustering. In comparing the results obtained with z scores and those obtained with a mean of 1, for example, it was found that by visual examination of the scatter plots produced for the first four data groups, a mean of 1 produced the most consistent and 'defensible' solutions. This is thought to be due to the point that standardising on z scores tends to cause a loss of proportionality in the data

(Sneath and Sokal, 1973). By standardising on a mean of 1 this feature of the data would appear to be better preserved whilst the requirement to avoid scaling bias is eliminated. In terms of the method of clustering, although some fairly minor differences were observed in testing clusters formed with single linkage and average within group linkage methods, the latter was adopted due to its inclusivity in terms of generating tighter clusters and the greater validity given to it in the literature.

The limitation of this study in terms of the use of cluster analysis is that, whilst being useful in terms of statistically classifying countries and generating hypotheses, hierarchical cluster analysis needs to be treated with some caution as the results vary according to the chosen data and the methods used to standardise them. By adopting a progressive method in this study, however, it has been possible to gain some confidence in the methods due to the use of scatter plots in conjunction with hierarchical cluster analysis for the initial pairs of variables.

Taking the case of the Netherlands and the variable *average length of stay* it is likely that data sources such as those complied by the OECD need a greater degree of standardisation and consistency in order to give greater validity to studies of this nature.

It is also the case that the results of the clustering are conditioned on the chosen variables. If key variables are omitted then clearly the groupings produced will be somewhat limited. In this chapter only nine variables have been used in an attempt to present a compact and generic solution. However, with the continuing development of the quality and range of available data (EUROSTAT, 1996) it will be possible to expand the chosen variables and anticipate an increase in their cross-national comparability and consistency.

The cluster solutions produced within the chosen framework have made it possible to place countries into discrete clusters, with two, three and four groups being formed dependent on the rescaled distances chosen from the dendrograms. Homogeneity of typology is often but not always evident in the clustering produced, although the clusters generated generally have an association with typology. NHS models, the most commonly used and increasing mode of organisation and delivery in the EU, appear to be better at containing expenditure than SI models, largely because of their centrally organised nature which offers opportunities for economies of scale and greater control through both supply-side and demand-side mechanisms.

In terms of health outcomes there is no clear division in terms of typology, although the data indicate a north-south divide in infant mortality, with Mediterranean countries performing worse than countries of the north, particularly those of Scandinavia.

Resources are generally more abundant in SI countries compared with countries with NHS modes of organisation, and admission rate and average length of stay are also generally higher in social insurance countries.

The composite solution, in relation to the question of convergence, is of particular interest as it clearly shows an association, taking into account all the chosen variables in the analysis, between grouping and the method of organisation. For policy makers, this strongly suggests that if convergence is to become an achievable goal in the EU, a degree of standardisation in terms of how health care is organised and delivered, is required. NHS models, according to this study, tend to produce similar health care characteristics, and likewise SI models. These findings thus show the degree of achieved convergence in 1995 and provide the foundation of determining how greater convergence can be achieved in the future.

Chapter Three

Convergence: Methodology and Analysis of EU Health Care Expenditure

3.1. Introduction

The aim of this first substantive chapter on convergence analysis is to develop a suitable methodology that can be used to test for the presence of convergence and then apply it to the chosen health care expenditure variables of the thesis. As such, in addressing the research questions of the thesis (see 1.2) it lays the foundation for the analyses that follow in chapters Four and Five in testing for convergence in health outcomes, resources and utilisation. The methods have been applied and reported in studies published elsewhere by the author (Nixon, 1999; Hitiris and Nixon, 2000; Nixon, 2000b; Hitiris and Nixon, 2001).

Building on the theoretical and analytical foundations laid out in Chapter One with regard to the specific techniques that have been chosen to test for convergence, the methodology involves the application of two statistical approaches. The first approach utilises cross-sectional data and non-parametric analysis for the period 1960-95. Following this convergence is tested for using a set of panel data for the period 1980-95 and the more rigorous form of parametric analysis. The influence of health care system on convergence is also examined to complete the analyses.

As well as fully describing the methods used, the various merits of the two techniques are discussed using graphical representations that help to explain the reasons for the observed convergence or divergence.

Finally, some influences on health care expenditure and therefore the findings of the chapter are examined, particularly in relation to the neo-classical growth model and the health care reforms that were introduced throughout the last three decades.

3.2. Measuring convergence

The two methods to be applied to test for convergence, as summarised in Chapter One, are σ and β-*convergence* which are derived from the study of economic convergence.

The first approach concerns 'cross-sectional dispersion' in which convergence exists if, for example, the standard deviation (s.d.) or coefficient of variation (c.v.) of a variable across a group of countries declines over time (Easterlin, 1960; Borts and Stein, 1964; Streissler, 1979; Barrow, 1984; Baumol, 1986; Dorwick and Nguyen, 1989; Barro and Sala-i-Martin, 1991, 1992a, 1992b). This technique is fully explained and then adapted by the introduction of a new method, developed by the author, for testing the statistical significance of any observed changes in the standard deviation over the period of interest.

The second approach, β-*convergence*, is based on the assumption that convergence exists if a poor economy tends to grow at a faster rate than a rich one such it tends to catch up in terms of *per capita* income or product (Barro, 1984; Baumol, 1986; DeLong, 1988; Barro and Sala-i-Martin, 1991, 1992a, 1992b; Sala-i-Martin, 1994; Boyle and McCarthy, 1997). β-*convergence* is also known as 'regression to the mean' (Barro and Sala-i-Martin, 1995, p. 383), which is a point of focus in the methods adopted in the present chapter in seeking a 'reliable point of reference, ' a stated objective of the thesis, from which to measure convergence trends. Although Sala-i-Martin (1996) has shown that β-*convergence* implies σ-*convergence,* both approaches are applied in this thesis as they offer different but informative perspectives.

3.3. Convergence scenarios and hypotheses

Presenting the results of convergence analyses in a clear and informative manner is important if the reasons for it occurring are to be grasped.

In this regard Leonardi (1995) has put forward a useful methodology for the study of economic and social convergence and the various hypotheses and scenarios he provides are described as:

- The equivalent growth hypothesis
- The upward convergence scenario
- The downward convergence scenario
- The reversal of roles scenario
- The divergence hypothesis.

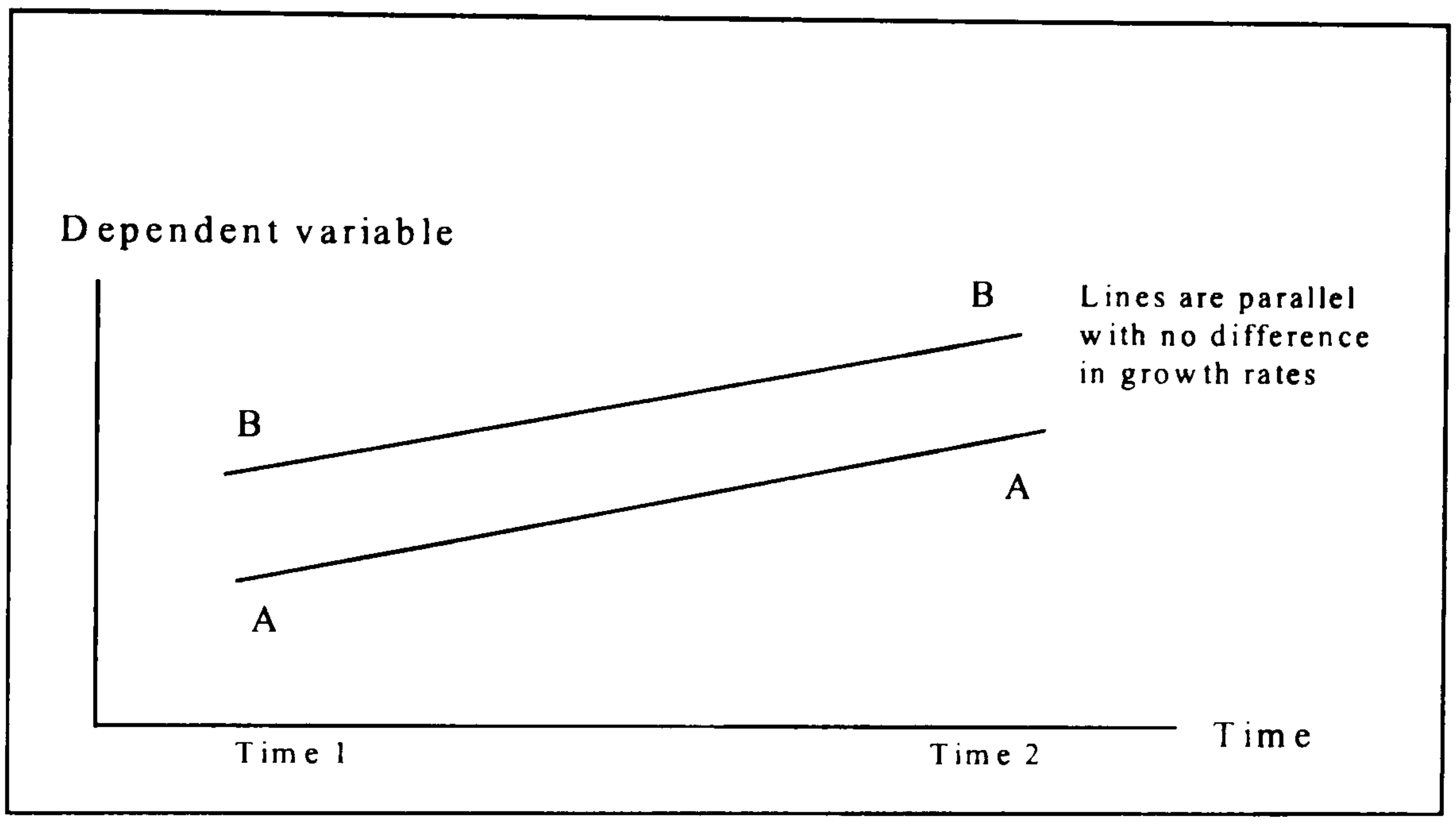
Each of these is illustrated graphically in Figures 3.1 to 3.5. Throughout the analyses of convergence in this and the remaining chapters these classifications are used to explain observed trends over time for each variable examined.

It should be noted, however, that the hypotheses among the above are not tested using statistical techniques, but are used in conjunction with histograms to show trends for individual countries with respect to the chosen reference point.

3.3.1 Equivalent growth hypothesis

Figure 3.1 shows that although there is an absolute increase in the dependent variable for both A and B between time periods 1 and 2, there is no relative change between the two. In this case both A and B experience the same growth and convergence does not take place between the two time periods.

Figure 3.1 Equivalent growth hypothesis

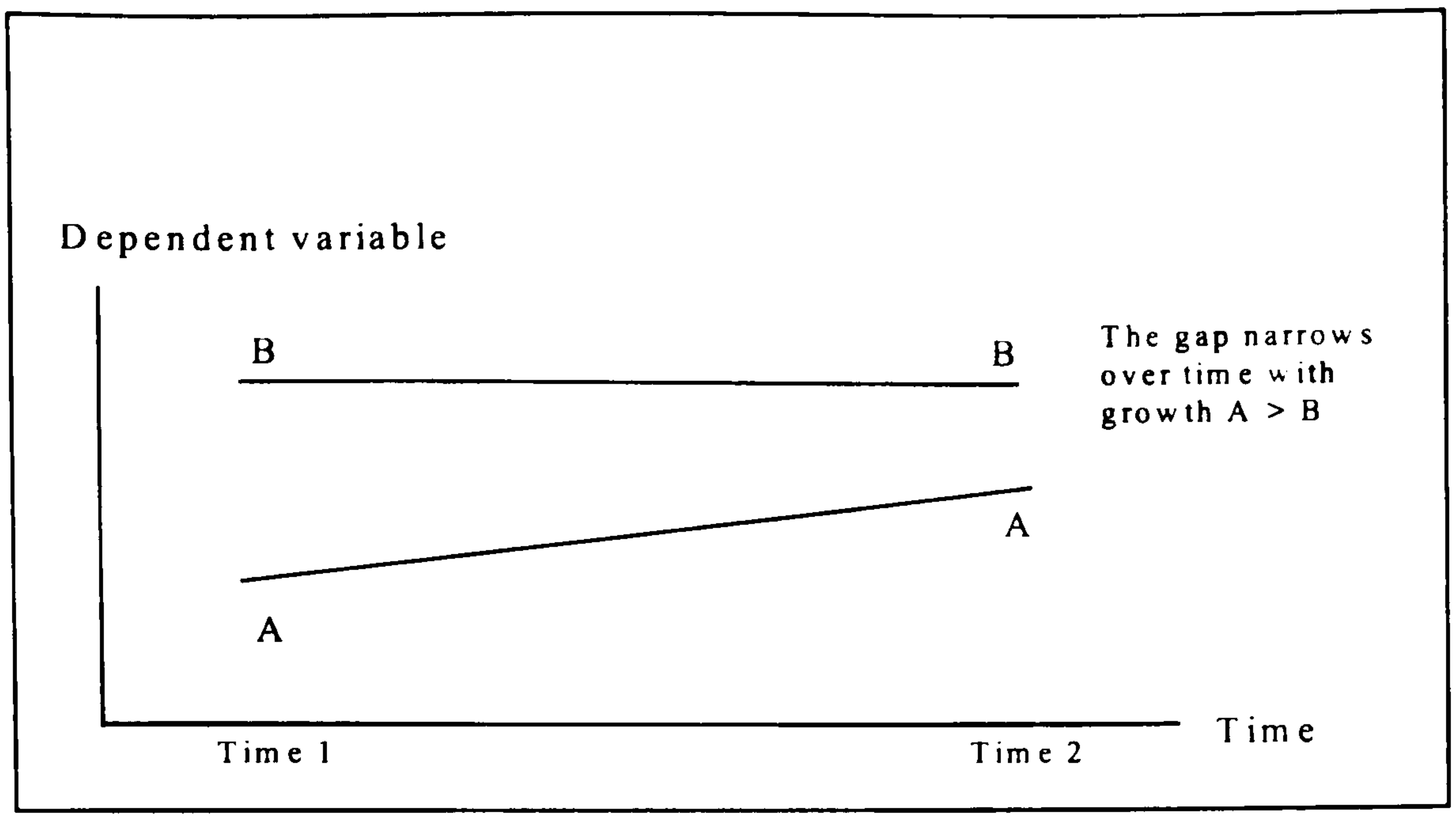


3.3.2 Upward convergence scenario

Figure 3.2 illustrates the case of upward convergence. Between time periods 1 and 2, B experiences low growth in real terms but A experiences real and upward growth towards the value attained by B.

This scenario is therefore classified as *upward convergence* as the initially inferior position of A is increasing at a faster rate than B.

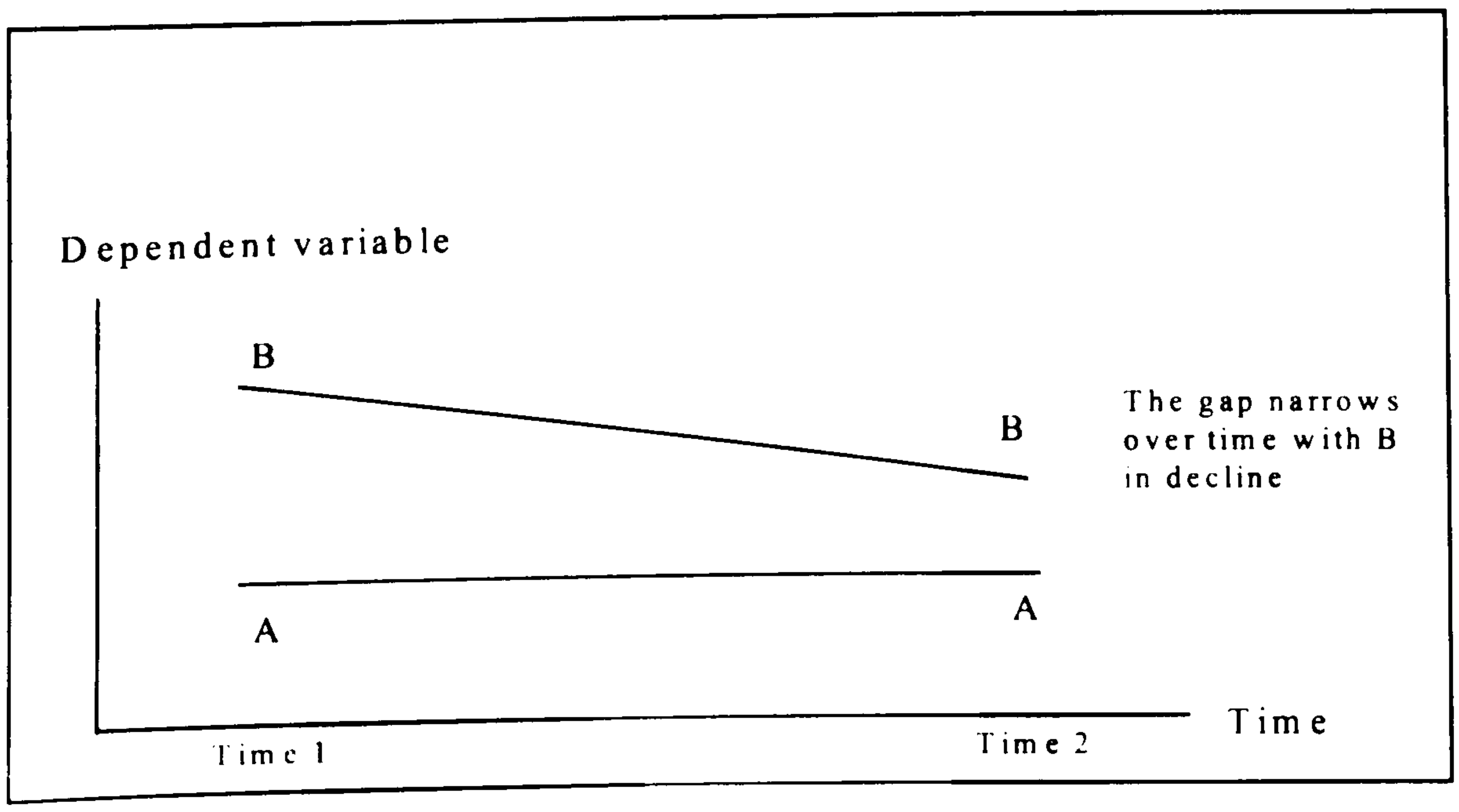
Figure 3.2 Upward convergence scenario



3.3.3 Downward convergence scenario

In this scenario, as illustrated in Figure 3.3, the relative gap between A and B reduces between time periods 1 and 2 , with A, the inferior, increasing or remaining constant in value and B, the superior, decreasing in value. In spite of this the initial ranking of A and B is unaltered by the convergence process.

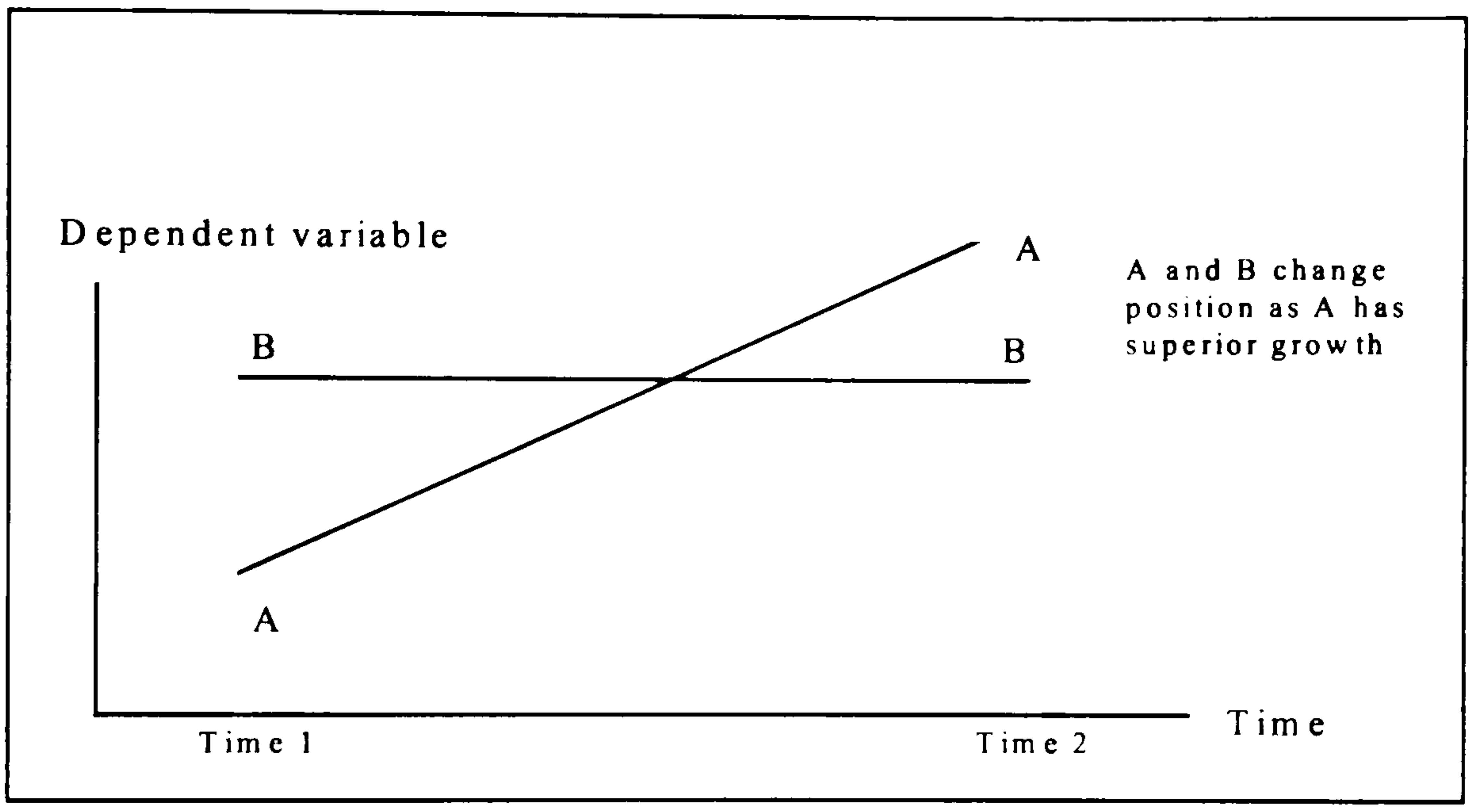
Figure 3.3 Downward convergence scenario



3.3.4 Reversal of roles scenario

As the title implies, over time periods 1 and 2 there is a reversal in the rank order of the two values, A and B, as shown in Figure 3.4. This may be due to the dynamics of either growth or decrease in the value attained by A, or a growth or a decline in the value attained by B. The result is that absolute differences still exist between A and B.

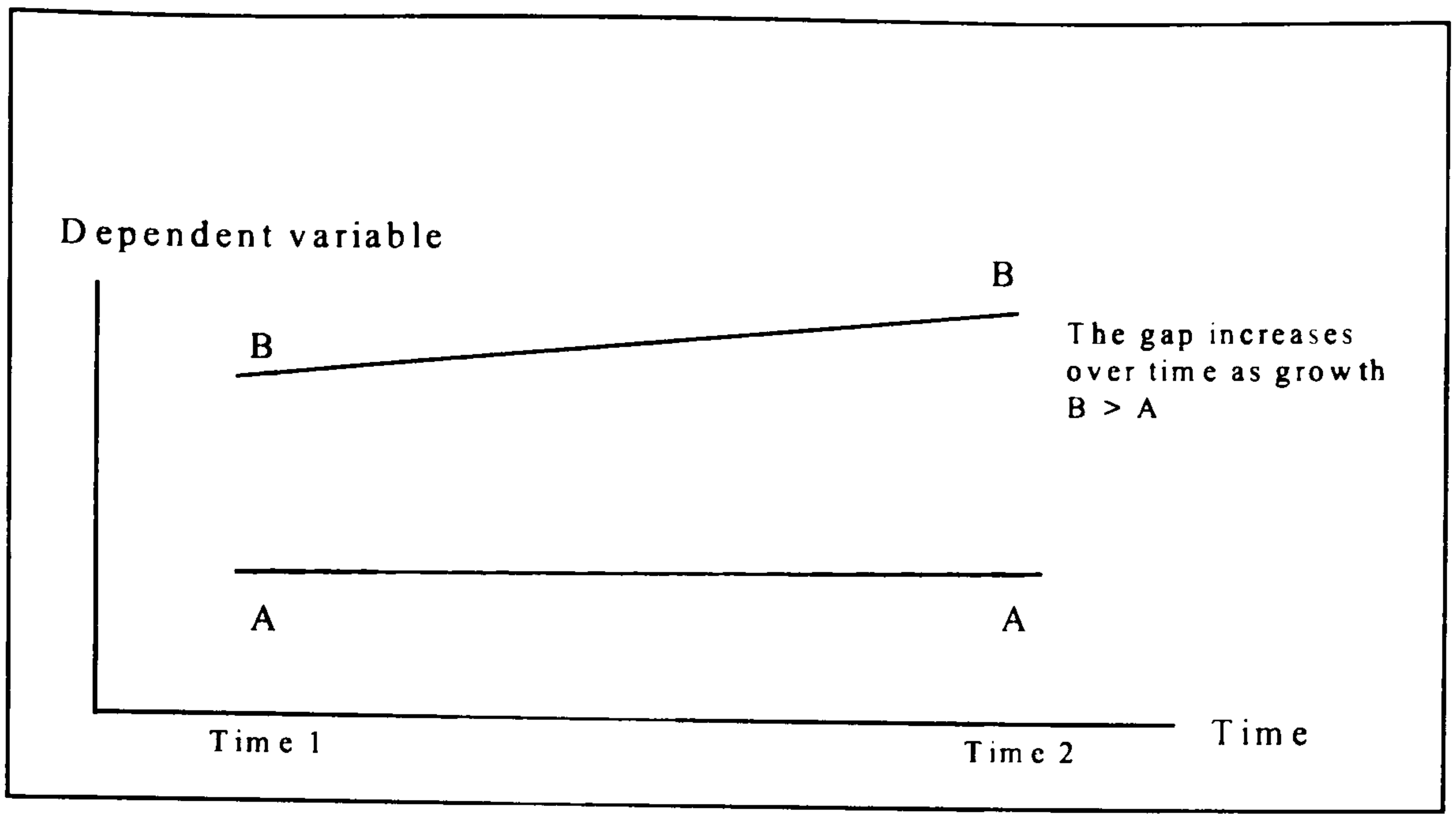
Figure 3.4 Reversal of roles scenario



3.3.5 *The divergence hypothesis*

Figure 3.5 depicts this situation in which, over time, the absolute gap between A and B increases, even though growth may be taking place for both A and B. In this scenario the rate at which growth is occurring is sufficiently different such as to create a widening gap between the inferior and the superior.

Figure 3.5 The divergence hypothesis



3.4. σ-convergence and the F-test

In the following cross-sectional analyses, use is made of OECD data on health (OECD/CREDES, 1997) which, within certain caveats, provides a reliable source for analysis. In this case the variables, total health care expenditure as a percentage of GDP and *per capita* PPP$ are recorded for the earliest and latest years for which a complete set of OECD data are available, separated by a 10-year period for the first four and a 5-year period for the last two; 1960, 1970, 1980, 1990, 1995.

For each year the mean is calculated which is used to determine the multiplier required to convert all the data to an index based on a mean of 100. In so doing it is possible to retain the original variation and proportionality in the data but at the same time allow changes in the dependent variables to be examined from a common reference point over time.

Having standardised the data for each of the years examined the standard deviation (s.d.) was calculated and used for trend analysis in determining the presence, or otherwise, of *σ-convergence*. The question that needs to be addressed in this form of analysis, however, relates to the statistical significance of any observed changes in s.d. and in this regard a suitable statistical tool, the F-test, was utilised by the author.

The F-test (one-sided) is calculated by dividing the variance of one sample by the variance of a second sample to test the null hypothesis:

$$\mathbf{H_0: s^2_{60} = s^2_{95}}$$

Against the alternative hypothesis,

$$\mathbf{H_A: s^2_{60} > s^2_{95}}$$

at the a = 5% level of significance. In this case the F-test = $\frac{s_{60}^{2}}{s_{95}^{2}}$, where s_{60}^{2} is the standard deviation squared for 1960 of observations n = 15, and s_{95}^{2} is the standard deviation squared for 1995 of observations n = 15. The rejection rule is to reject the null hypothesis if $F > F(n-1, a)$. Where appropriate, this analysis is conducted for intervening years between 1960 and 1995 as guided by the plot of standard deviations[1].

Where differences are observed based of typology (NHS versus SI countries) statistical significance is tested by means of a one-way ANOVA test at the 5% level of significance.

Finally, to provide an overall measure of change for each country over the period examined, the indexed values for 1995 were subtracted from the 1960 figure, with positive values indicating a net increase in spending on health care relative to the mean and negative values indicating a reduction.

[1] Note in this case the population and the sample are equivalent, thus σ and s are equivalent.

3.5. Results for σ-convergence

The raw data for health spending as a percentage of GDP and *per capita* spending in PPPS, along with the mean, multiplier, indexed scores and standard deviation for all 15 current members of the EU are shown in Tables 3.1 and 3.2, respectively.

As recorded in each table, the raw data are presented in the first column for each year examined whilst the second years provide the data in its indexed form, based on the mean and the multiplier. Taking an example for 1960 in Table 3.1 the raw mean is 3.4 from which it is possible to calculate the multiplier, which equals 100/3.4 = 29.6. All other data are then multiplied by 29.6 to obtain the indexed scores, recorded in the second column.

This method is consistent with the estimate of coefficient of variation:

$$c.v. = \frac{s.d.}{\bar{x}} \times 100$$

The mean, $\bar{x}$, is 100 giving the condition:

$$\boldsymbol{c.v. = s.d.} \textbf{ of the indexed values.}$$

This step avoids misrepresentation according to Galton's fallacy (Friedman, 1992) as the data have a stable reference, in this case a standardised mean of 100. In terms of the research questions of the thesis, this establishes 'the reliable reference point' from which trends around convergence can be assessed. The EU mean has been employed in other empirical studies of EU regional convergence, which adds support to the adopted approach here (Button and Pentecost, 1995)

Table 3.1 Health care spending as a percentage of GDP and indexed scores - 1960-95

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	4.4	130.4	5.4	109.0	7.9	114.5	7.1	98.3	7.9	102.2	-28.2
B	3.4	100.8	4.1	82.8	6.6	95.7	7.6	105.3	8.0	103.5	2.7
D	4.3	127.5	5.7	115.1	8.1	117.4	8.2	113.6	10.4	134.6	7.1
DK	3.6	106.7	6.1	123.1	6.8	98.6	6.5	90.0	6.4	82.8	-23.9
E	1.5	44.5	3.7	74.7	5.7	82.6	6.9	95.6	7.6	98.4	53.9
F	4.2	124.5	5.8	117.1	7.6	110.1	8.9	123.3	9.9	128.1	3.6
FIN	3.9	115.6	5.7	115.1	6.5	94.2	8.0	110.8	7.7	99.7	-16.0
GR	2.4	71.1	3.3	66.6	3.6	52.2	4.2	58.2	5.8	75.1	3.9
I	3.6	106.7	5.2	105.0	7.0	101.4	8.1	112.2	7.7	99.7	-7.1
IRL	3.8	112.6	5.3	107.0	8.8	127.5	6.6	91.4	6.4	82.8	-29.8
L	1.6	47.4	3.7	74.7	6.2	89.9	6.6	91.4	7.0	90.6	43.2
NL	3.8	112.6	5.9	119.1	7.9	114.5	8.3	115.0	8.8	113.9	1.2
P	1.5	44.5	2.8	56.5	5.8	84.1	6.5	90.0	8.2	106.1	61.7
S	4.7	139.3	7.1	143.3	9.4	136.2	8.8	121.9	7.2	93.2	-46.1
UK	3.9	115.6	4.5	90.8	5.6	81.2	6.0	83.1	6.9	89.3	-26.3
mean	3.4	100.0	5.0	100.0	6.9	100.0	7.2	100.0	7.7	100.0	
multiplier	29.6		20.2		14.5		13.9		12.9		
s.d. (c.v.)		32.2		24.4		21.1		17.2		16.3	

Source: OECD/CREDES (1997) *OECD Health Data 97 - A software for the Comparative Analysis of 27 Health Systems*, Paris, OECD/CREDES (for the first years given).

Note: First years in columns indicates raw data, the second column is the standardised data for that year. Health care expenditure as a share of GDP (X^y) is defined according to Chapter Two (section 2.3).

Table 3.2 Per capita spending on health and indexed scores - 1960-95

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	67.0	122.6	166.0	106.6	697.0	123.7	1180.0	103.3	1634.0	110.8	-11.7
B	53.0	97.0	131.0	84.1	588.0	104.4	1247.0	109.2	1665.0	112.9	16.0
D	91.0	166.5	230.0	147.7	860.0	152.6	1642.0	143.8	2134.0	144.8	-21.7
DK	67.0	122.6	215.0	138.1	595.0	105.6	1069.0	93.6	1368.0	92.8	-29.8
E	14.0	25.6	83.0	53.3	332.0	58.9	813.0	71.2	1075.0	72.9	47.3
F	73.0	133.5	208.0	133.6	716.0	127.1	1539.0	134.8	1972.0	133.8	0.2
FIN	55.0	100.6	165.0	106.0	521.0	92.5	1292.0	113.1	1373.0	93.1	-7.5
GR	16.0	29.3	60.0	38.5	190.0	33.7	389.0	34.1	703.0	47.7	18.4
I	50.0	91.5	157.0	100.8	591.0	104.9	1322.0	115.8	1507.0	102.2	10.8
IRL	37.0	67.7	98.0	62.9	468.0	83.1	748.0	65.5	1106.0	75.0	7.3
L	50.0	91.5	150.0	96.3	617.0	109.5	1499.0	131.3	2206.0	149.6	58.2
NL	68.0	124.4	205.0	131.6	693.0	123.0	1325.0	116.0	1728.0	117.2	-7.2
P	12.0	22.0	45.0	28.9	264.0	46.9	616.0	53.9	1035.0	70.2	48.3
S	90.0	164.6	274.0	175.9	867.0	153.9	1492.0	130.6	1360.0	92.3	-72.4
UK	77.0	140.9	149.0	95.7	453.0	80.4	957.0	83.8	1246.0	84.5	-56.3
mean	54.7	100.0	155.7	100.0	563.5	100.0	1142.0	100.0	1474.1	100.0	
multiplier	1.83		0.64		0.18		0.09		0.07		
s.d. (c.v.)		50.23		44.79		37.25		34.76		30.61	

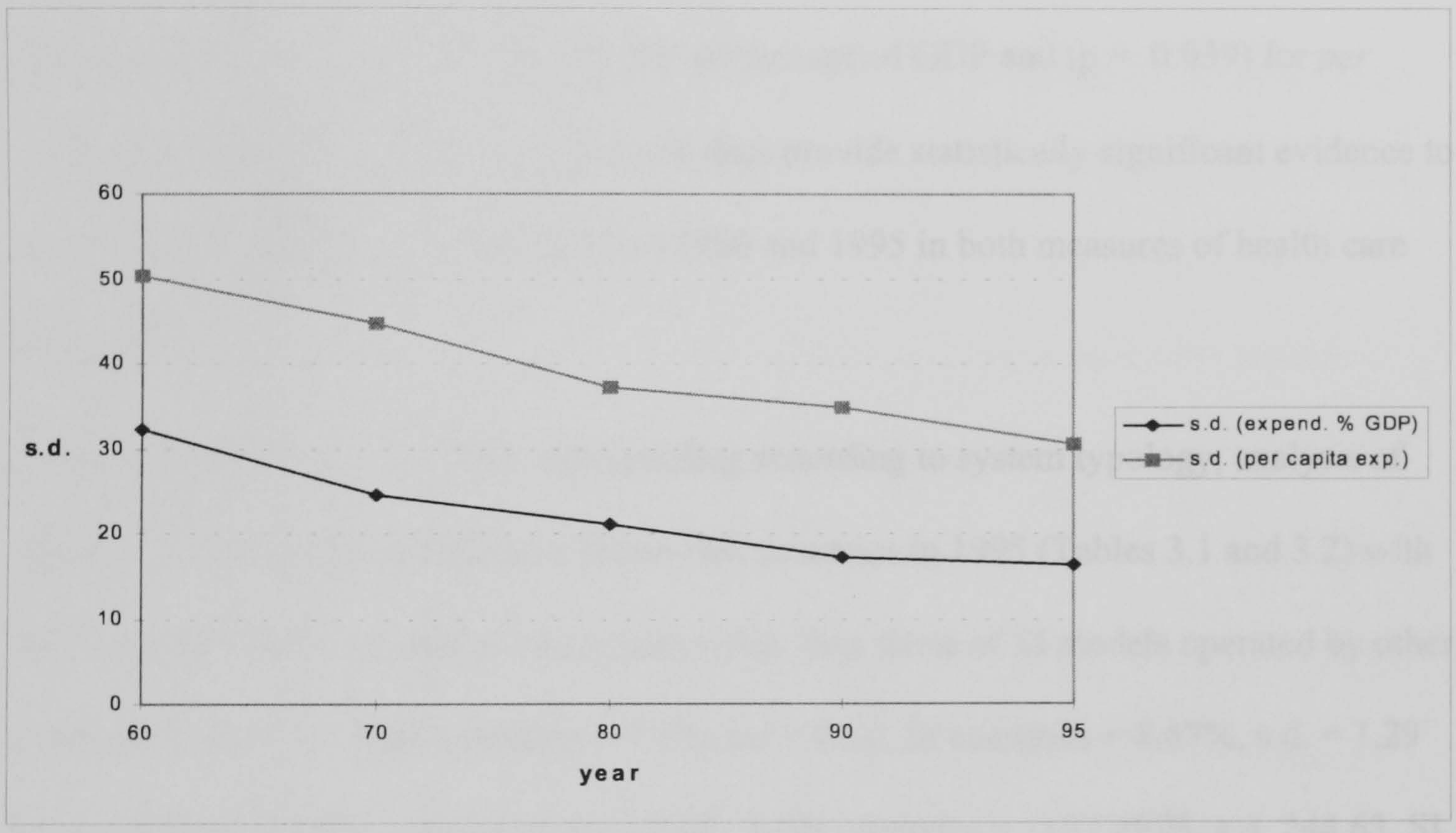
Source: OECD/CREDES (1997) *OECD Health Data 97 - A software for the Comparative Analysis of 27 Health Systems*, Paris, OECD/CREDES (for the first years given).

Note: First years in columns indicates raw data, the second column is the standardised data for that year. Health care expenditure *per capita* (X^h) is defined according to Chapter Two (section 2.3).

3.5.1 *Overall Measurement of σ-convergence*

The results for *σ-convergence* for both health care spending as a percentage of GDP and *per capita* spending are shown, by means of the trends in s.d. of the indexed scores, in Figure 3.6.

Figure 3.6 Standard deviation of health expenditure - 1960-95



In the case of spending as a percentage of GDP it can be seen that from 1960 the s.d. (c.v.) fell continuously from a figure of 32.2 in 1960 to 16.3 in 1995. For *per capita* PPP$ spending a similar trend is observed with the s.d. falling from a figure of 50.23 in 1960 to 30.61 in 1995. Again this clarifies acceptance of the hypothesis of σ-*convergence* in *per capita* spending over the period examined. Moreover, it is interesting to note that even though both sets of data were standardised on a value of 100 there is a greater spread of data as shown by the s.d. (c.v.) differences, in other words greater inequality, in *per capita* spending than share of GDP. This might indicate different preferences concerning health expenditure and that the purchasing power of currencies in terms of the 'basket of health care' that can be obtained within EU countries is rather different, which also implies that use of health care spending as a percentage of GDP has some limitations as a cross-national comparator of health expenditure. Expenditure *per capita* in standard units of money is therefore perhaps a better indicator in terms of measuring 'real' convergence.

The F-test results indicate that the null hypothesis can be rejected and the alternative hypothesis that $\mathbf{s}^2_{60} > \mathbf{s}^2_{95}$ (p = 0.008) for percentage of GDP and (p = 0.039) for *per capita* spending be accepted. These results thus provide statistically significant evidence to show that convergence occurred between 1960 and 1995 in both measures of health care expenditure.

In terms of differences in health care spending according to system typology, analysis of variance of health care expenditure shows that countries in 1995 (Tables 3.1 and 3.2) with NHS modes of delivery, had a lower mean value than those of SI models operated by other countries in the EU: NHS countries = 7.1%, s.d = 0.74; SI countries = 8.67%, s.d. = 1.29 for percentage of GDP, significant at $p<0.05$; NHS countries = 1197 PPP$, s.d. 244.63, SI countries = 1889.8 PPP$, s.d. 248.4, significant at $p<0.05$ level for *per capita* PPP$.

As such, it is possible to conclude that NHS countries are more effective in controlling public expenditure on health care. This is supported by the data findings in Figures 3.7 and 3.8 for 1995 as the majority of EU countries with NHS typologies are below the EU mean for percentage of GDP (Denmark, Finland, Greece, Italy, Spain, Sweden and the UK) and *per capita* PPP$ (Denmark, Finland, Greece, Portugal, Spain, Sweden and the UK). In contrast all SI countries except Luxembourg are above the EU mean (Austria, Belgium, France, Germany and the Netherlands) for percentage of GDP and all are above the EU mean for *per capita* spending.

3.5.2 *Graphical representations*

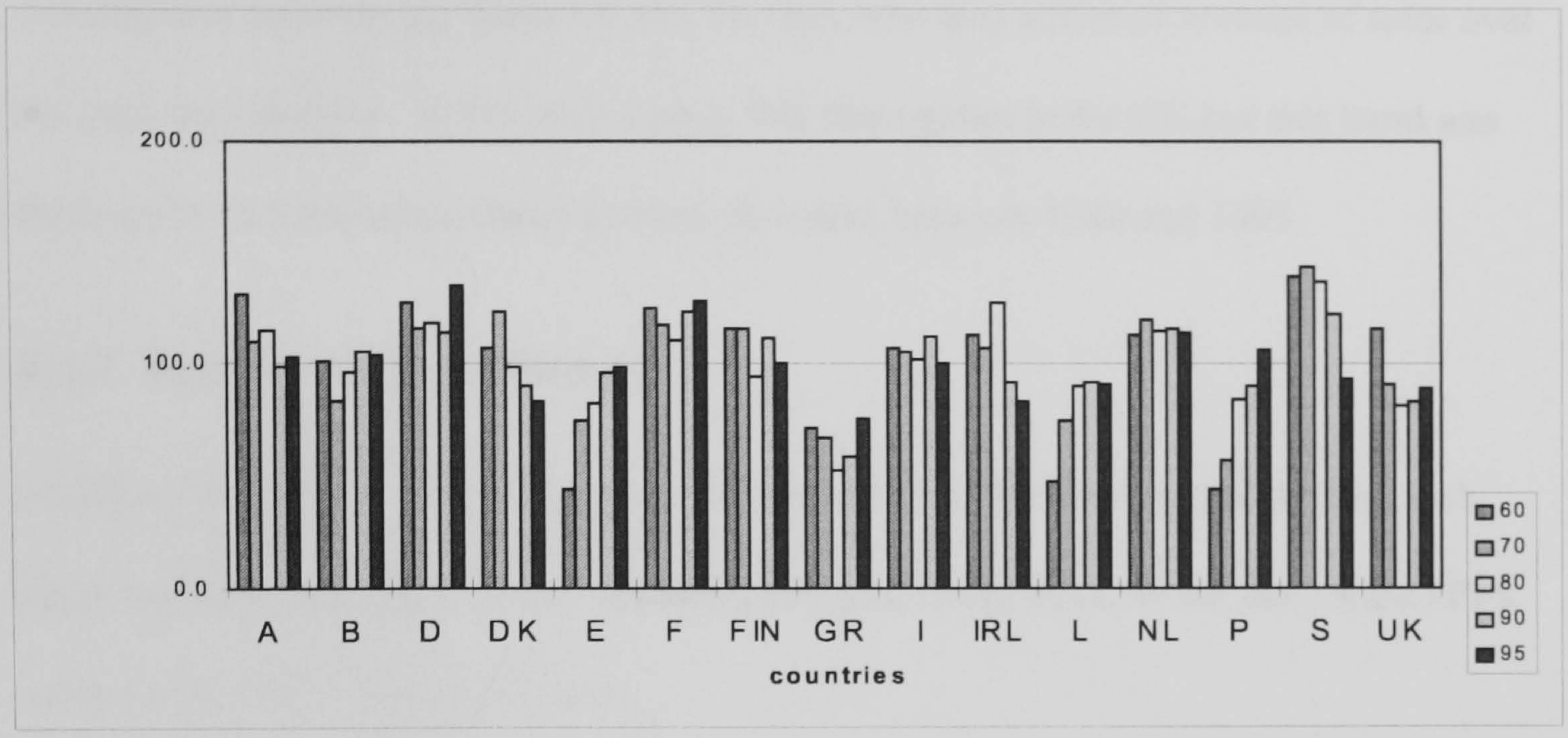
The results are illustrated graphically in Figures 3.7 and 3.8 below, which show which countries have been contributing most to the observed σ-*convergence*.

As can be seen from Figure 3.7, the principal countries conforming to the upward convergence scenario (over the whole period) for percentage of GDP are Spain and Portugal. Portugal has also conformed to the reversal of roles scenario as its values have gone from below the mean to above the mean in 1995. When examining countries which conform to the downward convergence scenario we see that this has occurred for Denmark, and Sweden (from 1965), both achieving the reversal of roles scenario from a position above to a position below the EU mean. Although all other countries exhibit periods of convergence or divergence, the above countries present themselves as being the ones to explain the majority of the observed σ-*convergence*.

If we now examine the situation for *per capita* expenditure, as shown in Figure 3.8, it is possible to observe similar trends but to varying degrees compared with percentage of GDP.

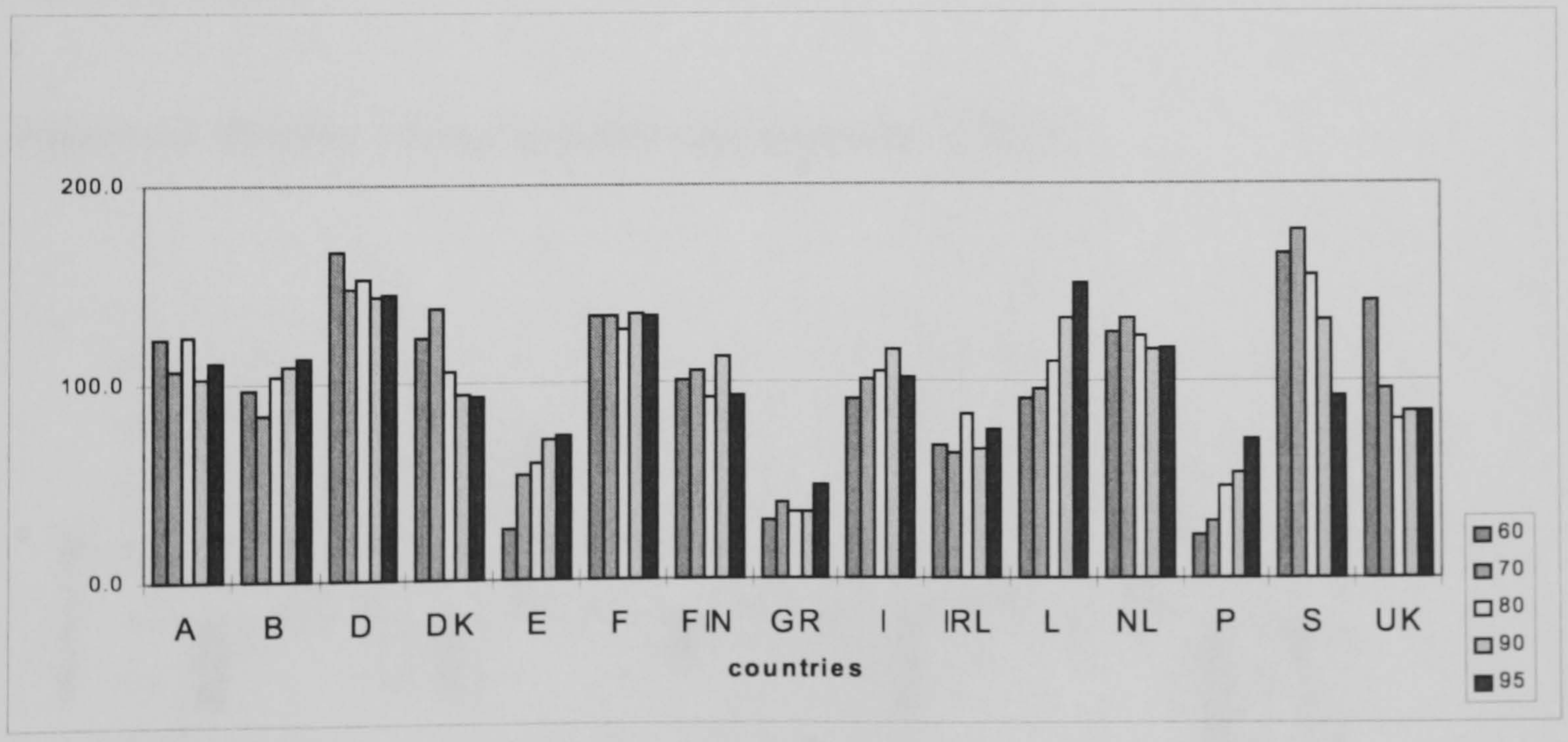
The countries conforming to upward convergence towards (and above) the mean are Belgium, Spain, Greece, Luxembourg and Portugal. However, for Spain, Greece, and Portugal the achieved convergence is less as their values in 1995 still remain well below the EU mean. In stark contrast, Luxembourg has *per capita* expenditure well above the EU mean after achieving the reversal of roles scenario. This reflects the relative strengths and weaknesses of member states' currencies relative to the size of their populations and their *per capita* GDP incomes.

Figure 3.7 Standardised health expenditure as a percentage of GDP, 1960-95



Spain, Greece and Portugal in particular exhibit relative weakness in this respect, whilst Luxembourg provides a good example of a country with a strong currency and high *per capita* income.

Figure 3.8 Standardised per capita spending on health in PPP$, 1960-95



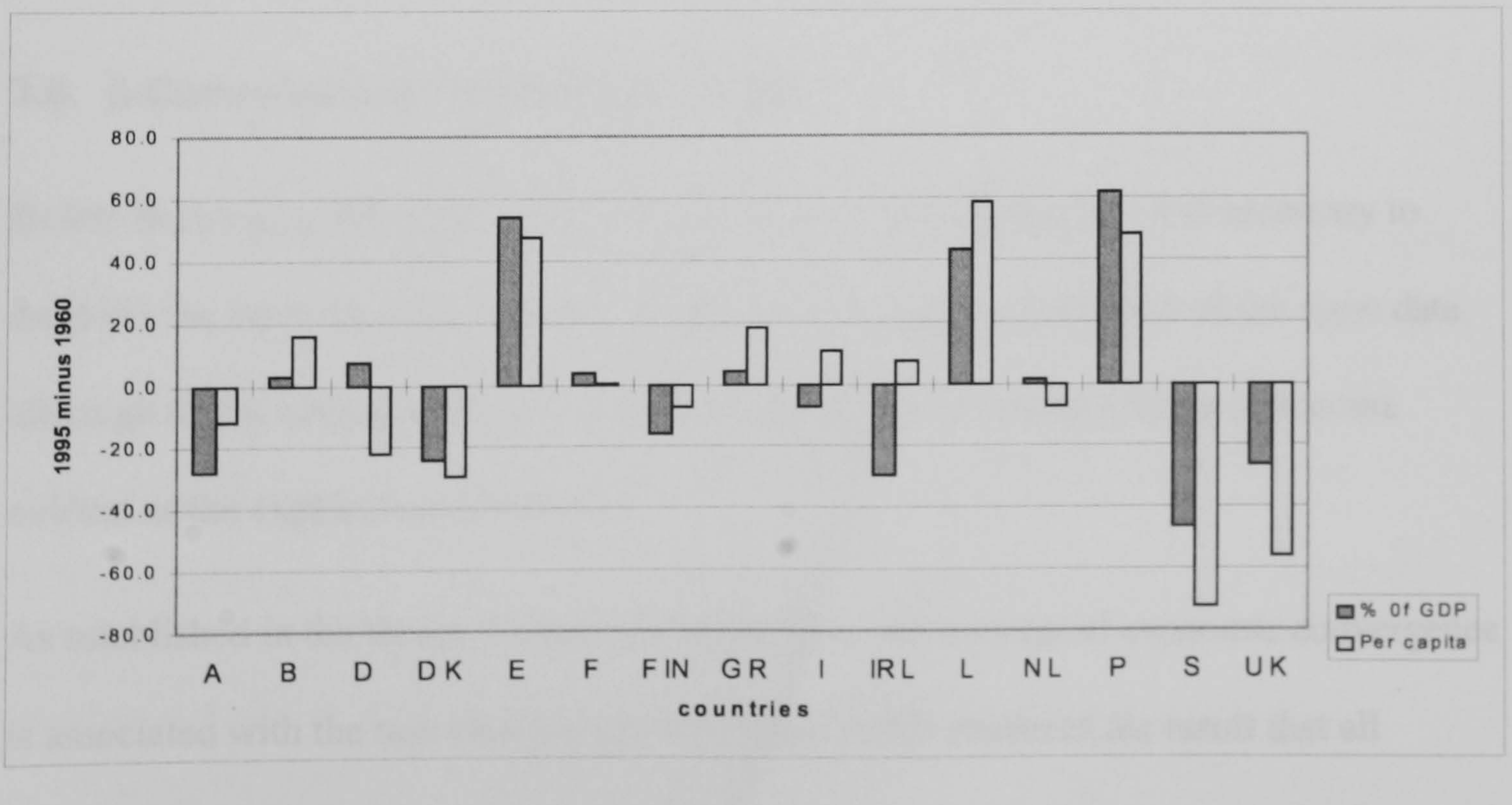
In a similar fashion to percentage of GDP, the countries which conform to the downward convergence scenario are Denmark and Sweden, who also achieved reversal of roles over the period of analysis. In the early stages, this also applies to the UK but this trend was reversed to upward convergence towards the mean between 1980 and 1995.

3.5.3 Relative change, 1960-95

Finally in this section, Figure 3.9 provides a snapshot of the relative changes that took place between 1960 and 1995 for spending as a percentage of GDP and *per capita* PPP$ values with respect to the EU mean.

The findings show that, with reference to the EU mean, there are countries which have reduced their expenditures, those which have increased their expenditures and those which have remained close to the EU mean. Countries which have achieved increased spending in both percentage of GDP and *per capita* PPP$ include Belgium, Spain, France, Luxembourg and Portugal. Countries which have achieved net reductions for both variables include

Figure 3.9 Relative change in health care spending, 1960-95



Austria, Denmark, Finland, Sweden and the UK. Both Italy and Ireland achieved a reduction in percentage of GDP spending but an increase in *per capita* PPPS. The countries, from these data, which achieved the smallest changes and therefore greatest stability would appear to be France and the Netherlands.

The above analyses have therefore established the methodology of *σ-convergence* which, when applied to health expenditure variables over the period 1960-95, reveal strong evidence for convergence. The method of standardising on a value of 100 and testing for statistically significant changes in the standard deviation is equivalent to the coefficient of variation approach. The F-test has also provided a means of testing the statistical significance of the results while the diagrams produced from the analyses show the direction of trends and explain the results in terms of Leonardi's scenarios and hypotheses.

This approach still remains, however, in the non-parametric category and therefore the following sections seek, by more rigorous parametric testing, to investigate the existence of *β-convergence*. This is necessary as a principal criticism of cross-sectional analysis is that it is disproportionately influenced by outliers and the approach over relatively long time periods cannot reflect trends in intervening years.

3.6. β-Convergence: theoretical issues

Before developing the methodology for the *β-convergence* approach it is necessary to establish the theoretical foundations of this form of parametric analysis of the same data, although this is conducted over a shorter period of time for reasons that will become evident as the explanation proceeds.

As established in the theory section of Chapter One, the concept of economic convergence is associated with the neo-classical growth model which produces the result that all countries with a high degree of homogeneity tend to a common level of capital and income *per capita*. This model leads to a relationship similar to:

$$y_{t+k} = f[y_t] \qquad (1)$$

where y_t is the logarithm of income, and there is a unique stable value of $y = y^*$, such that $y^* = f[*]$. In empirical studies on convergence a common practice is to take a linearised form of equation (1) such as:

$$y_{t+k} - y_t = f[y_t] - y_t = \alpha + \beta\, y_t \qquad (2)$$

and regress $y_{t+k} - y_t$ on y_t using country cross-sectional data of two periods separated by a time interval of k-years. Following Baumol (1986), the literature has defined *β-convergence* as requiring that the estimated coefficient β is negative, $\beta<0$, treating $\beta\geq0$ as the no convergence null hypothesis. This implies that the difference of logarithms in the left-hand side of equation (2), which is the growth rate in (*per capita*) income over the k-year period, is negatively correlated with the starting level of incomes[2]. However, $\beta<0$ does not necessarily guarantee that the variance of dependent variable is lower at the end of the period than at the beginning (Chatterji, 1992). The condition that the variance is lowering and the set of countries will converge to a steady state where y is equalised requires that $-2<\beta<0$. Therefore, two types of *β-convergence* are identified: weak convergence with $\beta<0$ and strong convergence with $-2<\beta<0$.

The literature also makes a further distinction between absolute (unconditional) and conditional convergence. Absolute convergence pertains to the coefficient β of the bivariate equation (2) which is based on the assumption that all countries in the sample

[2] For conceptual problems associated with this type of regression see Bliss (1999).

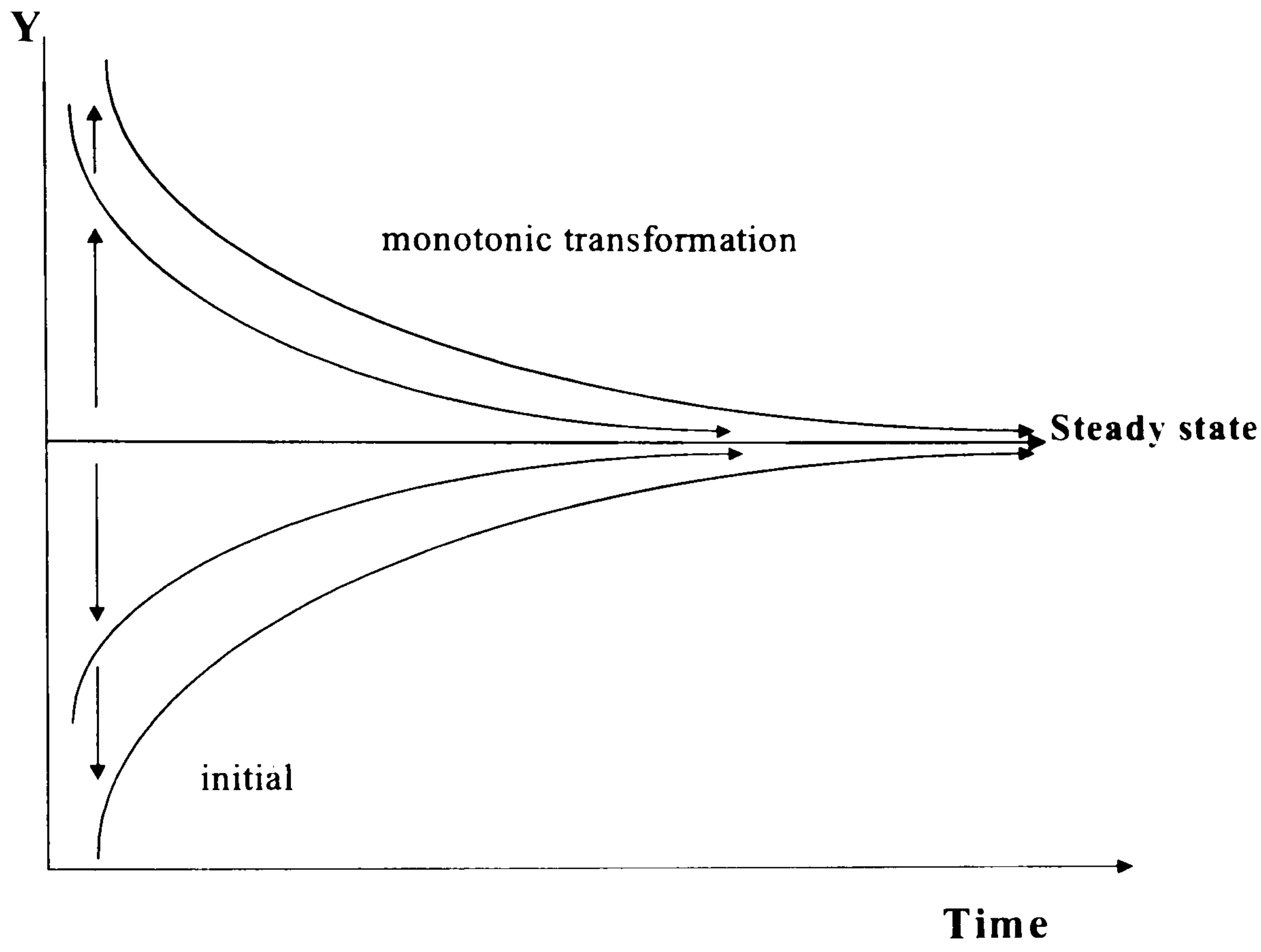
converge to the same steady state. Figure 3.10 illustrates the case of *absolute convergence* for countries which begin with different initial conditions but reach a common steady state in the long run (regression to the mean).

Conditional convergence pertains to the coefficient β of the variable y (partial derivative) in an equation which includes additional explanatory variables reflecting differences across countries which direct each economy to converge to its own steady state. Using Figure 3.10 as a reference, steady states would be reached at differing levels above or below the mean, resulting in convergence 'clubs' (Chatterji, 1992). In both cases the convergence hypothesis is that the growth rate of an economy will be positively related to the distance that separates it from its steady state. However, in empirical research, since *a priori* and objectively it is not known which countries are homogeneous or heterogeneous with regard to convergence both types of convergence are estimated (and in general both are confirmed: Sala-i-Martin, 1996).

The chosen sample consists of the EU countries which aspire to establish an economic union without regional or national boundaries. But at the moment the EU members differ both in their initial conditions and in their potential for reaching a steady state which will be common to all of them. Therefore, both types of β-*convergence* are the relevant concept for examination.

The empirical literature usually begins with the values of the variable under study, such as GDP, at a base year, t, and examines whether convergence has occurred at the end of subsequent time intervals, t+k, t+2k, etc.

Figure 3.10 Graphical representation of absolute convergence



This procedure may give rise to inconsistencies and spurious results arising from the arbitrary choice of a base year and the untraceability of the path of convergence through the time interval k-t and the inability of the employed technique to distinguish different patterns of convergence and no-convergence for different members of the cross-sectional set (Bernard and Durlauf, 1996).

The following approach takes into account both of these points.

3.6.1 β-convergence: study methods

Due to the limitations of data availability from the OECD data set and the need to utilise longitudinal data in the chosen approach to measure β-*convergence*, the period 1980-95 is examined using annual observations. This method also overcomes some of the limitations in the cross-sectional data analysis applied to the σ analyses in the previous sections.

Therefore, a panel data set is used which consists of 16 time-series observations for each of the 15 cross-sectional units, the EU member states.

To take account of both the intertemporal pattern of convergence and the cross-sectional variety of the EU countries, absolute convergence is specified by the equation:

$$X_{t+1,i} - X_{t,i} = \alpha + \beta X_{t,i} + \gamma D_i + \delta X_{t,i} D_i + \varepsilon_i$$

or

$$X_{t+1,i} = \alpha + (1+\beta) X_{t,i} + \gamma D_i + \delta X_{t,i} D_i + \varepsilon_I \qquad (3)$$

And conditional convergence by the equation

$$X_{t+1,i} = \alpha + (1+\beta) X_{t,i} + \zeta Y_{t,i} + \gamma D_i + \delta X_{t,i} D_i + \varepsilon_i \qquad (4)$$

where $X_{t,i}$, and $X_{t+1,i}$ are the natural logarithms of a measure of health care expenditure of an EU member state, $Y_{t,i}$ is a vector of variables that hold constant the steady state, subscript i=1, ...15 denotes the country and subscript t denotes the year. The set of dummy variables, D_i, for each cross-sectional unit, i, are included both as shift parameters, γ, and as slope parameters, δ, to reflect the potential spatial heterogeneity between the EU countries, that is differences in preferences and national health care expenditure policies.

In this case, the variable Y_i denotes real income *per capita* which previous research has confirmed as the most important determinant of health care expenditure (Newhouse, 1977). Since, equations (3) and (4) are standard difference equations, stability requires $-2<\beta<0$ which is the condition for strong β-*convergence*. Estimates of $\beta=0$ would imply a unit root process with t-statistic having an asymmetric non-standard distribution (Abadir, 1995), while $\beta>0$ would signify divergence.

In this analysis both absolute and conditional convergence are tested for using the previous measures of total expenditure on health, denoted here to accommodate the regression equations as: X^y = health care expenditure as a percentage of GDP, which is independent of the units of measurement; and X^h = health care expenditure *per capita*. Both variables (defined in Chapter 2.3) are taken as ratios of the EU mean, consistent with the σ analysis.

Therefore, the hypothesis testing for absolute convergence can be specified formally as:

$\mathbf{H_o = \beta \geq 0}$

$\mathbf{H_A = \beta < 0}$ as specified in equation (3)

And conditional convergence as:

$\mathbf{H_o = \beta \geq 0 \mid Y}$

$\mathbf{H_A = \beta < 0 \mid Y}$ as specified in equation 4 (Y being the conditioning variables)

Statistical significance being determined at $\alpha = 0.05$.

For the estimation, the time-series data of the 15 EU countries were pooled to form a sample of 240 observations (15-countries x 16-annual observations in real PPP$ 1990 values: OECD/CREDES, 1997), thus making use of both cross-section/long-run and time-series/short-run information[3]. However, lagging once for the calculation of $X_{t,i}$ reduces the sample used in the estimation to N=225 observations. Given the limited size of the data set, the analysis started from a general specification of absolute convergence, equation (3), containing the basic explanatory variable $X_{t,i}$ and 14 shift dummy variables D_i, one for each

[3] An alternative approach for the analysis of the times series tendency for convergence could be to test the stationary process of the relevant variable across countries, Bernard and Durlauf (1995). However, while this technique can be implemented fruitfully to the available long time series of income, the health care time series are too short to allow for valid application of these asymptotically based tests (Blomqvist and Carter, 1977).

Table 3. 3 Estimated coefficients of health care expenditure β-convergence

Coefficient	(1) X^y	(2) X^y	(3) X^h	(4) X^h
Constant α	- 0.011	- 0.011	- 0.001*	0.002*
	(0.003)	(0.003)	(0.002)	(0.002)
coefficient (1+β)	0.893	0.893	0.973	0.936
	(0.021)	(0.021)	(0.009)	(0.014)
income ζ		- 0.004*		0.091
		(0.011)		(0.018)
Dummy Variables (shift)	0.023 B	0.023 B	0.012 F	- 0.020 DK
	(0.008)	(0.008)	(0.006)	(0.005)
	0.044 D	0.042 D	0.026 L	0.033 P
	(0.011)	(0.012)	(0.007)	(0.016)
	0.041 F	0.041 F		
	(0.008)	(0.008)		
	0.026 NL	0.026 NL		
	(0.007)	(0.007)		
R^2 (Buse)	0.613	0.614	0.727	0.773
R^2 (observed/predicted)	0.967	0.967	0.987	0.985
β-coefficient	- 0.107	- 0.107	- 0.027	-0.064
	(0.021)	(0.021)	(0.009)	(0.014)
Wald $\chi^2_{(1)}$ test for β=0	25.715	25.766	9.056	20.39

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equations (1) and (2) refer to health care expenditure as a share of GDP, X^y; equations (3) and (4) refer to health care expenditure *per capita*, X^h. The country dummy variables (as in footnote 1) are shift dummies.

of the EU member states, with the UK as the 15th country being utilised as the reference intercept. After the first round of estimations[4], the model was simplified on the basis of the

[4] The econometric software package SHAZAM was used in conjunction with a method of estimation which takes account and corrects econometric problems arising from the nature of the data in the pooled set of country data, which is expected to be cross-sectionally correlated and time-wise autoregressive (Kmenta, 1986).

estimated coefficients of the dummy variables, their t-statistics and acceptability of other diagnostic tests. The slope dummy variables were then inserted and a process of elimination undertaken in order to arrive at a parsimonious model which provided the estimated equation (1) in Table 3.3.

3.6.2 Results for β-convergence

Overall, the estimation yielded high goodness-of-fit statistics[5] and statistically significant coefficients of the explanatory variables. In particular, the beta coefficient is negative and statistically significant with value $\beta = -0.107$ and (95% confidence interval: $-0.148 < -0.107 < -0.066$). The Wald test statistic also confirms that $\beta<0$. Therefore, strong convergence is confirmed.

The statistical significance of the shift dummy variables presented provides evidence of some diversity across the EU countries in the steady state but not in the speed of convergence since the slope dummies are found non-significant. On the whole, the results satisfy the strong conditions for convergence in the share of health expenditure on national income across the fifteen members of the European Union over the time period estimated[6]. Equation (2) in Table 3.3 presents the estimates for conditional convergence of the same dependent variable. The estimated coefficient of the income variable is statistically non-significant. Therefore, it is possible to conclude that the hypothesis of conditional convergence is rejected: the EU countries are moving towards a common steady state of health care expenditure as a ratio of national GDP.

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[5] For the estimation, the data are transformed and, therefore, the usual goodness of fit statistics are inappropriate. R_1^2, the Buse R-square was therefore used which measures the part of the generalised sum of squares attributable to the influence of the explanatory variables (Buse, 1973), and R_2^2, the R-square between observed and predicted values of the dependent variable.

[6] The results here contrast with those reached by other authors, such as Hitiris (1997), who have argued that the real differences in the health care policies of the EU member states mean that convergence in health care is still some way off and, therefore, economic integration in health care expenditure must be speeded up by harmonisation.

A similar procedure was followed in the estimation of absolute convergence of health care expenditure *per capita* and the parsimonious equation (3) in Table 3.3 was obtained. Once again, the overall explanatory power of our model is high and the estimated coefficients are statistically significant.

The statistically significant shift dummy variables identify only France (F) and Luxembourg (L) as deviating from the general pattern of the EU countries. On the whole, the results provide evidence of strong absolute convergence of *per capita* health care expenditure across the EU countries with $\beta = -0.027$ (95% confidence interval $-0.044 < -0.027 < -0.009$). Therefore, the speed of convergence is rather low: starting from the 1995 expenditure levels and EU mean, it would take Greece 28 years to come up, and Luxembourg 15 years to come down to the EU mean.

The results for conditional convergence are presented in Table 3.3, equation (4). They are also statistically significant with the value of $\beta = -0.064$ (confidence interval $-0.092 < -0.064 < -0.036$). Therefore, the health care expenditure per capita also displays strong conditional convergence across the EU countries[7].

3.7. Health care system and convergence

In this section, the question of whether convergence is associated with health care system, under a tripartite economic classification, of the EU countries is examined.

As indicated in Chapter One, the health care system different EU countries operate is ether NHS, which is characterised by universal coverage, tax financing and public provision; or

[7] The finding of absolute and conditional convergence is not contradictory if the common steady state and the national steady states follow a parallel course. Income *per capita*, Y, which reflects the differences among the EU countries, also displays strong convergence with $\beta = -0.019$ (standard error 0.009). This is comparable to the results obtained by other investigators who have found speed of convergence 2% per year ($\beta = -0.020$) for the OECD countries (Mankiw et al., 1995; Barro *et al.*, 1995; Sala-i-Martin, 1996).

SI, which is characterised by compulsory universal coverage, financed by employer and employee contributions through non profit insurance funds, and public and/or private providers. The former is more centralised than the latter and, therefore, potentially more effective with regard to controlling the growth of health care expenditure. In refining the classifications of Chapter One with regard to economic criteria, of the 15 EU member states, it is possible to identify six relatively wealthy countries that operate the NHS system (DK, I, IRL, FIN, S, UK) and six the SI system (A, B, D, F, L, NL). The three relatively poorer member states (E, GR, P) have also adopted the NHS system but rather lately and, due to their limited availability of resources, are still in the process of developing it[8]. Here, convergence is tested for under this tripartite classification. Given the nature of the two systems and the current pressures for controlling health care expenditure, which is mainly determined by the level of *per capita* income, it is reasonable to expect that the NHS countries display lower health care expenditure than the SI countries, while the LI group might be still striving to allocate more resources to health care. The results of these estimations are presented in Table 3.4.

On the whole they confirm the above-described expectations: the SI and Lower Income (LI) NHS groups of countries are shown with a higher steady state level of health care expenditure (shift dummies) than the NHS countries. Otherwise, the speed of convergence, the β coefficient, is common to all the groups with none of the slope dummies found to be statistically significant.

[8] Ireland (IRL) is also included among the developing EU countries with regard to income *per capita* but its NHS system is relatively advanced.

Table 3.4 Health Care System and Convergence

Coefficient	(1) X^y	(2) X^y	(3) X^h	(4) X^h
constant α	- 0.010	- 0.010	- 0.007	- 0.013
	(0.004)	(0.004)	(0.003)	(0.004)
coefficient (1+β**)**	0.953	0.953	0.956	0.917
	(0.017)	(0.019)	(0.016)	(0.019)
income ζ		- 0.015*		0.079
		(0.018)		(0.019)
Social Insurance Dummy, SI	0.017	0.013	0.018	0.022
	(0.008)	(0.006)	(0.006)	(0.006)
Lower Income Dummy, LI	0.017	0.024	0.009*	0.015*
	(0.005)	(0.011)	(0.013)	(0.013)
R^2 (Buse)	0.608	0.626	0.688	0.754
R^2 (observed/predicted)	0.958	0.957	0.987	0.987
β-coefficient	- 0.046	- 0.047	- 0.044	-0.083
	(0.017)	(0.018)	(0.016)	(0.019)
Wald $\chi^2_{(1)}$ test for β=0	7.374	6.323	7.595	19.994

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equations (1) and (2) refer to health care expenditure as a share of GDP, X^y; equations (3) and (4) refer to health care expenditure *per capita*, X^h. The countries in the shift dummies are: SI=A, B, D, F, L, NL; and LI=E, GR, P.

The health care expenditure as a percentage of GDP verifies that absolute convergence is occurring (equation 1) with β = - 0.046 (95% confidence interval - 0.079<-0.046<-0.013) while conditional convergence is not (equation 2). The shift dummy for the LI group of countries is statistically significant in both cases (but not different from that of the SI countries under absolute convergence). Similar results were obtained for expenditure *per* *capita*. Both absolute (β = -0.044, 95% confidence interval = -0.075<-0.044<-0.013) and conditional (β = -0.083, 95% confidence interval = -0.12<-0.083<-0.046) convergence occur but without a significant difference between the LI NHS group and the NHS group. The speed of absolute convergence is β = - 4.4 % annually. The results for conditional convergence (equation 4) confirm the patterns already detected, that the SI group of countries spend more on health care than the LI NHS and the NHS groups.

3.8. Graphical representations of β-convergence

The trends relating to the above analyses are represented in Figures 3.11 to 3.25 which show percentage of GDP, *per capita* health spending and *per capita* income for each of the 15 countries in the EU. Figure 3.26 shows health expenditure as a percentage of GDP for the group of SI countries, the group forming the NHS (with high incomes) countries and the (LI) NHS countries. Figure 3.28 shows *per capita* health expenditure for the same groups of countries, and Figure 3.29 shows *per capita* income again for the three groups of countries.

The countries which conform most closely to the equivalent growth hypothesis are Austria (Figure 3.11), the Netherlands (Figure 3.22) and the UK (Figure 3.25). It is interesting to note that in the case of the Netherlands, *per capita* income is below both expenditure as a percentage of GDP and *per capita* health expenditure, whilst for the UK this situation is reversed with *per capita* income being above both variables for health expenditure. The *per capita* income of Greece (Figure 3.18) also displays almost parallel growth with the EU mean.

The upward convergence scenario is evident for Spain (Figure 3.15), Greece (Figure 3.18), Ireland (Figure 3.20) (*per capita* income and *per capita* health expenditure) and Portugal

(Figure 3.23). For *per capita* income and *per capita* expenditure all these countries have values well below the EU mean for the majority of the period examined. Figure 3.20 shows that Ireland has achieved considerable upward convergence in *per capita* income, indicating a strengthening economy from the mid 1980s.

The downward convergence scenario is evident for Sweden for all three variables, achieving reversal of roles in the case of *per capita* expenditure and percentage of GDP in the mid 90s. For percentage of GDP, Ireland (Figure 3.20) experienced downward convergence until 1988 when reversal of roles occurred. From 1993, Belgium experienced downward convergence towards the mean for all three variables and France also experienced this scenario for *per capita* income. From 1991, Finland (Figure 3.17) also converged down towards the EU mean for percentage of GDP and reversal of roles to a position below the mean for both *per capita* expenditure and a little earlier for *per capita* income. Italy (Figure 3.19) has also converged down towards the mean for all three variables since 1991. Finally, the UK (Figure 3.25) experienced downward convergence for *per capita* income from 1997 and reversal of roles occurred in 1991.

In summary the trends indicated in Figures 3.11 to 3.25 show that all countries forming the LI (NHS) group (Spain, Portugal and Greece) are converging upwards towards the EU mean in terms of share of GDP, confirming increased effort at the policy level. Portugal, from this group, has achieved reversal of roles and in 1995 was allocating above the EU mean. The high income NHS countries are converging mostly downwards to a position on or below the EU mean. The most striking differences, however, are apparent in *per capita* expenditure as all the SI countries achieve *per capita* expenditures above the EU mean. In contrast, LI (NHS) countries are well below the mean although they are all converging towards the mean over the period examined. Again, NHS countries are converging to a point on or below the EU mean with Sweden experiencing the greatest degree of downward convergence over the period of analysis.

Figures 3.26 to 3.28 summarise the overall findings according to the groupings used.

Figure 3.26 confirms that at the policy level the SI countries have remained 20 to 30% above the standardised mean over the period of analysis and appear to be continuing to diverge upwards in recent years.

The NHS group (high income) is generally following a path just below the EU mean with some downward convergence away from the mean which is to be expected due to the influence of the downward convergence of the Scandinavian countries of Denmark and Sweden.

The LI (NHS) countries have, over the period of analysis, been below the NHS countries and exhibiting some downward divergence before following an upward convergence trend in the last few years of analysis.

Figure 3.27 shows almost identical patterns for *per capita* spending and Figure 3.28 reveals the differences in *per capita* income with the SI countries being well above the standardised mean, the NHS countries are at a point around 90% of the EU mean and the LI (NHS) countries at a figure of 80% although in the last five years of analysis the figure is diverging below the EU mean to approximately 75%.

Figure 3. 11 Health expenditure and per capita income - Austria

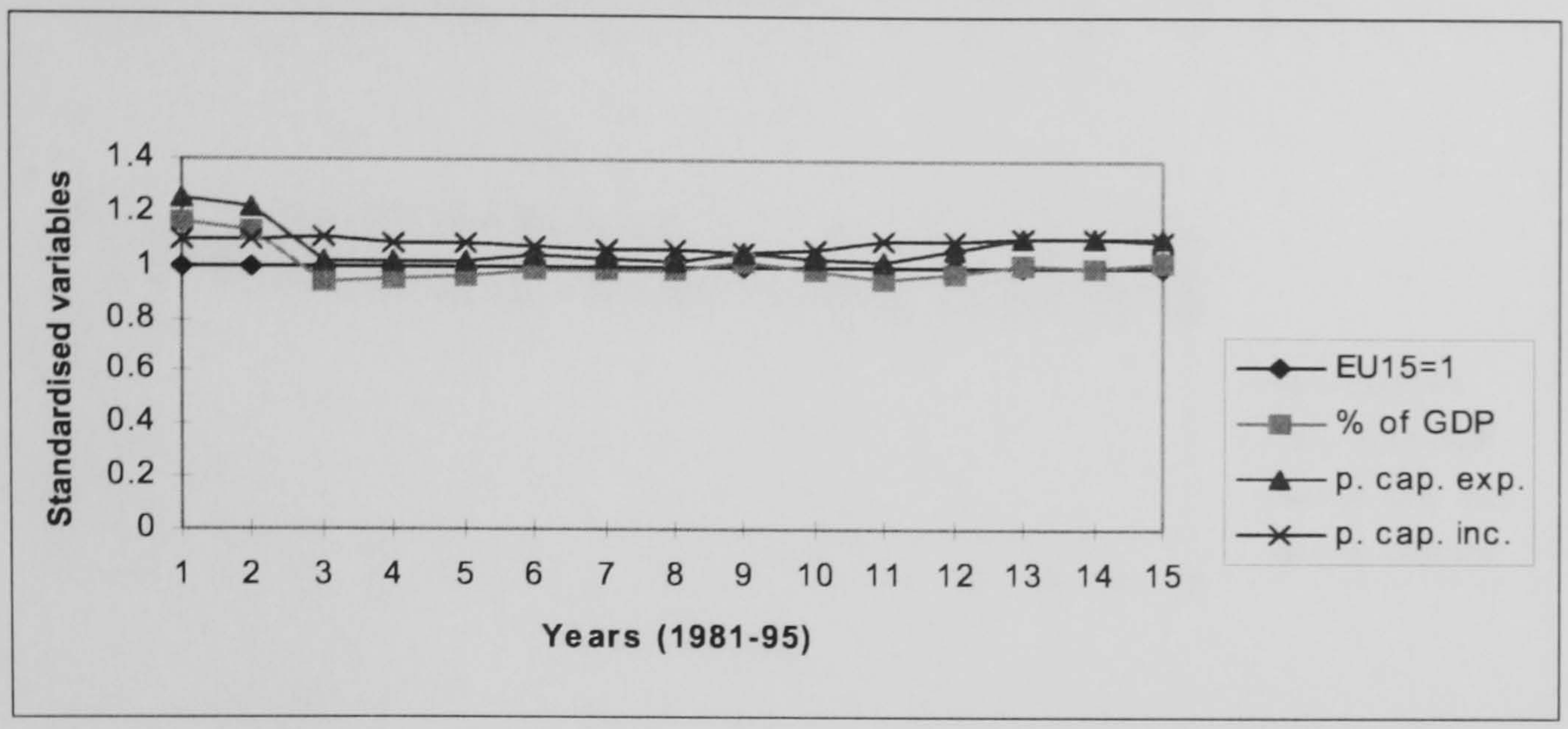


Figure 3.12 Health expenditure and per capita income - Belgium

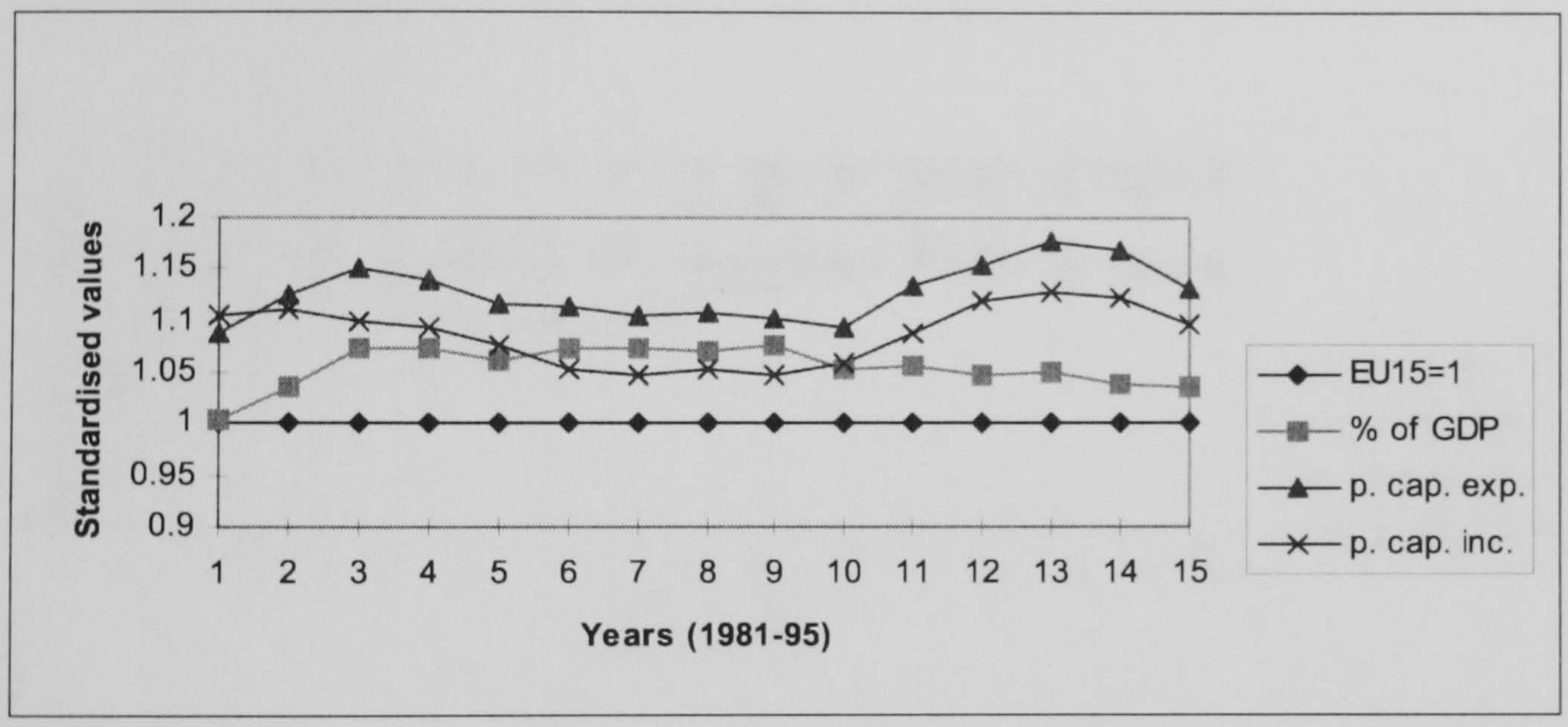


Figure 3.13 Health expenditure and per capita income - Germany

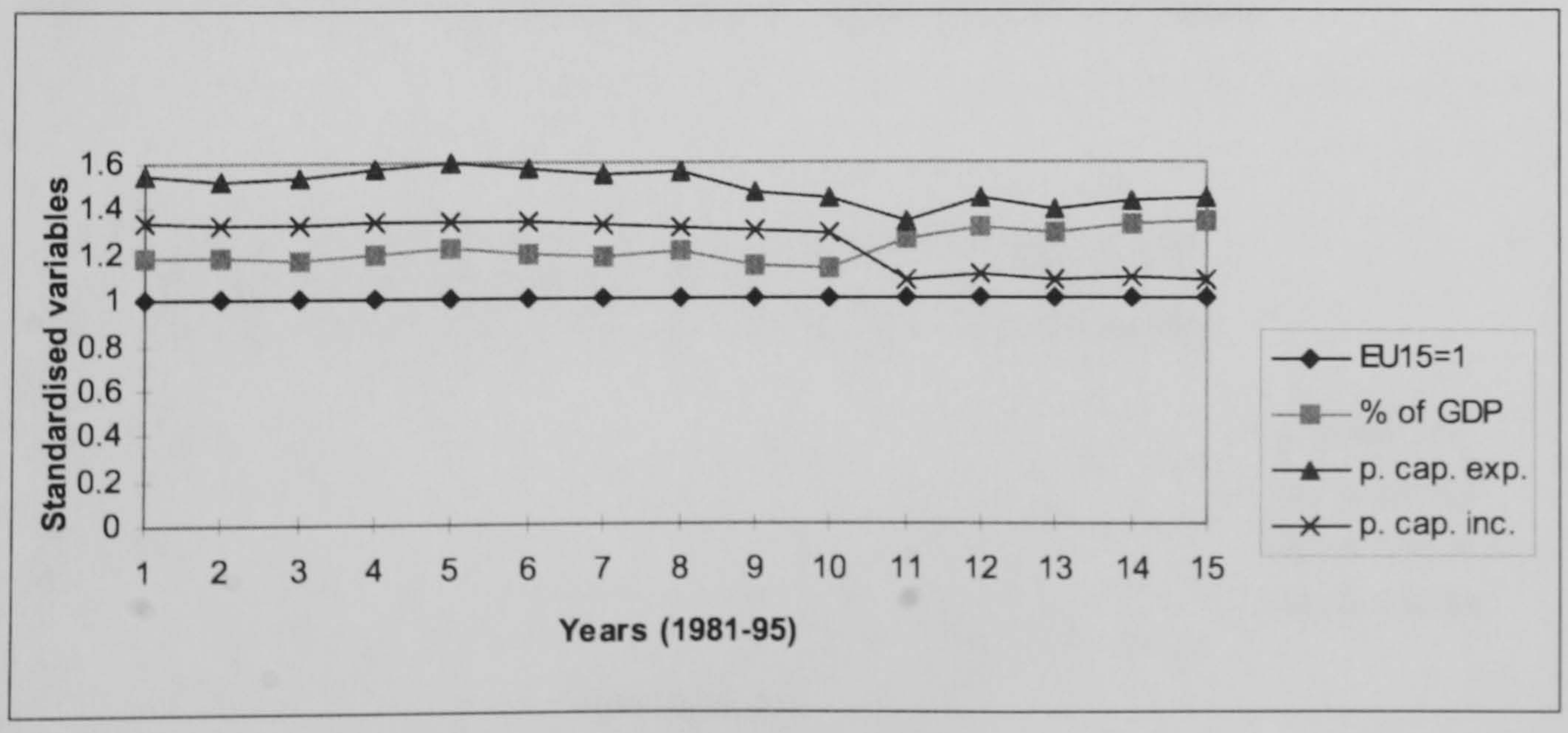


Figure 3.14 Health expenditure and per capita income - Denmark

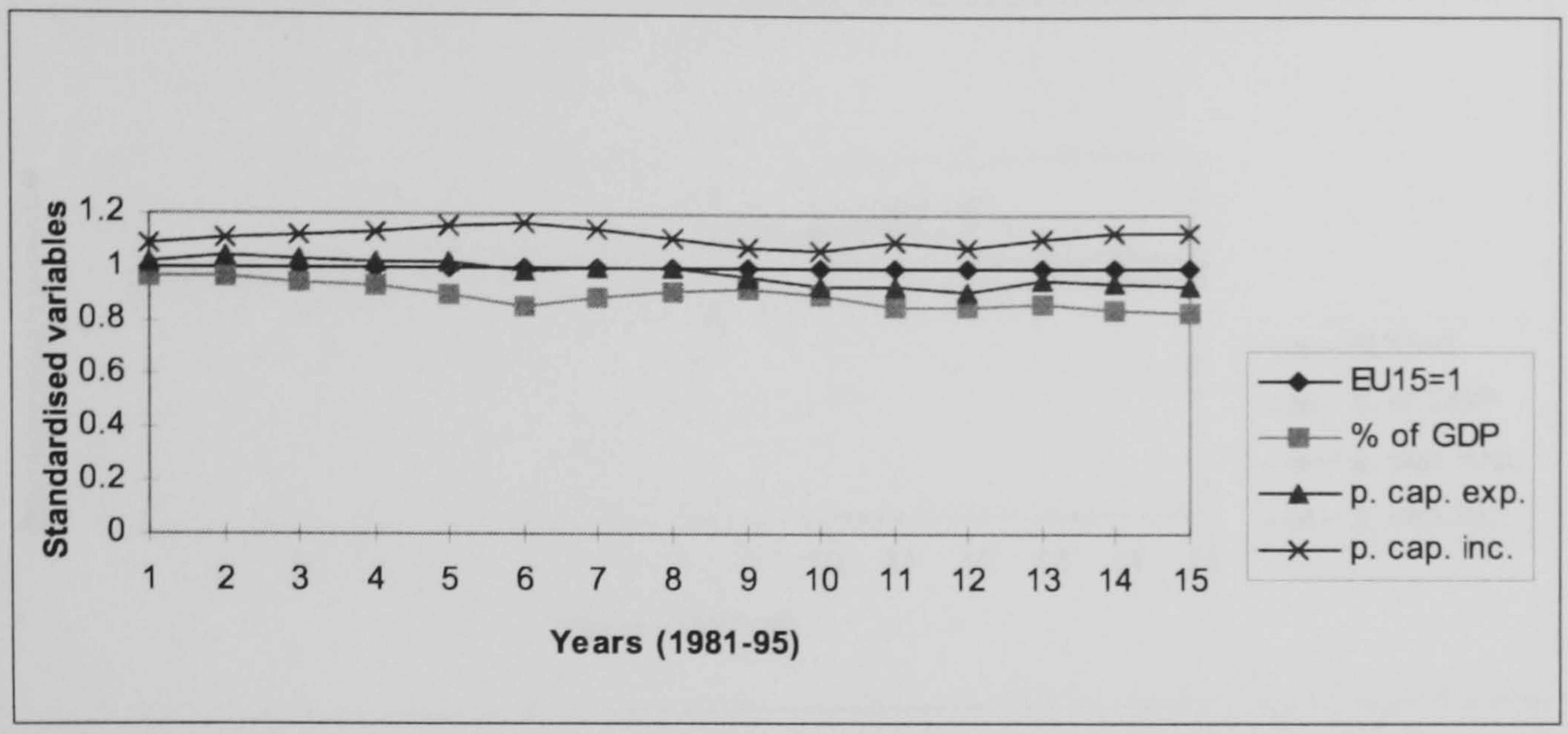


Figure 3.15 Health expenditure and per capita income - Spain

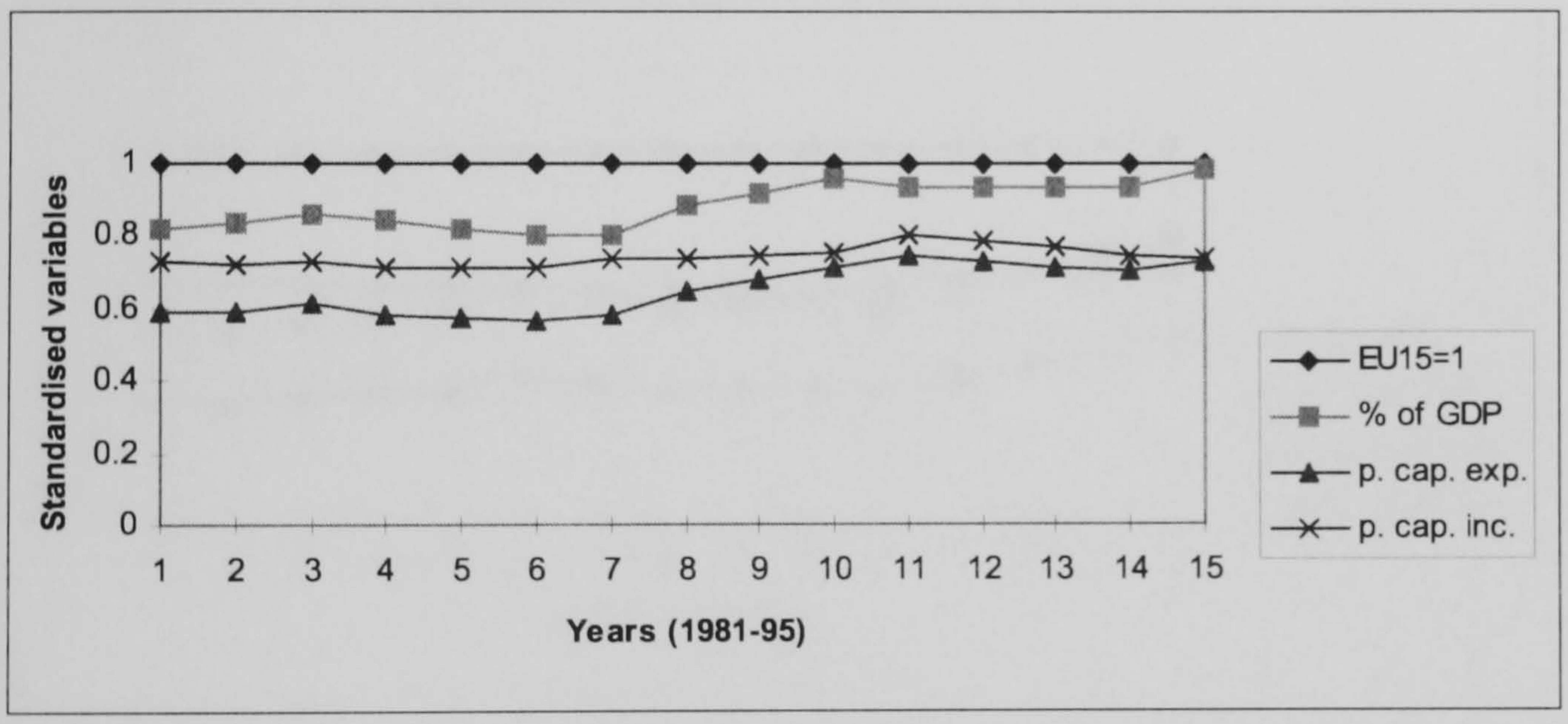


Figure 3.16 Health expenditure and per capita income - France

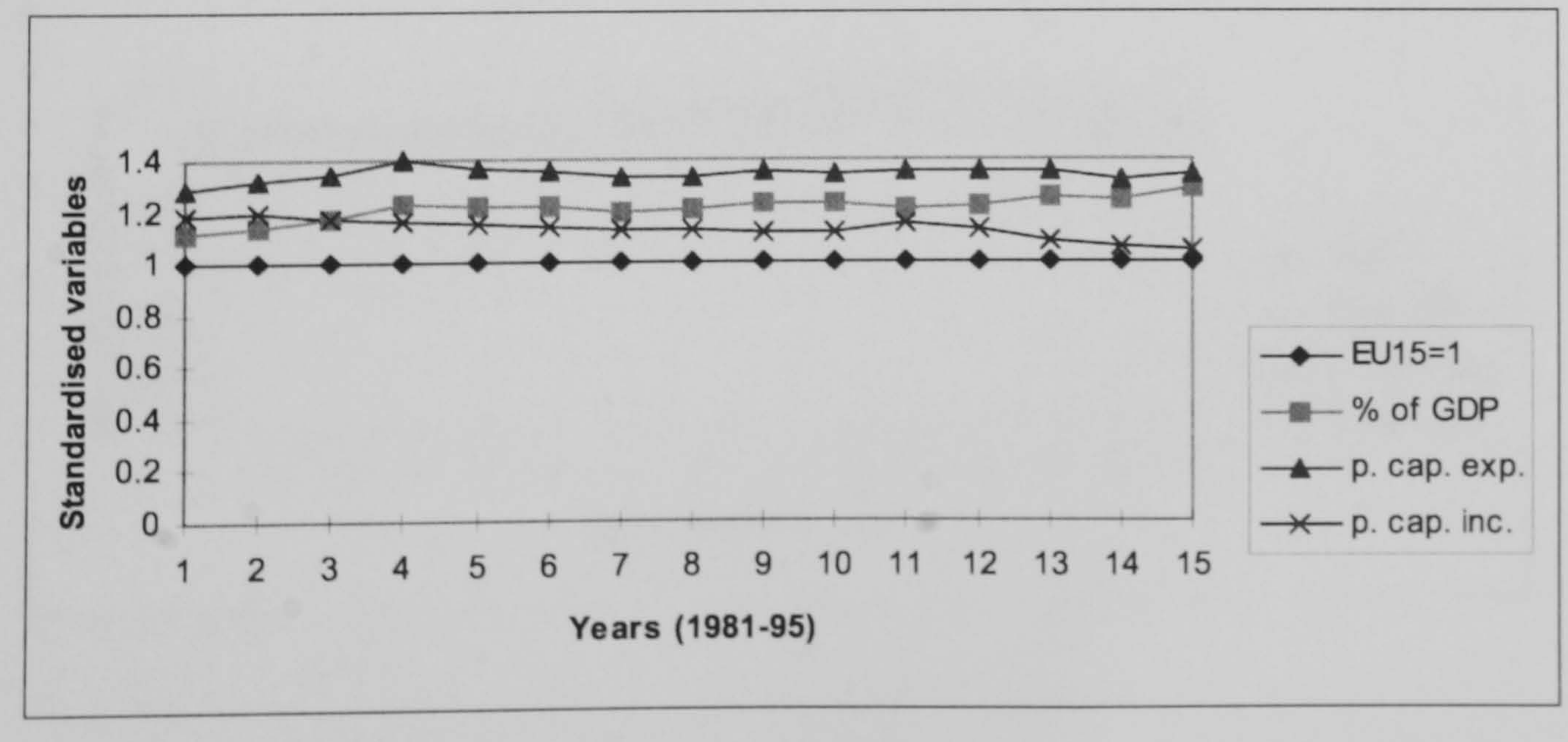


Figure 3.17 Health expenditure and per capita income - Finland

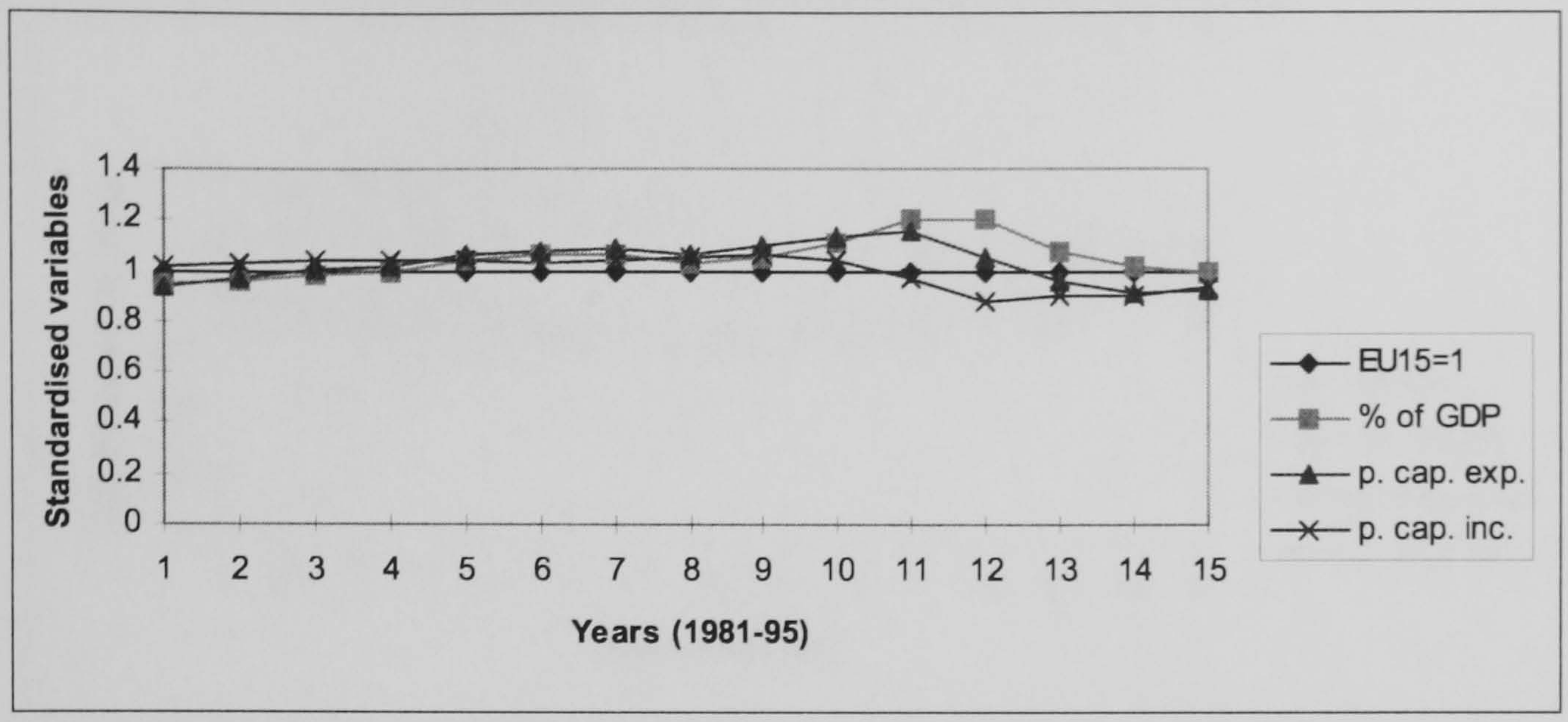


Figure 3.18 Health expenditure and per capita income - Greece

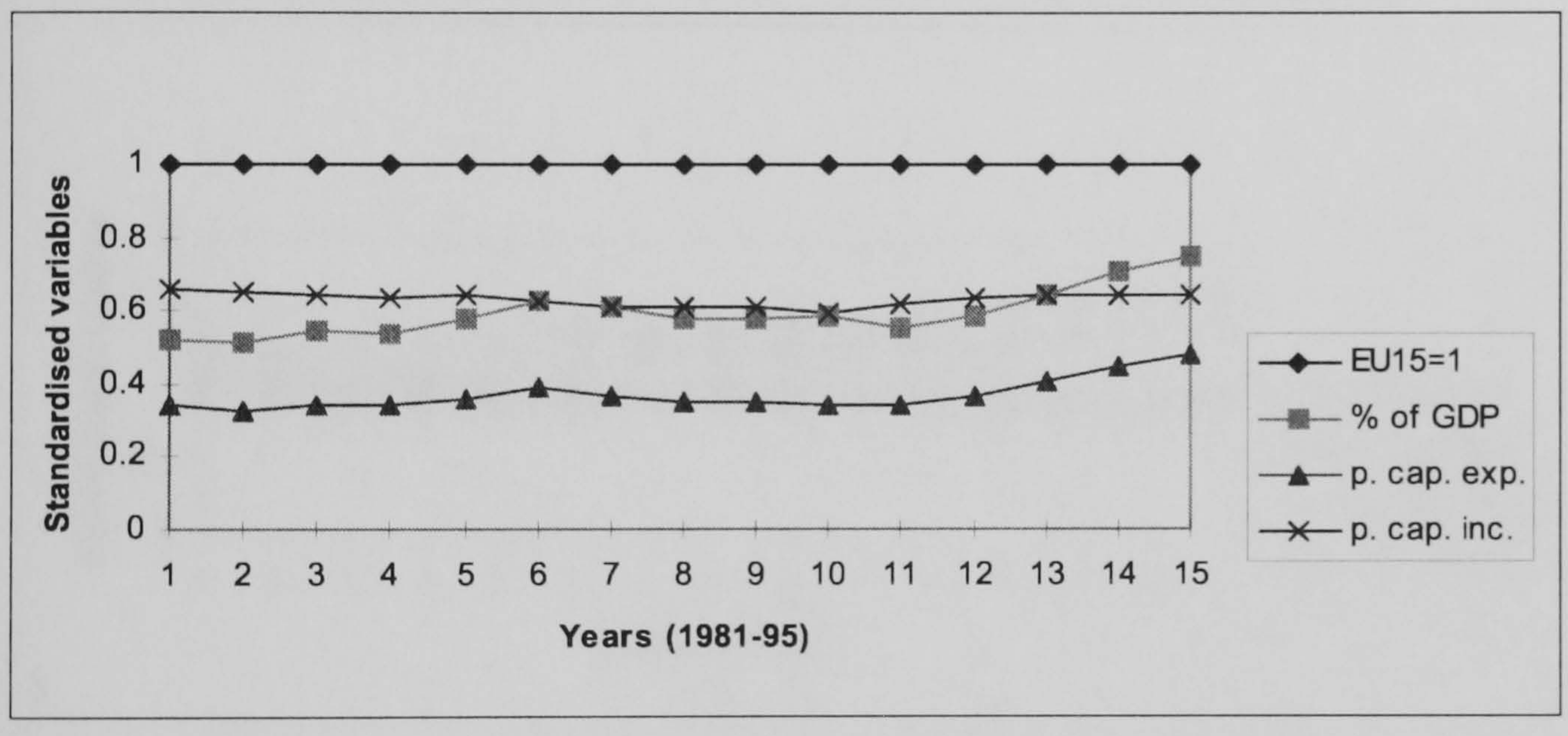


Figure 3.19 Health expenditure and per capita income - Italy

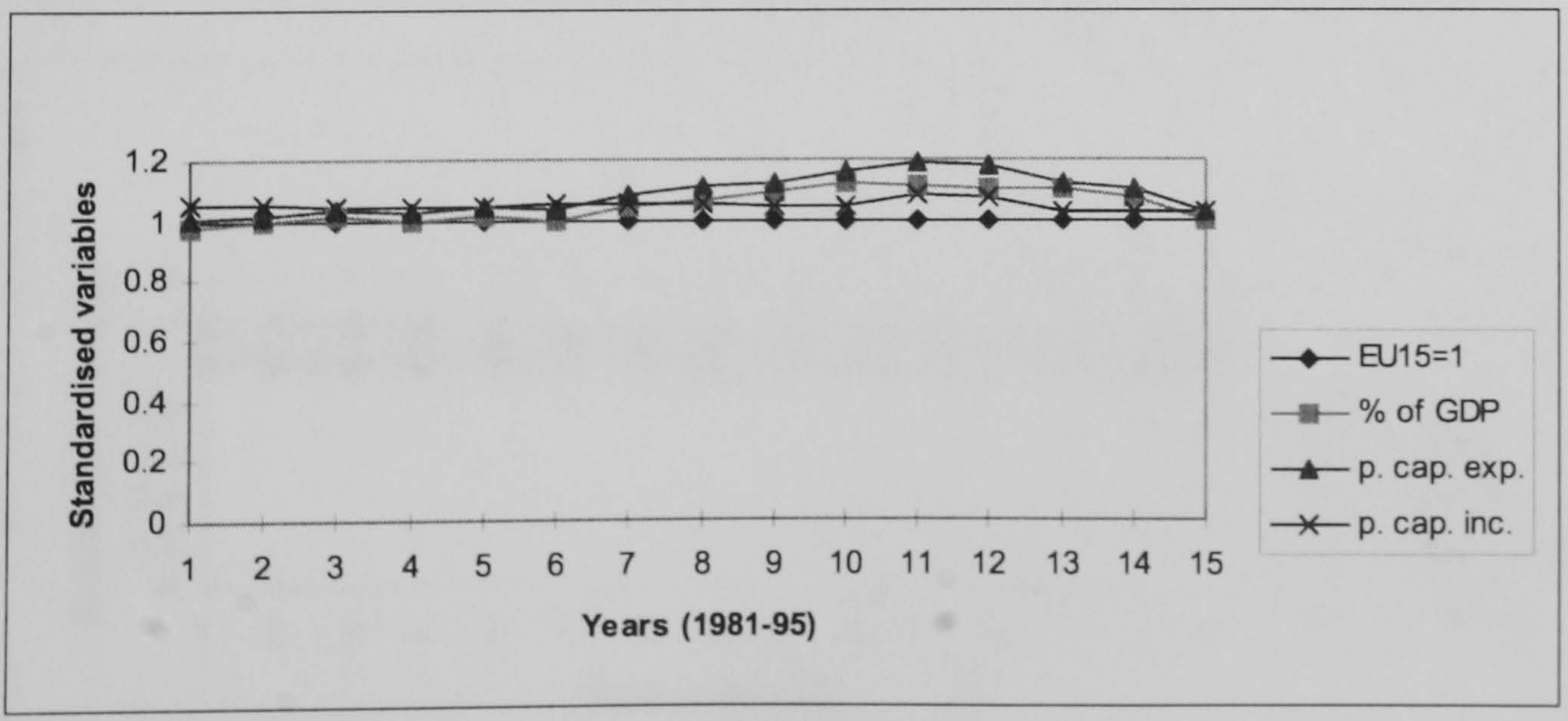


Figure 3.20 Health expenditure and per capita income - Ireland

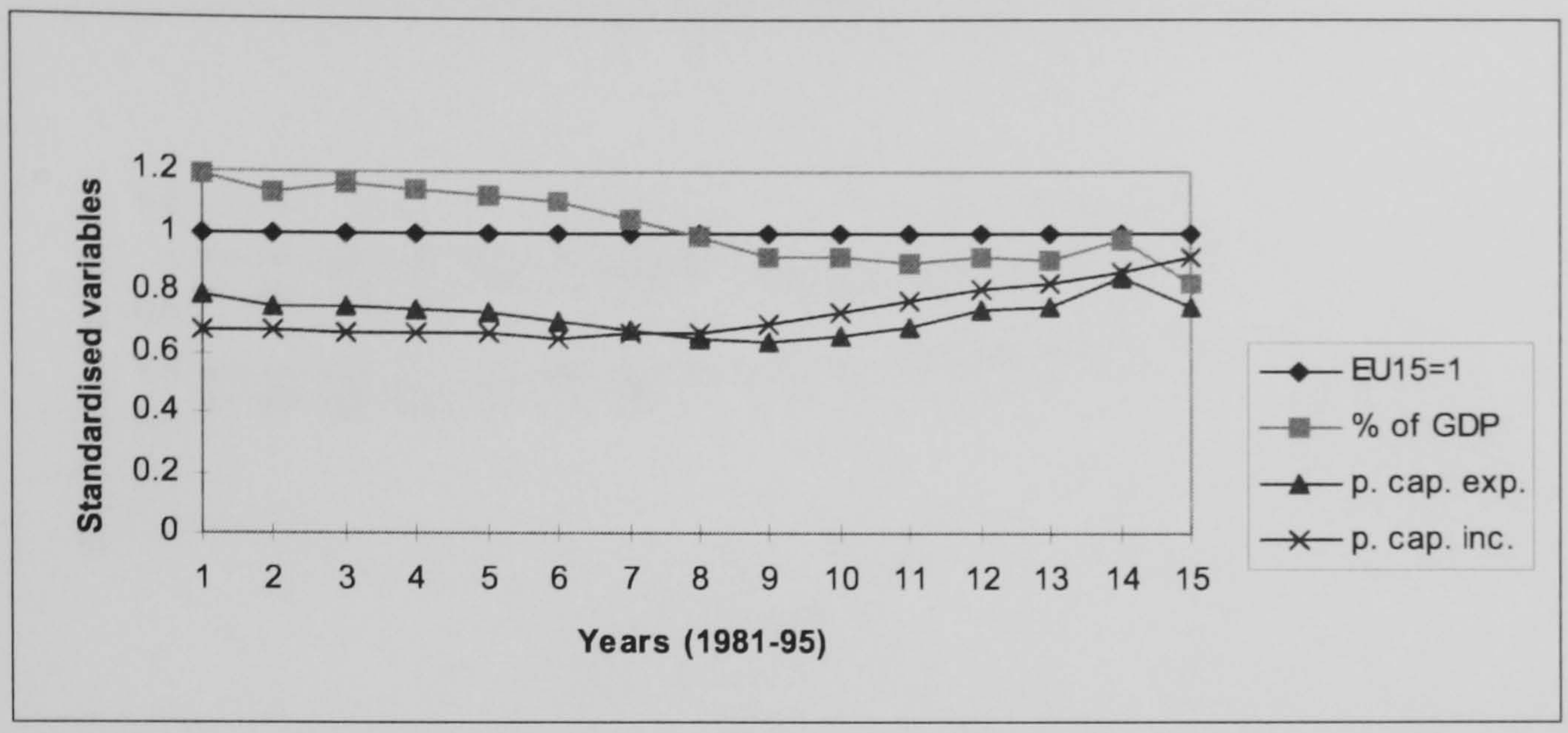


Figure 3.21 Health expenditure and per capita income - Luxembourg

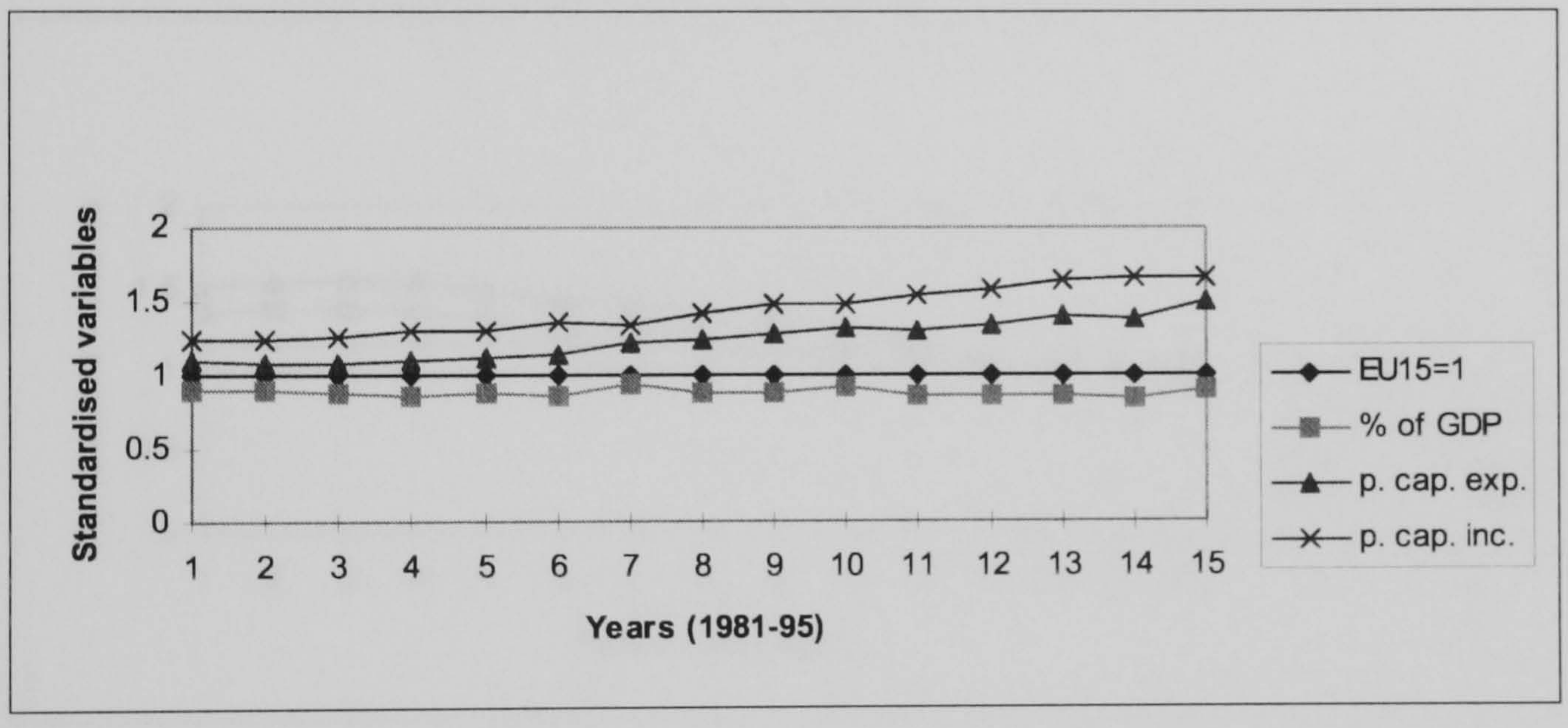


Figure 3.22 Health expenditure and per capita income - the Netherlands

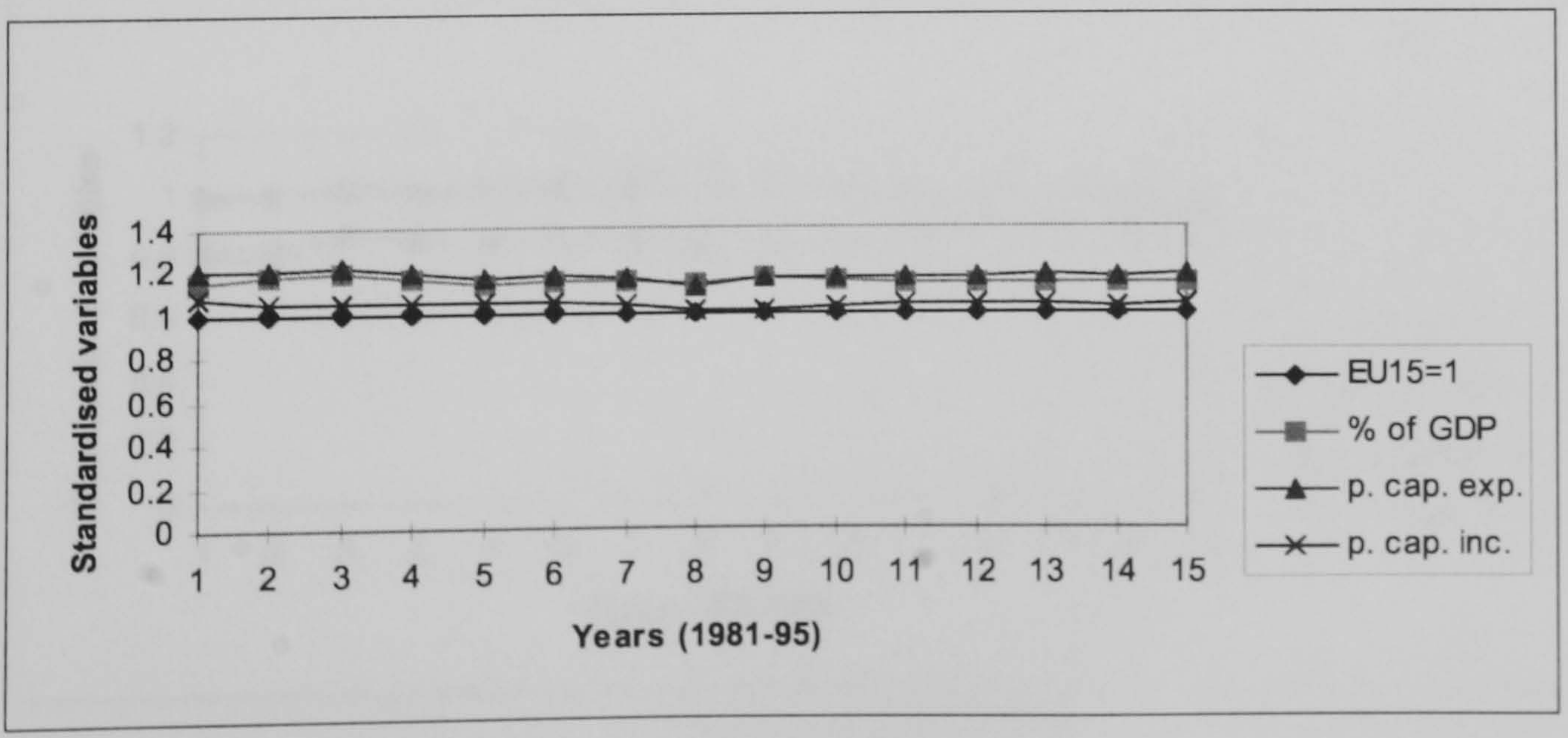


Figure 3.23 Health expenditure and per capita income - Portugal

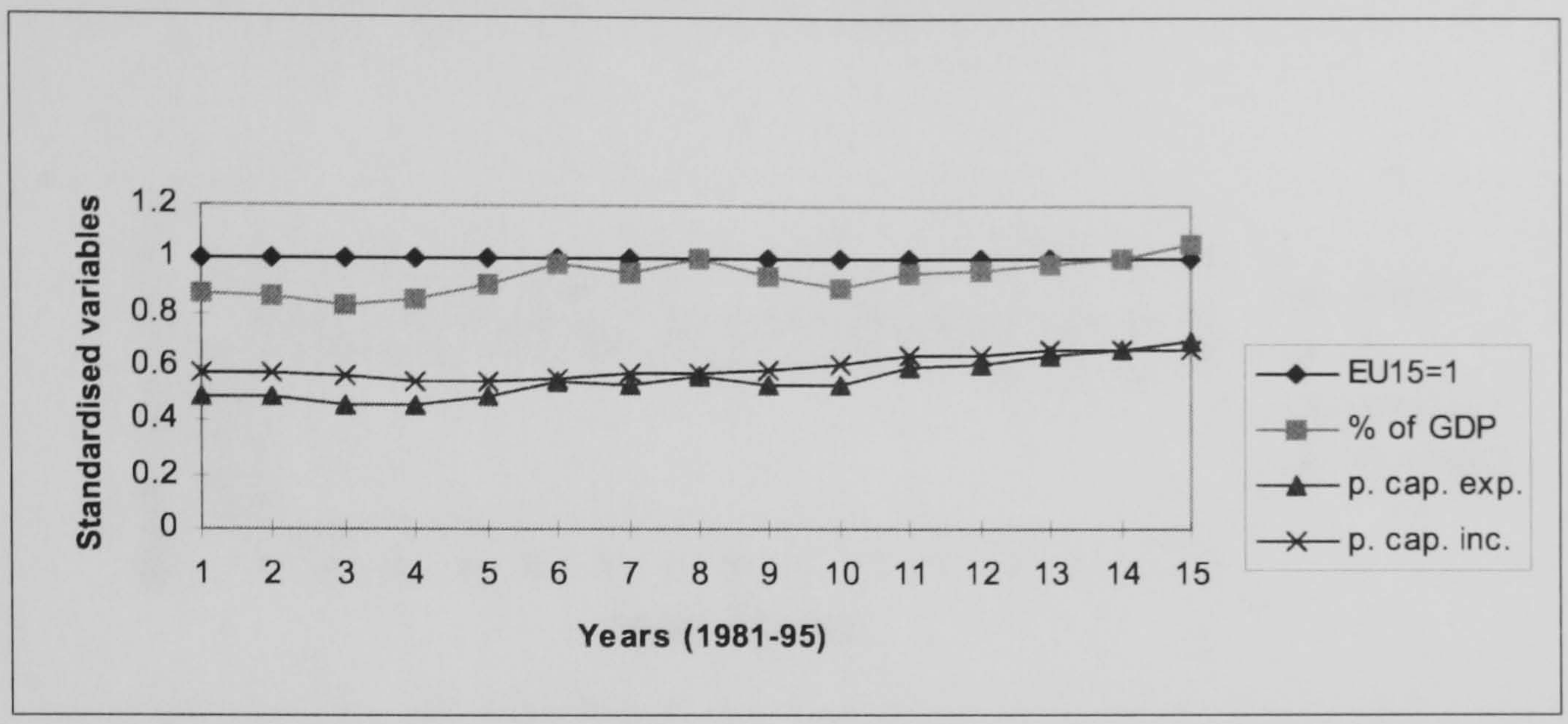


Figure 3.24 Health expenditure and per capita income - Sweden

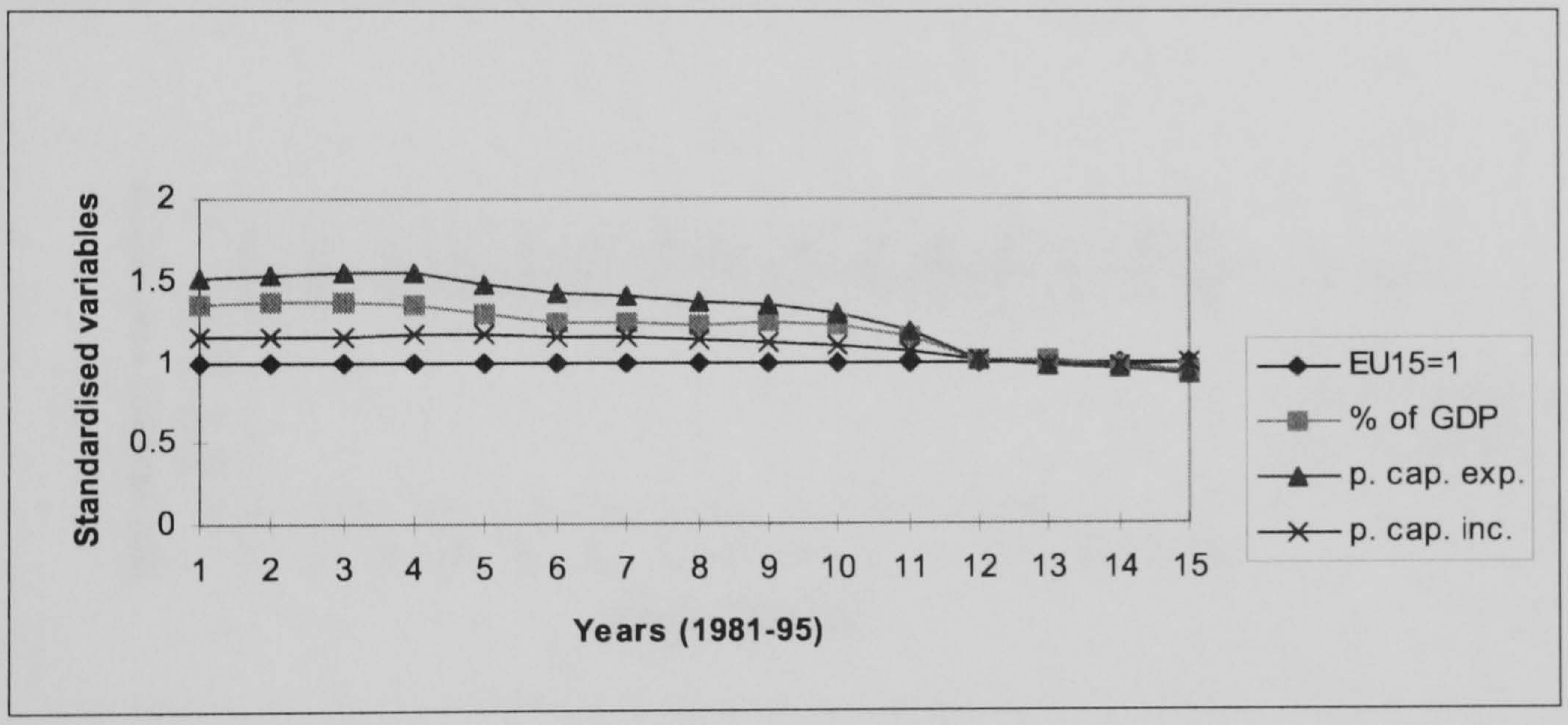


Figure 3.25 Health expenditure and per capita income - UK

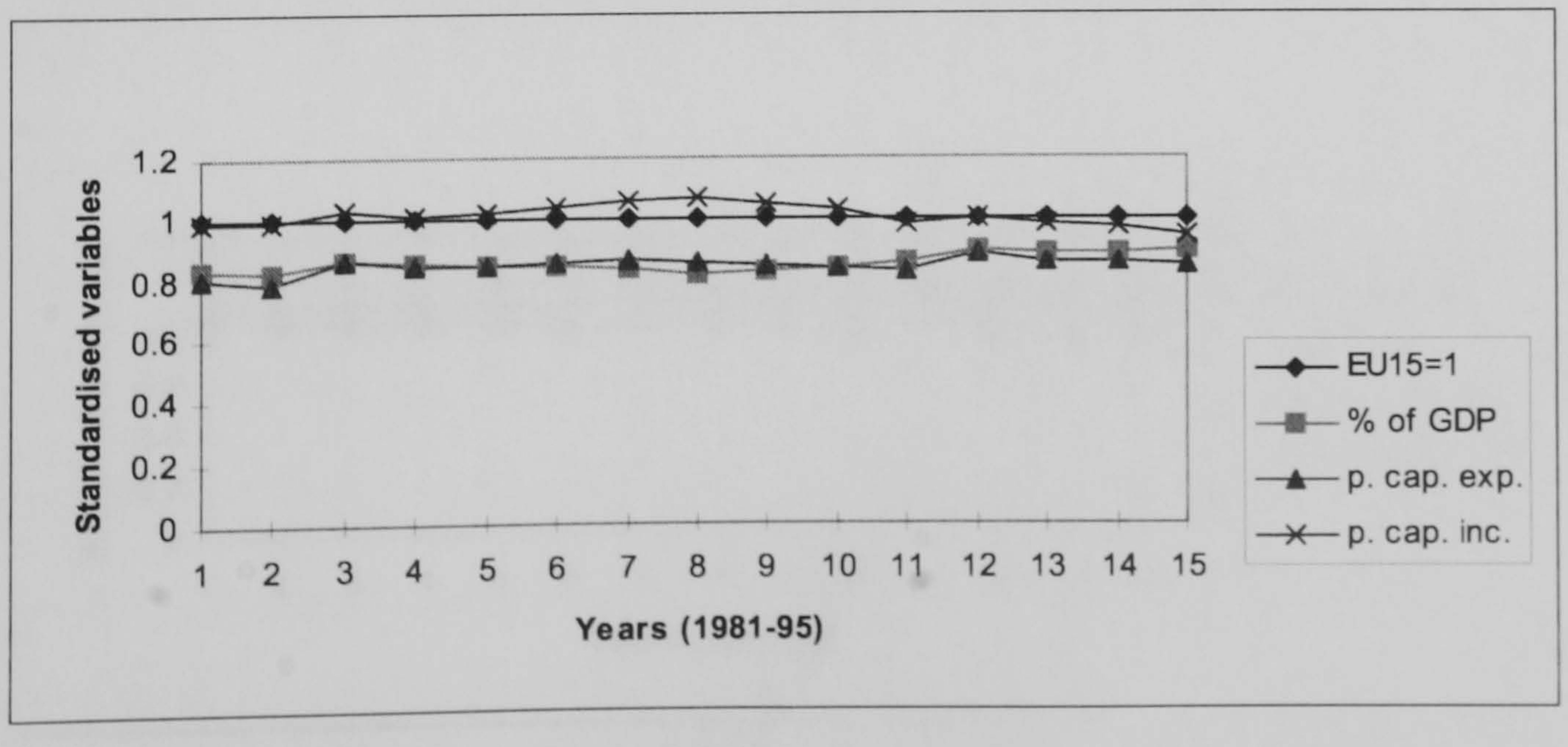


Figure 3.26 Health expenditure as a percentage of GDP - SI, NHS and LI countries

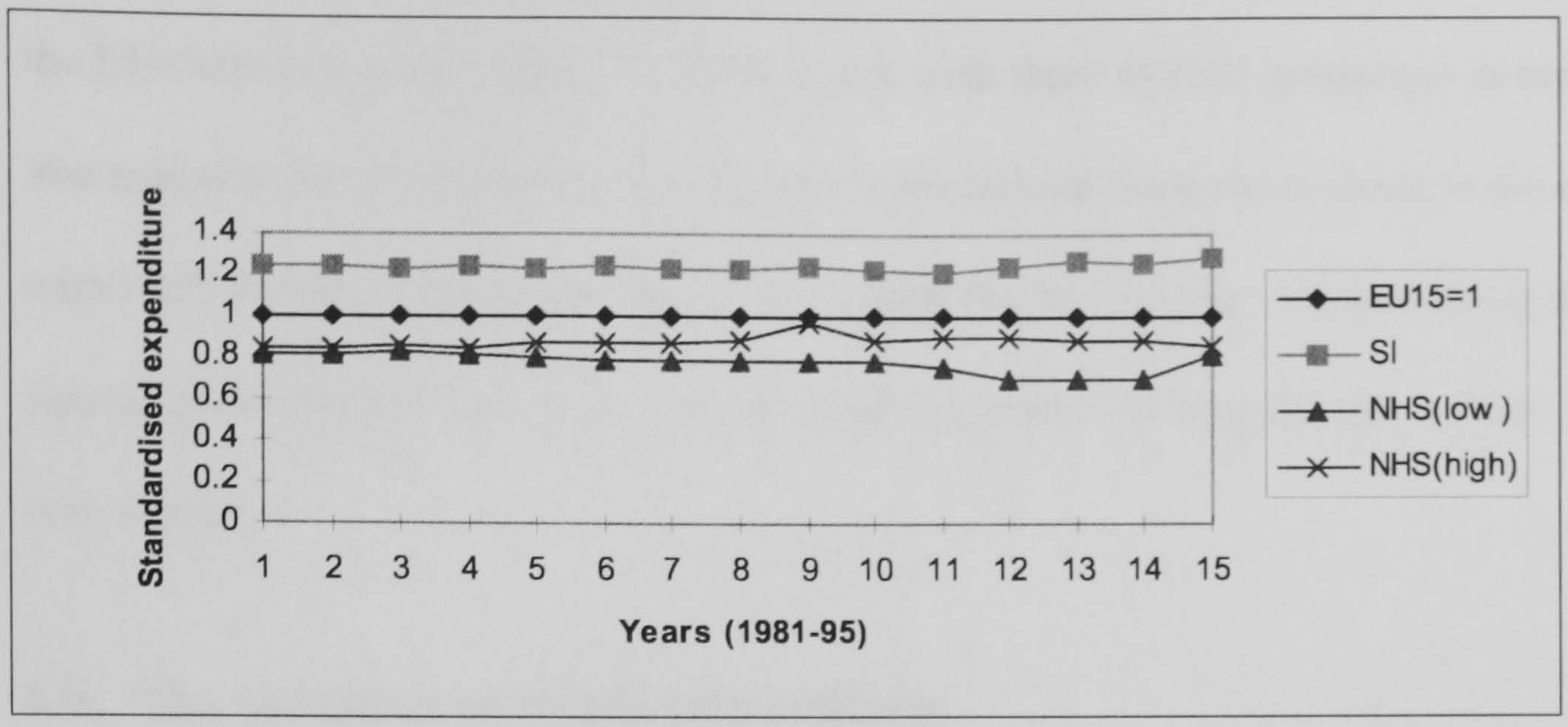


Figure 3.27 Per capita health expenditure - SI, NHS and NHS (LI) countries

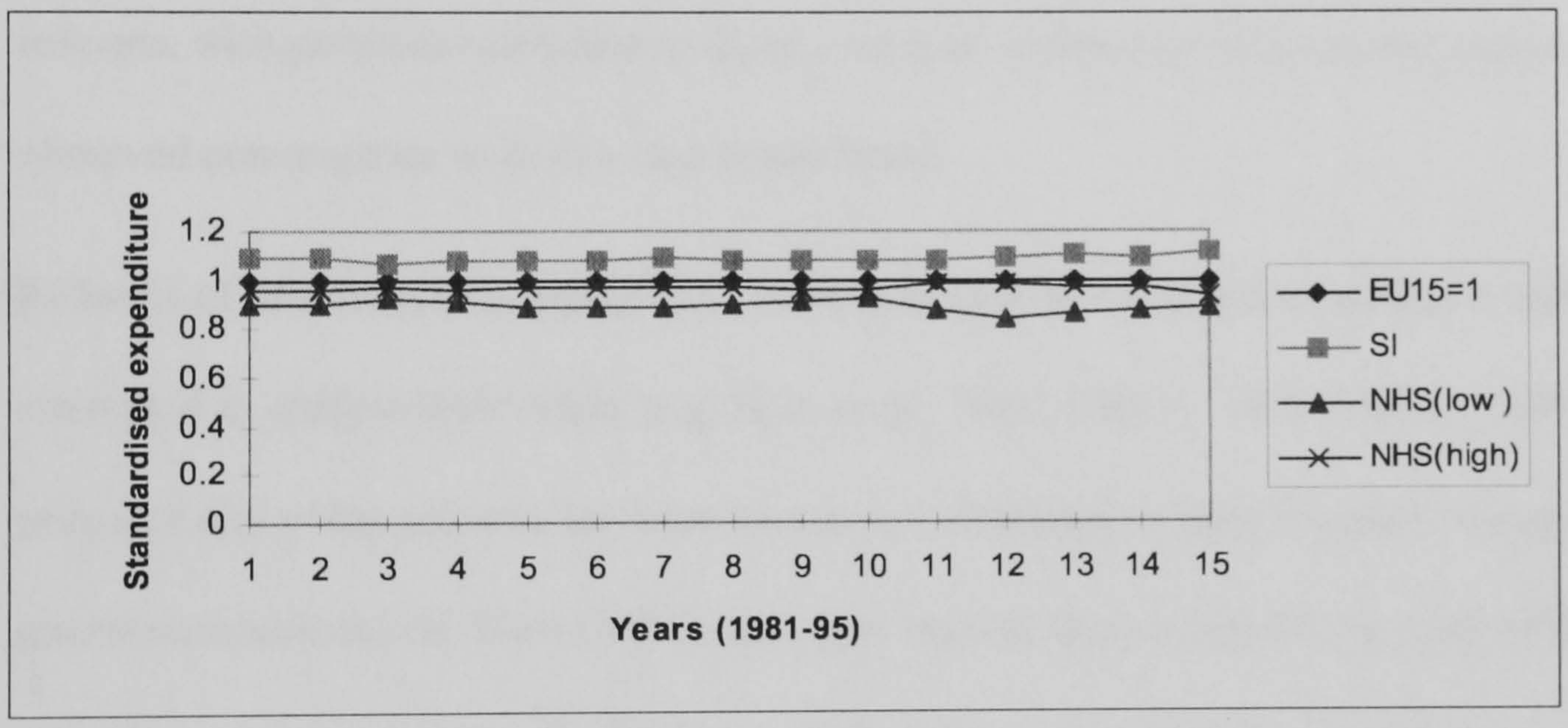
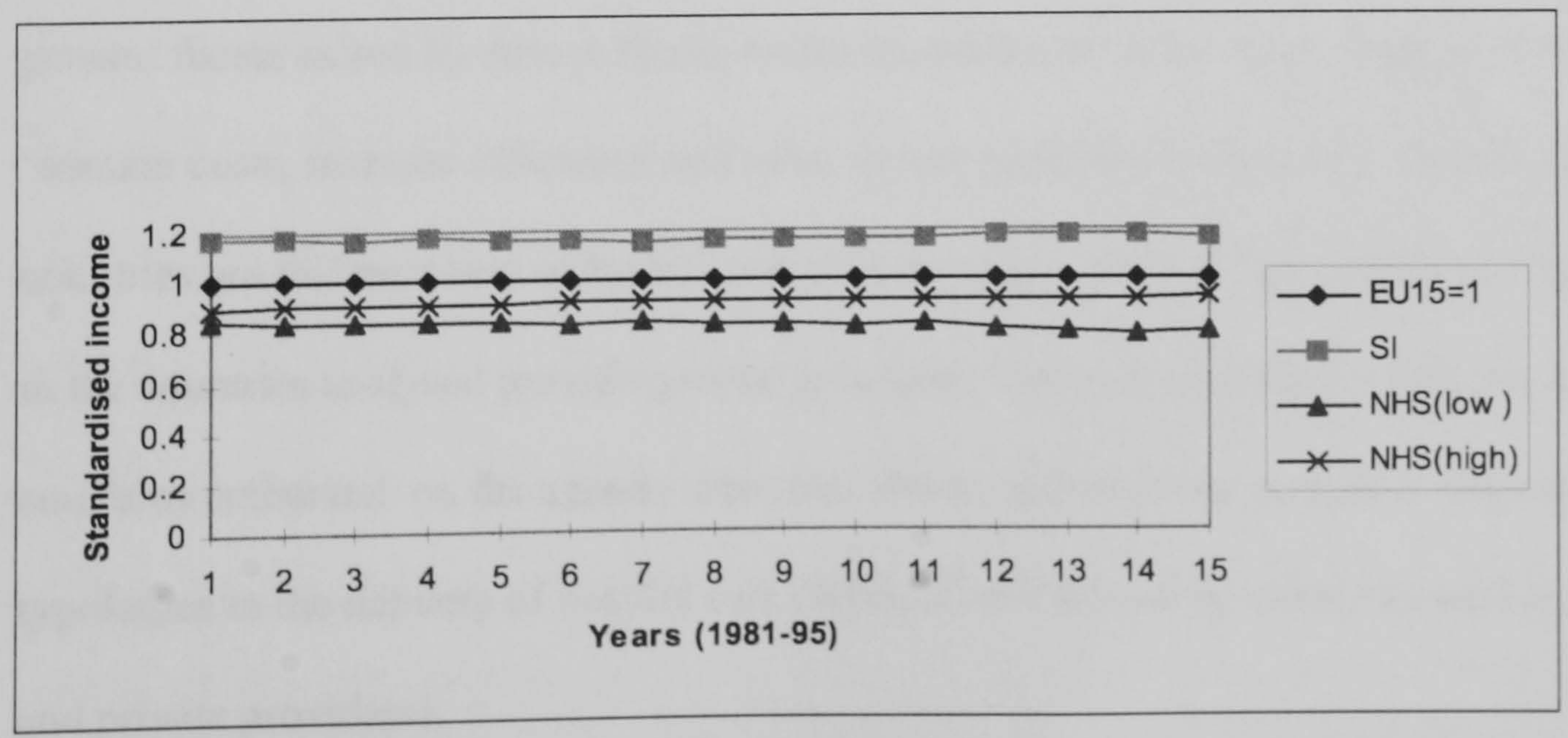


Figure 3.28 Per capita income - SI, NHS and NHS (LI) countries



This appraisal supports the finding that although convergence is confirmed for countries in the EU there is a good degree of heterogeneity with three distinct groupings in evidence. The majority of convergence would appear to be derived from movements in the countries with NHS modes of delivering health care whilst the SI countries are continuing to grow at figures above the EU mean which would tend to generate divergence rather than convergence.

3.9. The influence of health care reforms

The aim of this section is to examine the results of this chapter in the light of health care reforms, with particular attention to those countries which have contributed most to the observed convergence in health care expenditure.

Reforms of health care financing have been examined in a number of studies which have attempted to analyse their effect (e.g. Ham *et al.,* 1990; OECD, 1992; OECD, 1994b). The principal aim of the reforms has been to achieve efficiency at both the macro-economic and micro-economic levels. Ham (1997) and other authors from selected countries of the EU provide a useful summary of reforms over the period of interest in five countries: Germany, Sweden, the Netherlands, the United Kingdom (and the United States). The general theme raised by these reforms is that countries are under continuing pressure to 'contain costs, increase efficiency and raise service standards' (*ibid*, p.1). Four of these countries are full members of the EU and as Ham suggests in his book, reforms introduced in the countries analysed provide general principles that can be applied in various ways to countries embarked on the agenda identified above, and that they contain a range of typologies in the delivery of healthy care (NHS, SI and private insurance as well as public and private providers).

The specific strategies adopted by various member states of the EU have included the 'big bang' (Klein, 1995) market-type reforms of, for example, the UK with the introduction of an 'internal market' approach which divided the UK NHS into 'purchasers' and 'providers'.

In countries such as the Netherlands and Germany, however, the focus has been on an 'incremental' approach which has placed competition at the division between 'insurance companies' and 'providers' which reflects the nature of these systems as SI models. Moreover, due to the differences in political systems between countries such as the UK and the Netherlands, namely majority government versus consensus government, the incremental approach has taken much longer to introduce as exemplified by the Plan-Dekker, Plan-Simons reforms which created the foundation for reforms in the Netherlands but had remained incomplete in terms of implementation (Ven, 1998).

The third type of reform has come about as a result of a 'bottom-up' approach as witnessed in the case of Sweden (Rehnberg, 1998), which is characterised by its use of county councils to implement health care at a local level.

In contributing to the downward and reversal of roles hypotheses of convergence the countries of Scandinavia are highly relevant. In the case of Sweden, the most striking of the Scandinavian countries in terms of achieving cost containment since the 1970s, Rehnberg (1998) explains that the budget system used to allocate resources in the 1960s and 1970s suffered from overspending by clinical departments which the county councils in Sweden largely ignored. However, this situation was redressed by reforms in the 1980s that introduced global budgets which were capped. To further control health care spending, central government regulated total expenditure by placing limits on the amount of revenue that could be raised by county councils. Thus, unlike some other OECD countries, particularly those with private and SI systems, Sweden has been highly successful in containing its health care expenditure and is now not only close to the EU mean as confirmed in this thesis, but is also close to the OECD mean (*ibid*). The analysis here confirms that Scandinavian countries in general. but Sweden and Denmark in particular, have introduced effective reforms to control their growth in health care expenditures.

The analyses in this chapter have confirmed that countries with NHS modes of delivery, such as Sweden, have a lower mean value than those of SI models operated by other countries in the EU.

Studies by the OECD (1992; 1994b) add support to this analysis in providing evidence to show that integrated models appear to be the most successful in containing costs followed by contract models and reimbursement models. This is attributable to the economies of scale that more centralised, integrated models can achieve as well as centralised control of national expenditure.

In contrast, while some countries have been striving to contain public expenditure on health care the southern countries of Spain, Portugal and Greece (but also Luxembourg), as demonstrated in this thesis, have been increasing their commitment towards health expenditure and have achieved upward convergence towards the EU mean, as well as reversal of roles above the mean, for at least one of the variables analysed. Essentially this is due to the fact that these countries started at a comparatively low point with respect to other EU (and OECD) countries in 1960, for various reasons. In the case of Greece, Spain and Portugal this was due to factors such as political turmoil, the after-effects of revolution or social inequalities and inward migration (in the case of Portugal), and poor GDP performance. In the section below the cases of Spain and Portugal, in accounting for the convergence observed in this thesis, are examined in detail.

Health care provision in the post-war period in Portugal was characterised by variable provision. The responsibility for paying for health care either lay in the hands of individuals or their families, the government for selected groups such as civil servants, or was met by the *misericordias* which were religious charity hospitals. The government's role was a secondary one in that it filled in the gaps left by private initiatives and gave priority to preventive services (OECD, 1994b). Moreover, the quality and quantity of health care was influenced by geographical location, with the better quality services being located in Lisbon, Oporto and Coimbra. The need to expand its services can be illustrated by the low numbers of health professionals, which in 1970 included one doctor per 1,115 of population, of which there was one specialist per 2,636 of population, and only one fully qualified nurse per 1,600 of population (*ibid*). Essentially the standard of service was low, services were fragmented and dissatisfaction was felt by both consumers and professionals regarding services provided by the government. However, in 1965 and 1968 laws were passed to provide powers for the financing and organisation of primary health care and in 1979 a national health service was introduced.

The trends in health care provision can clearly be seen from INE *Health Statistics* for 1970, 1980 and 1990 (OECD, 1994b, p. 252) which shed some light on the consequences of increased expenditure and the move, more latterly, towards private health provision in Portugal. If we examine the mix of health institutions, in 1970 there were 171 government hospitals, 284 *misericordias*, and 160 private hospitals. In 1980 these figures had altered to 394 government hospitals, 8 *misericordias* and 89 private hospitals and by 1990 the figures had altered dramatically such that there were only 145 government hospitals, no *misericordias* and a total of 95 private hospitals. Similarly, the number of doctors increased from 8,580 in 1970 to 28,852 in 1990 whilst the number of nurses increased from

10,000 to 27,652 over the same period. These statistics are indicative of a complete switch away from relying on charity hospitals to more pluralistic modes of meeting health care needs and increased health expenditures within the overall context of an NHS mode of delivery.

In the case of Spain before the reforms in the 1980s its health care system was also characterised by variability and dominated by a compulsory health insurance system, *Instituto Nacional de la Salud* (INSALUD), which was part of the social security system. INSALUD covered approximately 90% of the population and as such gaps existed in terms of provision, with the poor and unemployed in society being excluded from INSALUD-financed care. Other major weaknesses in health care in Spain at that time included complaints concerning the inadequate levels of public spending, a view that the public sector was inefficient and impersonal, long waiting lists and overcrowded emergency departments, and stresses and strains at the so-described complex and permeable boundaries between public and private sectors caused by doctors dividing their attentions between them to the disadvantage of the public patients (OECD, 1994b; Miguel and Guillen, 1989; Rodriguez, Calogne and Rene, 1990). Brooks (1987) summarises the situation in the pre-reformed public sector in Spain as being fragmented, poorly co-ordinated, over-bureaucratic and under-managed.

The response of the Spanish government during reforms introduced in the 1980s included the consolidation of a national health system, the extension of compulsory health to virtually the entire population, better planning and integration of both primary and hospital care, increased reliance on funding from general taxation and the beginning of the devolution of health care administration to the autonomous regions (OECD, 1992, p. 103). As a result both percentage of GDP and *per capita* spending rose as indicated by the results of this thesis. Specifically referring to the concept of 'achieving greater convergence' the 1992 Reform stated: 'Within the framework of a government strategy of European convergence, (there was a) decision to move towards a greater autonomy of hospitals, (to be) converted into quasi-public corporations' (OECD, 1992, p.109).

Thus it may be reasonable to conclude that for countries such as Portugal and Spain, a number of factors relating to their economies and populations have meant that they have had a good deal of catching up to do but have been making inroads and are converging on and even exceeding (Portugal for % of GDP) the EU mean, at least over the period of analysis addressed in this thesis. Greece, on the other hand, which shares a number of socio-economic features with Spain and Portugal, has achieve the same trend to a somewhat lesser degree. However, as many studies have shown (c.f. Hitiris, 1997; OECD, 1995a), confirmed in this thesis, there is a strong correlation between health care expenditure and GDP wealth and Greece, in terms of this latter point, has not managed to achieve growths in GDP commensurate with its EU partners. As such, it might be concluded from the perspective of Greece, that whilst strong divisions remain in terms of GDP wealth in the countries of the EU, convergence will be accordingly inhibited.

3.10. Discussion and Conclusions

This chapter has developed the chosen methodology to test for convergence in the thesis and thus constructed the methodological foundation for the remaining analyses of convergence in subsequent chapters. The methods were then applied to health care expenditure over the period 1960-95 using cross-sectional data and σ-*convergence*, and for 1980-95 using the more rigorous β-*convergence* approach.

Due to gaps in the OECD health data set for the earlier decades examined, 10 year gaps (5 years for 1990-95) were employed in the σ-*convergence* analyses which has the limitation that movements and trends in the intervening years were not captured but this limitation was mitigated in the latter β-*convergence* work which utilised panel data with observations available for each year within the period of analysis. This latter approach also enabled the influence of health care system on the convergence process to be analysed. The findings support the presence of σ- and β-*convergence* for both *per capita* health care expenditure and as a percentage of GDP.

The β-*convergence* testing has confirmed, consistent with the predictions of the neo-classical growth model for macroeconomic measurements, that the further away health care expenditure is from its steady state the faster it approaches.

It is interesting to note that heterogeneity was found to be a feature of health expenditure within the countries of the EU, with SI countries sharing common characteristics which place them above the EU mean for both share of GDP and *per capita* expenditure, whilst two sub-groups of NHS countries also exist which exhibit a north-south divide based on GDP income. However, the low income NHS countries of the south (Spain, Portugal and Greece) are all converging upwards towards the EU mean. In the second group of NHS countries, Sweden and Denmark are prominent in achieving a high level of downward convergence.

The results thus suggest that greater convergence may be achieved through harmonisation in the way in which health care is financed and organised as countries belonging to SI or NHS countries tend to have similar health expenditure profiles, within the caveat of sub-group analysis for NHS countries.

In terms of explaining these findings three key approaches to system financing reforms throughout the period were examined, focussing largely on countries which were contributing most to the observed convergence. Reforms are tempered by the political system of countries and the way in which healthcare is delivered. Thus countries with centralised control of expenditure, predominantly NHS countries, are able to exercise the 'big bang' approach and achieve results in a relatively short time span. In contrast, SI countries often adopt a more incremental approach and place their attention at the interface between insurance and providers, or limit reimbursements from health funds as in the case of France. However, they are less able to control expenditure in comparison with NHS countries and are associated with a diverging hypothesis. The bottom-up approach, exercised by the health councils of Sweden in particular, has provided an alternative means of containing the growth in health expenditure over economic growth, the common factor driving most of the reforms aimed at controlling expenditure. In contrast, however, the analyses of this chapter have shown that countries of the south such as Spain, Portugal and Greece, which initially started off a lower expenditure levels, have making strides to catch up and are explaining much of the observed convergence in health expenditure.

In confirmation of these findings, analysis of growth rates in a related work by the author (Hitiris and Nixon, 2000, p.175) demonstrated that the growth rate for health care expenditure as a percentage of GDP rose by 4.7% in SI countries over the period 1960-95, while for high income NHS countries the figure was 1.8%, and 4.0% for the LI (NHS) countries over the same period. These figures therefore add further clarification regarding the reasons for convergence to have occurred and the differences according to system typology and geographical/economic influences. In terms of other methods that might be used to test for convergence, the data for health care expenditure were also tested using the

Gap approach (Chatterji, 1992: see Appendix B), with the results suggesting that one convergence club will result, but that spatial differences exist in terms of the amounts spent. As such, the findings are supportive of analyses using the principal techniques developed for the thesis. Other methods are also discussed in Chapter Seven. The results have also revealed that differences, particularly in *per capita* income, also greatly influence variations in health expenditure although it may be the case that these may be diminished further over time as EU wealth re-distribution policies and the continuing introduction of the EMU take further effect. However, in this respect, the subsidiary result obtained in this analysis of convergence in GDP income among the EU countries is bringing about its own force for health expenditure convergence due to the well established link between these two variables.

As noted in the review of the literature on convergence in Appendix A the approach to measuring convergence varies and it is therefore worth entering into some discussion regarding the statistical tests used in the analyses. In this regard it should be borne in mind, for example, that the two techniques utilised are seeking to discover different manifestations of convergence. In the case of *σ-convergence* the aim is simply to determine if dispersion in the data is diminishing over time, with the refinement of using the coefficient of variation enabling relative changes over time to be more faithfully recorded. If present it is reasonable to argue that differences, in this case in health care expenditure, are diminishing over time if the hypothesis of *σ-convergence* is confirmed. Where this form of convergence is discovered, it is possible to examine the relative movements for individual countries with respect to a common reference, in this case the mean, to identify upward or downward convergence scenarios and hypotheses according to Leonardi's classifications. Essentially, convergence will occur if some countries are converging downwards towards the mean and/or others are converging upwards towards the mean. However, as the case of the scenario of reversal of roles illustrates, a country converging towards the mean may overshoot and start diverging above or below the mean, revealing that the two paths were predicted to meet (through a diminution of the vertical distance between the two) but not necessarily to converge and remain at the same level.

In contrast, *β-convergence* analysis seeks to determine if, as a country approaches the mean level, the rate at which it approaches slows down such that the two meet and then remain on the same (or a parallel) path. As the models used utilise logs, the direction of approach is not relevant and upward and downward convergence are not the principal issue of concern. Within this analysis, absolute convergence means that the sample is approaching a common level, whilst conditional convergence analysis attempts to determine if the levels attained are different and conditional on other variables of interest. As such, the it is argued that the methods are complementary and offer different but informative perspectives regarding the study of convergence. They are therefore applied in chapters Four and Five which examine convergence in the remaining variables of the thesis framework.

Finally, the results of this chapter are important in that they have formed the basis of the first detailed study confirming that the general move towards closer economic integration in the EU extends also to the health care sector, where strong forces appear to be at work for convergence in health care expenditure towards EU-wide standards. Moreover, the chapter has also revealed to policy makers that the way in which health care systems are organised and financed makes a difference in terms of overall expenditure. The following chapter investigates the question of whether convergence in health expenditure is matched by convergence in health outcomes.

Chapter Four

Convergence Analysis of EU Health Outcomes

4.1. Introduction

The definitions associated with, as well as the methods adopted to test for convergence in this chapter, are based on the methodology fully outlined in Chapter 3 (see also Nixon, 1999; Hitiris and Nixon, 2000). This chapter uses empirical data and σ and β-*convergence* analyses to test for the presence of convergence in health outcomes over the period 1960-95, and 1980-95, in the countries of the EU. The aim is to determine if the convergence observed in health expenditure is also present in health outcomes and to briefly explore any associations that may exist between the two, further investigated in Chapter Six.

The philosophy of convergence in health outcomes, it should be noted, is somewhat different from that associated with health care expenditure. In the case of health care expenditure it would be a reasonable and justifiable expectation for countries to move towards the EU mean value (Nixon, 2000a), and use that as a yardstick in adjusting their expenditure levels[1]. Therefore at a policy level there would be perhaps limited argument against either increased or decreased expenditure to converge to the mean value for the EU. However, in the case of health outcomes the expectation is that governments will wish to

[1] For example, the UK Prime Minister, Tony Blair, argued for the UK NHS to move towards what he termed 'European standards' of expenditure following the flu epidemic in the winter of 1999 2000 when 57,000 planned elective procedures were cancelled due to pressure placed on hospital emergency admissions (National Audit Office, 2000).

attain the 'best' outcomes possible. This study, as in the case of previous analysis in chapter 3, uses the EU mean value as a reference for determining relative movement concerning convergence, or otherwise, around this value, but there is no inference that this is the 'target' for countries with better health outcomes than the EU mean. In the case of health outcomes the most defensible position to take would be to argue that EU health systems, albeit indirectly, will strive towards 'optimal' outcomes and therefore tend to converge irrespective of any process of economic integration. This argument would equally apply, however, to all countries such as those belonging to the OECD who also strive to improve their health outcomes.

It is also the case that in order to present a coherent argument in accounting for any observed convergence in health outcomes it will be necessary to present suitable explanations. However, the relationship between health outcomes and health care 'inputs' is a complex one, and the topic is addressed fully in chapter 6 taking into account all findings of the convergence analyses of chapters 3, 4 and 5.

The chapter begins by identifying and explaining the rationale for the chosen variables before testing, cross-sectionally, for σ-*convergence* over the period 1960-95. The aim of this analysis is to determine if the coefficient of variation for each health outcome variable is diminishing over this period. The results of the σ-*convergence* analysis are then presented along with an examination of the relative changes over the period and associations with the type of health care system used by EU member states.

Following this, more rigorous β-*convergence* analysis is applied to a panel of data derived from the same variables over a shorter period of time, 1980-95, for the same rationale applied in Chapter Three. The results of the β-*convergence* analysis are then presented.

The results of both approaches are examined before coming to conclusions regarding the findings along with an assessment of the policy implications for EU member states.

4.2. Outcome measures of health used

Previous studies have shown that measuring health outcomes for any country will have its limitations. These limitations will be further exacerbated by the likelihood that a group of fifteen countries such as the EU will have some variations in the way that each country defines and records data (Anderson *et al.*, 1999). As Macbeth (1996) rather pessimistically points out, this diversity of definitions invalidates many comparisons. Despite these difficulties Goldcare (1996, p.70) supports the view that 'population-based measures of health outcome have a crucial place in the overall assessment of health services. They are the ultimate validators of societal achievement in respect of health and as such investment in their study in appropriate detail seems warranted.'

Because the traditionally used health outcomes of longevity and infant mortality are regarded as fairly crude proxies for health status which are not very sensitive to changes in health care financing and delivery systems (Kindig, 1997), a number of measures are being developed. These include, amongst others, single measures of quality-adjusted life years (QALY), and health-adjusted life years. Linked to this research are a number of instruments which measure health utilities, including the SF-36 and SIP which have been adapted for use in other languages and cultures (Anderson, *et al.*, 1999). Some researchers and countries are developing multiple indicators of population health status.[2]

[2] See Roos *et al.* (1996). The UK is piloting an information system that will allow comparison of health status along a number of dimensions. Other countries, including Australia, Canada, the Netherlands, New Zealand, are developing similar systems.

However, as these health status measurements are still in the process of development and not available for cross-country comparisons, the chosen variables to represent health outcomes are *infant mortality, life expectancy (females) at birth and life expectancy (males) at birth*. It is felt, *a priori*, that infant mortality will be a more representative and reliable health outcome than life expectancy as the latter is more attributable to factors not related to the health care system, whereas the risks associated with child birth and life in the first year of an infant are reduced by better health care facilities and procedures.

The chosen variables might be termed 'global' or 'macro' health outcomes and are available for all the present EU countries over the period of interest through the OECD Health Data set (OECD/CREDES, 1997, see chapter 2.3 for full definitions). Moreover, these indicators are commonly utilised as yardsticks in international comparisons and are therefore considered to be the most appropriate choice for this study.

4.3. Results: σ-analysis

The raw data for infant mortality, life expectancy (females) and life expectancy (males), along with the mean, multiplier, indexed scores and s.d. (c.v.) for all 15 current members of the EU are shown in Tables 4.1, 4.2, and 4.3 respectively.

Table 4.1 shows that for infant mortality the raw mean level fell continuously from 3.3 in 1960 to 0.6 in 1995, indicating an overall improvement for the period examined. The s.d. (c.v.) of the indexed values rose from 45.9 to 47.1 between 1960 and 1970 ($p = 0.54$, NS), and also rose from 16.8 to 19.6 between 1990 and 1995 ($p = 0.71$, NS), indicating two periods of divergence, although not statistically significant. However, between 1970 and 1990 there was sustained convergence from an s.d. (c.v.) of 47.1 to a figure of 16.1 ($p = 0.0002$), indicating statistically significant *σ-convergence* for this period.

When examining the results for life expectancy (females) in Table 4.2 it can be seen that the

Table 4.1 Infant mortality and indexed infant mortality - 1960-95

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	3.8	113.5	2.6	113.2	1.4	116.3	0.8	100.5	0.5	93.9	-19.7
B	3.1	94.5	2.1	92.2	1.2	98.4	0.8	103.1	0.7	121.7	27.2
D	3.4	102.3	2.3	102.3	1.3	103.3	0.7	91.5	0.5	92.1	-10.2
DK	2.2	65.1	1.4	62.1	0.8	68.3	0.8	96.6	0.6	95.6	30.5
E	4.4	132.3	2.6	114.9	1.2	100.1	0.8	97.9	0.6	95.6	-36.7
F	2.7	83.0	1.8	79.5	1.0	81.3	0.7	94.1	0.5	86.9	3.9
FIN	2.1	63.6	1.3	57.7	0.8	61.8	0.6	72.2	0.4	69.5	5.9
GR	4.0	121.4	3.0	129.4	1.8	145.6	1.0	125.0	0.8	140.8	19.4
I	4.4	132.9	3.0	129.4	1.5	118.8	0.8	105.7	0.6	107.8	-25.2
IRL	2.9	88.7	2.0	85.2	1.1	90.3	0.8	105.7	0.6	109.5	20.8
L	3.2	95.4	2.5	108.8	1.2	93.5	0.7	95.4	0.5	86.9	-8.5
NL	1.8	54.2	1.3	55.5	0.9	70.0	0.7	91.5	0.6	95.6	41.4
P	7.8	234.7	5.5	240.8	2.4	197.7	1.1	141.8	0.7	128.6	-106.0
S	1.7	50.3	1.1	48.1	0.7	56.1	0.6	77.3	0.4	71.3	21.0
UK	2.3	68.1	1.9	80.9	1.2	98.4	0.8	101.8	0.6	104.3	36.2
Mean	3.3	100	2.3	100.0	1.2	100.0	0.8	100.0	0.6	100.0	
Multiplier	30.3		43.7		81.3		128.9		173.8		
s.d. (c.v.)		45.9		47.1		35.9		16.8		19.6	

Source: OECD/CREDES (1997), *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems. Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. Infant mortality (im) is defined according to Chapter Two (section 2.3).

Table 4.2 Life expectancy and indexed life expectancy at birth (females) - 1960-95

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	71.9	99.1	73.4	98.5	76.1	98.7	78.9	99.7	80.1	100.1	1.0
B	73.5	101.4	74.2	99.6	76.8	99.6	79.1	99.9	80.0	100.0	-1.4
D	72.4	99.8	73.8	99.0	76.6	99.4	79.1	99.9	79.5	99.4	-0.5
DK	74.1	102.2	75.9	101.8	77.6	100.7	77.7	98.1	77.8	97.3	-4.9
E	72.2	99.6	75.1	100.8	78.6	102.0	80.5	101.7	81.2	101.5	1.9
F	73.6	101.5	75.9	101.8	78.4	101.7	80.9	102.2	81.9	102.4	0.9
FIN	71.6	98.7	74.2	99.6	77.6	100.7	78.9	99.7	80.2	100.3	1.5
GR	70.7	97.5	73.6	98.7	76.6	99.4	79.4	100.3	80.3	100.4	2.9
I	72.3	99.7	74.9	100.5	77.4	100.4	80.0	101.1	80.8	101.0	1.3
IRL	71.8	99.0	73.2	98.2	75.0	97.3	77.5	97.9	78.5	98.1	-0.9
L	71.9	99.1	73.9	99.2	75.1	97.4	78.5	99.2	79.5	99.4	0.2
NL	75.5	104.1	76.6	102.8	79.2	102.7	80.1	101.2	80.4	100.5	-3.6
P	67.2	92.7	71.0	95.3	76.6	99.4	77.9	98.4	78.6	98.3	5.6
S	74.9	103.3	77.1	103.4	78.8	102.2	80.4	101.6	81.5	101.9	-1.4
UK	74.2	102.3	75.2	100.9	75.9	98.5	78.6	99.3	79.7	99.6	-2.7
Mean	72.5	100.0	74.5	100.0	77.1	100.0	79.2	100.0	80.0	100.0	
Multiplier	1.4		1.3		1.3		1.3		1.3		
s.d. (c.v.)		2.8		2.1		1.7		1.3		1.4	

Source: OECD/CREDES (1997), *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems, Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. Life expectancy for females (LEF) is defined according to Chapter Two (section 2.3).

Table 4.3 Life expectancy and indexed life expectancy at birth (males) - 1960-95

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	65.4	96.8	66.5	97.0	69.0	98.0	72.3	99.4	73.5	99.9	3.1
B	67.7	100.2	67.8	98.9	70.0	99.5	72.4	99.5	73.3	99.6	-0.6
D	66.9	99.0	67.4	98.4	69.9	99.3	72.7	99.9	73.0	99.2	0.2
DK	72.3	107.0	70.7	103.2	71.4	101.5	72.0	99.0	72.5	98.5	-8.5
E	67.4	99.7	69.6	101.6	72.5	103.0	73.4	100.9	73.2	99.5	-0.3
F	67.0	99.1	68.4	99.8	70.2	99.8	72.7	99.9	73.9	100.4	1.3
FIN	64.9	96.0	65.9	96.2	69.2	98.3	70.9	97.5	72.8	98.9	2.9
GR	67.5	99.9	70.1	102.3	72.2	102.6	74.6	102.5	75.1	102.1	2.2
I	67.2	99.4	69.0	100.7	70.6	100.3	73.5	101.0	74.4	101.1	1.7
IRL	68.5	101.4	68.5	100.0	69.5	98.8	72.0	99.0	72.9	99.1	-2.3
L	66.1	97.8	67.0	97.8	68.0	96.6	72.3	99.4	72.5	98.5	0.7
NL	71.6	105.9	70.9	103.5	72.4	102.9	73.8	101.4	74.6	101.4	-4.6
P	61.7	91.3	65.3	95.3	67.7	96.2	70.9	97.5	71.5	97.2	5.9
S	71.2	105.4	72.2	105.4	72.8	103.4	74.8	102.8	76.2	103.6	-1.8
UK	68.3	101.1	68.6	100.1	70.2	99.8	72.9	100.2	74.3	101.0	-0.1
Mean	67.6		68.5		70.4		72.7		73.6		
Multiplier	1.5		1.5		1.4		1.4		1.4		
s.d. (c.v.)		4.0		2.8		2.3		1.6		1.6	

Source: OECD/CREDES (1997), *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems, Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. Life expectancy for males (LEM) is defined according to Chapter Two (section 2.3).

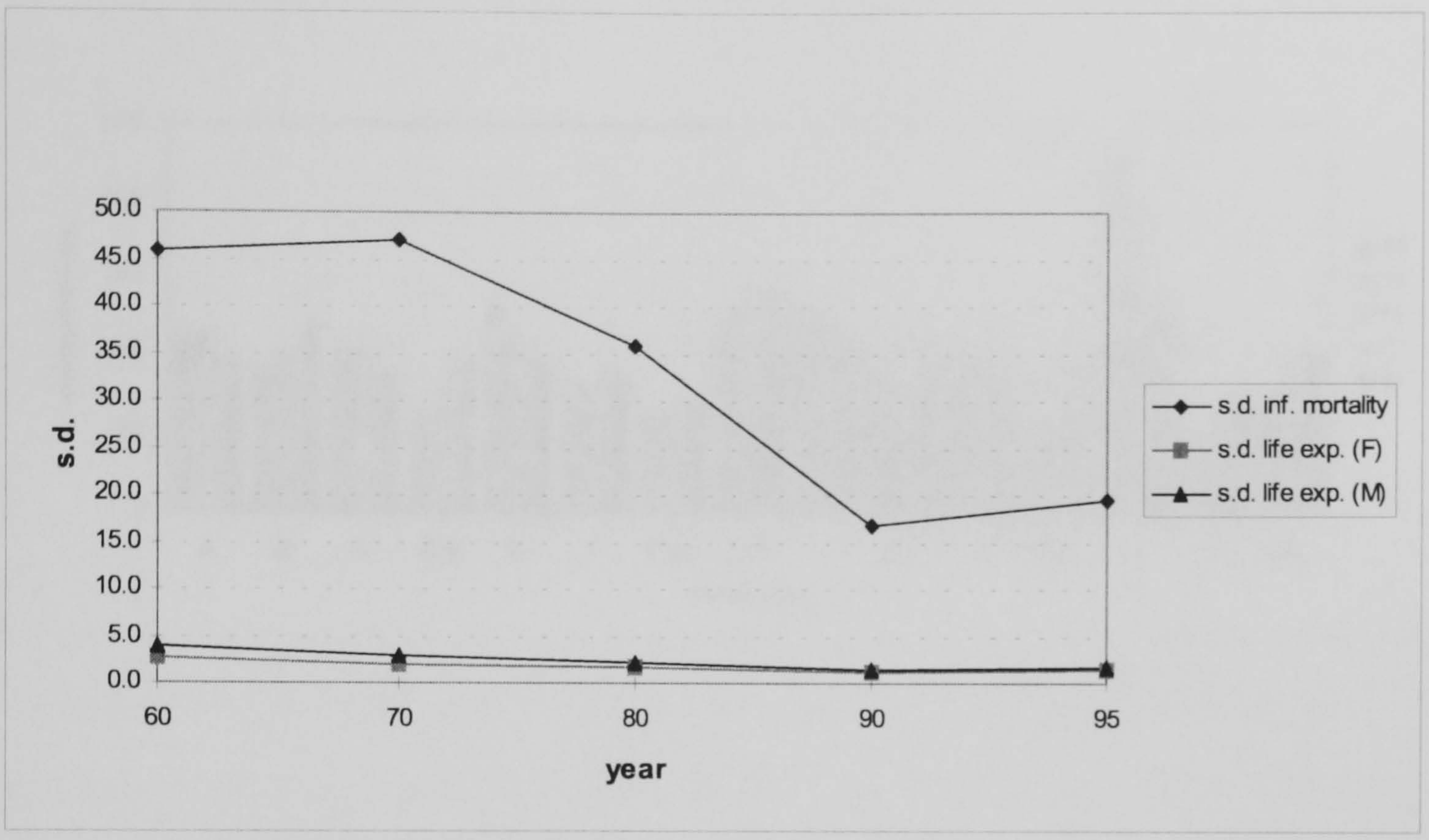
raw mean value rose from 72.5 in 1960 to 80 in 1995, indicating a marked improvement in life expectancy for females within the EU over the period of interest. The s.d. (c.v.) scores show that overall and continuous convergence occurred between 1960 and 1990 with the s.d. (c.v.) falling from 2.8 in 1960 to 1.3 in 1990 ($p = 0.15$). For the period 1990-95 there was a slight degree of divergence as the s.d (c.v.) rose to a figure of 1.4 ($p = 0.59$), although neither of these changes are statistically significant.

The results for life expectancy (males), shown in Table 4.3, indicate that the raw mean value rose from 67.6 years in 1960 to 73.6 years in 1995, again indicating a continuous improvement over the period examined. For overall convergence, the s.d. (c.v.) results show that continuous convergence occurred between 1960 and 1990 with the value falling from 4.0 in 1960 to 1.6 in 1990 ($p = 0.001$), a statistically significant change. Between 1990 and 1995 no convergence or divergence occurred as the values are identical for both years.

Trend analyses of *σ-convergence* for each health outcome are summarised in Figure 4.1. The results show more clearly the stark differences that exist between the s.d. (c.v.) of infant mortality and the s.d. (c.v.) of life expectancy. The high values for infant mortality indicate that larger differences exist between the member states of the EU, although these differences have diminished through the process of convergence, particularly between 1970 and 1990.

However, although convergence occurred for life expectancy the variations that exist between the member states of the EU are much smaller, as indicated by the low values of s.d. (c.v.), and only statistically significant levels of convergence occurred in life expectancy for males. It is worth recalling that the values for s.d. (c.v.) are based on standardised mean scored of 100 for all three variables and as such the differences are relative ones.

Figure 4.1 s.d. (c.v.) of health outcomes - 1960-95



4.3.1 Trend Analysis for each Country

The above results therefore confirm that in an overall sense all measures of health outcomes have experienced statistically significant levels of σ-*convergence* within the period 1960 to 1995, although some non-significant divergence has also been experienced. However, the general finding is that infant mortality rates and life expectancy are becoming more similar throughout the EU.

In this section the relative (to the mean) changes are examined under Leonardi's hypotheses and scenarios as outlined in chapter 3 (Nixon, 1999) based on the common reference point of a mean of 100 to reveal the principal countries that account for the above findings. The trends for infant mortality, life expectancy (females) and life expectancy (males), are shown for the period 1960-95 in Figures 4.2, 4.3 and 4.4, respectively.

Figure 4.2 Standardised infant mortality - 1960-95

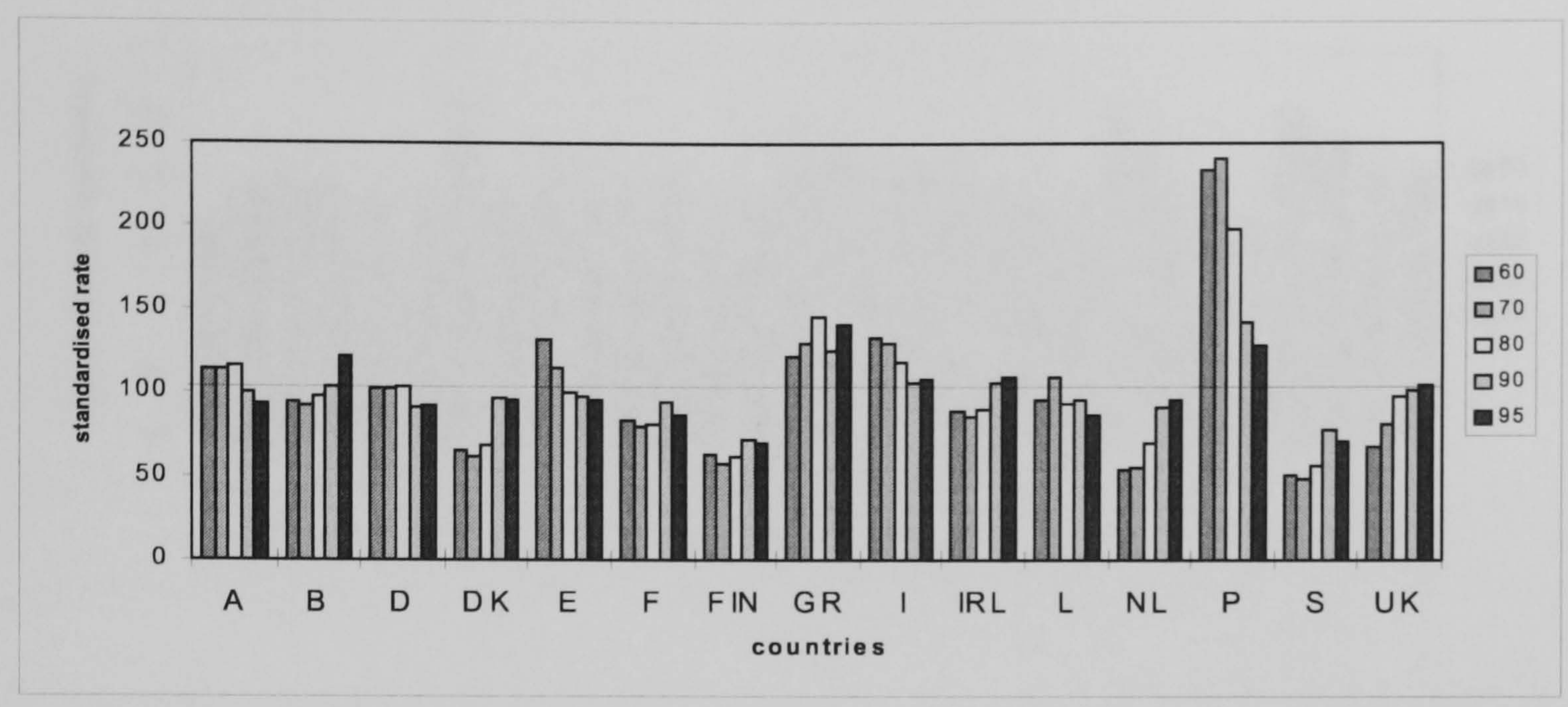


Figure 4.3 Standardised life expectancy for females (EU mean = 100) - 1960-95

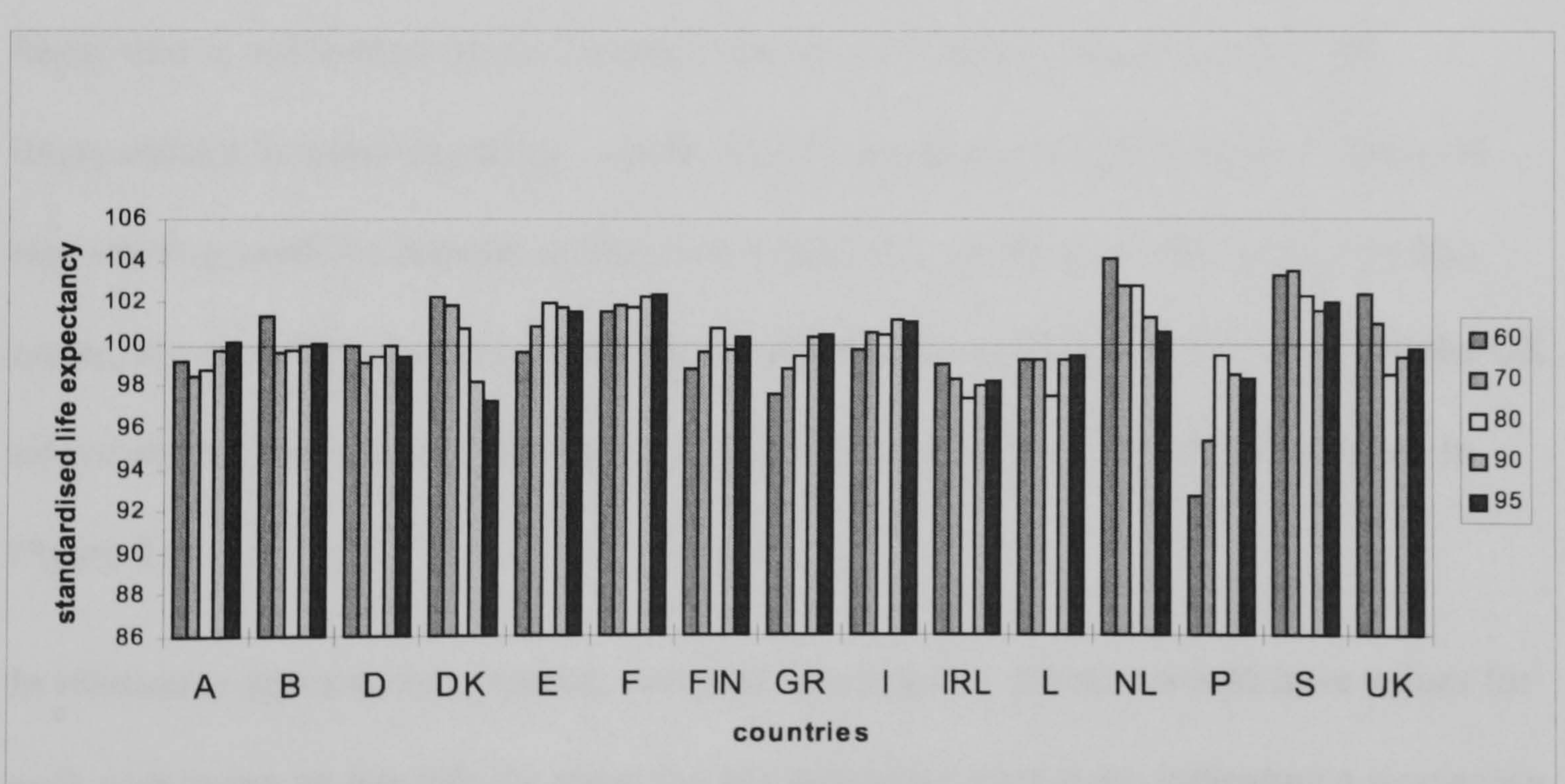
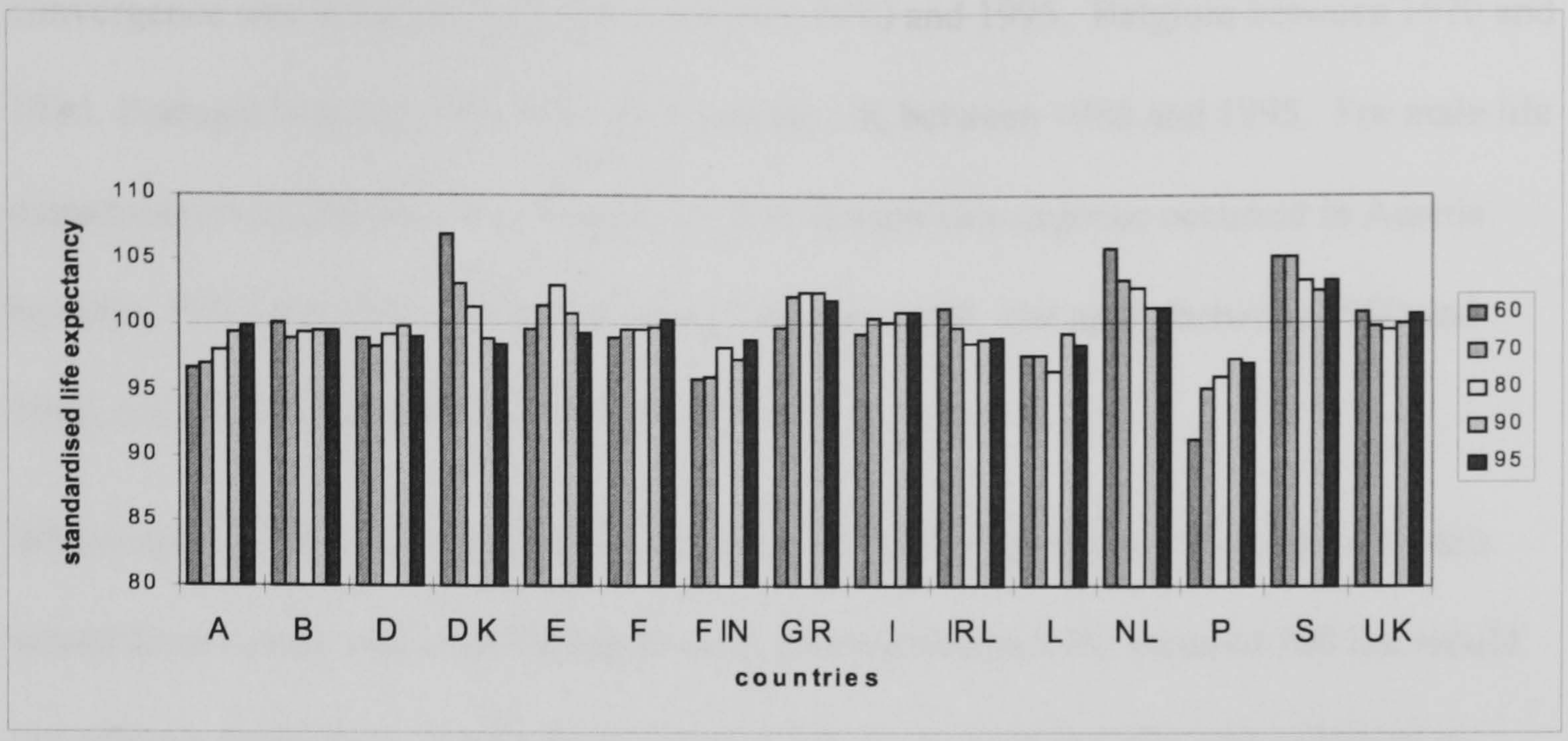


Figure 4.4 Standardised life expectancy for males - 1960-95



In terms of equivalent growth, from Figure 4.2 it can be seen that for infant mortality no countries achieved this although Germany comes closest, particularly between 1960 and 1980, from which point on the figures fall but remain parallel for 1990 and 1995. It is likely that re-unification of the German states in 1989 had an impact on this step improvement in infant mortality. Again, for life expectancy Germany comes closest to equivalent growth for females as shown in Figure 4.3. In terms of life expectancy for males, the countries closest to fulfilling this hypothesis are Belgium, Germany and the UK, all remaining just below or just above (UK) the standardised mean of 100 as shown in Figure 4.4.

In relation to upward convergence, countries meeting this criterion would have values for each year rising up towards the mean but not achieving cross-over, indicating a worsening in their infant mortality rates with respect to the EU mean. This has occurred for Denmark, the Netherlands, Finland (between 1970 and 1990) and Sweden (also between 1970 and 1990).

In examining life expectancy for females (Figure 4.3), it can be seen that upward convergence was achieved by Austria between 1970 and 1995, Belgium between 1970 and 1995, Portugal between 1960 and 1980, and the UK between 1980 and 1995. For male life expectancy it can be seen from Figure 4.5 that upward convergence occurred in Austria between 1960 and 1995, Finland between 1960 and 1980, and again between 1990 and 1995, and in Portugal between 1960 and 1990.

When considering trends in relation to downward convergence, countries achieving this would have values which are falling towards the standardised EU mean of 100 but would not achieve cross-over. Again from Figure 4.3 it can be seen that this was achieved in terms of infant mortality for Italy (between 1960 and 1990) and Portugal. The most dramatic improvement has been achieved by Portugal which, in 1970, had a standardised infant mortality rate almost two and a half times greater than the mean. Although in 1995 it is still above the standardised EU mean, it has figures comparable to Greece and Belgium. In examining life expectancy for females (Figure 4.3) it can be seen that downward convergence occurred in the Netherlands between 1960 and 1995, and in Sweden between 1970 and 1990. For males (Figure 4.4), downward convergence occurred in the Netherlands between 1960 and 1995, and in Sweden between 1970 and 1990.

Countries achieving the reversal of roles scenario would change positions over the period examined with respect to the standardised EU mean, in either an upward or downward trend. When infant mortality is considered Figure 4.2 reveals that the UK achieved upward (worsening) convergence in infant mortality between 1960 and 1980 and then reversal of roles between 1980 and 1995. This also occurred for Ireland between 1970 and 1995, and Belgium between 1970 and 1995. Countries achieving a downward (improving) reversal of roles were Austria between 1980 and 1995, and Spain between 1960 and 1995.

In examining life expectancy for females (Figure 4.3) it can be seen that Denmark experienced a reversal of roles in a downward (worsening) direction between 1960 and 1995, and the UK experienced this between 1960 and 1980. In terms of improving reversal of roles, this occurred in Spain between 1960 and 1980, in Finland between 1960 and 1980 and again between 1990 and 1995, in Greece between 1960 and 1995, and in Italy between 1960 and 1990. For male life expectancy (Figure 4.4), downward (worsening) reversal of roles occurred in Denmark between 1960 and 1995, in Ireland between 1960 and 1980, and in the UK between 1960 and 1980. In terms of upward (improving) reversal of roles this occurred in France between 1960 and 1995, Italy between 1960 and 1995, and the UK between 1980 and 1995.

Finally, in terms of the divergence hypothesis this indicates countries are moving away from the standardised EU mean over time, either in an upward or downward direction. For infant mortality Figure 4.2 indicates that this occurred for upward (worsening) divergence in the case of Greece between 1960 and 1980 and again between 1990 and 1995, Belgium between 1990 and 1995, Ireland between 1990 and 1995 and marginally for the UK between 1990 and 1995. In terms of downward (improving) divergence this occurred for Spain between 1990 and 1995 and in Luxembourg between 1990 and 1995. For female life expectancy (Figure 4.3) the data show that upward divergence (improving) occurred in the cases of France and Italy between 1980 and 1995. Downward convergence (worsening) occurred for Germany and Denmark between 1990 and 1995, and Portugal between 1980 and 1995. For male life expectancy (Figure 4.4) the results show that upward divergence (improving) occurred in the cases of Spain between 1970 and 1980, Italy between 1980 and 1995, and the UK between 1990 and 1995. Downward convergence (worsening) only occurred for Denmark between 1990 and 1995.

4.4. Relative change 1960-95

In summarising the above trends, an overview of the relative changes in standardised infant mortality, life expectancy (males and females) is provided by means of the histograms of Figures 4.5 and 4.6, respectively.

Figure 4.5 Relative change in infant mortality rate - 1995-60

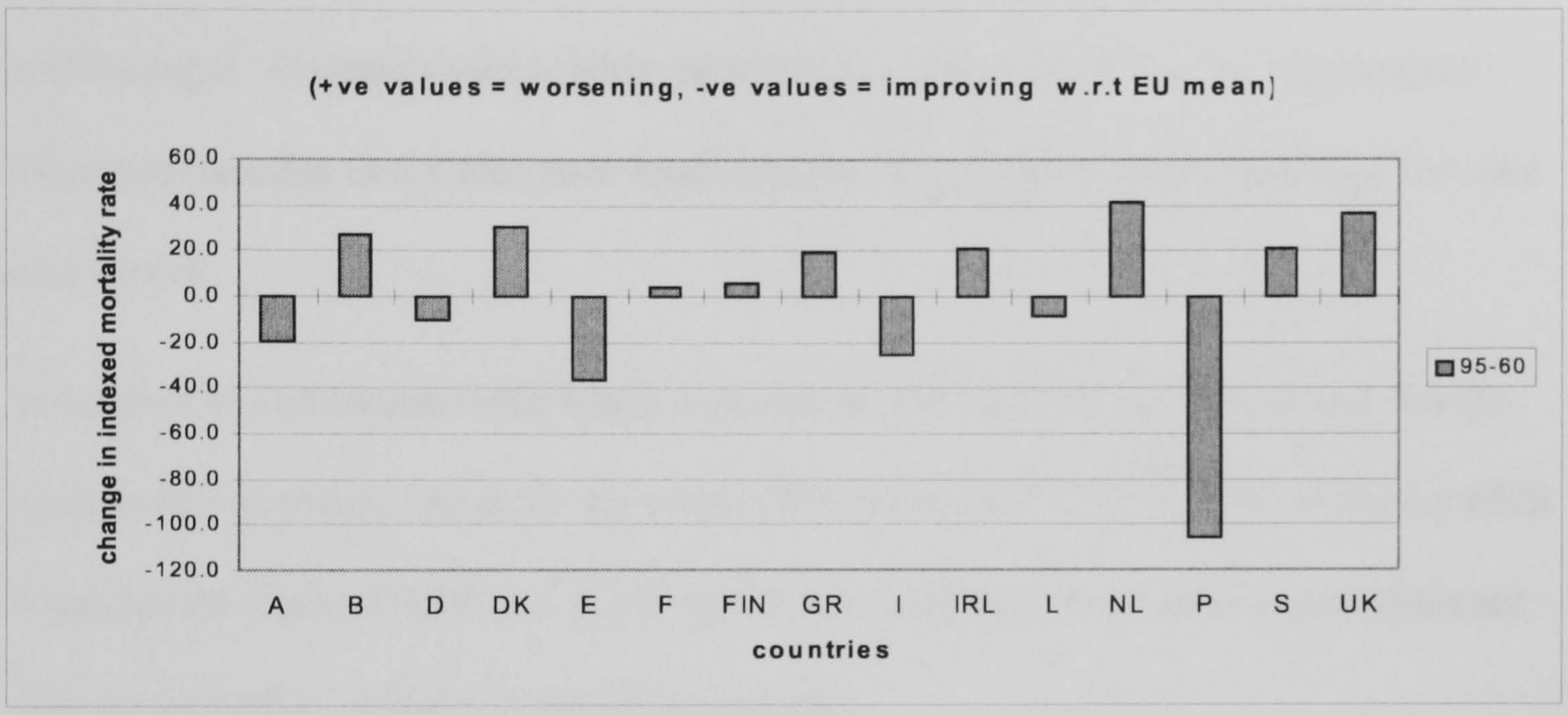
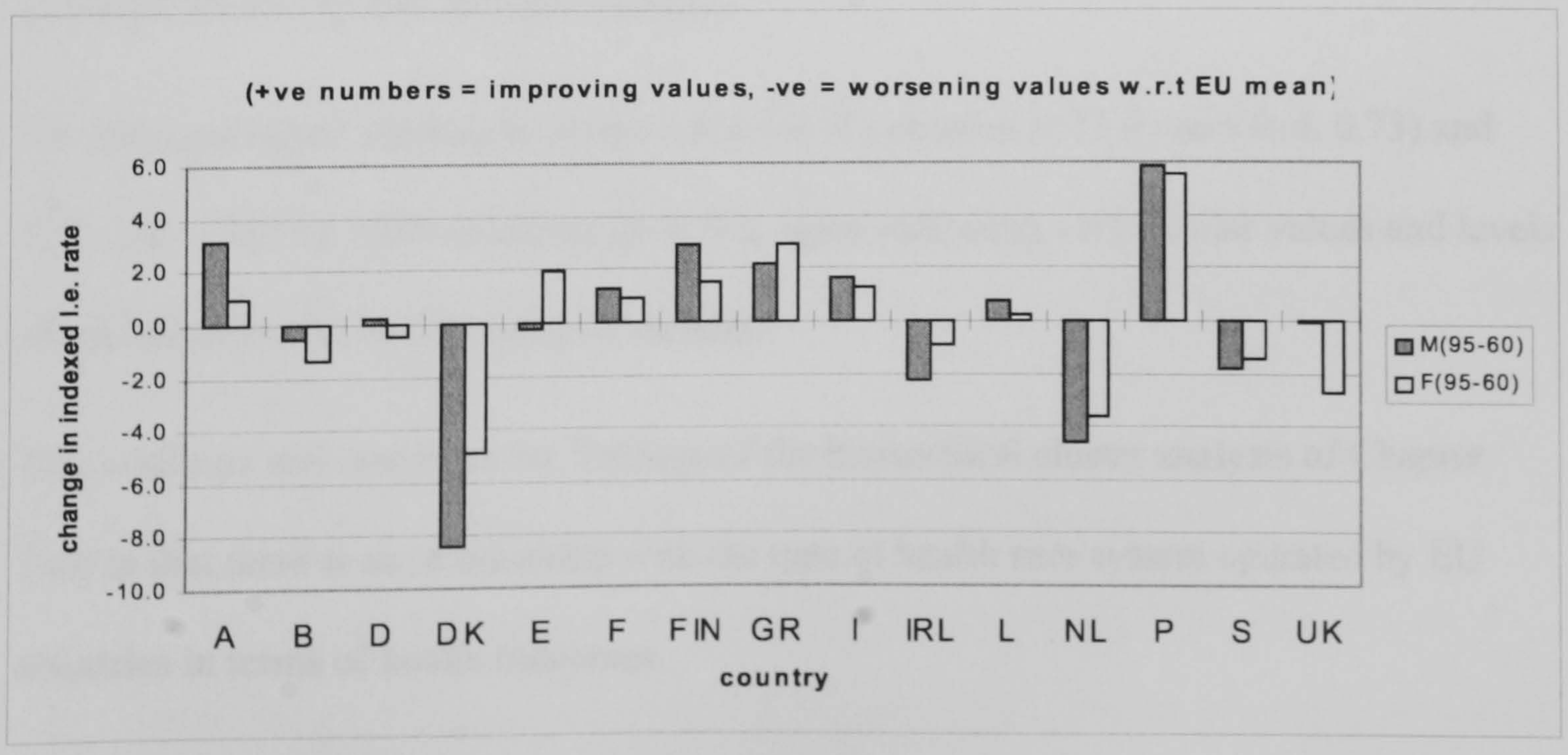


Figure 4.6 Standardised change in male and female life expectancy - 1995-60



In the case of Figure 4.5 the countries with worsening infant mortality levels relative to the standardised mean over the whole period of 1960-90 include Belgium. Denmark. France. Finland, Greece, Ireland, the Netherlands, Sweden and the UK. Improving rates were achieved by Austria, Germany, Spain, Italy, Luxembourg and Portugal.

In terms of life expectancy countries with improving (positive) levels include Austria, Germany (males only), Spain (females only) France, Finland, Greece, Italy, Luxembourg and Portugal. Countries which achieved worsening (negative) levels include Belgium, Germany (females only), Denmark Spain (males only), Ireland, the Netherlands, Sweden and the UK.

In relation to associations with health care system, the ANOVA results showed that the mean infant mortality rate in SI countries (1995 values) is 0.55 (s.d. 0.08) whilst for NHS countries the figure is 0.59 (s.d. 0.13) (p=0.522), indicating a non-significant difference with much higher variance in the NHS countries.

For life expectancy (females) the mean value for SI countries is 80.2 years (s.d. 0.89) and 79.8 (s.d. 1.3) for NHS countries (p=0.53), indicating very similar values and levels of variation for this health outcome variable.

For life expectancy (males) the mean value for SI countries is 73.4 years (s.d. 0.73) and 73.7 (s.d. 1.46) for NHS countries (p=0.76), again indicating very similar values and levels of variation for this health outcome variable.

This confirms and amplifies the findings of the hierarchical cluster analysis of Chapter Two in that there is no relationship with the type of health care system operated by EU countries in terms of health outcomes.

4.5. Associations with health expenditure

In chapter Three (see also Hitiris and Nixon, 2000; Nixon, 1999) it was shown that expenditure levels vary across the countries of the EU but that they too are converging towards the mean under the expectations of the neo-classical growth model (Barro and Sala-i-Martin, 1995) and influenced by a raft of health care reforms throughout the period examined and health care typologies (Ham, 1997, OECD, 1995b; Mossialos and Le Grand, 1999). Health care expenditure has been shown to be correlated with GDP income (Hitiris, 1997; OECD, 1995a) and Hitiris and Nixon (2000) have demonstrated health care expenditure convergence is statistically associated with GDP income. However, little work has been undertaken to show a similar correlation between health expenditure and health outcomes.

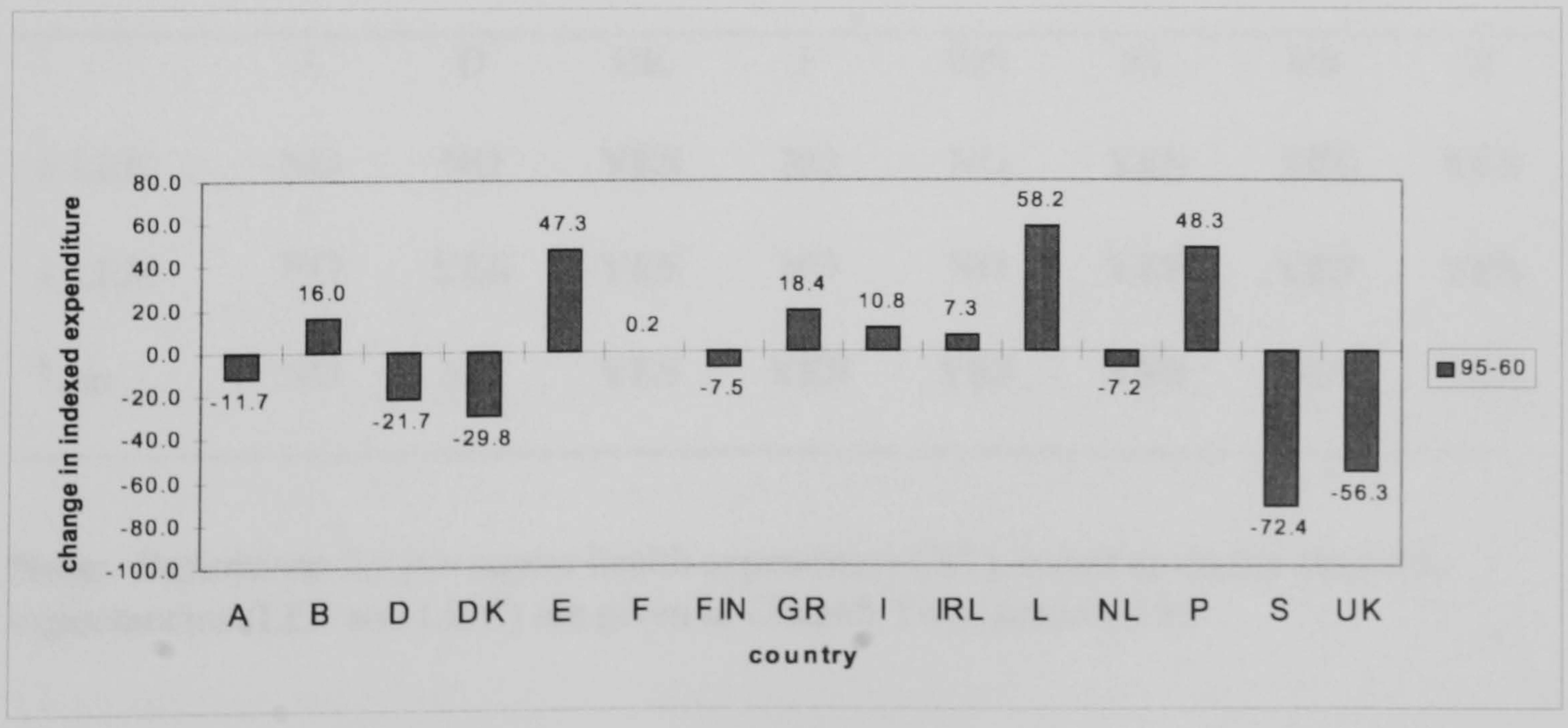
In the following section, therefore, the issue of association between health care expenditure and health outcomes is briefly explored, specifically in attempting to identify if downward convergence towards the mean in expenditure is associated with worsening (relative to the standardised EU mean) health outcomes, and conversely if upward convergence towards the mean is associated with improving health outcomes.

The relative changes in standardised *per capita* spending between 1995 and 1960 are shown in Figure 4.7. The findings are summarised in Table 4.4 which show health outcomes in relation to (a) increased expenditure and (b) decreased expenditure, and which countries are associated with each category.

Figure 4.7 and Table 4.4 show that six countries have achieved increases in health expenditure with respect to their standardised values between 1960 and 1995. These countries are Belgium (+16.0), France (+0.2), Spain (+47.3), Greece (+18.4), Italy (+10.8), Ireland (+7.3), Luxembourg (+58.2) and Portugal (+48.3). It is worth noting that all the countries of the South are included in this category. Among these, increased expenditure has been matched with in improvements in all three health outcome measures for Italy, Luxembourg and Portugal, improvements in both life expectancy indicators for Greece, and improvements in life expectancy for females as well as infant mortality in Spain. It is also interesting to note, however, that increased expenditure for Belgium and Ireland was associated with a worsening of all three health outcome indicators in relation to the standardised EU mean of 100.

Again from Figure 4.7 and Table 4.4 it can be seen that 8 countries have achieved a reduction in their standardised health expenditure levels between 1960 and 1995. These countries are Austria (-11.7), Germany (-21.7), Denmark (-29.8), Finland (-7.5), the Netherlands (-7.2), Sweden (-72.4) and the UK (-56.3). It is notable that all the countries of Scandinavia (including Finland) are in this group. Decreased standardised *per capita* expenditure resulted in a worsening (with respect to the EU mean) of all three health outcome measures in Denmark, the Netherlands, the UK and Sweden. Both France and

Figure 4.7 Relative change in indexed per capita health expenditure - 1995-60



Finland had worsening infant mortality rates and Germany had a slight worsening in its life expectancy for males.

These findings indicate that there might be an association between health expenditure levels and health outcomes, and that convergence is coming about in the countries of the EU due to downward and effective pressure to control health expenditure from some countries, resulting in a worsening position with respect to the standardised EU mean of 100, and efforts to improve health care expenditure in others, which is associated with improving health outcomes.

Table 4.4 Relationship between per capita health expenditure and health outcomes

Increased *per capita* expenditure, X^h, in relation to improving health outcomes

	B	E	GR	I	IRL	L	P
↑ LEF	NO	**YES**	**YES**	**YES**	NO	**YES**	**YES**
↑ LEM	NO	NO	**YES**	**YES**	NO	**YES**	**YES**
↓ im	NO	**YES**	NO	**YES**	NO	**YES**	**YES**

Decreased *per capita* expenditure, X^h, in relation to worsening health outcomes

	A	D	DK	F	FIN	NL	UK	S
↓ LEF	NO	NO	**YES**	NO	NO	**YES**	**YES**	**YES**
↓ LEM	NO	**YES**	**YES**	NO	NO	**YES**	**YES**	**YES**
↑ im	NO	NO	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**

Note: Definitions for *per capita* health expenditure (X^h), infant mortality (im), life expectancies (LEF and LEM) are given in Chapter Two (section 2.3).

These results are suggestive of a causal link between health expenditure and health outcomes. However, such links have to be taken into account within the context of other variables that may have an influence on health outcomes. This is a topic which is fully explored in Chapter Six and at this point in the analysis the above findings are exploratory in nature.

4.6. Results: β-convergence

The results of the β-*convergence* analyses are based on the methodology fully described in Chapter Three, with some changes is nomenclature here to accommodate the regression equations for health outcomes.

Tests are applied for both absolute and conditional convergence in three health outcome measures: H^{im} = infant mortality for 100 live births; H^{LEF} = life expectancy at birth (females); and H^{LEM} = life expectancy at birth (males). All three variables are taken as ratios of the EU mean. As in Chapter Three, for the estimation the time-series data of the 15 EU countries were pooled to form a sample of 240 observations (15-countries x 16-annual observations) thus making use of both cross-section/long-run and time-series/short-run information. However, lagging once for the calculation of $H_{t,i}$ reduces the sample used in the estimation to N=225 observations.

The results revealed significant findings for absolute convergence but there were no significant variables for conditional convergence. The variables tested for conditional convergence were: GDP income, health care expenditure as share of GDP, *per capita* health care expenditure, number of hospital beds, number of doctors *per capita*, length of in-patient stay, and admission rate. This means that steady states apply to all EU countries for infant mortality and both classifications of life expectancy. The results for the model estimates for each health outcome are shown in Table 4.5.

4.6.1 Convergence in infant mortality

Overall, the estimation for infant mortality yielded high goodness-of-fit statistics and statistically significant coefficients of the explanatory variables, with R^2 = 96.7% and R^2 Buse = 67.8%. The β coefficient is negative and statistically significant with a resultant value $\beta = -0.163$ (95% confidence interval $-0.21 < -0.163 < -0.11$). The Wald test statistic also confirms that $\beta < 0$. Therefore, the hypothesis of absolute β-*convergence* is confirmed.

The statistical significance of the shift dummy variables provides evidence of some diversity across the EU countries in the steady state but not in the speed of convergence since the slope dummies are found non-significant. The results therefore satisfy the conditions for strong convergence in infant mortality across the fifteen members of the European Union over the time period estimated. The countries with statistically significant shift dummies are Germany (-0.018), Finland (-0.055), Greece (+0.043), Portugal (+0.048) and Sweden (-0.045), where negative values indicate countries which are significantly below the reference intercept of the UK (in this case favourable) and positive values indicate values statistically above the reference intercept (unfavourable) over the period of analysis. Graphical representations of the results are illustrated and analysed in the sections following the results for life expectancy.

4.6.2 Convergence of life expectancy (females)

Similar results are found for life expectancy in females as shown in the second column of Table 4.5, with $\beta = -0.262$ (95% confidence interval $-0.33 < -0.262 < -0.19$). Again the results confirm the presence of strong convergence for this health outcome.

Table 4.5 Health outcomes – absolute convergence

Coefficient	(1) H^{im}	(2) H^{LEF}	(3) H^{LEM}
constant α	0.002*	0.0009*	0.000*
	(0.003)	(0.0003)	(0.000)
coefficient (1+β)	+0.837	+0.738	+0.873
	(0.026)	(0.036)	(0.025)
Dummy Variables (shift)	-0.018 D	-0.005 DK	-0.002 DK
	(0.007)	(0.001)	(0.0004)
	-0.055 FIN	+0.005 E	-0.002 FIN
	(0.018)	(0.0001)	(0.001)
	+0.043 GR	+0.006 F	-0.003 P
	(0.014)	(0.0001)	(0.001)
	+0.048 P	+0.001 FIN	+0.003 GR
	(0.017)	(0.0006)	(0.001)
	-0.045 S	+0.002 GR	+0.001 NL
	(0.013)	(0.0005)	(0.0007)
		-0.005 IRL	+0.004 S
		(0.001)	(0.001)
		+0.004 NL	
		(0.001)	
		-0.005 P	
		(0.001)	
		+0.006 S	
		(0.001)	
R^2 (Buse)	0.678	0.635	0.769
R^2 (observed/predicted)	0.967	0.975	0.983
β-coefficient	- 0.163	-0.262	-0.127
	(0.026)	(0.036)	(0.025)
Wald $\chi^2_{(1)}$ test for β=0	39.307	54.253	26.42

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equation (1) represents infant mortality for absolute convergence. Equation 2 represents life expectancy for females. Equation (3) represents life expectancy for males. The country dummy variables are shift dummies.

All variables are defined according to Chapter Two (section 2.3).

The statistical significance of the shift dummy variables provides, however, greater diversity across the EU countries but again not in the speed of convergence since the slope dummies are found non-significant. The countries with statistically significant shift dummies are Denmark (-0.005), Spain (+0.005), France (+0.006). Finland (+0.001) Greece (+0.002), Ireland (-0.005), the Netherlands (+0.004), Portugal (-0.005) and Sweden (+0.006), where negative values indicate countries which are significantly below the reference intercept (in this case unfavourable) and positive values indicate values statistically above the reference intercept (favourable) over the period of analysis. Graphical representations of the results are illustrated and analysed in the sections following the results for life expectancy (males).

4.6.3 Convergence of life expectancy (males)

Again, similar results are found for life expectancy in males as shown in the third column of Table 4.5, with $\beta = -0.127$ (95% confidence interval $-0.18 < -0.127 < -0.08$). The results therefore confirm the presence of strong convergence for this health outcome.

The statistical significance of the shift dummy variables provides, however, diversity across the EU countries in the steady state but again not in the speed of convergence since the slope dummies are found to be non-significant. The countries with statistically significant shift dummies are Denmark (-0.002), Finland (+0.002), Portugal (-0.003). Greece (+0.003), the Netherlands (+0.001), and Sweden (+0.004). where negative values again indicate countries which are significantly below the reference intercept (in this case unfavourable) and positive values indicate values statistically above the reference intercept (favourable) over the period of analysis. Graphical representations of the results are illustrated and analysed in the following sections following.

4.7. Graphical representations of β-convergence results

In this section the results of the β-*convergence* analysis for all three health outcomes are presented graphically with respect to the EU mean.

Figure 4.8 shows the results for infant mortality for Greece, Portugal and Italy. A trend of downward convergence towards the mean is in evidence, particularly for Greece and Portugal (but both statistically above the EU mean in 1995). This indicates that these countries have been improving their infant mortality rates with respect to the EU mean.

Figure 4.8 Infant mortality for Greece, Portugal and Italy

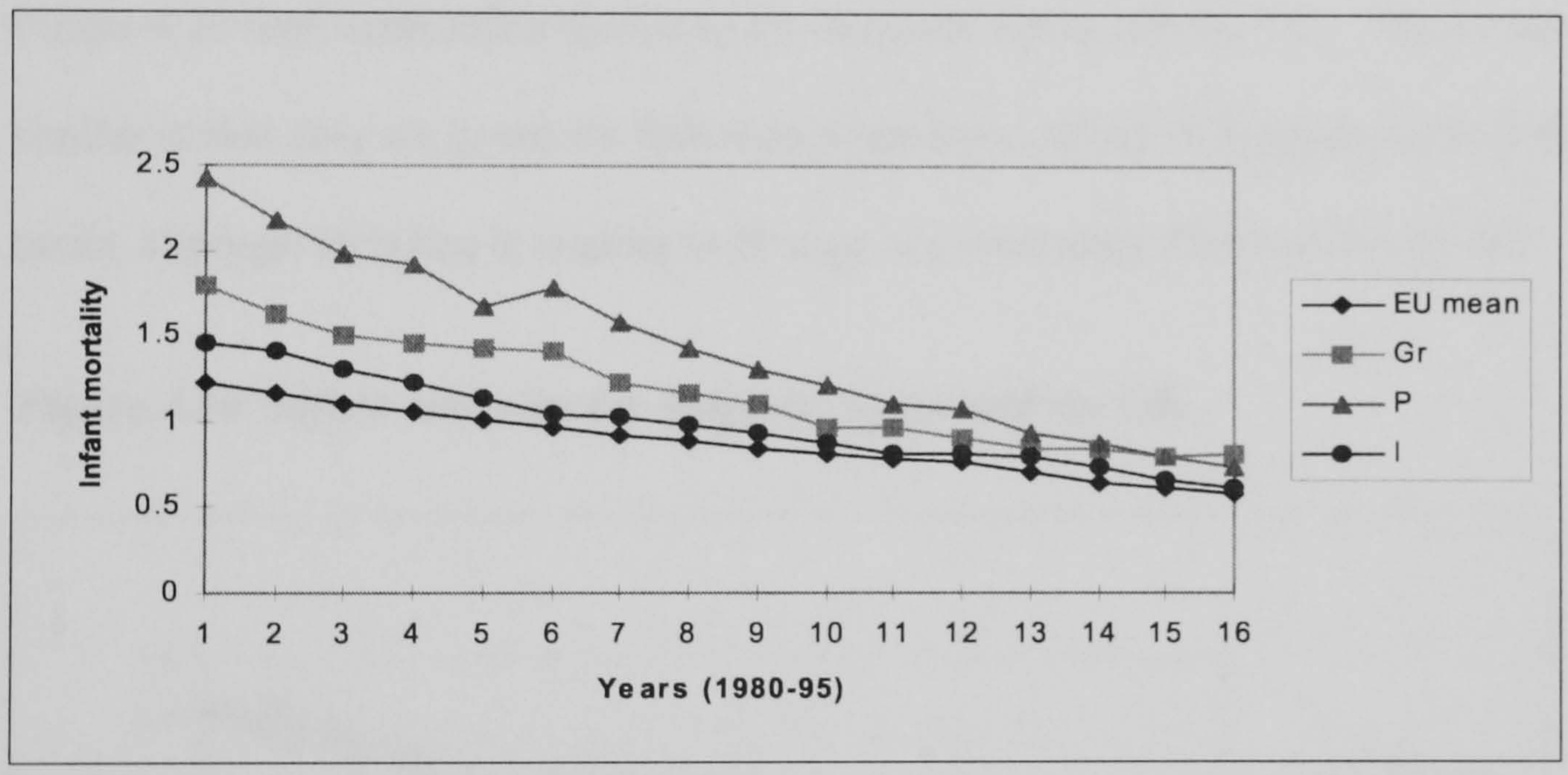


Figure 4.9 provides the infant mortality results for Germany, Finland and Sweden. These countries are all below the EU mean with Sweden and Finland exhibiting steady improvements (from already significantly better positions) and Germany following a parallel trend below the EU mean.

For these countries it is perhaps more accurate to say that the EU mean is converging downwards towards the favourable positions they hold.

Figure 4.9 Infant mortality for Germany, Finland and Sweden

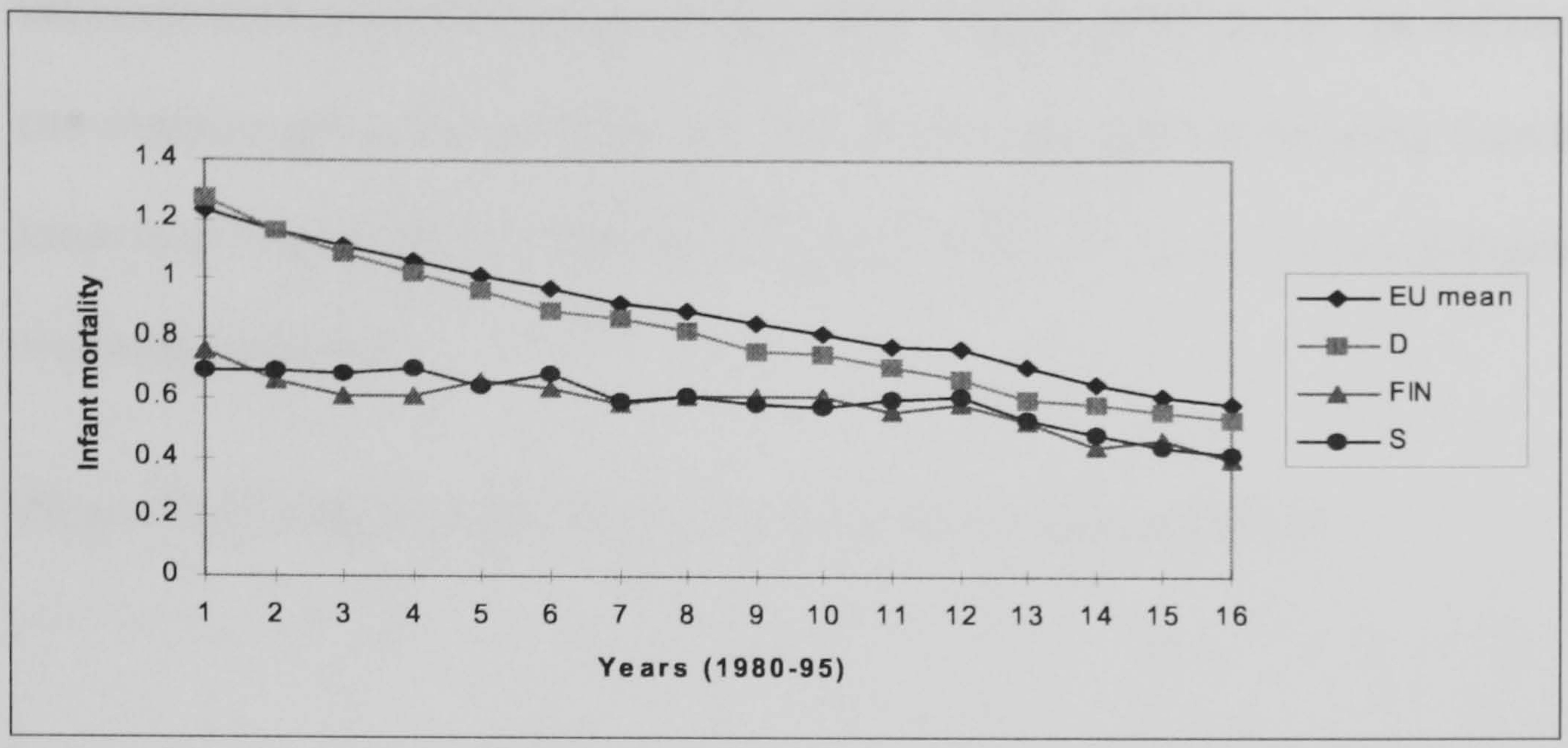


Figure 4.10 represents infant mortality for Belgium, Spain and the UK. These countries are similar in that they are generally following equivalent growth in comparison with the EU mean, although Belgium is tending to diverge in a worsening direction since 1990.

Figure 4.10 Infant mortality for Belgium, Spain and the UK.

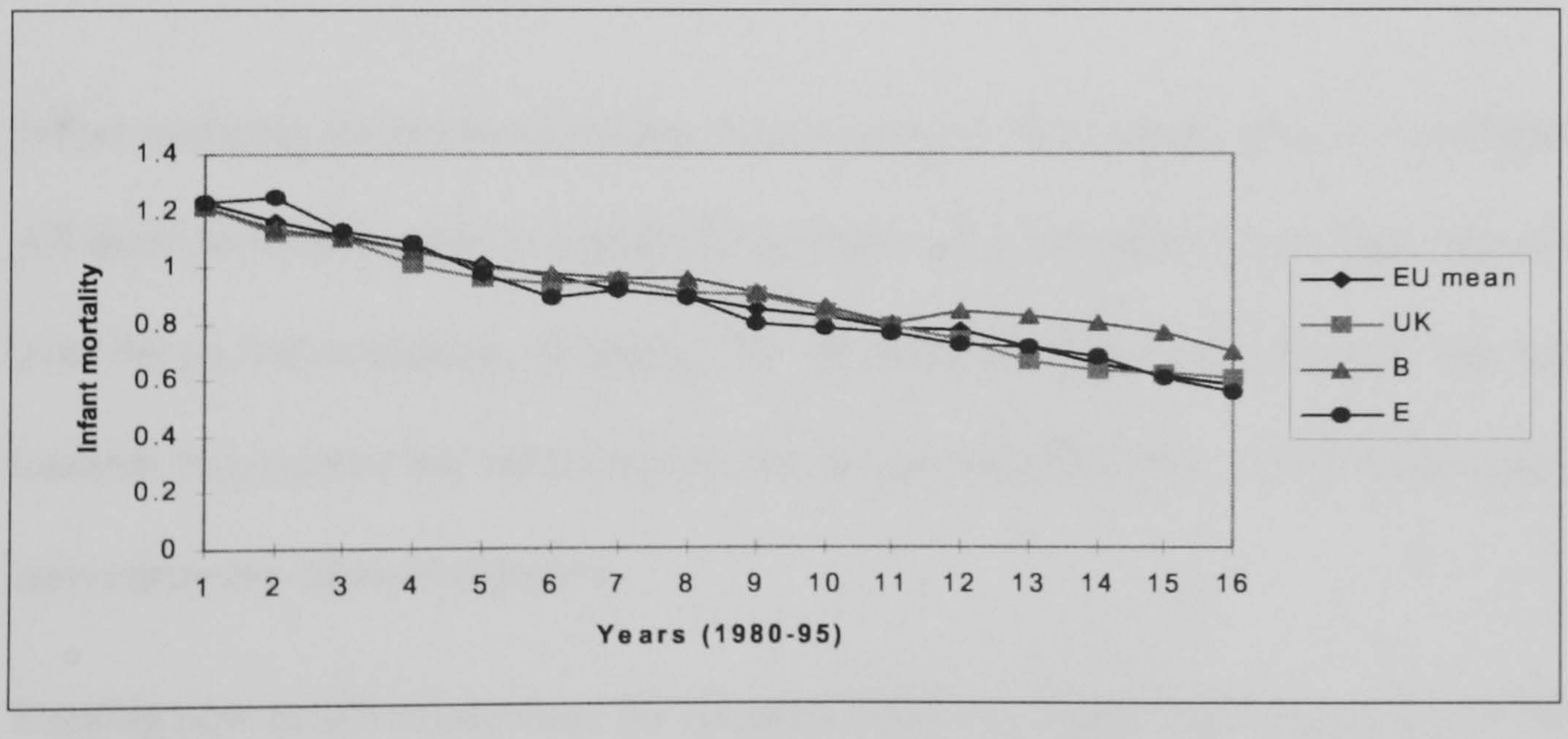
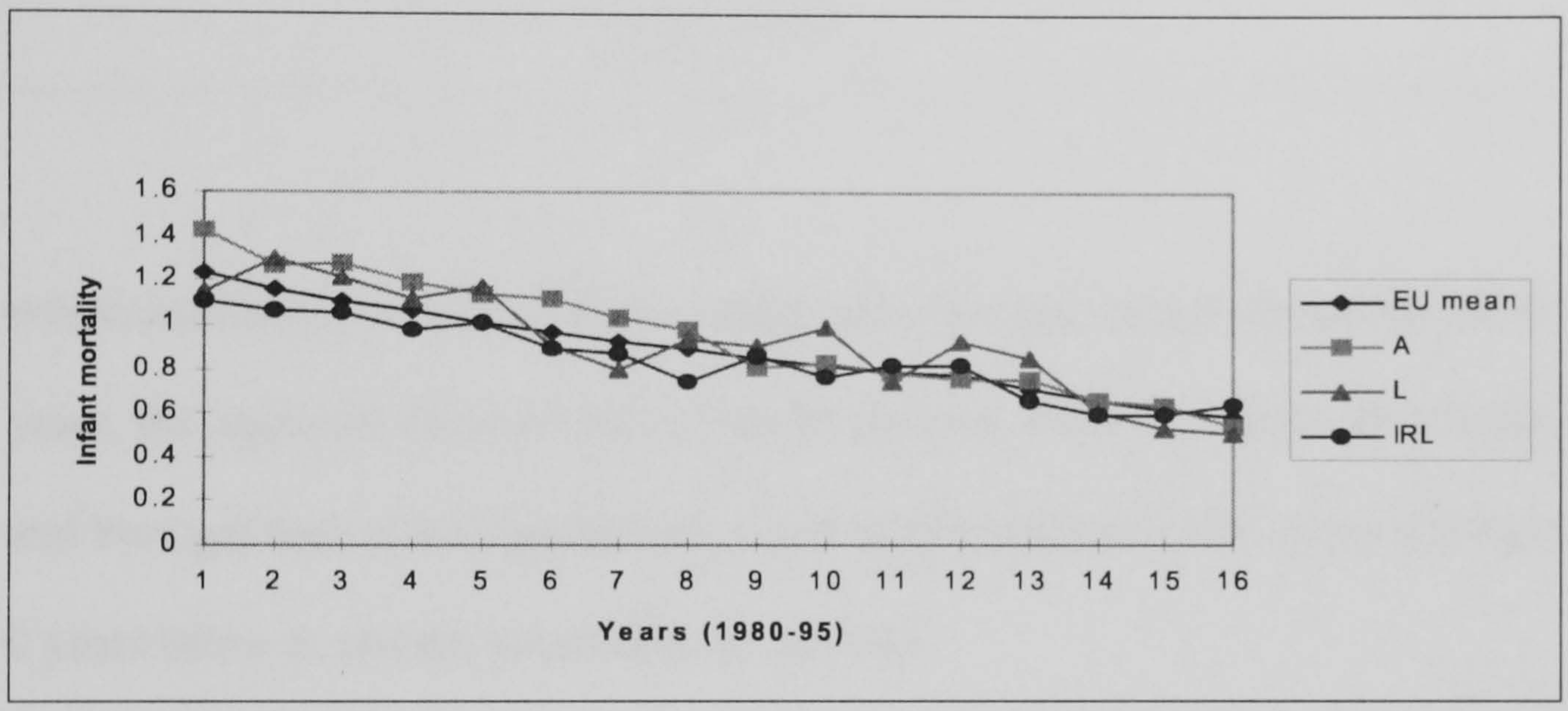


Figure 4.11 shows infant mortality trends for Austria, Luxembourg and Ireland. In the case of Austria infant mortality has converged downwards the EU mean and remained parallel with it since 1988. For Luxembourg, a rather erratic trend has been in evidence

with periods above and periods below the EU mean. From 1993 the trend has been an improvement to a position below the EU mean. Ireland, in this group, has had periods of convergence upwards towards the EU mean, along with other periods away from the EU mean in an improving direction, but between 1994 and 1995 experienced divergence in a worsening direction.

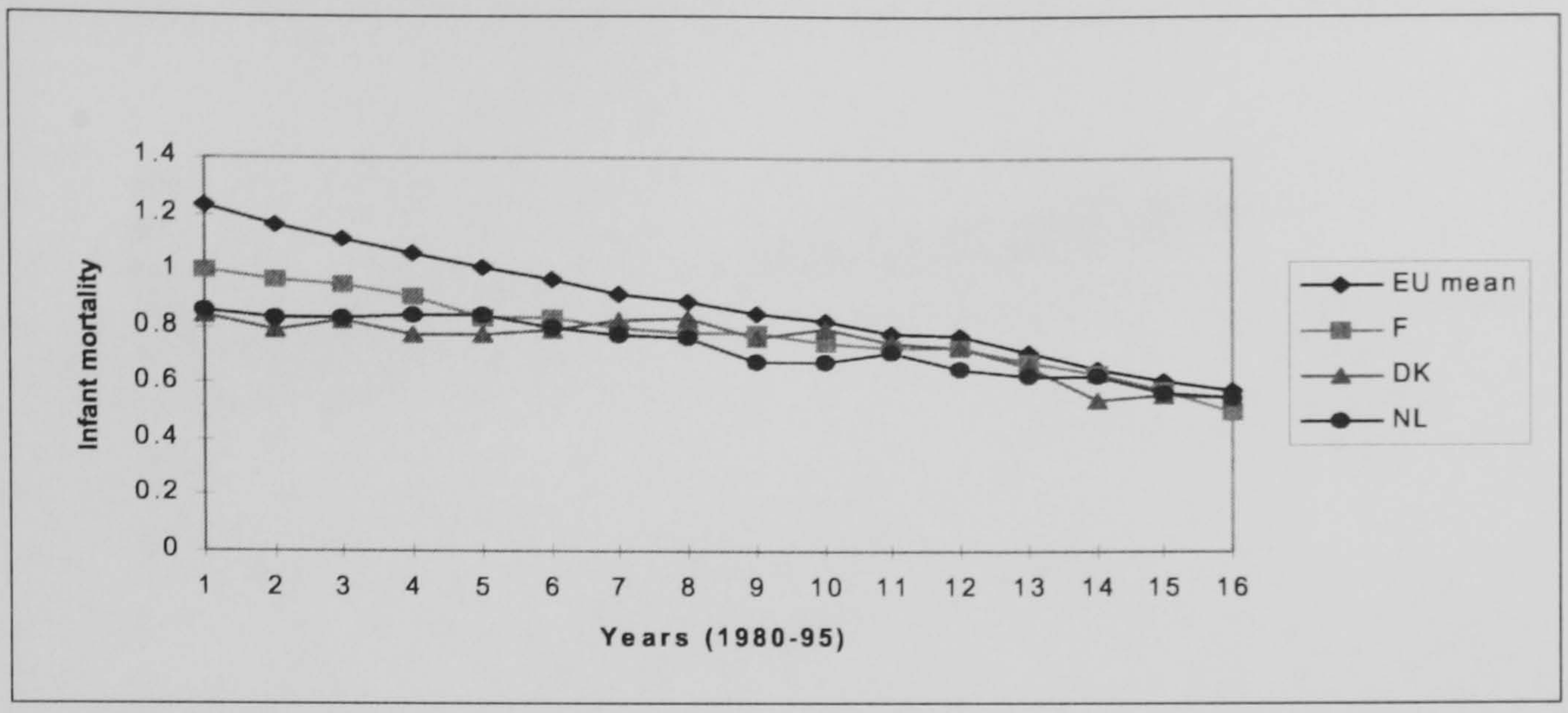
Figure 4.11 Infant mortality for Austria, Luxembourg and Ireland



Infant mortality trends for Denmark, France and the Netherlands are given in Figure 4.12. All three have converged to a position just below the EU mean with steady improvements over the period examined. However, the EU mean has been converging downwards towards these countries' rates over the period and the differences are now marginal as convergence is almost complete.

Turning now to life expectancy for females, Figure 4.13 provides the results for Denmark, Ireland and Portugal. We observe that these countries are well below the EU mean although the situation for Denmark is somewhat different, and perhaps of concern, in that since 1981 female life expectancy has been diverging away from the EU mean in a

Figure 4.12 Infant mortality for Denmark, France and the Netherlands



worsening direction. In fact, while average life expectancy has risen steadily from 77 to 80 years, the figure for Denmark has remained steady at about 77.5 years. In contrast, Ireland and Portugal have almost equivalent growth with respect to the EU mean at a figure about 2 years below it, and are not exhibiting catch-up.

Figure 4.13 Life expectancy (females) for Denmark, Ireland and Portugal

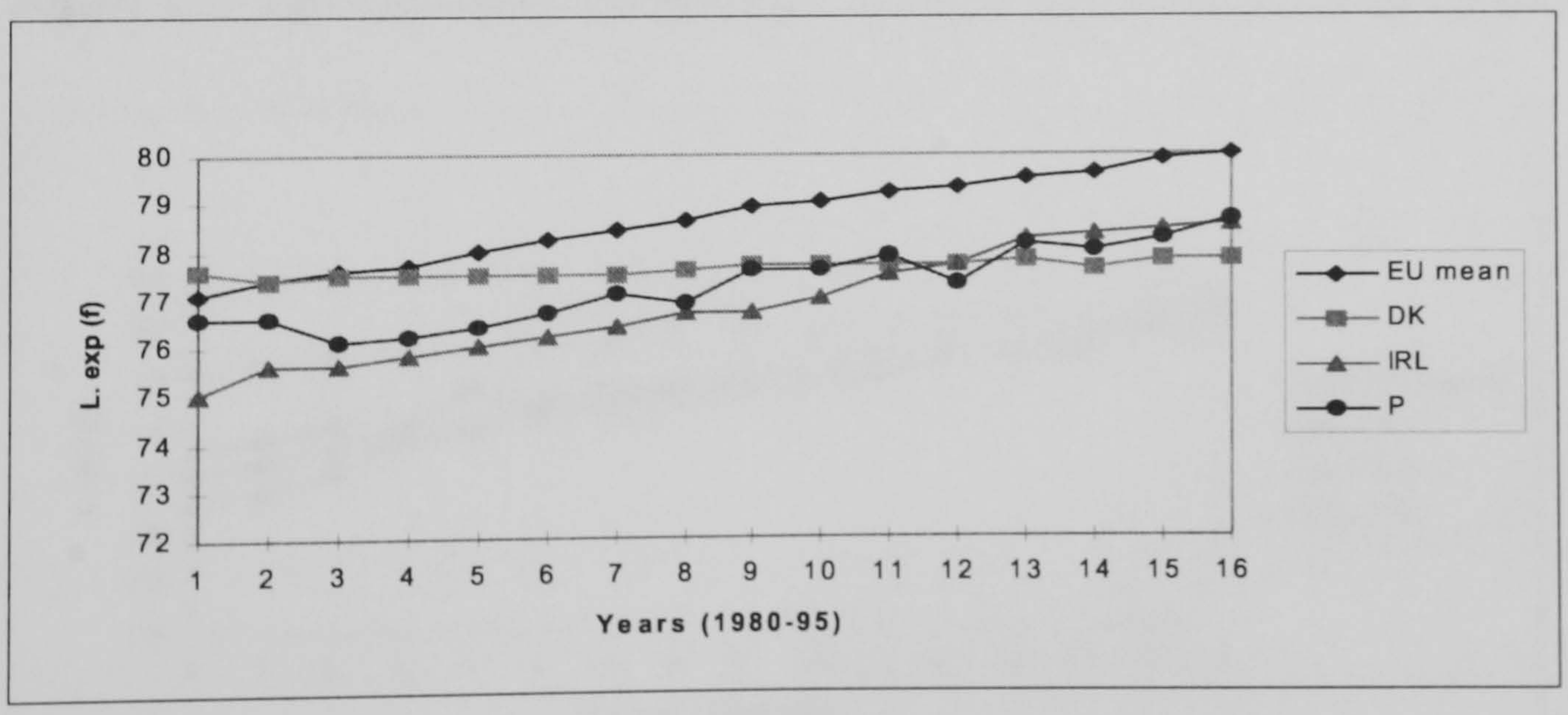
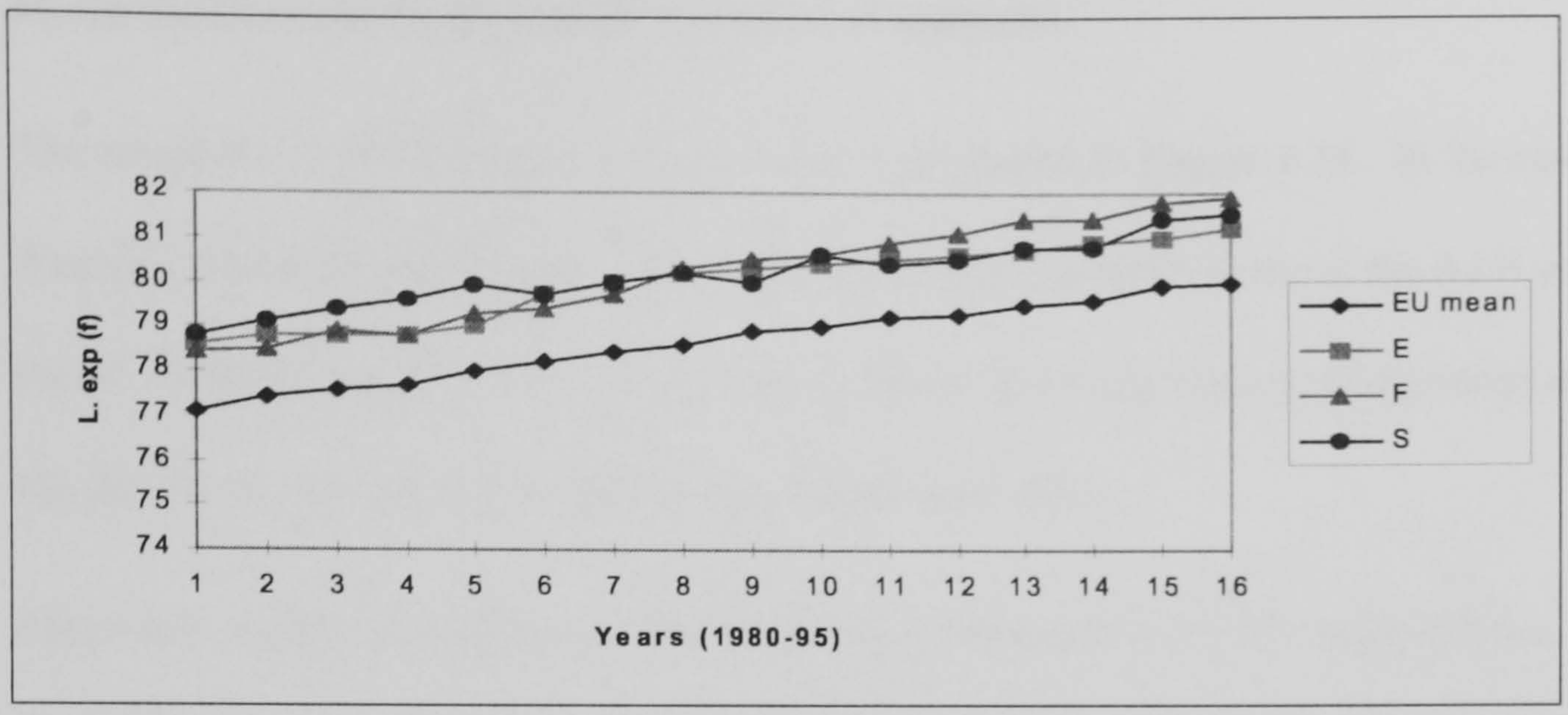


Figure 4.14 shows three countries, Spain, France and Sweden, that are following almost equivalent growth paths above the EU mean, representing life expectancies for females that

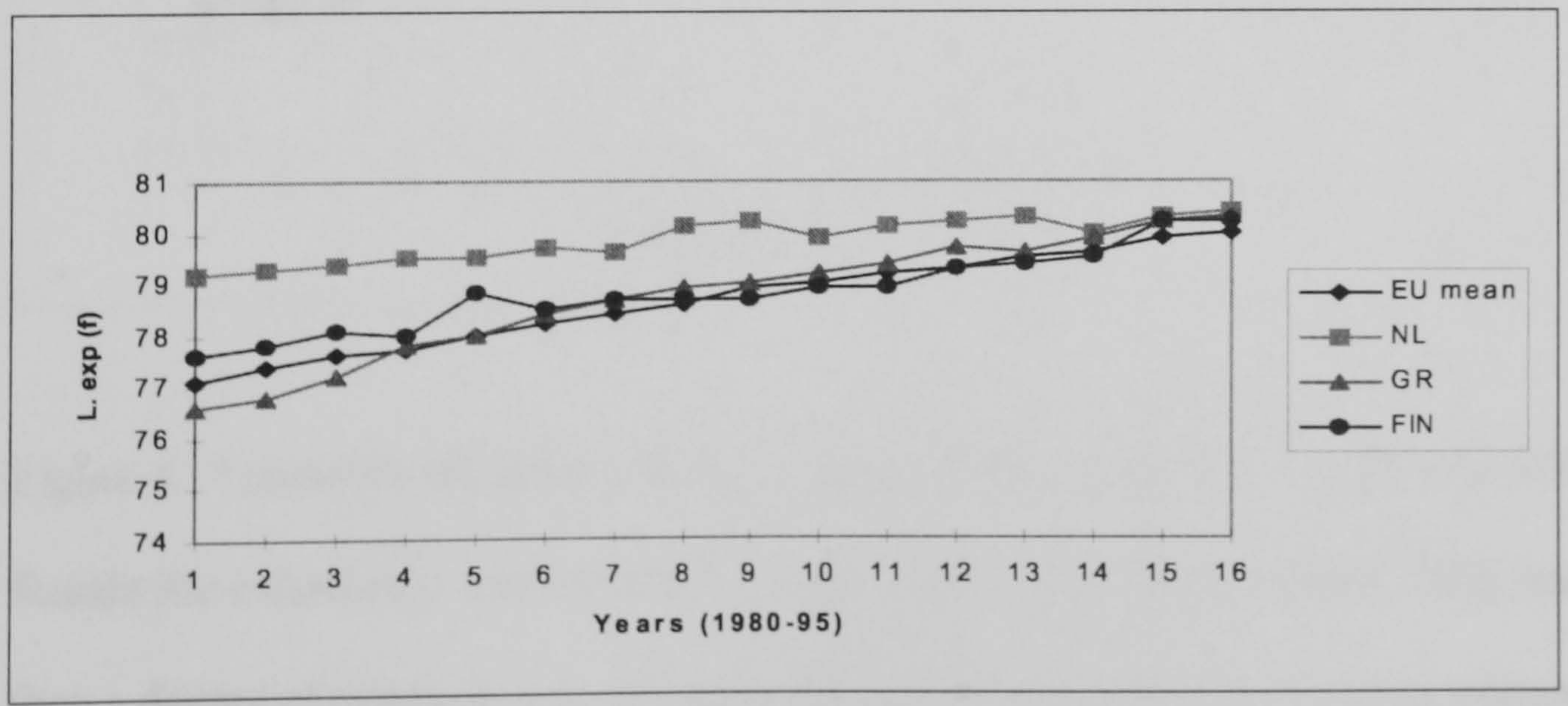
Figure 4.14 Life expectancy (females) for Spain, France and Sweden



are consistently 1-2 years above the EU mean.

Figure 4.15 shows life expectancy for females for Finland, Greece and the Netherlands. Whilst the general trend for Greece and Finland has been to follow equivalent growth with respect to the EU mean over the period examined, the EU mean, along with Greece and Finland, has been converging upwards towards the female life expectancy of the

Figure 4.15 Life expectancy (females) for Finland, Greece and the Netherlands



Netherlands, which has increased only steadily over the same period. All countries remain above the EU mean at the end of the period of analysis.

The trends for Austria, Belgium and Germany are shown in Figure 4.16. In the case of Austria, female life expectancy has clearly converged upwards to attain the level of the EU mean. Belgium has achieved a similar trend whilst Germany converged upwards to attain the EU mean level in 1985 which it maintained until 1991.

There was a rather abrupt downward divergence trend between 1991 and 1992 for Germany, followed by a parallel trend below the EU mean since then. Previous analysis in health expenditure convergence analysis indicates that this is likely due to German re-unification.

Figure 4.16 Life expectancy (females) for Austria, Belgium and Germany

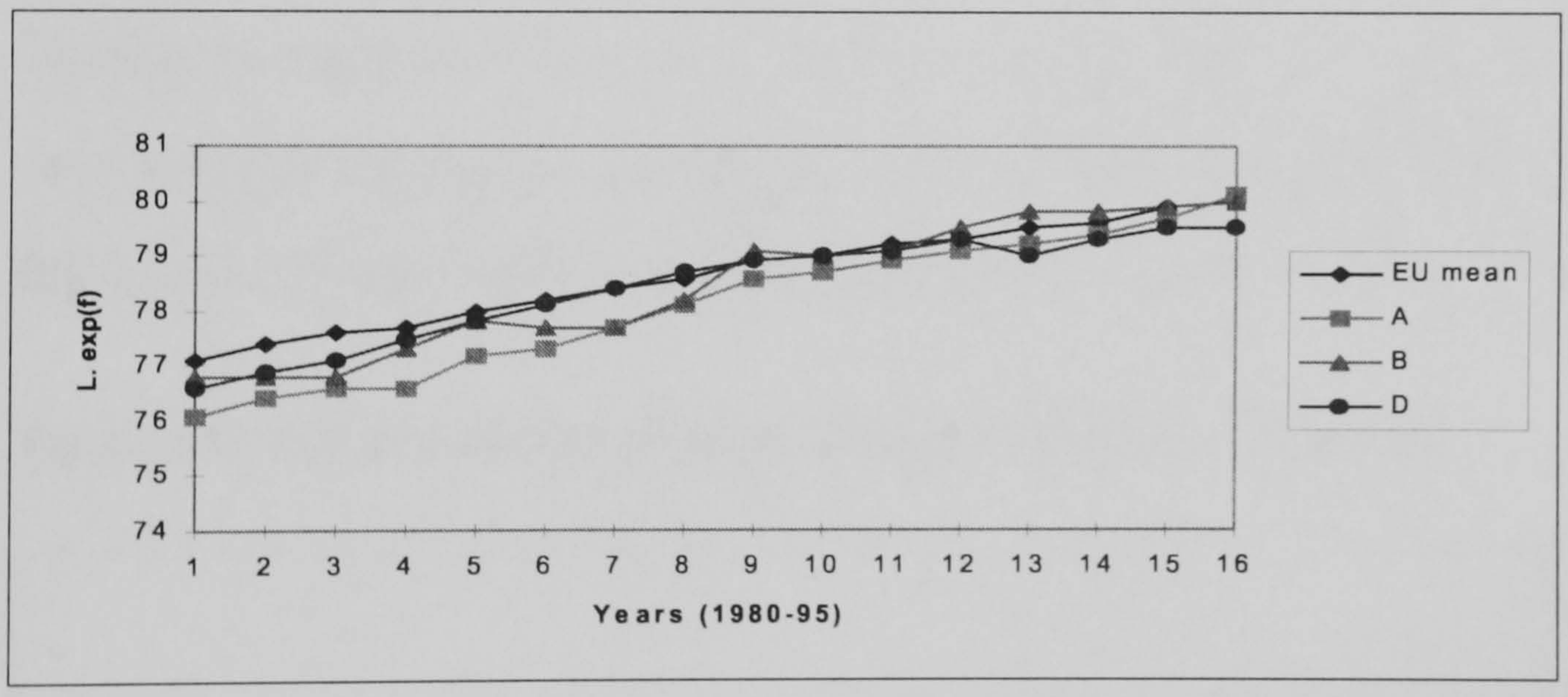
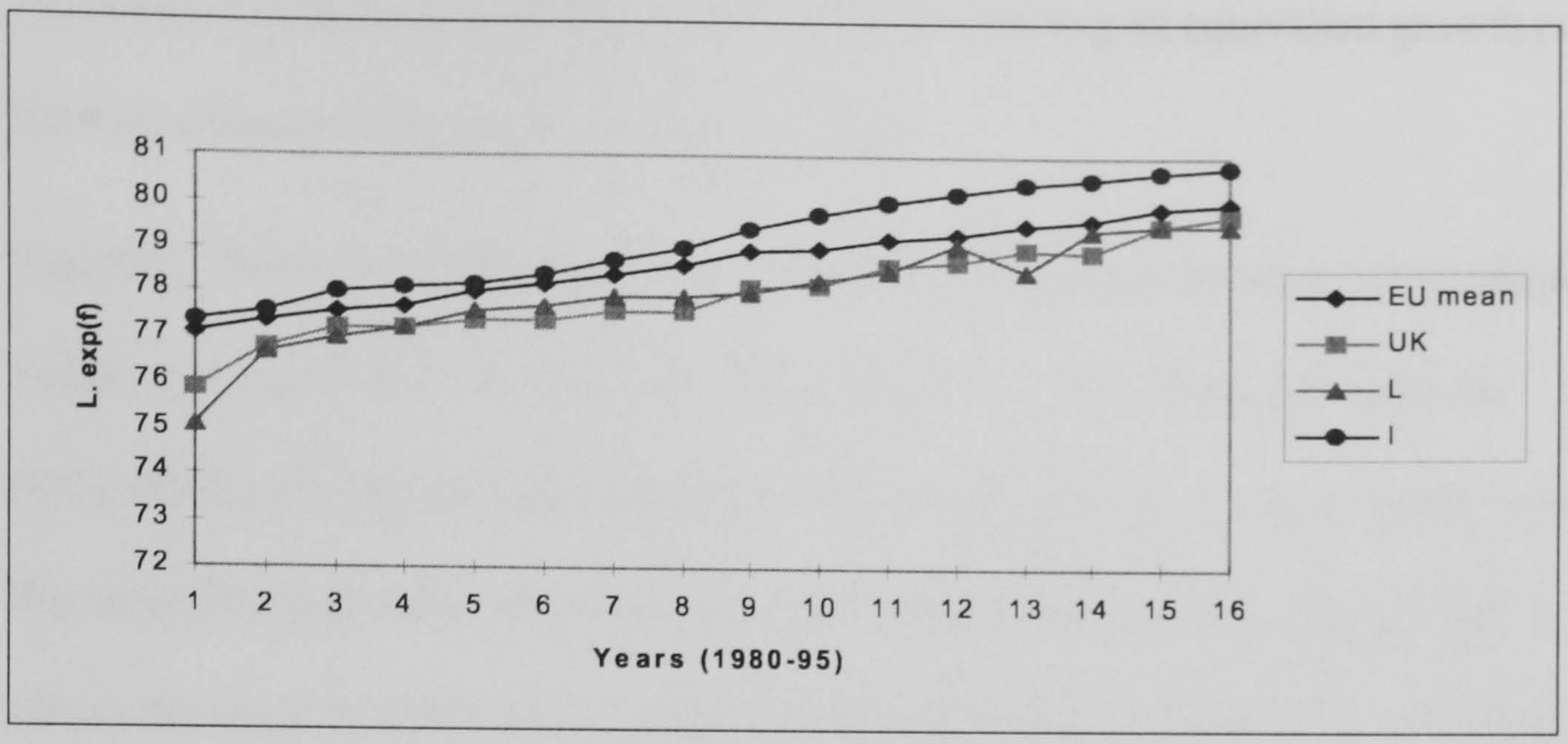


Figure 4.17 provides the trends for Italy, Luxembourg and the UK. In the case of Italy female life expectancy was close to but slightly above the EU mean until 1988, but since then a degree of divergence in an improving trend has occurred with Italian women having a life expectancy about one year above the mean, which is statistically significant. Both Luxembourg and the UK have female life expectancies a little below the EU mean and are

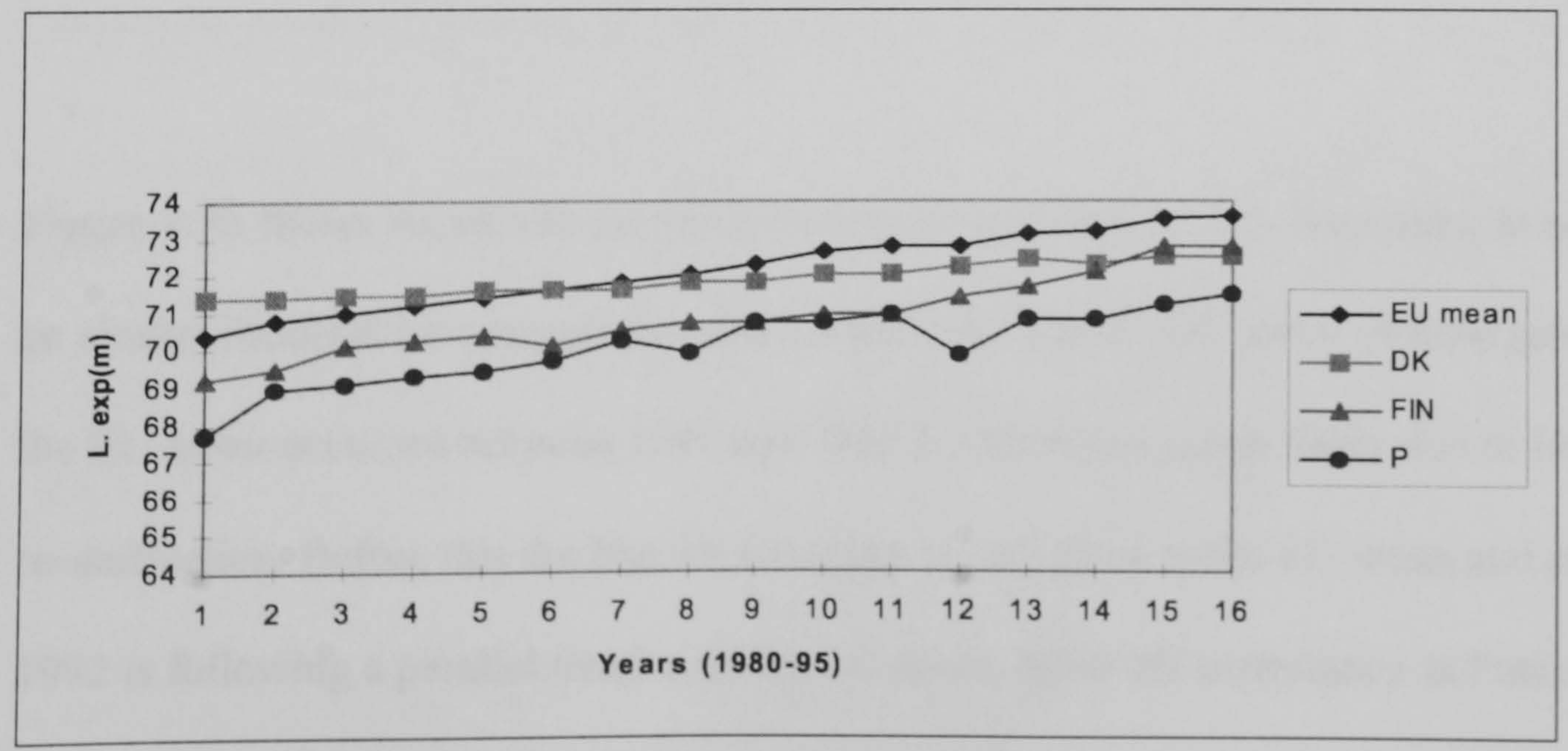
Figure 4.17 Life expectancy (females) for Italy, Luxembourg and the UK



generally following an equivalent growth path in comparison with the EU mean.

Turning now to life expectancy for men the first three countries of interest are Denmark, Finland and Portugal, as shown in Figure 4.18. As with life expectancy for females, Denmark has experienced a reversal of roles scenario in going from above the EU mean in 1980, and since 1985 has been diverging below the EU mean, although life expectancy for Danish males is rising (but at a slower rate in comparison with the EU mean).

Figure 4.18 Life expectancy (males) for Denmark, Finland, and Portugal



In the case of Portugal and Finland male life expectancy has been consistently below the EU mean over the period examined but both are following an equivalent growth path with life expectancies 1-2 years below the EU mean.

Figure 4.19 shows the trends for Greece, the Netherlands and Sweden, all of which have values well above the EU mean. Whilst the EU mean is converging towards the Netherlands, it is approximately parallel with Greece, but Sweden is diverging away from the mean life expectancy for males in an improving position with a figure about 3 years above the mean in 1995. All countries remain above the EU mean at the end of the period of analysis.

Figure 4.19 Life expectancy (males) for Greece, the Netherlands and Sweden

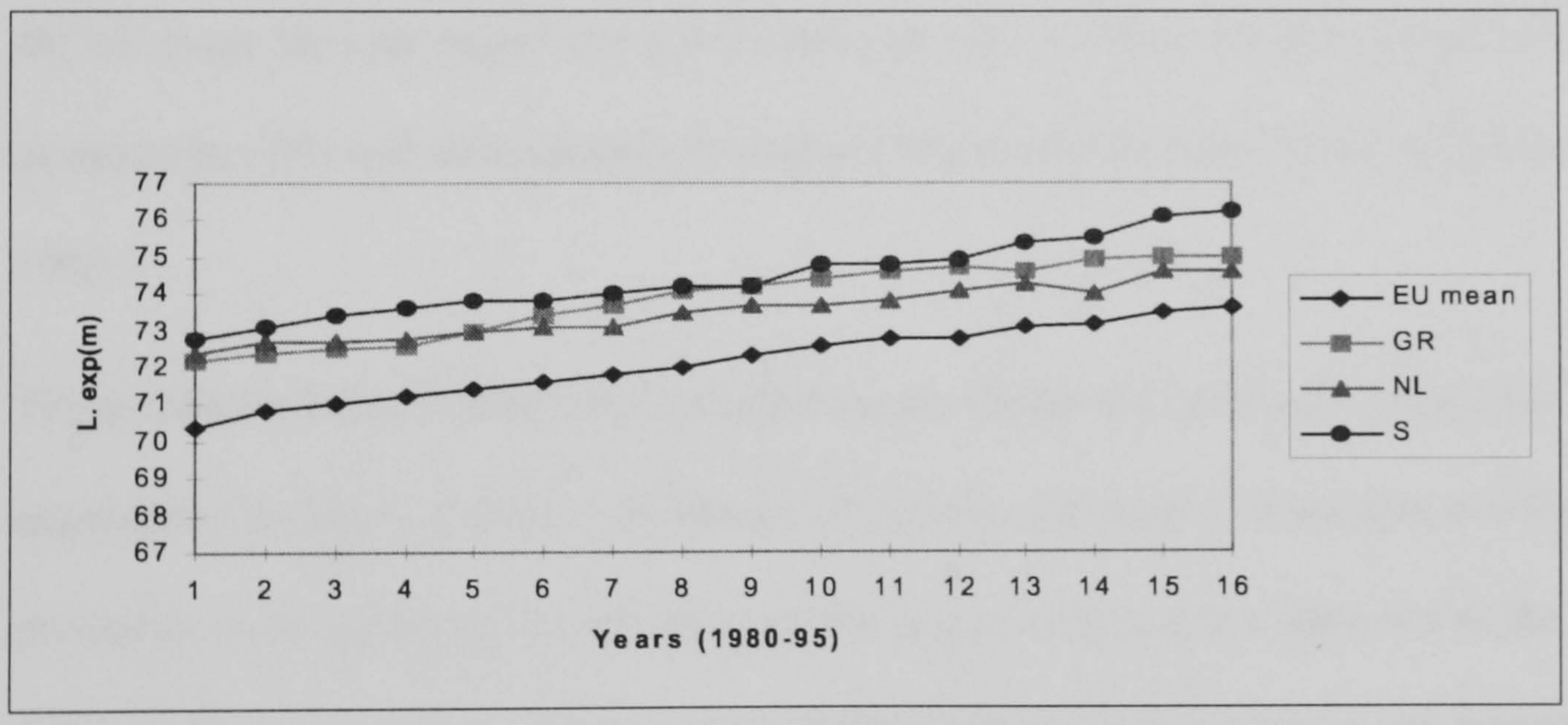
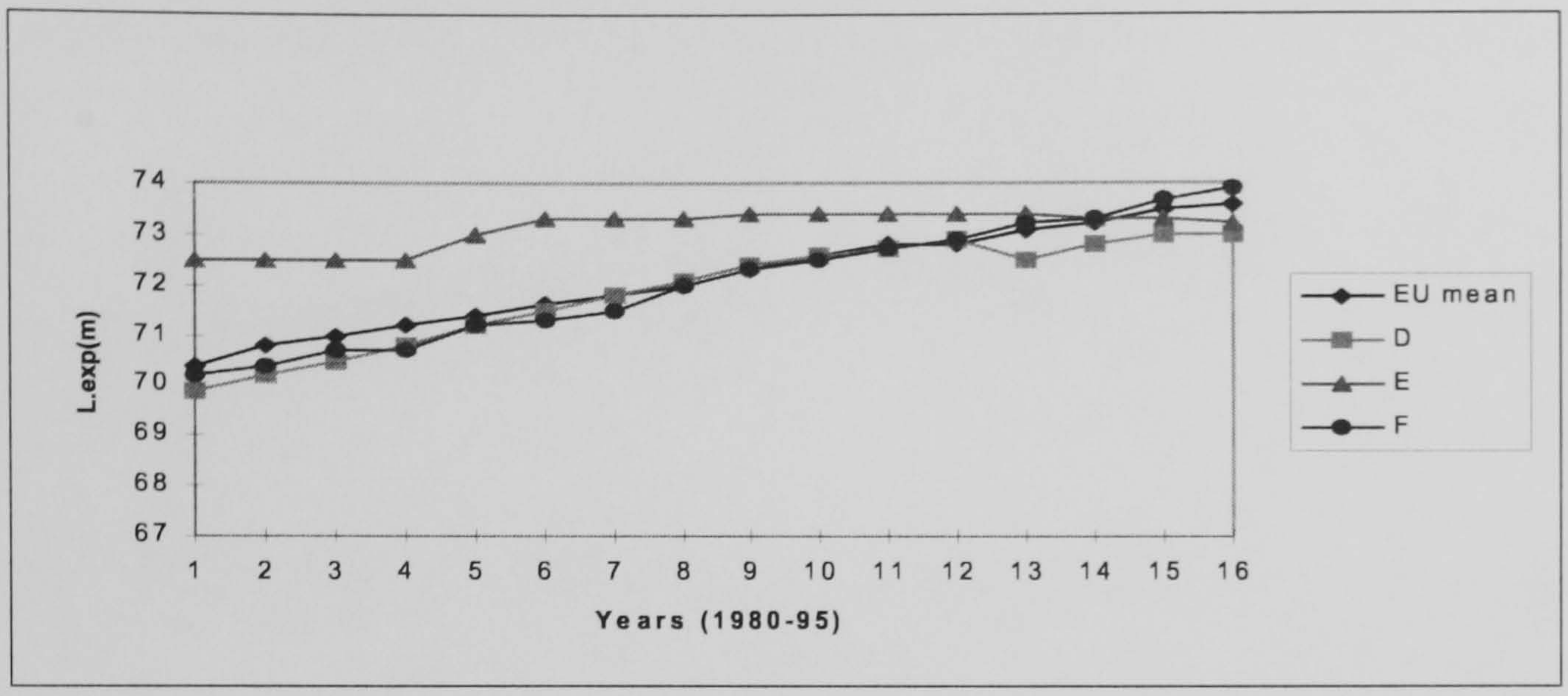


Figure 4.20 shows the results for Spain, Germany and France. It is interesting to note that an almost identical (in comparison with female life expectancy) period of divergence below the EU mean occurred between 1991 and 1992 for Germany, again likely due to German re-unification. Before this the line for Germany is very close to the EU mean and since 1992 is following a parallel trend with the EU mean. Male life expectancy in France

Figure 4.20 Life expectancy (males) for Spain, Germany and France



generally follows equivalent growth with the EU mean although it has been slightly diverging above the mean (improving) since 1991. The line for Spain is of most concern as the EU mean has converged upwards towards the line for Spain and a reversal of roles occurred in 1993 and subsequently divergence below the EU mean between 1993 and 1995.

The results for Italy, Ireland and Luxembourg are shown in Figure 4.21. Male life expectancy in Italy is a little above the EU mean over the period of analysis and is also diverging in an improving trend, although this is not occurring at a high rate as the differences remain small. In the cases of Ireland and Luxembourg male life expectancy is below the mean for the whole period of analysis and generally parallel to it. The trends also show that since 1988 some periods of divergence and convergence are in evidence for both of these countries but both finishing at a value of about one year below the EU mean at the end of the period.

Figure 4.21 Life expectancy (males) for Italy, Ireland and Luxembourg

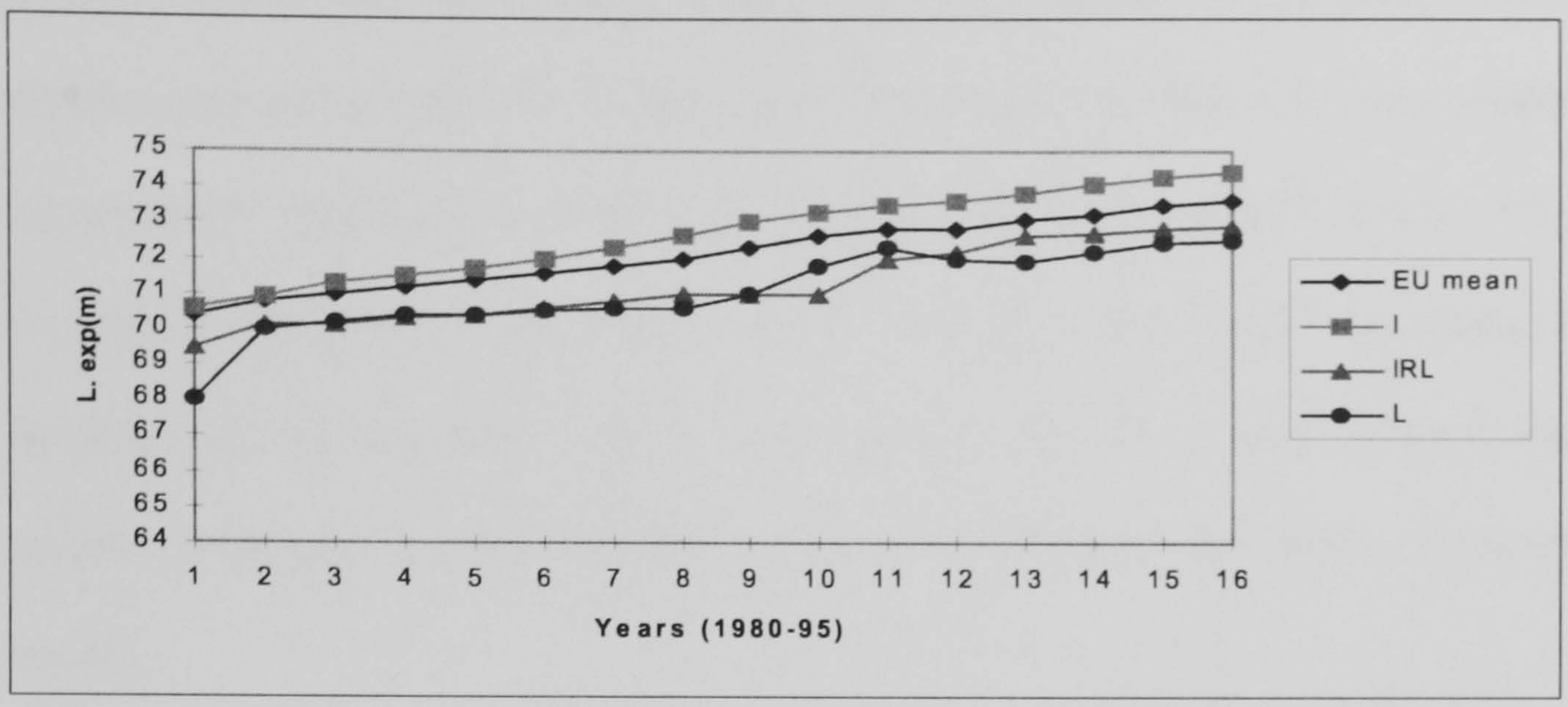
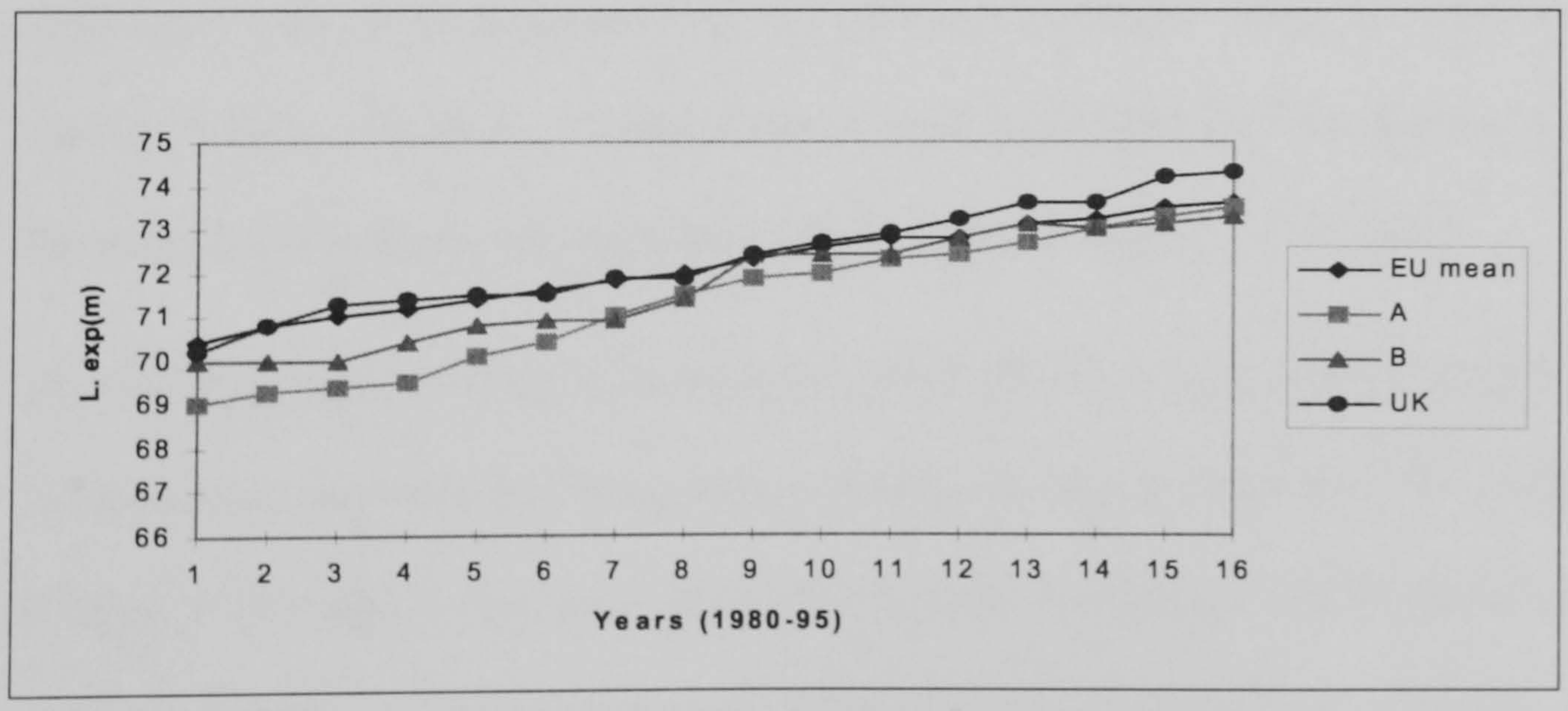


Figure 4.22 provides the results for Austria, Belgium and the UK. In the cases of Austria and Belgium male life expectancy has converged upwards to a point on or slightly below the EU mean, whilst life expectancy for UK males followed equivalent growth with the EU mean until 1990 since when it has tended to diverge upwards in an improving trend.

Figure 4.22 Life expectancy (males) for Austria, Belgium and the UK



The above diagrams therefore provide an overview of the trends for each health outcome measure and member state relative to the EU mean and enable the grouping of countries in similar positions with respect to this value. They make it possible for policy makers to assess which countries have favourable and those with less favourable trends. For example Sweden is continuing to enjoy leading values above EU mean for life expectancy, whilst Denmark is exhibiting trends which raise concern as its position with respect to the EU mean is in decline. Similar analyses are possible according to the variable or country of interest.

4.8. Discussion and Conclusions

Analyses of both σ and β-*convergence* in this chapter have confirmed the presence of statistically significant convergence in the three health outcomes of infant mortality, life expectancy (females) and life expectancy (males) examined. In the case of β-*convergence* this was confirmed for absolute but not conditional convergence.

Graphical representations for each country show that the observed σ-*convergence* is explained by upward convergence towards the standardised EU mean for some countries, namely Belgium, Denmark, Finland, Ireland, the Netherlands, Sweden and the UK, and downward convergence for Spain, Italy and to a greater extent by Portugal.

The findings for life expectancy show clearly that there is a much smaller overall variation between countries compared with infant mortality and for the majority of the period 1960-95 further convergence has been achieved in male life expectancy, although there is evidence of slight divergence between 1990 and 1995 for female life expectancy. Analyses to explain the observed σ-*convergence* show that the Scandinavian countries, the Netherlands and the UK have converged towards the mean in a downward (worsening) direction, whilst the southern countries and Luxembourg have been converging towards the mean in an upward (improving) direction.

The results for β-*convergence* confirm the presence of statistically significant absolute convergence and also reveal the countries which are statistically different in terms of shift dummies in comparison with the reference intercept used (UK), with these countries having values either above or below the EU mean in the steady state. The hypothesis of conditional convergence is not accepted. Therefore the EU countries are tending to converge to a common value but with some spatial heterogeneity in evidence.

The graphical representations for the panel data employed over the period 1980-95 generally confirm but also clarify the convergence and divergence hypotheses and scenarios observed *for σ-convergence* analysis. However, the diagrams clarify that although trends may be 'worsening' with respect to the standardised EU mean, for example in the case of the Scandinavian countries of Sweden and Finland, they still have among the highest health outcomes in the EU. The analysis presented here, particularly for infant mortality, suggests that the EU mean is tending to catch up and converge towards the favourable positions they enjoy. In contrast, the countries of the south for infant mortality are converging towards the mean in an improving direction, particularly in the case of Portugal and Spain. Trends for health outcomes in Denmark show a rather static situation over the period of analysis, with other EU countries improving at a higher rate.

When considering the influence of health care system and health outcomes, no statistically significant differences were observed for the latest date analysed (1995) according to this criterion.

In attempting to explain the findings the chapter briefly examined *per capita* health expenditure in order to identify trends between the two. This analysis revealed that worsening standardised health outcomes with respect to the EU mean are, in the majority of countries with this trend, associated with reducing relative health care expenditure. Again, this was found to be the case for the Scandinavian countries, but also for the Netherlands and the UK. Conversely, the improving expenditure levels for countries of the south are associated with improving health outcomes over the period examined, particularly for Portugal, Spain and Italy, and to a lesser degree for Greece. Potential causal links between health expenditure and health outcomes, among other possible explanatory variables, will be examined in detail in chapter Six.

Regarding the chosen measures to assess convergence in health outcomes it is acknowledged that the development of more sensitive and inclusive health status measures in the future will improve the validity of international comparisons. At the population level, data collection efforts, as Anderson *et al.* (1999) argue, should reflect the health status (including quality of life) and be sensitive to interventions in the health care financing and delivery systems.

From a societal perspective the observation of convergence in health outcomes is a productive exercise as its presence tells us that things are becoming more similar over time. This implies a greater degree of equality at the macro level is being achieved across the countries of the EU, although it has to be acknowledged that this cannot reveal differences within countries. However, this diminution in differences may be in spite of rather than due to EU social policies as many countries have not been members of the EU throughout the period examined, policies relating to health in the EU are restricted to public health and collaboration in research and dissemination, and subsidiarity remains the guiding principle. It is also the case that health outcomes, particularly in the case of life expectancy, may be more attributable to lifestyle, diet and environmental factors rather than the individual health care systems of the EU.

However, the analyses presented here provide an indication to policy makers regarding the countries which need to take measures to improve their health outcomes, and those which are losing their advantage such that further convergence can be achieved.

Chapter Five

Convergence Analysis of EU Health Care Resources and Utilisation Rates

5.1. Introduction

The definitions associated with, as well as the methods adopted to test for convergence in this chapter, are based on the principles fully outlined in chapter Three (Nixon, 1999; Hitiris and Nixon, 2001), the results of which clearly showed that there is evidence of convergence in health care spending within the countries of the EU over the period 1960-95. Further analysis on health outcomes in chapter Four demonstrated that convergence has also been achieved in the countries of the EU for infant mortality and life expectancy. The aim of this chapter is to complete the empirical work by testing for convergence in health care resources and utilisation within the member states of the EU.

The rationale for examining convergence in health care resources and utilisation rates is identified by Donabedian (1966). He explains that an alternative approach to health expenditure and health outcomes analyses, as measures of quality assessment, is to study the structure of care, such as resources, facilities, hospital beds, equipment and available staff for care. The assumption made is that given appropriate structure appropriate care will follow, although this argument is clearly open to scrutiny as merely having sufficient resources is not enough to guarantee that they will be deployed in an optimal fashion (Ham, 1997), or be delivered efficiently (Maynard, 1994). and variations in medical practice - even with similar available resources - are well recognised (Andersen and Mooney, 1990). However, Donabedian's principal point here is that without adequate resources it will not be possible to deliver good quality health care, and is therefore a pre-requisite rather than an assurance of optimal health care. In spite of this caveat, the method is attractive as it deals with information that is concrete and accessible but its limitation is that the relationship between structure and process, or structure and health outcomes, is not well established.

For example, one may wish to question if a relatively high number of beds per unit of population is a 'good' or a 'bad'? In recent decades most industrialised countries have steadily and substantially reduced the number of beds *per capita,* have reduced lengths of time spent in hospital by patients, and have emphasised the importance of care outside the institution of hospitals where possible, 'particularly for the elderly, mentally ill, mentally handicapped and those with chronic conditions' (Macbeth, 1996, p.77). This may have been partly brought about by new technologies and procedures such as key hole surgery which reduce the required length of stay in hospital and therefore the need for in-patient beds. These trends may in fact reflect a productivity increase in the delivery of health care. Nonetheless, criticisms of bed closures are a common and emotive feature of political debate with regard to the perceived opportunities to access health care and the quality of available medical services.

Additionally, one may wish to know if a high admission rate is desirable or not. While lengths of stay per admission have fallen in recent years, admission rates have risen. Bed numbers overall have fallen because the effect of the fall in patients' lengths of stay has outstripped that of the rise in admission rates. Increasing admission rates are portrayed as a 'good' in the managerial and political debate - 'more patients treated more than ever before' is a common claim made by politicians - but the real benefits of this can only be measured in terms of improved health outcomes and in meeting the health care needs of the general population

With these concepts in mind and in order to develop the analysis of convergence into this area of interest, the aim of this chapter is to empirically test for convergence, or otherwise, in health care resources and utilisation levels over the periods 1960-95 and 1980-95.

The chapter begins by identifying the variables to be used in the analysis before testing, the over the chosen time period firstly using σ-*convergence* analysis, as illustrated in Chapter Three. The trends for each country are then presented in conjunction with graphical representations of the results. Where differences are observed between NHS and SI countries they are tested for statistical significance by means of a one-way ANOVA test at the 5% level of significance. Following this, more rigorous β-*convergence* analysis is applied to a panel of data derived from the same variables over a shorter period of time, 1980-95, using the same methodology as used in Chapter Three. The results of the β-*convergence* analysis are then presented. Due to the large number of variables examined in this chapter in comparison with Chapters Two and Three, graphical representations of these results are not provided as the reporting would be excessive. To compensate for this, the descriptions of the σ analyses are country-specific as opposed to examining the data under the scenarios and hypotheses of Leonardi (1995), which was the adopted procedure in Chapters Three and Four. The results of both approaches are then discussed and compared before coming to conclusions regarding the findings along with an assessment of the policy implications for EU member states.

5.1.1 Chosen resource and utilisation variables

As in the case of health outcomes, it is recognised that any limited number of variables chosen to represent the resources used by any health care system, as well as the utilisation rates of patients making use of that system, will have a number of limitations. The aim, however, has been to choose four variables that represent how well each system is resourced and how patients in EU member states make use of their health care system.

With these limitations in mind, the two variables selected to represent resources are the *number of practising physicians per capita* and the *number of hospital in-patient bed per capita.* In terms of utilisation rates, the *average in-patient length of stay* and annual *in-patient admission rate* were chosen. All variables are defined fully in Chapter Two, section 2.3, and were taken from the latest available OECD health care data (OECD/CREDES, 1997) over the chosen period of 1960-95.

5.2. Results: σ-analysis

The tables and figures providing the results for health care resources will first be presented along with trend analyses for each country according to Leonardi's (1995) classifications of convergence. To complete the σ analyses the relative changes that have occurred over the period 1960-95 are illustrated for each country, before considering any observed associations regarding health care system. This approach is then repeated for the utilisation variables.

5.2.1 Health care resources

The raw data for number of active physicians and number of in-patient beds, along with the mean, multiplier (raw mean x multiplier = indexed score for each country), indexed scores

Table 5.1 Number of active physicians per 10,000 of population

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	14.0	133.6	13.6	107.7	16.4	86.6	22.2	86.2	26.6	94.7	-38.9
B	12.9	123.1	15.4	122.0	23.1	122.0	34.4	133.6	37.4	133.1	10.0
D	14.3	136.5	16.4	129.9	22.6	119.3	30.9	120.0	33.6	119.6	-16.8
DK	12.1	115.5	14.0	110.9	21.7	114.6	27.8	108.0	29.0	103.2	-12.2
E	11.6	110.7	13.4	106.1	23.1	122.0	38.2	148.4	41.0	145.9	35.3
F	9.6	91.6	12.6	99.8	19.7	104.0	26.5	102.9	29.4	104.7	13.0
FIN	5.7	54.4	9.4	74.4	17.4	91.9	24.2	94.0	27.7	98.6	44.2
GR	12.5	119.3	16.2	128.3	24.3	128.3	34.0	132.1	38.8	138.1	18.8
I	5.3	50.6	7.8	61.8	12.0	63.4	15.4	59.8	17.0	60.5	9.9
IRL	10.5	100.2	12.0	95.0	13.1	69.2	15.5	60.2	17.2	61.2	-39.0
L	10.1	96.4	11.3	89.5	17.1	90.3	20.1	78.1	22.3	79.4	-17.0
NL	11.2	106.9	12.5	99.0	19.1	100.8	25.1	97.5	25.2	89.7	-17.2
P	8.4	80.2	9.7	76.8	19.7	104.0	28.4	110.3	29.9	106.4	26.3
S	9.5	90.6	13.1	103.7	22.0	116.2	28.7	111.5	30.7	109.3	18.6
UK	9.5	90.6	12.0	95.0	12.8	67.6	14.8	57.5	15.6	55.5	-35.1
mean	10.5	100.0	12.6	100.0	18.9	100.0	25.7	100.0	28.1	100.0	
multiplier	9.5		7.9		5.3		3.9		3.6		
s.d. (c.v.)		25.3		19.3		21.3		27.9		27.8	

Source: OECD/CREDES (1997). *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems, Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. The variable used is DOC, as defined in Chapter Two (section 2.3).

Table 5.2 Number of hospital beds per 1000 of population

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	10.8	114.3	10.8	106.5	11.2	111.0	10.2	122.4	9.3	129.6	15.3
B	8.0	84.7	8.3	81.9	9.4	93.2	8.1	97.2	7.6	105.9	21.3
D	10.5	111.2	11.3	111.4	11.5	114.0	10.4	124.8	9.7	135.2	24.1
DK	8.1	85.7	8.1	79.9	8.1	80.3	5.6	67.2	4.9	68.3	-17.4
E	4.0	42.3	4.7	46.4	5.4	53.5	4.3	51.6	4.0	55.8	13.4
F	9.0	95.3	9.2	90.7	11.1	110.0	9.7	116.4	8.9	124.1	28.8
FIN	11.5	121.7	15.1	148.9	15.6	154.7	12.5	150.0	9.3	129.6	7.9
GR	5.8	61.4	6.2	61.1	6.2	61.5	5.1	61.2	5.0	69.7	8.3
I	8.9	94.2	10.5	103.6	9.7	96.2	7.2	86.4	6.4	89.2	-5.0
IRL	12.0	127.0	12.6	124.3	9.6	95.2	5.7	68.4	5.0	69.7	-57.3
L	11.9	126.0	12.7	125.2	12.8	126.9	11.8	141.6	11.1	154.7	28.8
NL	11.0	116.4	11.4	112.4	12.3	121.9	11.5	138.0	11.3	157.5	41.1
P	5.7	60.3	6.5	64.1	5.2	51.6	4.6	55.2	4.1	57.2	-3.2
S	14.2	150.3	15.3	150.9	15.1	149.7	12.4	148.8	6.3	87.8	-62.5
UK	10.3	109.0	9.4	92.7	8.1	80.3	5.9	70.8	4.7	65.5	-43.5
mean	9.4	100.0	10.1	100.0	10.1	100.0	8.3	100.0	7.2	100.0	
multiplier	10.6		9.9		9.9		12.0		13.9		
s.d. (c.v.)		29.2		30.6		31.5		36.3		35.9	

Source: OECD/CREDES (1997). OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems, Paris. OECD/CREDES

Note: First years in columns indicates raw data, the second column is the standardised data for that year. The variable used is BED, as defined in Chapter Two (section 2.3).

and s.d. (c.v.) for all 15 current members of the EU are shown in Tables 5.1 and 5.2 respectively.

In terms of trends over the period, from Table 5.1 it can be seen that the raw mean number of physicians rose steadily throughout the period 1960 to 1995, from a value of 10.5 to 28.1 per 10,000 of population. As the results show, without exception all countries in the EU increased the number of doctors they have but some more than others.

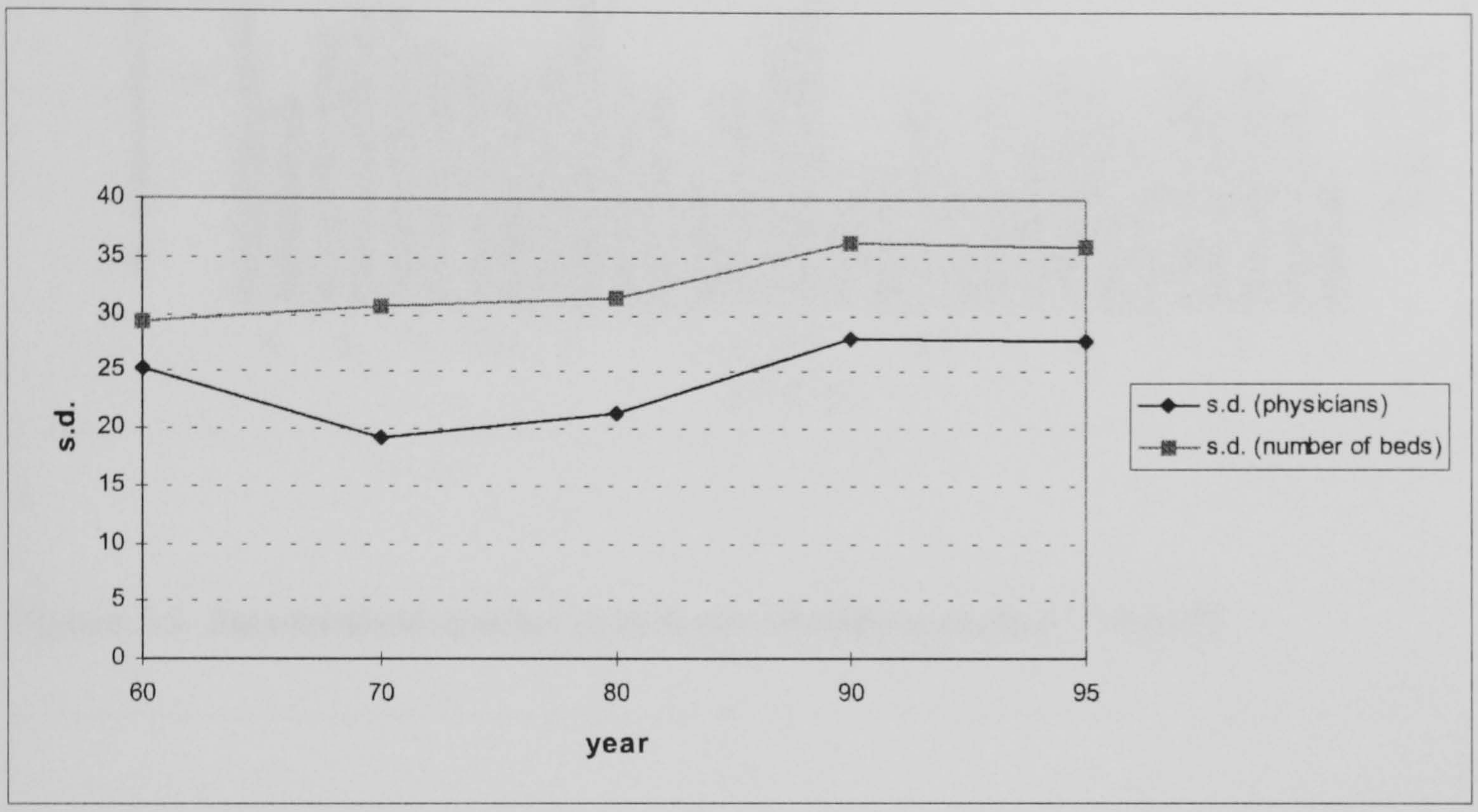
In Table 5.2 it can be seen that the raw mean for number of beds has in fact achieved the opposite trend, falling from 9.4 per 1,000 of population in 1960 to 7.2 in 1995. However, reductions were much more pronounced in NHS countries while most SI countries showed little or no variation.

5.2.2 Overall measurement of σ-convergence - resources

The results for *σ-convergence* for health care resources are shown by means of the trends in s.d. (c.v.) of the indexed scores as recorded in Tables 5.1 and 5.2 are represented graphically in Figure 5.1.

From the trends observed it is evident that very similar changes have been occurring for both variables, with the general trend for both physicians and number of beds being divergence (increasing s.d.(c.v.)) between 1960 and 1995, although a period of convergence did occur between 1960 and 1970 for number of physicians. Interestingly, between 1990 and 1995 there would appear to have been little change as both lines are almost parallel. For the standardised data the relative size of the s.d. (c.v.) tells us that there is greater variation in the number of beds than number of physicians as the s.d. (c.v.) of the former rose from 29.2 in 1960 to 35.9 in 1995, whilst for number of physicians the s.d. (c.v.) went from 25.3 in 1960 to 27.8 in 1995, indicating very little change in overall variation, especially in the case of number of physicians.

Figure 5.1 Standard deviation of number of physicians and number of beds - 1960-95



In terms of the hypotheses testing, the results of the F-test (p= 0.36 for number of physicians and p = 0.227 for number of beds, NS at the <0.05 level) indicate that the null hypothesis of σ-*convergence* cannot be rejected. This tells us therefore that although a degree of divergence did occur for both variables over this period, it was not statistically significant and further that σ-*convergence* did not occur.

5.2.3 Trend analysis for each country - resources

The analyses of s.d. (c.v.) therefore confirm that in an overall sense divergence occurred between 1960 and 1995 in terms of health care resources, but at non-significant levels. In this section these changes are examined under the five scenarios and hypotheses of Leonardi (1995) using the approach described in Chapter Three.

Figure 5.2 Active physicians per 10,000 of population - 1960-95

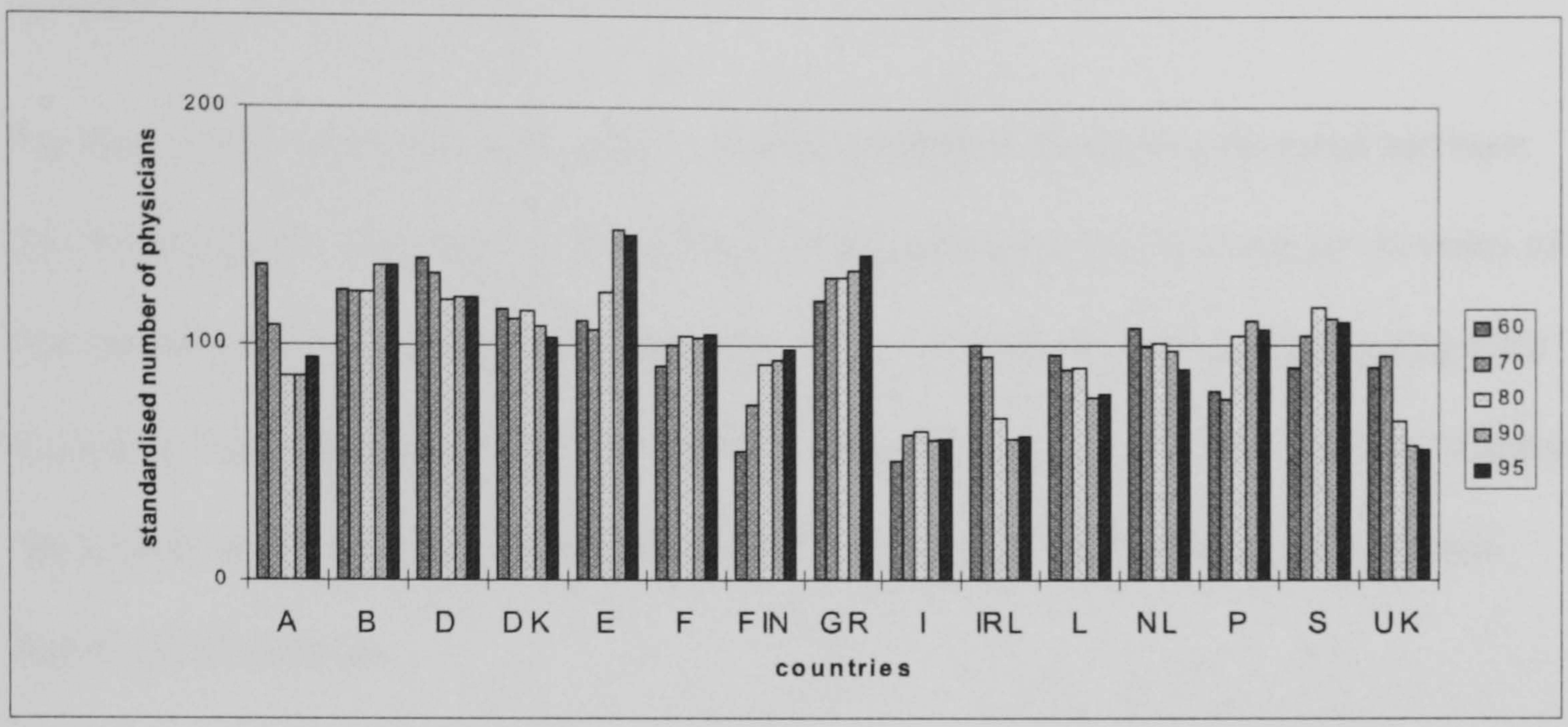
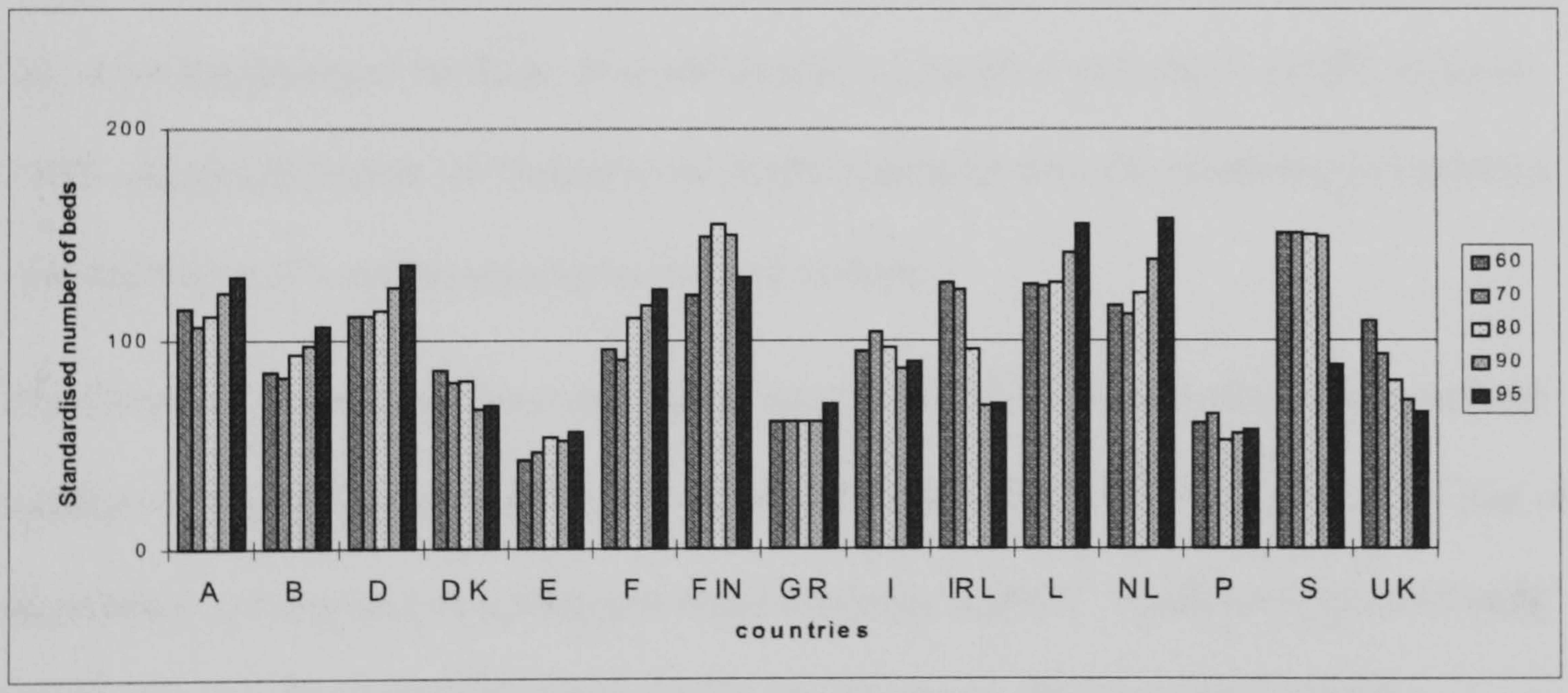


Figure 5.3 Standardised number of beds per 10,000 population - 1960-95



For Austria it can be seen that the number of physicians basically achieved reversal of roles over the period from a position well above the standardised mean in 196- to a position below the mean in 1995, essentially a downward trend although this increased towards the mean between 1990 and 1995. For number of beds (Figure 5.3) the trend for Austria has been one of divergence in an increasing direction. perhaps typical for an SI country in this variable.

For Belgium it can be seen in Figure 5.2 that for number of physicians the trend has been one of divergence above the EU mean, thus a relative increase in this resource. In terms of number of beds it is clear that Belgium achieved the reversal of roles scenario, going from a position below the mean in 1960 to a position above the mean in 1965. Thus for Belgium the general trend relative to the rest of the EU is an increase in resources, again perhaps typical of SI countries.

In the case of Germany it can be seen from Figure 5.2 that the number of physicians has reduced, converging downward towards the EU mean but in the last 15 years of the period has followed an equivalent growth path above the standardised mean. For number of beds, the value has diverged markedly over the period to a position well above the EU mean in 1995. Again, the trends for Germany are rather consistent with the remaining SI countries and indicative of a well-resourced health care system.

For Denmark we observe downward trends with respect to the standardised mean for both number of physicians and number of beds. For number of physicians the scenario is that of downward convergence to a point just above the mean in 1995, while for number of beds the trend is clearly that of divergence below the EU mean. These trends are fairly consistent with many other NHS countries in the EU, essentially demonstrating relative reductions in resources with respect to the standardised mean.

In the case of Spain as an NHS country, Figure 5.2 shows an untypical trend for number of physicians in that the value is diverging strongly above the EU mean for most of the period. Interestingly, although Spain appears to be well endowed with doctors, for number of beds it at a value about half that of the standardised mean. However, this value is steadily increasing in achieving the upward convergence towards the mean over the whole period of analysis.

Figure 5.2 shows that in the case of France reversal of roles has occurred from a position below the standardised mean in 1960 to a little above the mean in 1995, but in general France has been around average in terms of number of physicians. An identical but more pronounced trend was also achieved for number of beds for France, achieving reversal of roles but clearly diverging over the last three observations 1980-95. In this regard, as an SI country, exhibits the common trend for this variable with high resourcing levels.

From Figures 5.2 and 5.3 the trends for Finland are perhaps more in keeping with an SI rather than an NHS country as Finland is. For number of physicians Finland clearly achieved upward convergence over the period 1960-95, settling on a value almost exactly on the standardised mean value. For number of beds, Finland has throughout the period of analysis had values well above the mean, although in the last 15 years there is a trend of downward convergence towards the mean. However, in comparison with other NHS countries, Finland, as shown in the analysis of Chapter Two, has good levels of resources.

In the case of Greece, Figures 5.2 and 5.3 reveal an almost identical picture as that of Spain. The number of physicians in Greece has steadily diverged away from and above the standardised mean to a position about 20 percent above this value. Like Spain, however, the number of beds in Greece is about 60% of the standardised mean, although there is evidence of upward convergence towards the mean between 1990 and 1995.

In the case of Italy it can be seen that not much change has occurred over the period of analysis for number of physicians, the figure remaining at around 50-60 percent of the standardised mean. For number of beds the general trend has been rather random at a figure just below the mean.

Ireland has experienced trends one would associate with a typical NHS country over the period. Figure 5.2 shows that divergence below the standardised mean has occurred, settling on a value of about 60 percent of the mean. For number of beds, Ireland exhibits the reversal of roles scenario in going from a position well above the mean in 1960 to a position well below the mean in 1995, again to a point of about 70 percent of the mean. This shows that Ireland has been reducing its resources relative to the rest of the EU systems.

Figure 5.2 shows that for Luxembourg its number of physicians have been generally diverging below the standardised mean over the whole period, finishing with a value of 80 percent of the standardised mean, which is a little untypical of an SI country. However, in terms of number of beds Figure 5.3 shows that Luxembourg has been increasing this resource relative to the EU mean, reaching a value only second to the Netherlands in 1995, which is much more in keeping with SI countries.

An almost identical trend is observed for the Netherlands, with the number of physicians experiencing reversal of roles from a position above the standardised mean in 1960, to a position about 90 percent of the mean in 1995. However, a steep level of divergence above the mean has occurred for the Netherlands over the period in number of beds, as shown in Figure 5.3.

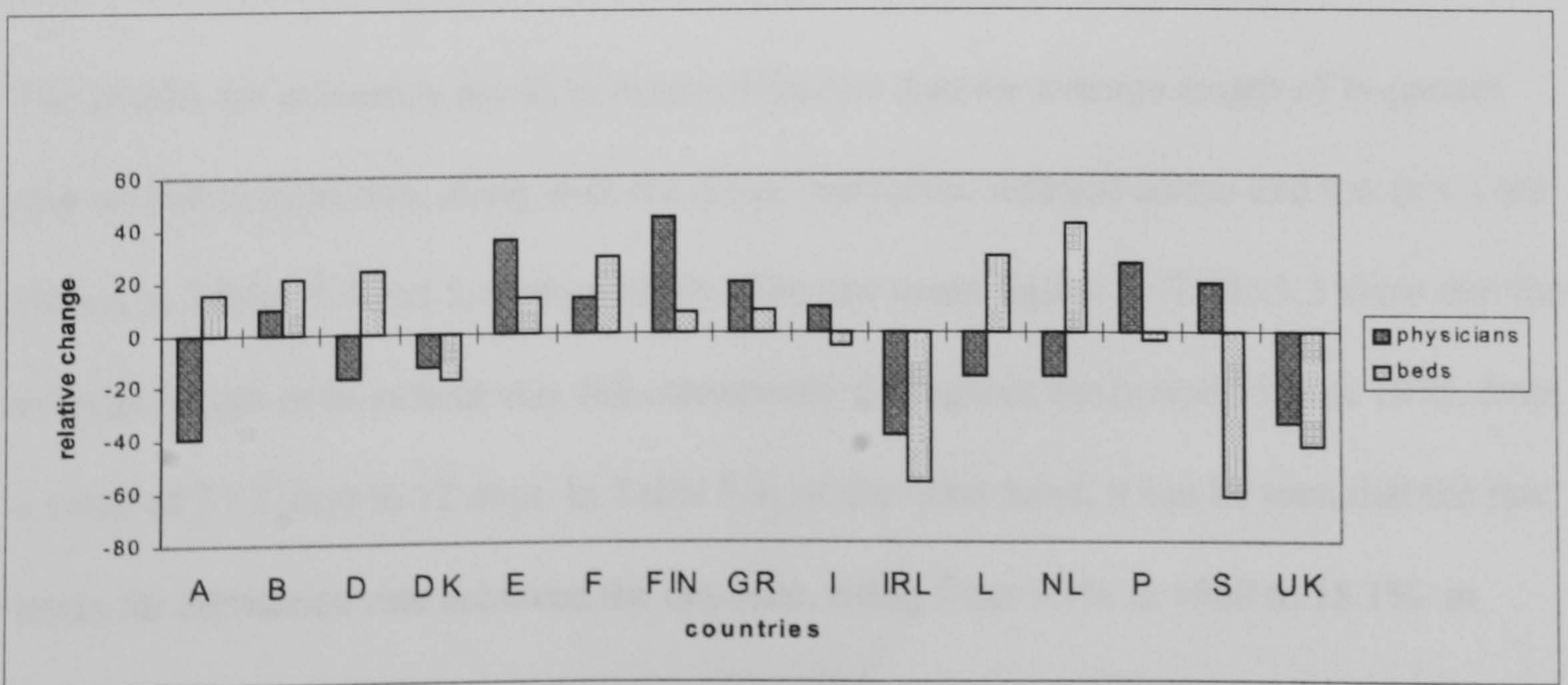
The trend in physicians for Portugal has been one of reversal of roles from below the mean in 1960, to something a little over the standardised mean in 1995. However, for number of beds the position of Portugal is rather similar of other NHS countries, particularly those within the Southern subgroup, remaining at something around 60 percent of the mean over the whole period. Figure 5.2 shows that for Sweden, a very similar trend has occurred to that of Portugal for number of physicians, in effect achieving reversal of roles from below it in 1960 to a little above in 1995. For number of beds, Figure 5.3 shows that Sweden achieved equivalent growth with the standardised mean for number of physicians between 1960 and 1990, but dramatically dropped to a position around 90 percent of the mean in 1995.

Finally the results for the UK show evidence of strong downward pressure on resources. In Figure 5.2, it can be observed that the number of physicians diverged in a downward direction from 1970 to 1995, to a figure of 55 percent of the standardised mean. Similarly, the number of beds in the UK achieved reversal of roles from a position above the standardised mean in 1960 to a position well below the mean in 1995 (65 percent). It is interesting to note that these trends have been almost identical to those of Ireland.

5.2.4 Relative change, 1960-95

In providing a summary of the relative changes that have taken place between 1960 and 1995, Figure 5.4 shows the results of subtracting the 1995 value from the 1960 value for each country. Positive values indicate an increase and negative values a decrease in the relevant resource.

Figure 5.4 Relative changes in number of physicians and number of beds - 1995-60



The countries which achieved a net increase in both number of physicians and number of beds include Belgium, Spain, France, Finland and Greece. A negative change or reduction in both variables occurred in the case of Denmark, Ireland and the UK. A net reduction in the number of physicians and a net increase in the number of beds occurred in Germany and Luxembourg. Conversely, a net increase in the number of physicians and a net decrease in the number of beds occurred in the case of Italy, Portugal and Sweden.

In summarising these results and trends it is possible to argue that while the dominant thrust in NHS countries has been to reduce levels of resources, the SI countries have generally been doing the opposite, especially in number of beds. This would also have been the case for number of physicians if Greece and Spain had not followed untypical trends compared with most of the other NHS countries.

The results of ANOVA testing for 1995 values (OECD/CREDES, 1997) show that there is a statistically significant difference in number of beds between NHS (5.22) and SI (9.65) countries ($p<0.05$). For number of physicians, although the mean number of physicians is higher in the SI (29.1) than the NHS (27.4) countries, this difference is not statistically significant ($p=0.7$).

5.2.5 Utilisation rates

The results for utilisation levels in terms of the raw data for average length of in-patient stay and admission rate, along with the mean, multiplier, indexed scores and s.d. (c.v.) are shown in Tables 5.3 and 5.4, respectively. The raw mean figures in Table 5.3 show that the average length of in-patient stay fell consistently throughout the period 1960 to 1995, from a value of 27.3 days to 12 days. In Table 5.4, on the other hand, it can be seen that the raw mean for admission rate achieved the opposite, rising from 9.9% in 1960 to 18.1% in

1995. These data confirm the view that more and more people are being treated in hospital but they are remaining there for increasingly shorter periods of time.

Table 5.3 Average in-patient length of stay (days)

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	24.8	90.9	22.2	98.5	17.9	97.6	13.0	88.3	10.9	91.0	0.1
B	27.0	98.9	22.5	99.8	19.5	106.3	13.8	93.8	11.5	96.0	-2.9
D	28.7	105.2	24.9	110.4	19.7	107.4	16.7	113.5	14.2	118.6	13.4
DK	22.0	80.6	18.1	80.3	12.7	69.2	8.0	54.3	7.5	62.6	-18.0
E	26.0	95.3	18.5	82.1	14.8	80.7	12.2	82.9	11.0	91.9	-3.4
F	23.0	84.3	18.3	81.2	16.7	91.0	13.3	90.4	11.2	93.5	9.3
FIN	27.3	100.0	24.4	108.2	21.6	117.7	18.2	123.6	11.8	98.6	-1.5
GR	20.0	73.3	15.0	66.5	13.3	72.5	9.9	67.3	8.2	68.5	-4.8
I	27.0	98.9	19.1	84.7	13.5	73.6	11.7	79.5	10.5	87.7	-11.3
IRL	15.0	55.0	13.3	59.0	9.7	52.9	7.9	53.7	7.2	60.1	5.2
L	29.0	106.3	27.0	119.8	23.2	126.5	17.6	119.6	15.3	127.8	21.5
NL	42.0	153.9	38.2	169.4	34.7	189.1	34.1	231.7	32.8	273.9	120.0
P	29.8	109.2	23.8	105.6	14.4	78.5	10.8	73.4	9.8	81.8	-27.4
S	31.8	116.5	27.2	120.6	24.4	133.0	18.0	122.3	7.8	65.1	-51.4
UK	35.9	131.6	25.7	114.0	19.1	104.1	15.6	106.0	9.9	82.7	-48.9
Mean	27.3	100.0	22.5	100.0	18.3	100.0	14.7	100.0	12.0	100.0	
Multiplier	3.7		4.4		5.5		6.8		8.4		
s.d. (c.v.)		23.6		26.9		33.5		43.1		51.8	

Source: OECD/CREDES (1997), *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems. Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. The variable used is LOS, as defined in Chapter Two (section 2.3).

Table 5.4 In-patient admission rate (percentage)

Country	1960	1960	1970	1970	1980	1980	1990	1990	1995	1995	95-60
A	14.1	141.9	15.5	125.1	19.5	123.9	23.4	134.8	24.7	136.2	-5.8
B	7.0	70.5	9.3	75.0	13.6	86.4	18.6	107.1	19.8	109.2	38.7
D	13.3	133.9	15.4	124.3	18.8	119.5	19.0	109.4	20.7	114.1	-19.8
DK	12.5	125.8	14.4	116.2	18.3	116.3	21.2	122.1	20.4	112.5	-13.4
E	7.0	70.5	9.3	75.0	9.3	59.1	9.7	55.9	10.0	55.1	-15.3
F	6.5	65.4	7.4	59.7	19.3	122.7	23.2	133.6	22.7	125.1	59.7
FIN	13.1	131.9	18.2	146.9	21.0	133.5	22.4	129.0	25.4	140.0	8.1
GR	7.0	70.5	10.5	84.7	11.8	75.0	12.8	73.7	13.6	75.0	4.5
I	9.4	94.6	15.7	126.7	18.1	115.0	15.5	89.3	16.0	88.2	-6.4
IRL	11.5	115.8	12.4	100.1	17.2	109.3	15.1	87.0	15.5	85.4	-30.3
L	11.6	116.8	13.4	108.1	16.6	105.5	19.9	114.6	19.4	106.9	-9.8
NL	8.4	84.6	10.0	80.7	11.7	74.4	10.9	62.8	11.1	61.2	-23.4
P	5.1	51.3	6.9	55.7	8.9	56.6	10.8	62.2	11.3	62.3	11.0
S	13.4	134.9	16.6	133.9	18.3	116.3	19.5	112.3	18.5	102.0	-32.9
UK	9.1	91.6	10.9	88.0	13.6	86.4	18.4	106.0	23.0	126.8	35.2
mean	9.9	100.0	12.4	100.0	15.7	100.0	17.4	100.0	18.1	100.0	
multiplier	10.1		8.1		6.4		5.8		5.5		
s.d. (c.v.)		30.3		28.3		24.9		26.7		27.6	

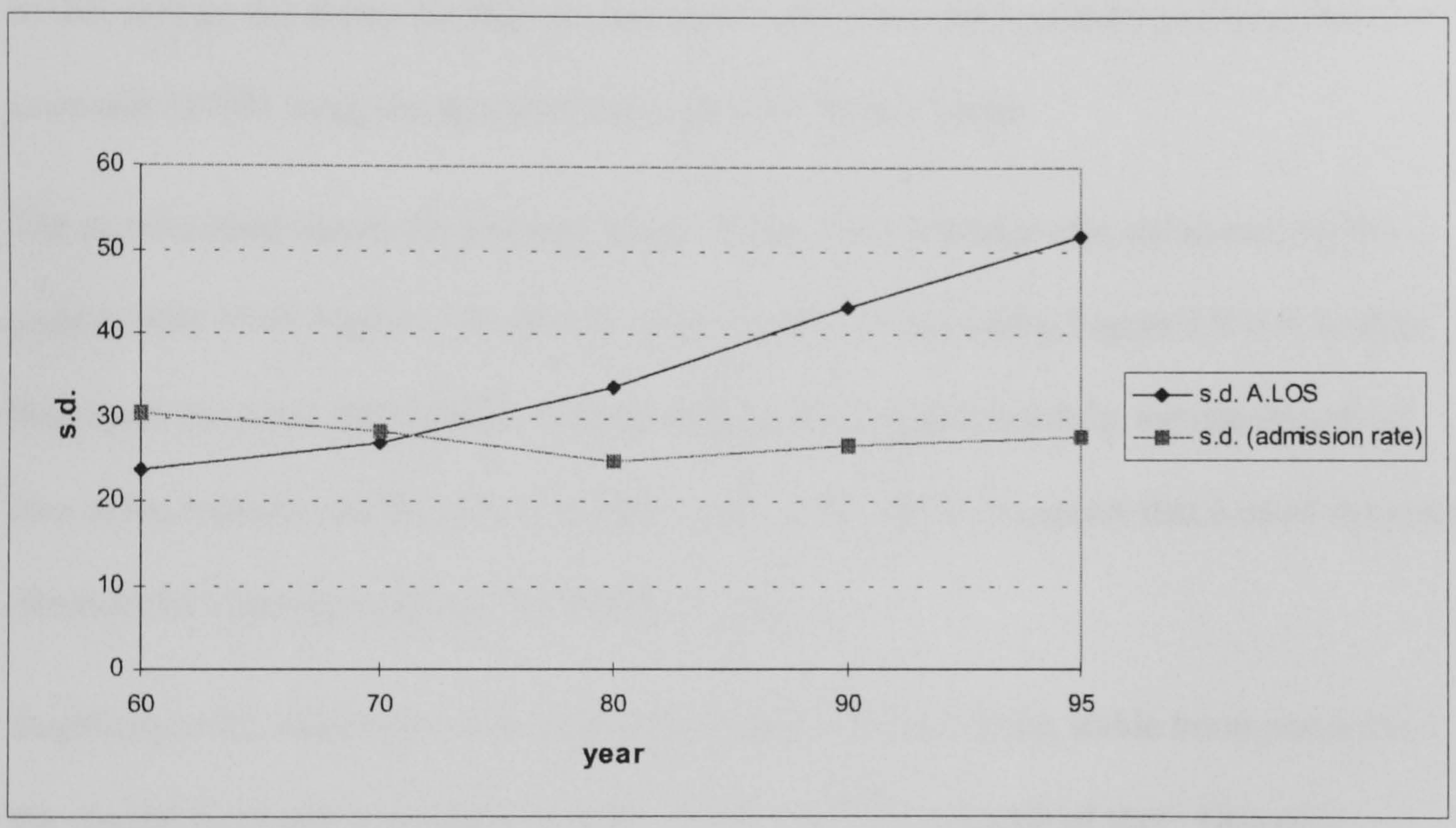
Source: OECD/CREDES (1997). *OECD Health Data 97. A Software for the Comparative Analysis of 27 Health Systems. Paris, OECD/CREDES.*

Note: First years in columns indicates raw data, the second column is the standardised data for that year. The variable used is AR, as defined in Chapter Two (section 2.3).

5.2.6 Overall measurement of σ-convergence - utilisation

The results for σ-*convergence* for utilisation are shown by means of the trends in s.d. (c.v.) of the indexed scores as recorded in Tables 5.3 and 5.4, which are represented graphically and for purposes of clarity in Figure 5.5.

Figure 5.5 Standard deviation of average LOS and admission rate - 1960-95



From Figure 5.5 it is evident that hardly any change in s.d. (c.v.) occurred in terms of admission rate, but continuous divergence did occur in average length of stay between 1960 and 1995. For the standardised data the relative size of s.d. (c.v.) reveals that there was initially greater variation in admission rate than average length of stay (1960-70), but since then the situation reversed from 1970 onwards when there was increasing variation in average length of stay when compared with admission rate.

In terms of the hypotheses testing the results of the F-test ($p = 0.0029$, significant at the <0.05 level) indicate that it is necessary to reject the null hypothesis and therefore accept the alternative hypothesis of divergence in average length of stay. For admission rate, the F-test result (p = 0.366) indicates that it is not possible to reject the null of no convergence. This indicates that although a small amount of convergence occurred in admission rate between 1960 and 1995, it was not statistically significant.

5.2.7 Trend analysis for each country - utilisation

In this section the above findings are examined under the five scenarios and hypotheses of Leonardi (1995) using the approach described in Chapter Three.

The standardised values for average length of stay and admission rate are shown for the period 1960-95 in Figures 5.6 and 5.7, respectively. In examining Figure 5.6 it is evident that, apart from the Netherlands, a fairly stable picture is presented for average length of stay in the majority of the other countries, whereas Figure 5.7 suggests that a more dynamic situation has been in evidence for admission rates.

Beginning with Austria it can be seen from Figure 5.6 that a fairly stable trend just below the standardised mean occurred over the period 1960-95 in length of stay. However, admission rates for Austria as shown in Figure 5.7 have remained well above the mean over the whole period, with evidence of divergence above the standardised mean since 1980.

Again, a similar trend is observed for Belgium with regard to length of stay, remaining at a figure very close to the standardised mean over the whole period. For admission rate, however, Figure 5.7 shows that admission rates in Belgium have been increasing over the whole period such that reversal of roles, from a position below the mean in 1960, to a position above the standardised mean in 1995, occurred. This is indicative of a situation of treating increasing patients over the period of analysis.

Figure 5.6 Standardised average in-patient length of stay - 1960-95

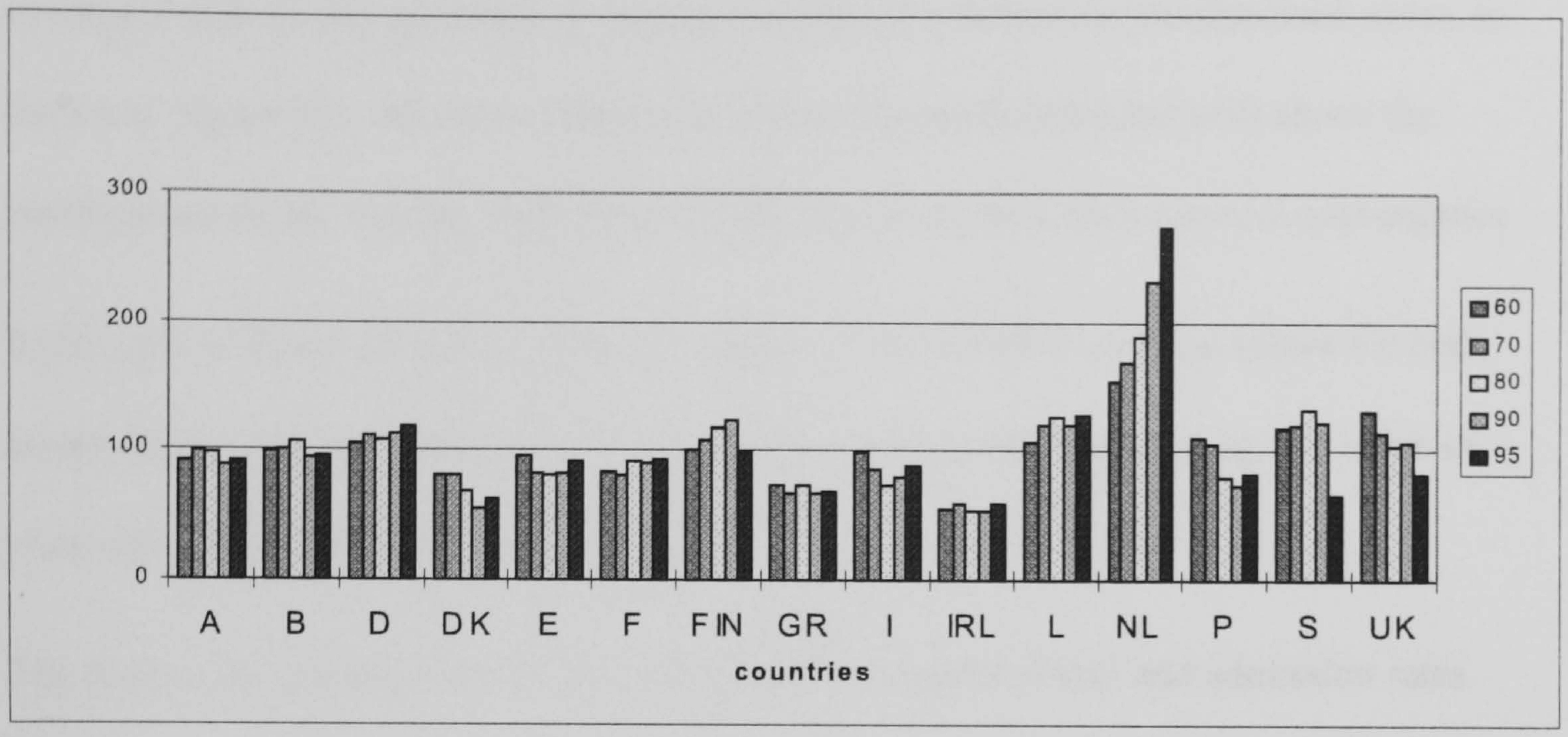
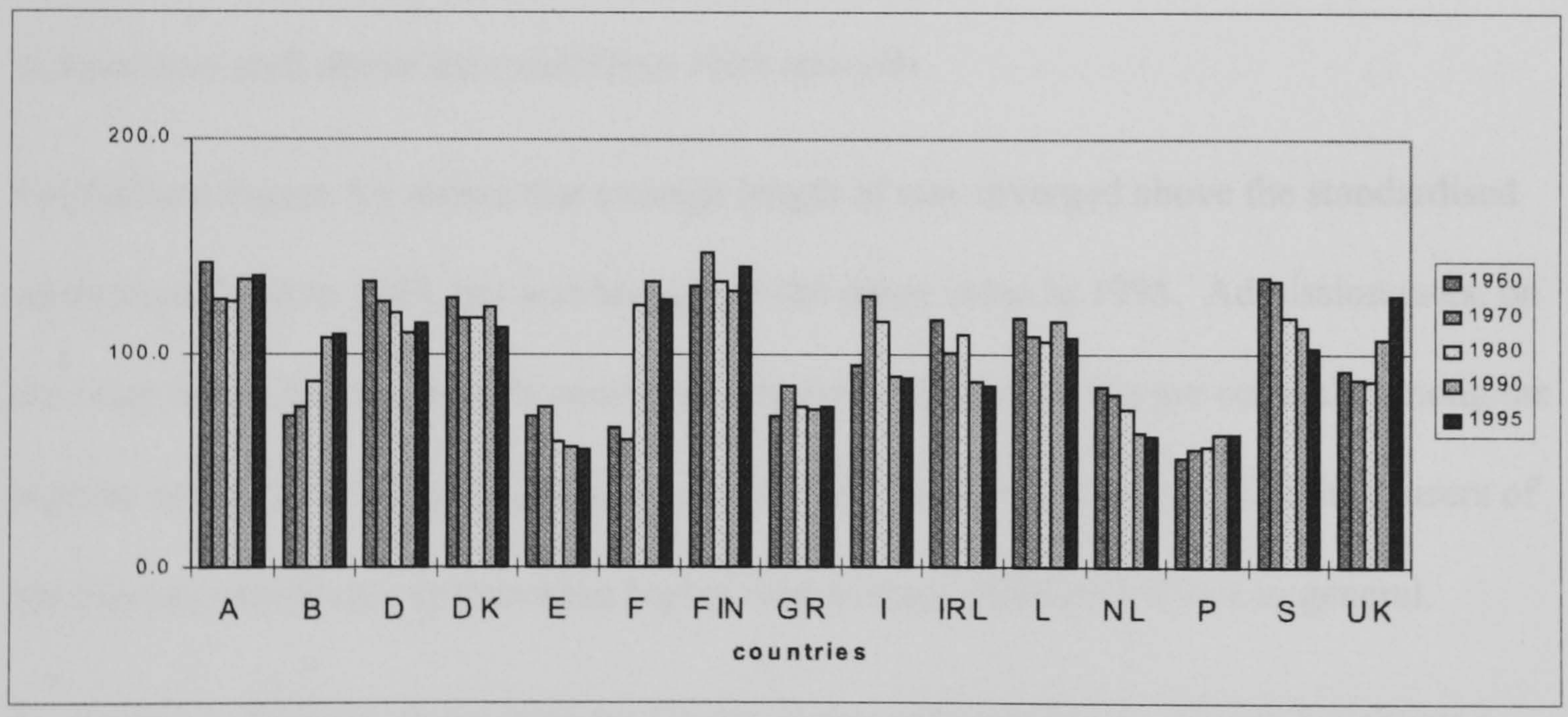


Figure 5.7 Standardised admission rates (%) - 1960-95



In the case of Germany, Figure 5.6 shows that average length of stay was diverging above the standardised mean between 1960 and 1995. For admission rate, there was a clear trend of downward convergence towards the mean until 1990 when some upward divergence occurred.

For Denmark the picture is one of short lengths of stay and high admission rates. with average length of stay generally diverging in a direction below the standardised mean. as shown in Figure 5.6. However, admission rate in Denmark remained well above the standardised mean over the whole period with a general trend of downward convergence.

In the case of Spain the data in Figures 5.6 and 5.7 show below average values for both length of stay and admission rate, with admission rate generally diverging to a value of about 60 percent of the standardised mean.

The picture for France is one of increasing relative lengths of stay and admission rates. Figure 5.6 shows that there was a general trend of upward convergence towards the mean for average length of stay. However, there was a dramatic increase in admission rate after 1970 such that reversal of roles occurred from a position well below the standardised mean to a position well above the mean from 1980 onwards.

For Finland Figure 5.6 shows that average length of stay diverged above the standardised mean from 1960 to 1995, but was brought to the mean value in 1995. Admission rates, on the other hand, did not reveal a consistent trend over the period but are certainly among the highest in the EU at about 20-30 percent above the standardised mean. Certainly, users of the Finnish health care system have higher than average utilisation levels in general.

In contrast to Finland, the picture for Greece is somewhat different. Figure 5.6 shows a more or less equivalent growth trend at a position of about 70 percent of the standardised mean. This is a trend repeated in Figure 5.7, revealing an admission rate for Greece of 70-80 percent of the standardised mean. This strongly illustrates low utilisation rates for users of the Greek health care system.

Average length of stay in Italy experienced a period of divergence below the mean between 1960 and 1980, but between 1980 and 1995 a period of upward convergence occurred. Figure 5.7 shows that the dominant trend in admission rates was one of reversal of roles, from a position well above the standardised mean in 1970 to a position of about 90 percent of the mean in 1995. In general, the picture for Italy is below average utilisation rates.

From Figure 5.6 it can be seen that average length of stay in Ireland has followed an equivalent growth path of about 55 percent of the standardised mean. Figure 5.7 also reveals a downward trend for admission rates in Ireland, in fact achieving a reversal of roles from above the mean to below it in 1995. Utilisation rates therefore are low in Ireland in comparison with the remainder of the EU.

Returning to the common trend of many SI countries Figure 5.6 shows that in the case of Luxembourg average length of stay has been above the standardised mean over the whole period of analysis, with divergence being the dominant trend. For admission rate, Figure 5.7 shows that no consistent trend has been in evidence, other than the fact that the value is consistently above the standardised mean and fairly stable. The general picture, therefore, is one of high utilisation.

The picture for the Netherlands is of particular interest as both measure of utilisation show consistent trends. In the case of average length of stay the value markedly diverged above the standardised mean over the whole period to a position two and a half times above in 1995, as shown in Figure 5.6, while admission rate showed steep downward divergence. Thus the Netherlands is becoming less like the mean position for the EU in terms of utilisation levels with patients being admitted less often, but staying in hospital for longer periods of time.

In the case of Portugal Figure 5.6 shows there was a clear trend of downward pressure in average length of stay, achieving reversal of roles from a position above to a position below the standardised mean over the period of analysis. Figure 5.7 shows a consistent trend of upward convergence towards the mean in admission rate, but still only to a level of about 60 percent of the mean in 1995.

Sweden is another country which stands out due to its downward trends in utilisation rates. Figure 5.6 shows a fairly stable situation in average length of stay above the standardised mean until 1990, when this value fell dramatically to a position of only 65 percent of the standardised mean. Admission rate in Sweden also clearly went through a period of consistent and downward convergence towards the mean, as shown in Figure 5.7. Thus, utilisation levels in Sweden are following a clear trend towards much lower levels than was previously the case.

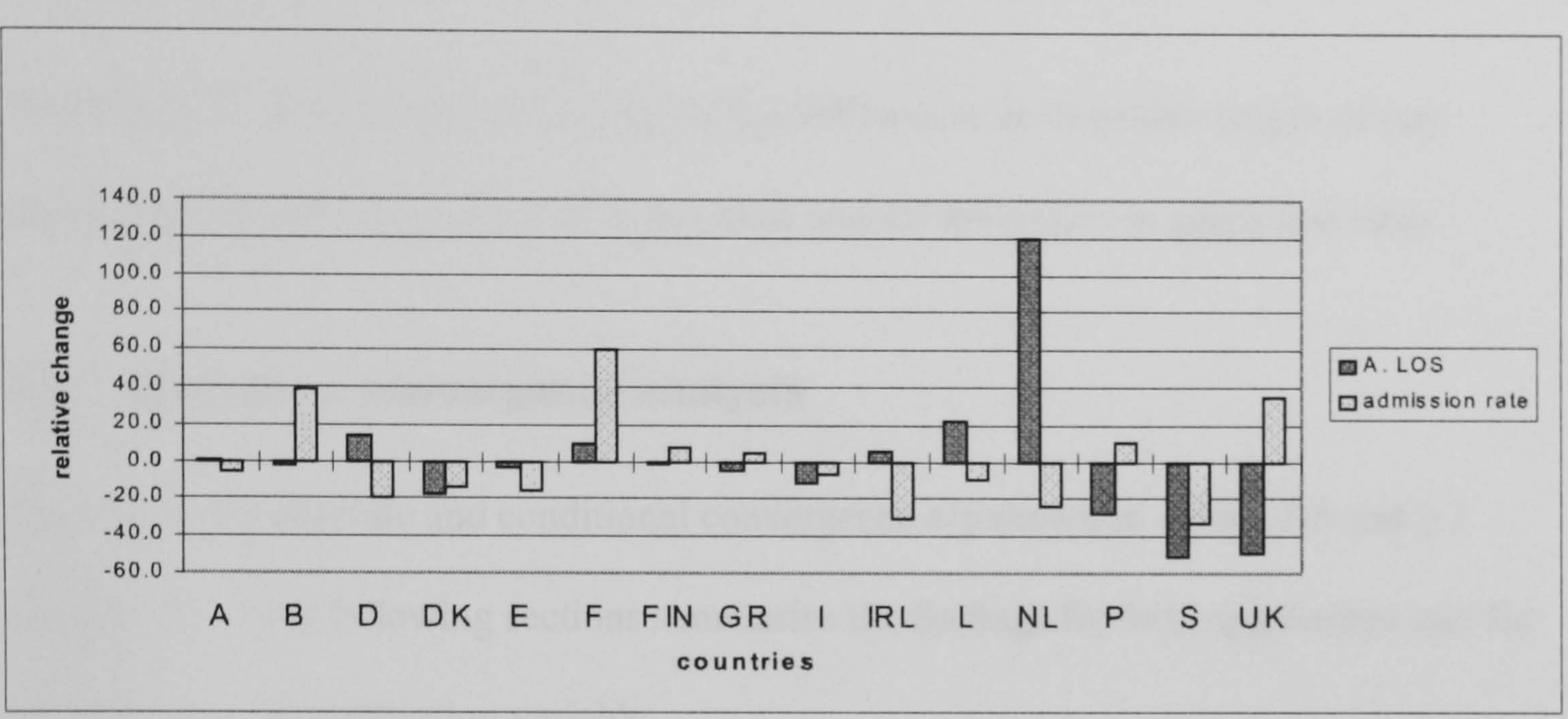
Finally for the UK Figure 5.6 shows a similar pattern to that of Sweden and Portugal, with reversal of roles occurring from a position well above the standardised mean in 1960, to a position well below the mean in 1995. As a mirror image of this, Figure 5.7 shows that admission rates achieved reversal of roles from below the standardised mean until 1980, to a position well above the EU mean in 1995. The general picture for the UK, therefore, is one of increasing throughput of patients but with reducing lengths of stay.

5.2.8 Relative change for length of stay and admission rate, 1960-95

The above trends can be summarised by providing a snapshot of the relative changes that have taken place between 1960 and 1995, as shown in Figure 5.8. The findings show the results of subtracting the 1995 value from the 1960 value for each country for both average length of stay and admission rate.

Positive values indicate a net increase and negative values a net decrease.

Figure 5.8 Relative change in standardised average LOS and AR – 1995-60



It is interesting to note that only one country, France, achieved a net increase in both average length of stay and admission rate. Net increases in only average length of stay were achieved in the cases of Belgium, Ireland, Luxembourg, the Netherlands, while net decreases in this variable were achieved by Denmark, Spain, Finland, Italy, Portugal, Sweden and the UK (note that all these countries have NHS modes of delivering health care). Net increases in admission rate, on the other hand, occurred in Belgium, France, Finland, Portugal and the UK. Again, the most striking change is evident for the Netherlands in terms of average length of stay.

In relation to associations with health care system, the ANOVA results showed that the mean length of stay in SI countries (1995 values) is 16 days (s.d. 8.4) whilst for NHS countries the figure is 10.1 (s.d. 2.5) days (p=0.068), indicating a substantial but non-significant difference with much higher variance in SI countries.

For admission rate the mean value for SI countries is 19.7% (s.d. 5.2) and 17.1% (s.d. 4.7) for NHS countries (p=0.33), indicating very similar values and levels of variation for this utilisation variable.

Thus there are fairly large but non-significant differences in in-patient length of stay according to health care system, but very little overall difference in admission rates.

5.3. Results: β-convergence analysis

The results for absolute and conditional convergence are shown in Tables 5.6 and 5.7 respectively. The following sections summarise the findings for both approaches and for each resource and utilisation variable.

5.3.1 Convergence in number of physicians

In terms of absolute convergence for number of physicians, shown in Table 5.6, the estimation revealed favourable goodness-of-fit statistics and a statistically significant coefficient of the explanatory variables, with $R^2 = 99.6\%$ and R^2 Buse = 75.4%.

The value of β is –0.33 (95% confidence interval -0.38<-0.33<-0.28) which is statistically significant. The Wald test statistic also confirms that β<0. Therefore, the hypothesis of absolute β-*convergence* is confirmed, indicating that the countries of the EU are tending towards a common level in the *per capita* number of physicians.

In terms of spatial differences, the statistical significance of the shift dummy variables shows evidence of substantial diversity across the EU countries in the steady state but not in the speed of convergence since the slope dummies are found non-significant. The countries which have significant shift dummies (positive values in Table 5.6 indicate values significantly above, and negative values significantly below the reference country, the UK) are: Austria . Belgium, Germany. Denmark, Spain, France. Finland. Greece. Ireland, Luxembourg. the Netherlands, Portugal and Sweden. There is therefore a high degree of heterogeneity in the number of doctors throughout member states of the EU, with only Italy coming out as not significantly different from the reference.

The above finding of absolute convergence is not in accord with the findings of the σ-*convergence* analysis for number of physicians, suggesting that although variance in the data may have increased over time the long-term prediction is for β-*convergence*, but with several clubs in evidence.

In terms of the hypothesis of conditional convergence, as shown in Table 5.7 the coefficient of *per capita* health expenditure is not significant and can therefore be rejected. The general conclusion therefore for number of physicians is that this variable is converging but with a good degree of heterogeneity predicted in the steady state..

5.3.2 Convergence in number of beds

In terms of absolute convergence for number of beds, shown in Table 5.6. the estimation produced high goodness-of-fit statistics and statistically significant coefficients of the explanatory variables, with R^2 = 99.5% and R^2 Buse = 88.5%. The value of β is –0.016 (95% confidence interval -0.03<-0.016<0.0003) which is statistically significant. The Wald test statistic also confirms that β<0. Therefore. the hypothesis of absolute β-*convergence* is confirmed. suggesting that the EU is moving to a common level in this variable.

However, in spite of this finding diversity across the EU countries is predicted in the steady state but not in the speed of convergence as the slope dummies are found to be non-significant. The countries which have significant shift dummies are: Austria, Belgium,

Table 5.5 Rresources and utilization rates (absolute convergence)

Coefficient	(1) R^{DOC}	(2) R^{bed}	(3) U^{LOS}	(4) U^{AR}
Constant α	-0.179	-0.001	-0.003*	0.002*
	(0.015)	(0.003)	(0.003)	(0.002)
Coefficient (1+β)	+0.669	0.984	0.983	1.003
	(0.026)	(0.008)	(0.009)	(0.006)
Dummy Variables (shift)	0.136A	0.023A	0.041NL	-0.019IRL
	(0.018)	(0.005)	(0.1)	(0.009)
	0.221B	0.017B		-0.014NL
	(0.022)	(0.005)		(0.006)
	0.231D	0.024D		-0.011S
	(0.020)	(0.006)		(0.004)
	0.205DK	0.020F		
	(0.020)	0.006)		
	0.311E	0.029L		
	(0.025)	(0.007)		
	0.186F	0.031NL		
	(0.016)	(0.007)		
	0.162FIN			
	(0.014)			
	0.279GR			
	(0.023)			
	0.035IRL			
	(0.013)			
	0.095L			
	(0.011)			
	0.164NL			
	(0.016)			
	0.210P			
	(0.019)			
	0.217S			
	(0.020)			
R^2 (Buse)	0.754	0.885	0.813	-0.064
R^2 (observed/predicted)	0.996	0.995	0.995	0.074
β-coefficient	-0.331	-0.016	-0.017*	+0.003*
	(0.026)	(0.008)	(0.09)	(0.006)
Wald $\chi^2_{(1)}$ test for β=0	158.524	4.543	3.698	0.261*

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equation (1) represents the number of physicians *per capita*. Equation 2 represents number of beds *per capita*. Equation (3) represents average in-patient length of stay. Equation 4 represents the average in-patient admission rate. The country dummy variables are shift dummies. All variables are defined in Chapter Two (section 2.3).

Table 5.6 Resources and utilization rates (conditional convergence)

Coefficient	(1) R^{DOC}	(2) R^{bed}	(3) U^{LOS}	(4) U^{AR}
Constant α	-0.181	-0.067	-0.003*	0.007
	(0.016)	(0.003)	(0.003)	(0.003)
Coefficient $(1+\beta)$	+0.663	0.982	0.972	0.966
	(0.029)	(0.011)	(0.011)	(0.014)
Per capita h. exp	0.011*	0.017	(0.009)	0.019
	(0.013)	(0.012)	(0.006)	(0.007)
Dummy Variables (shift)	0.136A	0.019A	0.047NL	-0.024E
	(0.018)	(0.005)	(0.011)	(0.009)
	0.273B	0.012B		-0.020IRL
	(0.024)	(0.005)		(0.009)
	0.229D	0.024GR*		-0.037NL
	(0.021)	(0.013)		(0.010)
	0.207DK	0.022L		-0.017S
	(0.021)	(0.006)		(0.005)
	0.320E	0.025NL		
	(0.029)	(0.007)		
	0.184F			
	(0.017)			
	0.164FIN			
	(0.016)			
	0.295GR			
	(0.032)			
	0.038IRL			
	(0.014)			
	0.093L			
	(0.012)			
	0.163NL			
	(0.016)			
	0.219P			
	(0.024)			
	0.217S			
	(0.020)			
R^2 **(Buse)**	0.734	0.842	0.808	0.800
R^2 **(observed/predicted)**	0.996	0.994	0.995	0.995
β**-coefficient**	-0.337	-0.018*	-0.028	-0.034
	(0.029)	(0.011)	(0.011)	(0.014)
Wald $\chi^2_{(1)}$ **test for** $\beta=0$	133.01	2.829	6.045	5.842

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equations (1) to (4) and country abbreviations are as for table 5.6. All variables are defined in Chapter Two (section 2.3).

Germany. France, Luxembourg and the Netherlands. Again, the sign indicates the direction as either above (positive) or below (negative) the reference country of the UK.. As in the previous case, the above finding of convergence is not in accord with the findings of the σ-*convergence*, suggesting that although variance in the number of beds may be increasing over time, the long-term prediction is for β-*convergence*.

In terms of conditional convergence, as shown in Table 5.7, the coefficient of *per capita* health expenditure is not significant and the hypothesis of conditional convergence can therefore be rejected.

The general conclusion therefore for number of beds is similar to number of physicians in that all countries are moving towards a common level, but significant differences in levels exist in the steady state.

5.3.3 Convergence of length of stay and admission rate

In terms of absolute convergence for length of stay and admission rate, as shown in Table 5.6, the values of β were not significant (columns 3 and 4). Therefore the hypothesis that all countries in the EU are converging to a common point for these two variables can be rejected. This finding generally confirms the result for σ-*convergence* in admission rate and does not contradict the finding of divergence in the σ-*convergence* (see Figure 5.5).

However, when considering the hypothesis of conditional convergence, using *per capita* health expenditure as the conditional variable, this was confirmed for admission rate as shown in column (4) of Table 5.6, with β = -0.034 (95% confidence interval -0.06<-0.034<-0.007). In this part of the analysis shift dummies were found to be significant for the following countries: Spain, Ireland, the Netherlands and Sweden, providing evidence of spatial differences among admission rate but not in the rate of convergence as no slope dummies were found to be significant. For length of stay conditional convergence was not found as *per capita* expenditure was found to be non-significant as shown in Table 5.6.

5.4. Discussion and Conclusions

The study of convergence in resources and utilisation levels of health care systems offers an alternative and informative perspective on health care delivery as it reflects the changing patterns of health care provision in the EU countries. However, any assumption that having 'sufficient' resourcing within a health care system is some form a guarantee of good health outcomes should be avoided at this stage as this issue is investigated further in Chapter Six.

When considering resource levels, trend analyses clearly showed that over the period 1960-95 the mean number of doctors *per capita* in the EU had increased while the mean number of beds had decreased. The σ analysis revealed non-statistically significant divergence for number of beds which may be associated with the increasing levels of doctors, compared with the EU mean, in the SI countries while the NHS countries have been reducing this resource over the period.

The results for the β-*convergence* analysis showed that absolute convergence was confirmed for number of beds, but at a much slower rate than that of number of physicians. Again, some diversity in the steady state was in evidence with all the SI countries found to be statistically significantly higher than the reference intercept of the UK. This latter finding is somewhat at odds with the σ-*convergence* analysis for this variable, as the coefficient of variation increased. However, in this regard it should be borne in mind that σ-*convergence* was examined over a longer period of time, 1960-95, and over the period 1980-95 the change in coefficient of variation was much less and in either event the results for the σ analysis were not significant. Again, conditional convergence on *per capita* health expenditure was not confirmed due to the non-significance of this variable in relation to number of beds.

For number of active physicians the finding for absolute convergence was a rapid degree of convergence, due to a high value of β. However, 11 countries were also found to have statistically significant shift dummies which confirms that a good deal of diversity exists in terms of steady state levels, even though the results suggest that all countries are moving towards a common point at similar rates. The hypothesis of conditional convergence for number of physicians was rejected due to non-significant findings for the *per capita* health expenditure variable.

When considering system typology in association with resources, the number of beds was found to be significantly different between the NHS and the SI countries using 1995 values, with SI countries being well above NHS countries.

In relation to how often and for how long EU citizens use their health care systems, the data analyses for utilisation confirmed that the average length of stay was less than half its value in 1995 compared with 1960, suggesting that in some countries either treatments are becoming more effective or patients are being discharged as early as is clinically viable. In fact both of these are likely to be occurring. However, one reason to explain this is that over the same period the mean EU admission rate doubled, meaning more and more patients were being treated in hospitals over the period of analysis. For these two variables, however, there was no clear association found in relation to health care system typology.

The hypothesis testing for σ-*analysis* for utilisation variables found only length of stay to have experienced statistically significant divergence over the period 1960-95. Trend analyses to explain this reveal it is largely due to upward divergence (away from the mean) on behalf of some SI countries such as Germany, Luxembourg and the Netherlands, and downward divergence (away from the mean) by some NHS countries such as Denmark, Portugal, Sweden and the UK. Policies adopted by NHS countries to achieve efficiency at the micro level in terms of reducing length of stay and increasing throughput are therefore shown to be having an impact. Conversely, the SI countries in general seem to be allowing, or are not able to prevent, length of stay to increase relative to EU mean.

When testing for associations with health care system it was found that average length of stay in SI countries was six days higher than in NHS countries, although this difference did not reach statistical significance. Similarly, but to a much lower extent, admission rates were 2 percent higher in SI countries than in NHS countries.

In the β-*convergence* analyses of utilisation levels it was found that for both length of stay and admission rate absolute convergence was not confirmed, which is in accord with the findings of the σ analyses. Conditional convergence was found, however, for admission rate with some spatial heterogeneity in evidence as four countries were found to have statistically significant shift dummies (which accords with the findings in the σ analyses). The hypothesis of conditional convergence for length of stay was rejected.

The findings of this chapter thus support the general perception that more treatments are becoming available with more doctors being introduced within EU health care systems, but that the time spent in hospital (with the exception of some countries such as the Netherlands) is reducing under the influences of new procedures such as day care surgery, minimally-invasive procedures (see for example Cerveira *et al.*, 1999) and a general thrust towards achieving micro-efficiency (more output for given levels of resources) in treating more patients in hospitals. The influence of demographic changes and the resulting increase in demand for health care are also undoubtedly having an impact in this regard. The findings also indicate that some of the more advanced countries may be more successful in implementing new technologies than others in enabling lengths of in-patient stay and in-patient beds to be reduced, although these may have been unduly decreased under aggressive health care reforms and policies to constrain health care expenditure rises (see Chapter Three; Nixon, 2000a) among some countries in the EU.

The results also reveal issues relating to the control of resources, particularly for the number of doctors and admission rates. For example, it can be seen that the Southern European countries have relatively more doctors that those countries of the North, although this may also reflect the low starting point in these countries' resources at the early stages of their development. In Spain and Greece in particular there has been a lack of control in the number of doctors entering medical schools or going abroad to study medicine. The reasons for this are partly cultural in that doctors are perhaps more highly valued within families or society which, coupled with the lack of control in numbers, has meant that these countries are well endowed in doctors even though the intensity of their participation in the health care systems may be lower than in other EU countries. In contrast there are countries such as the UK which exercise strong control over the number of doctors that are allowed to be trained.

When considering admission rates the differences across the EU may also be partly explained by the participation of the family in caring for sick relatives in the home rather than in hospital. Again in the Southern European countries of Spain, Greece and Portugal, admission rates are well below the EU mean but this trend may change in time as care in the home becomes less of an option as more women enter the workforce, and admission rates may rise accordingly.

With these findings in mind, however, the main point of interest in examining factors such as resource levels and utilisation rates is to determine their influence on health outcomes. For example, is the observed decrease in length of in-patient stay and number of beds having a detrimental impact of patients' health outcomes? Does the number of physicians per head of population also impact on health outcomes? What is the relationship of these variables with health expenditure?

These issues are addressed in detail in Chapter Six, which seeks to establish causal links relating to health outcomes and a range of explanatory variables, and discussed further in Chapter Seven.

Chapter Six

Investigating Associations and Modelling EU Health Care Convergence

6.1. Introduction

The aim of this chapter is to investigate associations between the variables used in the framework, which will allow the development of a conceptual model for the study of convergence in the health care systems of the EU. This is of value in view of the observed convergence in the previous chapters and in bringing the analyses to a coherent conclusion.

In order to achieve this, regression analyses are undertaken using all variables in the health care expenditure, health outcomes, resource and utilisation rate categories analysed in chapters, 3, 4 and 5, respectively. However, as other factors are required to be included in the analysis, additional explanatory variables are also employed.

The question of which variable/s should be used as dependent and explanatory variables therefore needed to be considered. The most appropriate model one could perhaps develop from the thesis framework would be to utilise *health outcomes* as the dependent variables and all others, plus any new variables considered to be influencing health outcomes, to be used as explanatory variables. As such, it is possible to hypothesise that health outcomes (infant mortality, life expectancy (females) and life expectancy (males)) can be explained to one degree or another by health care expenditure, health care resources, health care utilisation rates and other relevant social, economic and lifestyle factors. The chapter thus allows the 5th and 6th study questions, as stated in Chapter One, to be explored. Namely:

- Can a generic model be developed for the study of health care convergence?
- Is there evidence of convergence in other non-EU OECD countries?

In order to determine the chosen variables and a suitable methodology it was necessary to examine relevant literature analysing the determinants and production of health. The chapter therefore begins with a brief overview of key studies and models in this area of health economics before focusing on an approach appropriate for the previous foundations of the thesis and the aggregate, macro-level data used.

This is followed by a brief description of how each of the chosen variables intended for inclusion in the modelling is expected to influence health outcomes. The chosen regression models are then presented, followed by the results of the tests. The results are discussed in the light of other similar studies exploring such significant associations.

Following this, in order to tie all the strands and findings of the thesis together, a conceptual model for the study of health and health care convergence in the EU is constructed, based on the statistically significant findings of the thesis.

Finally, to address the question of how EU membership has influenced the results, a sample of non-EU OECD countries is taken and tested for convergence in the principal areas of the developed conceptual model. This enables the development of a plausible set of conclusions and policy implications to be drawn in the discussion and conclusions.

6.2. Health production models and functions

In this field of study it is possible to distinguish two distinctive approaches that have been adopted by other researchers. The first approach is grounded in the work of Michael Grossman's human capital theory at the level of the individual, which regards health as a commodity which the individual will wish to consume and maximise, subject to his budget constraints, in conjunction with a number of endogenous and exogenous variables or characteristics which have an impact on an individual's health. Grossman's household production function model of consumer behaviour was further developed to account for the gap between health and medical care as one of the many inputs into its production.

The second approach considers health as a production function which is addressed using aggregate or macro-level data. The basic tenets of this approach are that health can be viewed as an 'output,' say of a health care system, which is influenced by the 'inputs' to that system. In particular researchers adopting this approach wish to investigate the relationship between health care expenditure, or medical care resources, as inputs, and health outcomes as the output of that system.

However, the distinction between these approaches has become somewhat blurred and there is a degree of overlap as many of the variables employed in the two approaches are the same, and they are both categorised as 'production functions.' With this potential difficulty in mind, the following sub-sections are developed along these lines, beginning with a brief overview of the Grossman model and its developments, plus identification of recent reviews and critiques of Grossman-type studies.

This is followed by a review of studies falling into the second approach, which, because of the nature and similarity of the data used, is adopted as the platform with which to conduct the empirical analyses of this chapter.

6.2.1.1 The Grossman Model

The pioneering work in this area (Grossman, 1972a; 1972b) was in the development of the 'investment model of demand,' which dealt with a theoretical and empirical investigation of the demand for the commodity 'good health' (Grossman, 2000, p. 349). The model essentially regards health as a capital good that is inherited and depreciates or deteriorates over time. The theory posits that investment in health is a process in which medical care is combined with other relevant factors to produce new health, which, in part, offsets the process of deterioration in health stock. The positive correlation between education and the health of an individual is central to the thesis of Grossman, and has been confirmed in many subsequent studies *(ibid).*

The implications for Grossman's work are threefold. The first relates to the effects of age on the demand for health and medical care and in this regard Muurien (1982) suggested that a change in stock occurs if the gross investment in health differs from the deterioration in stock. Moreover, the rate of depreciation in health is a function of age and a set of exogenous variables that include environmental, occupational and lifestyle factors that might adversely affect health status. Coupled with this is the concept that as an individual ages, medical services become less productive in generating health benefits which means that in order to compensate for these influences consumers increase their expenditure on, and use of, medical services.

The second implication relates to the effect of education and other exogenous factors on the demand for health and medical care. Grossman argues that education increases health productivity in that better educated people are more skilful in combining inputs to produce health. Acton (1975) was early in confirming this in the finding that the net change in the use of ambulatory services produced by increasing levels of education is negative.

As Rosco and Broyles (1988) point out, among the advantages of the above-described approach, is the potential for examining the influence of environmental and occupational factors on the deterioration in health and therefore the demand for health care. In this respect Cropper (1977) developed a model in which investment in health during an individual's life is assessed with regard to occupational choice and also exposure to hazards in the workplace. Ippolito (1981) also examined the optimal age profiles of consuming goods that are hazardous to health.

The third implication of the investment models concerns the impact of increasing income (through wages and non-wage income) on the demand for medical care. According to the theory, as wages rise the value of time spent on the consumption of medical care, as well as the value of health time, rise. The consequence of this element of the model is that as wages rise so do expenditures on health care. In this regard Auster *et al.* (1969) found that the elasticity of health with respect to the consumption of health services was approximately –1 (i.e. a 1 percent increase in the consumption of health care reduces mortality by 1 percent). They also found that education was twice as effective in producing health. Grossman (1972a) also found negative income elasticities with regard to health even though the elasticity of income in relation to health care was positive.

The implications regarding the findings of income in relation to health are most likely attributable to lifestyle, environment and occupational factors. In other words, rising incomes (for the individual) may also be associated with adverse diets, the purchasing of fast cars, and participating in lower levels of exercise. Moreover, in order to acquire higher incomes, individuals may belong to professions with high levels of stress and exposure to health risks or injury. Thus, it is likely that after a certain level, the adverse effects of income on health exceed the beneficial effects of income, resulting in an inverted U shape between income and health. This latter point was confirmed by recent work by Mayston (2000, p. 28) who suggests that as absolute income increases, an individual's health status increases but falls again (forming an initial inverted U). However, this is followed by a U shape as the individual adjusts his/her behaviour. The relationship between health status and income is therefore more likely to be non-linear and non-monotonic.

The original Grossman model has in fact been developed and expanded upon in many empirical studies. Among these, Acton (1975), and Phelps and Newhouse (1974) investigated the sensitivity of health care demand to changes in time prices and found that as time prices decline, elasticities with respect to money prices rise. These analyses were confirmed and expanded upon by Salkever (1976), Inman (1976), Luft *et al.* (1976), and Taylor *et al.* (1981). That time prices influence demand for health care is also supported by the findings of many others, including Colle and Grossman (1978).

The above outline therefore summarises the foundations of Grossman's work and concepts. However, the literature on the Grossman model and related works is vast and beyond the scope of this chapter to cover fully. In a more recent publication (Grossman, 2000) Grossman examines more fully subsequent extensions and empirical testing of the model. This is done with regard to cross-sectional data, focusing on work undertaken by Wagstaff (1986), Erbsland *et al.* (1995), and Stratmann (1999), longitudinal empirical analyses by Van Doorslaer (1987) and Wagstaff (1993). In terms of the theoretical extensions to the basic model that have occurred, Grossman focuses on those undertaken by Cropper (1977), Muurinen (1982), Dardanoni and Wagstaff (1987; 1990), Seldon (1993), Chang (1996), and Liljas (1998). Finally, criticisms of Grossman's work in a review by Zweifel and Breyer (1997) are also responded to.

In summarising the influence of the investment demand model and subsequent analyses, their principal value has been in the formulation of health care policy. By focusing on health rather than health services, the model emphasises the role of environmental, occupational, and lifestyle factors and their influence on morbidity and the use of health care services that this triggers. Given the influence of the central theme of education, as Rosco and Broyles (1988) argue, focus on public policy should be on the 'provision of health information rather than health services'. However, one cannot ignore the increasing demand for health care caused by technological change and the growth of ageing populations. Thus, bearing in mind the underlying theory of the investment theory of demand, emphasis, according to this paradigm, should be placed on health care policies that reduce the effects of factors that are detrimental to an individual's health while enhancing those that are beneficial.

6.2.1.2 Aggregate health production functions

Although the work outlined in the previous section must be acknowledged as fundamental to the understanding of health and its determinants, the thesis is primarily concerned with the relationship between aggregate 'inputs' to a health care system or population and the aggregate health 'outputs' that are produced (Zweifel and Breyer, 1997). In this context, therefore, it more beneficial to consider health as a production function, which will take into account many of the above factors, but have an emphasis on data at the macro level.

From this perspective, the most influential early study of this type to examine the effects of medicine from an economic perspective was undertaken by Auster, *et al.* (1969). Its aim was to examine the marginal productivity of medical care relative to other factors such as lifestyle in the production of health. Using the states of the United States as their unit of observation, their dependent variable was mortality rates and their 12 explanatory variables were contained within the classifications 'economic factors (income per capita. average number of years schooling, share of population in urban areas and share of industry in total employment),' 'factors related to consumption (alcohol consumption per capita, cigarette consumption per capita),' medical factors (pharmaceutical outlay per capita, number of physicians per capita, medical auxiliary staff per capita, capital stock of hospitals per capita),' and 'organisational factors (share of group practices and existence of medical schools).' They converted all data to natural logs and applied ordinary least-squares estimates (OLS). Their findings were that higher incomes do not lead to a reduction in mortality, prolonged schooling appears to reduce mortality rates, increased physician density leads to increases in mortality rates while increased auxiliary staff reduces mortality rates. The conclusion from this study was that the marginal productivity of medical infrastructure in the United States may fall short of additional schooling. However, as Zweifel and Breyer point our (1997, p. 98), 'it must be noted that this conclusion is based on observations from at least 30 years ago, which fail to reflect the developments of high-tech medical care.' A rather surprising finding from this study was that countries with a higher physician density have higher child and infant mortality rates. Grossman and Jacobowitz (1981) suggest that this finding may reflect a shift away from the more beneficial 'motherly care,' which is substituted for medical care in modern industrialised countries.

The study by Cochrane *et al.* (1978) is of particular interest to this thesis as it used OECD data and age-specific mortality rates as dependent variables. The seven explanatory variables were physicians *per capita*, GNP *per capita*, Cigarette consumption *per capita*, alcohol consumption *per capita*, population density, public share of public in total health care expenditure, and sugar intake *per capita*.

The results of their estimations were that a rise in GNP by one standard deviation is related to a decrease in the mortality rate at birth (11 percent), during infancy (16 percent), in the first four years (8 percent), and in the last ten years of life (9 percent). In terms of alcohol consumption there is evidence that these are related positively with mortality rates (i.e. as consumption of these goods increases so does mortality). Increased public spending on health care was also found to lower mortality rates, and sugar consumption has a negative effect on the mortality rate.

In a study of socio-economic and environmental influences on mortality rates for two neighbouring states (Nevada and Utah) in the US, Fuchs (1974; 1975) found that infant mortality rates were 42 percent and 35 percent higher in Nevada for boys and girls, respectively. In explaining this Fuchs centres attention on the fact that Nevada has a predominantly immigrant and mobile population (especially up to the end of the 1970s), the percentage of adults born in Nevada was only 10 percent compared with 63 percent for Utah, and almost half of the 35-64 year old men were single or no longer married to their first wife. The point that Utah has a predominantly Mormon population with an emphasis on abstinence, in contrast to Las Vegas and Reno in Nevada, is illustrative of the differing lifestyles between these two states. This particular study supports the view that lifestyle may have a greater impact on mortality rates than medical care or economic factors (which, in *per capita* terms, were found to be similar).

Wolfe (1986) and Wolfe and Gaby (1987) tested a health production function model which incorporated latent lifestyle variables such as tobacco and alcohol consumption, to a time-series data set from 7 and 22 OECD countries, respectively. However, they were not able to produce statistically significant results for these explanatory variables.

Also at the level of aggregate data Brenner (1979; 1983) investigated the effects of economic instability on health status and found that between 1936 and 1976 in England and Wales, there was a significant connection between mortality rate and unemployment rate. The two most relevant other explanatory variables were the trend in real income *per capita* and the deviation of current income from this trend. The impact on the individual may be poor health and possible increase in the probability of death. In contrast to the work of Wolfe, and Wolfe and Gabay (*ibid*), Brenner (1983) found that cigarette and alcohol consumption have statistically significant impacts on mortality, and that (NHS) expenditure seems to reduce mortality (confirmed on a country-wide basis by Cochrane *et al.* (1978).

However, Gravelle (1984) criticised the methodology and theoretical foundations of Brenner and, moreover, Gravelle *et al.* (1981) found that regressions using latent variables are unstable over time due to the effect of lags (in effect). In the case of cigarette smoking, this lagged effect may range from two to five years. In a later study by Brenner (1985) of five industrialised countries this latter point was confirmed.

Finally, in these types of analyses it is necessary to be aware of the point that aggregate data are being used, meaning that overall effects on mortality are examined rather than mortality for those affected by a particular variable such as unemployment or cigarette consumption.

In summarising studies that have used aggregate data to explore causal links between health status and economic, the health care system, and environmental and lifestyle explanatory variables, there are some conflicting results and methodological issues that need to be addressed, suggesting more work needs to be done in this area (Zweifel and Breyer, 1997).

6.2.1.3 Diminishing returns in health production functions

A concept of relevance and interest in health production functions from the perspective of a health care system is that of diminishing returns, which is outlined in the following.

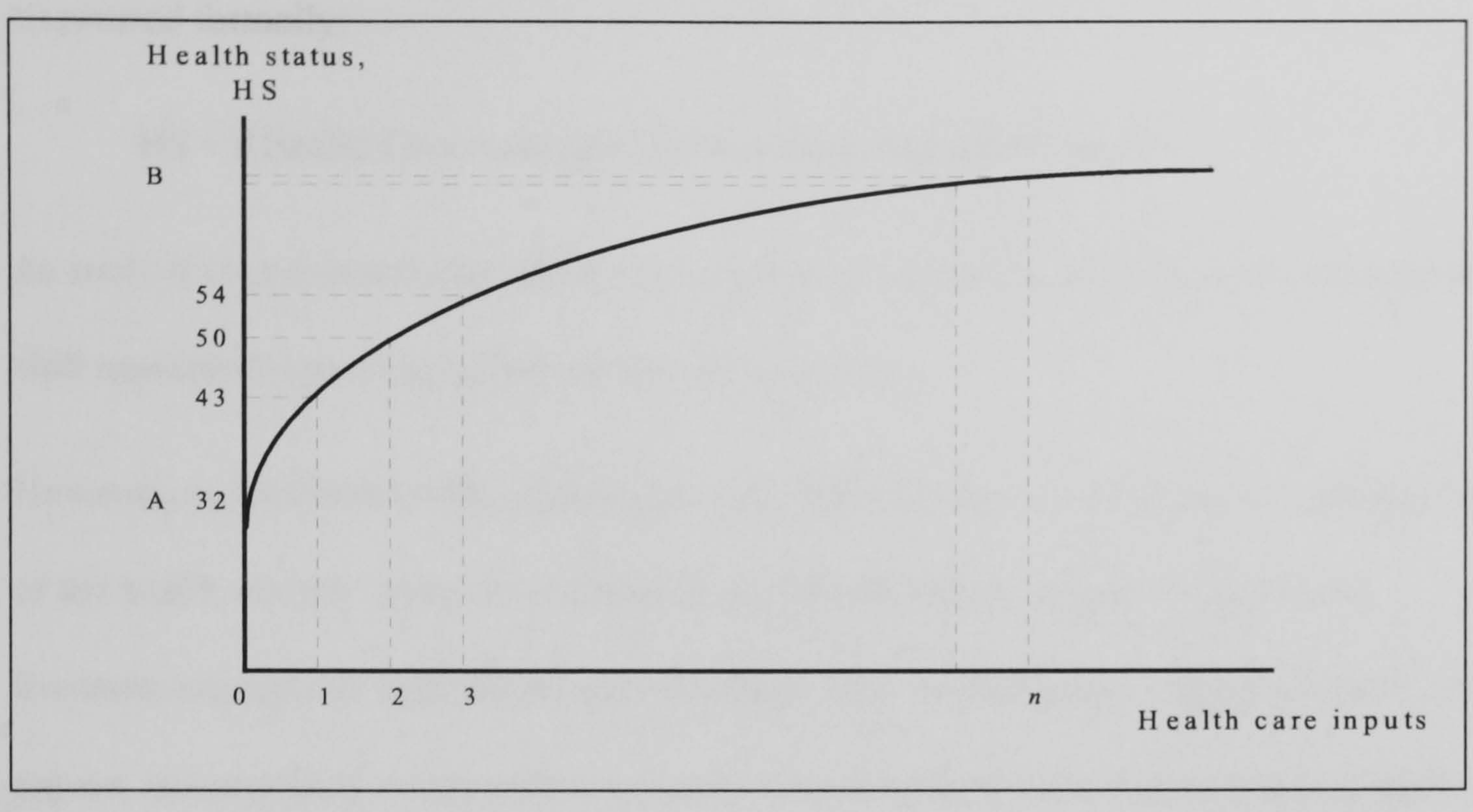
As Folland *et al.* (1993) argue, the question of how health care inputs affect health outcomes is a complex one and often produces the claim that health care and/or health expenditure has a low influence on health. This is because historically many of the big reductions in mortality rates were not brought about by practitioner-provided health care but by a number of environmental and lifestyle changes. In this respect the principal breakthroughs in improving health and life expectancy came about from improved nutrition, better hygiene resulting in a decline of water and food-borne diseases, improved water quality and sewage disposal systems, and finally immunisation and therapeutic measures (McKeown, 1979).

Preventative rather than curative measures have therefore brought the biggest gains in improving health outcomes but in moving forward beyond these developments all countries of the EU place great emphasis now on personal behaviour such as diet, exercise, tobacco consumption, alcohol, drugs etc. (McGuire *et al.,* 1994) as means of improving health status. Elective procedures are often assumed not to be having a marked impact on global health outcomes and may, rather, focus on improving quality as well as duration of life.

However, it is essential to bear in mind that the *stage* of development of a health care system is an important factor in determining its added value. Thus, within a theoretical framework it is possible to represent the distinction between total and marginal contributions to health by means of the health production function, illustrated in Figure 6.1.

If we assume that a suitable measure of health status (HS) has been determined and an

Figure 6.1 Production function of health



accurate means of representing it exists, HS is shown to be an increasing function of health care. In simple terms, as we introduce more health care inputs HS increases but with diminishing marginal returns to health, as depicted by the flattening of the curve.

To illustrate, with zero health inputs HS = 32 (point A). For the first unit of health input (1) HS increases to a figure of 43, expressed formally the marginal increase in health state, $\Delta HS_1 = 43\text{-}32 = 11$. For the second identical unit of health care input (2) , the marginal increase, $\Delta HS_2 = 50\text{-}43 = 7$, and the third unit of health care input, $\Delta HS_3 = 54\text{-}50 = 4$. For the last unit of health care input, n, the increase in health status, ΔHS_n, is extremely small (point B). Thus there comes a point when providing additional health care has little or no impact, and due to the risks associated with some medical interventions, may even result in a reduction in the population's health status.

However, of perhaps equal or greater importance is the argument that improvements in health are brought about by other factors additional to the health care system of a country, including lifestyle, environment and human biology (Folland *et al*, 1993, p.102). Expressed formally:

HS = *f*(Health Care, Lifestyle, Environment, Human Biology)

As such, if improvements are made to any of the above factors, the HS curve will tend to shift upwards (improving health status) and *vice versa*.

However, as Goldacre (1996, p.69) points out, 'the difficulty of isolating the contribution of the health service 'input' as a determinant of health status 'output' is one which frustrates attempts to measure the overall effectiveness and efficiency of health care.' As he argues, in comparing trends within a country over time there is no experimental control group providing comparable data in the absence of health services. Moreover, a number of anomalies are thrown up by such analyses of health care inputs and health outputs.

For example, life expectancy in the UK is very similar to that of the United States despite considerably higher *per capita* health expenditure in the USA[1]. However, the lack of universality and inequity of access in the provision of health care in the United States, despite such high overall levels of expenditure[2], may largely explain this particular observation and health care system (and implicitly, the coverage it provides to the population), as illustrated in chapters Two and Three, has a significant role to play. In the context of this overall debate, researchers who point to the United States as a means of undermining causal links between health outcomes and health care inputs do not take the above features of the US health care system fully into account.

[1] *Per capita* spending in the United States in 1997 was $3,925, which represents 13.5% of GDP. For the same year the figure for the UK was $1,347, which was 6.7% of GDP (OECD, 1998).

[2] In 1997 only 33% of the US population had health insurance assured by the government (Medicare, Medicaid, Indian Health Service, Civil Service and the Military) while 43 million Americans were estimated to be without adequate health insurance (*Current Population Reports*, 1998).

The question of income distribution is also highly relevant in the case of the United States due to the well established link between income and health care expenditure (see chapter Three). Analysis of 15 OECD countries (Atkinson *et al.*, 1997) showed that the United States had the highest level of income inequality as measured by the Gini index. These features re-inforce the view that the United States is a special case and its health care system is fundamentally different from those of the EU, both in terms of philosophy and operation.

However, in spite of this argument it is still the case that most previous studies attempting to show a causal relationship between health expenditure and health outcomes have generally found limited success (Newhouse, 1977; Cochrane *et al.* 1978, Leu, 1986; Parkin, *et al.,* 1987; Hitiris and Possnett, 1992). The study by Cochrane *et al.* (*ibid*), for example , studied health service 'input' and mortality 'output' by reporting on a range of indicators of health care facilities and age-specific mortality rates in 18 developed countries. Their findings suggested that there was no evidence to show that low mortality rates correlated with high levels of health care 'input.' Leu (*ibid)* failed to identify a relationship between medical care expenditure and lower mortality rates after controlling for *per capita* income. Hitiris and Posnett (*ibid*) also found limited evidence in support of a relationship between health care expenditures and mortality rates, in spite of the use of large pooled time series and cross-section analysis with corrections for heteroskedasticity and autocorrelation. Some recent studies, however, have found more encouraging results and the disappointing findings summarised above may partly be due to heterogeneity inherent in data sources used in international analyses (Cremiêux *et al.*, 1999).

In the late 1980s Corman and Grossman (1985) and Corman *et al.* (1987), for example, reported studies of the determinants of neonatal mortality rates in cross-sections of countries in the United States. Somewhat different from infant mortality (the number of deaths under the age of one for every 100 live births) the neonatal mortality rate is the ratio of deaths of infants aged one month or less per thousand live births. Between 1964 and 1982, the average neonate mortality dropped from 17.9 to 7.7.

Contributions of specific types of medical care and specific types of neonate-related programmes were considered. The production function estimates enabled the authors to evaluate the projects, including maternal and infant care as well as community care centres. Their data indicated that of the total reduction in neonate mortality for whites during the period, 1.9 deaths per 1000 live births or 25.3%, can be explained by the observed factors (which included nutrition programmes, organised family planning, use of community services, neonatal intensive care units, abortion, and prenatal care). One might conclude, therefore, that these increases in the availability of resources led to improvements in health outcomes, and that these resources were made available though appropriate expenditure on health care. In terms of the objectives of this thesis, one of the most encouraging recent studies to show a causal link between health care expenditure and health outcomes has come from Canada[3] (Cremiêux *et al.*,1999). Their findings are summarised in the following quotation:

> *Whilst previous researchers found it difficult to establish such a relationship (between health care spending and health outcomes) based on international comparisons, the results based on rather homogeneous province-specific Canadian data show that lower health care spending is associated with a statistically significant increase in infant mortality and a decrease in life expectancy in Canada. (p. 627).*

[3] Another recent study investigating the determinants of national life expectancy in Canada was conducted by Barlow and Vissaudjec (1999).

Of particular interest in the above study, which covered a 15-year time period, was that the results were shown to be 'independent' of various economic[4], socio-economic[5], nutritional and lifestyle factors[6], as well as province specificity or time trend. In correlations between health care spending and health outcomes the authors found figures of -0.74307 and -0.66544 for male and female infant mortality, respectively, and 0.88631 and 0.81834 for male and female life expectancy, respectively. These figures indicate an association (higher health care expenditure is associated with lower infant mortality and higher life expectancies) but on their own do not confirm a causal link. However, the results of their regression analysis, in summary, show that when omitting lifestyle and nutritional variables, the impact of a 10% reduction in health spending results in a 0.5% increase in male infant mortality, a 0.4% increase in female infant mortality, a 6-month decrease in male life expectancy and a 3-month decrease in female life expectancy. The authors conclude that 'even though differences in health care expenditure levels across Canadian provinces are small, they remain strong determinants of health outcomes' (*ibid,* p.638). They also show from their results that supply-side variables such as health expenditure and the number of available physicians are highly significant determinants of health outcomes, even after controlling for age and other socio-economic factors.

Similar findings from a recent study (Barlow and Vissandjée, 1999) of national life expectancy at birth for 1990 found that *per capita* income and literacy rate were found to be strong predictors which influence other relevant determinants - in their case fertility (low fertility is associated with increased life expectancy), nutrition, and water supply. The authors' finding in regard to health expenditure was that it was demonstrated to have a

[4] Number of physicians *per capita*, GDP *per capita*.

[5] Number of graduates *per capita*, poverty rate and population density.

[6] Percentage of smokers, alcohol consumption *per capita*, spending on meat, spending on fat.

weak influence, and that intake of animal products has an inverted U-shape relationship with life expectancy . In other words low and high intakes are associated with reduced life expectancy, with a range of beneficial levels in between these extremes.

The concept of diminishing returns and its influence on establishing causal links and associations between inputs and outputs to a health care system, along with the findings of the above overview of relevant studies, forms the basis for the selection of suitable explanatory variables to augment the thesis framework.

However, it should be noted that when the updated OECD Health data (OECD/CREDES 2000) set was examined some of the sought-after variables were not available or there were too many missing values for inclusion. The following sections therefore outline the data that were available and provide definitions for each variable considered for inclusion in the chosen regression models.

6.3. Regression models

The chosen generic health production function for the dependent variables of all three health outcomes (infant mortality, life expectancy (females), life expectancy (males)), H, based on the above summarised studies and available OECD data, is as follows:

$$H = f(X^h, GDP^h, DOC, BED, AR, LOS, COV, UNE, ALC, TOB, NUT_1, NUT_2, POL)$$

In other words, health is a function of a number of inputs, namely *per capita* health expenditure, health expenditure as a share of GDP, the number of doctors, the number of beds, the admission rate, in-patient length of stay, the coverage a health care system provides to its population, unemployment, alcohol consumption, expenditure on tobacco, nutrition (fruit and vegetable intake), nutrition (protein intake), and environmental pollution). Each of these explanatory variables are defined below with their expected influence on the dependent variable(s).

6.3.1 X^h - Total per capita health care expenditure

Measured in US PPP$. It is thought that the coefficient of this variable will be positive for life expectancy in that increased expenditure on health care *per capita* will increase life expectancy, but negative for infant mortality in that increases in health care expenditure will result in reductions in the infant mortality rate.

6.3.2 GDP^h - Per capita income

Measured in US PPP$. It is anticipated that the coefficient of this variable will be positive for life expectancy in that increased *per capita* income will increase life expectancy, but negative for infant mortality in that increases in income will result in reductions in the infant mortality rate. It is known that the first variable, *per capita* health care expenditure, is correlated positively with *per capita* income and this is addressed in the regression analyses.

6.3.3 DOC - Number of active physicians per capita

Defined fully in Chapter Two (section 2.3), this variable is thought to have a positive coefficient for both measures of life expectancy and a negative coefficient for infant mortality. In other words increasing the number of physicians will tend to increase life expectancy and reduce infant mortality.

6.3.4 BED - Number of in-patient beds per capita

Defined fully in Chapter Two (section 2.3), this variable is thought to have a positive coefficient for life expectancy and a negative coefficient for infant mortality, as above, increasing the number of beds available to patients should increase life expectancy and reduce infant mortality.

6.3.5 AR - In-patient admission rate (percentage)

Defined fully in Chapter Two (section 2.3), this variable is thought to have a positive coefficient for life expectancy and a negative coefficient for infant mortality, with an expected increase in life expectancy and a reduction in infant mortality as the admission rate increases.

6.3.6 LOS - Average length of inpatient stay

Again, defined fully in Chapter Two (section 2.3), this variable is thought to have a positive coefficient for life expectancy and a negative coefficient for infant mortality, in that increasing length of stay may be associated with increased life expectancy and reduced infant mortality rates.

6.3.7 COV - Percentage of total population covered for health care

This variable is thought to have a positive coefficient for life expectancy and a negative coefficient for infant mortality. In other words as health care coverage of the population increases life expectancy should increase and infant mortality decrease.

6.3.8 UNE - Percentage of total population unemployed

This variable is thought to have a negative coefficient for life expectancy and a positive coefficient for infant mortality. In other words as unemployment rises, life expectancy decreases and infant mortality increases. It was hoped that education level could be used as an explanatory variable but a sufficiently comprehensive data range was not available and as a consequence unemployment has been used as a proxy.

6.3.9 ALC - alcohol consumption

Measured in litres *per capita* (15 years and over). This variable is thought to have a negative coefficient for life expectancy and a positive coefficient for infant mortality. In other words as alcohol consumption increases life expectancy will fall and infant mortality will rise. This assumption, it is recognised, may have some limitations as moderate consumption of alcohol may be associated with positive dietary and health benefits.

6.3.10 TOB - Household expenditure on tobacco per capita

Measured in US PPP$. This variable is thought to have a negative coefficient for life expectancy and a positive coefficient for infant mortality. In other words increased expenditure on tobacco is associated with reductions in life expectancy and increases in infant mortality. Actual tobacco consumption in standard units per day was a preferred variable but the data were not sufficiently complete for inclusion.

6.3.11 NUT_1 - Fruit and vegetable intake

Measured in kilos *per capita*. This variable is thought to have a positive coefficient for life expectancy and a negative coefficient for infant mortality such that increasing intake of fruit and vegetables is associated with increased life expectancy and decreased infant mortality rate.

6.3.12 NUT_2 - Total protein intake

Measured in per caput intake. The level of protein intake may have a variable influence on health outcomes (both too little or too much would generally have adverse effects on life expectancy and infant mortality), confirmed by the work of Barlow and Vissandjée (1999).

6.3.13 POL - Pollution

This variable is used as a proxy for environment. POL is the sulphur oxide emission, measured in kilos *per capita* and is expected to have a negative coefficient for life expectancy and a positive coefficient for infant mortality. That is, increasing pollution levels are associated with reductions in life expectancy and increases in infant mortality rates.

These were the data that could feasibly be derived from the latest OECD health data set (*ibid*). It was not possible to obtain some data of interest, such as education level. Some variables above, such as unemployment, alcohol and tobacco consumption, however, might be capable of capturing some of the effects of education on the dependent variables.

6.4. Regression equations: methodology

Having gathered the above data (OECD/CREDES, 2000) for each year over the period 1980-95 testing was undertaken using infant mortality, life expectancy (females) and life expectancy (males) in turn as the dependent variables[7]. In order to increase the linearity between the dependent and explanatory variables, natural logs were taken according to the accepted convention of this form of analysis (for example, Cochrane *et al.,* 1978) which was confirmed as optimal through the results of Box-cox tests[8].

The first step was to derive a correlation matrix for all variables to determine potential causal relationships. These are shown below in Table 6.1. In most cases, the signs of the correlations confirm the predictions outlined earlier in the chapter (sections 6.3.1 to 6.3.13). Of particular interest were the correlations that existed between *per capita* health

[7] The software package employed for the regression analysis was SHAZAM.

[8] This procedure examines the dependent and explanatory variables used in the regression analyses (White, 1993).

expenditure (X^h) and the chosen dependent variables. Between X^h and infant mortality (im) the correlation was **-0.76** which was in the predicted direction (more money spent on health care results in a reduction in infant mortality rate). Between X^h and life expectancy for females (LEF) the correlation was **0.57** which again was in the predicted direction (an increase in health care expenditure results in an improvement in female life expectancy). For male life expectancy (LEM) and X^h a similar result was found but not as high, **0.36**, but again it suggests that life expectancy for males is improved with increases in health care spending. These results were fairly similar (except male life expectancy) to those found by Cremiêux *et al.* (1999) in their study of the Canadian provinces.

The next observation made was the high degree of correlation (**0.933**) between X^h and *per capita* income (GDP^h), which, throughout this thesis has been recognised and observed. Therefore in the derivation of the regression models GDP^h was removed and only X^h used as an expenditure explanatory variable. It is recognised here that the decision to remove GDP^h is a little contentious as, bearing in mind the work reviewed earlier in the chapter, income might be better able to capture some of the influences of lifestyle factors on health outcomes. However, many of these lifestyle variables will remain in the chosen explanatory variables used in the regression analyses, which partly overcomes the methodological drawback of eliminating income as a regressor. Moreover, the principal input variable used in the thesis framework, as defined in Chapter One, is health expenditure and therefore the use of GDP^h would result in a loss of coherence in the analyses undertaken throughout the thesis. For these reasons, *per capita* health care expenditure was retained.

Having assessed the correlation matrix it was possible to construct and test the required health outcome regression models, as described in the following.

In order to take into account heterogeneity in the countries of the EU with regard to health outcomes, shift dummies where significant are used to modify the models' constant values.

Table 6.1 Correlation matrix for variables included in the overall model

	X^h	im	LEF	LEM	BED	DOC	LOS	GDP^h	AR	COV	NUT_1	POL	UNE	ALC	NUT_2	TOB
X^h	1.0															
im	-0.76	1.0														
LEF	0.57	-0.66	1.0													
LEM	0.36	-0.57	0.82	1.0												
BED	0.38	-0.2	0.01	-0.19	1.0											
DOC	0.12	-0.26	0.48	0.4	-0.26	1.0										
LOS	0.12	-0.02	0.09	-0.1	0.7	-0.08	1.0									
GDP^h	0.93	-0.7	0.6	0.46	0.25	0.16	0.02	1.0								
AR	0.58	-0.46	0.06	-0.04	0.56	-0.2	-0.09	0.57	1.0							
COV	-0.05	0.04	-0.2	-0.24	-0.21	-0.11	-0.6	0.17	0.40	1.0						
NUT_1	-0.2	0.34	0.26	0.38	-0.44	0.3	-0.18	-0.05	-0.5	-0.1	1.0					
POL	-0.5	0.3	-0.46	-0.38	-0.19	-0.21	-0.1	-0.46	-0.1	0.3	-0.1	1.0				
UNE	-0.07	-0.15	0.2	0.21	-0.52	0.12	-0.35	-0.13	-0.3	-0.1	-0.01	0.1	1.0			
ALC	0.06	0.32	-0.15	-0.35	-0.07	-0.01	-0.09	0.02	-0.2	0.02	0.27	0.07	0.04	1.0		
NUT_2	-0.1	-0.07	0.08	0.11	-0.01	0.13	0.16	0.06	0.1	-0.01	-0.1	0.2	0.02	-0.2	1.0	
TOB	0.42	-0.36	-0.02	0.13	0.05	-0.17	-0.2	0.6	0.38	0.25	-0.09	-0.07	-0.3	-0.03	-0.3	1.0

The models were all derived through the following process.

All remaining explanatory variables were initially entered into the model and their t-statistics checked for statistical relevance. After taking into account the interrelationships and intercollinearities between the explanatory variables, those with non-significant t statistics were removed and the new model tested once more. This process was repeated until only explanatory variables which met the required economic (paying attention to the size and sign of estimated coefficients) and econometric (statistical significance of estimates) criteria were left in the model. As the coefficients of explanatory variables are provided in logs, their values represent elasticities and their individual impact on the dependent variables can be quantified.

In pooled regressions using cross-sectional, time-series data, it is also important to address a number of methodological issues that can help to eliminate potential modelling problems, fixed effects due to country-specific differences, and latent variables. The first is addressed by ensuring appropriate tests are carried out in the econometric and economic modelling processes, while fixed effects usually involves the application of dummy variables (as described above) for each country, and latent variables are dealt with by lagging.

However, the issue of fixed effects can also be addressed by taking differences in the original data which are aimed at 'sweeping out' the fixed differences between countries in the sample. Differencing can also be used to address potential problems of autocorrelation and multicoliniarity. For these reasons, pooled regression analyses using first differences were also applied by replacing dependent (lnY(t)) and explanatory variables (lnX(t)) with first differences of the logs (Wooldridge, 2002), as follows:

$$\mathbf{DlnY(t) = lnY(t) - lnY(t\text{-}1)}$$

and

$$\mathbf{DlnX(t) = lnX(t) - lnX(t\text{-}1)}$$

In the approach using dummy variables and the absolute (logged) data, the analyses are conducted on 240 observations according to the pooling methodology of Kmenta (1986; White, 1993). This process undertakes a wide range of model selection tests according to the criteria of Judge *et al.* (1995) and Ramanathan (1992), and allows for the correction of a number of potential problems, such as the presence of autocorrelation, multicolliniarity and heteroskedasticity. Lagging was also undertaken on those variables susceptible to latency, in this case expenditure on cigarette smoking, alcohol consumption and pollution. This latter technique was applied to the dependent variables life expectancy (males and females) but not infant mortality as latency is not relevant for this particular health outcome.

In the first differences method, the sample is reduced to 15 cross-sectional and 15 time-series observations, i.e. 225. The methodology adopted in the first differences analyses also included the introduction of lagged explanatory variables associated with latent effects, as above, with the number of available observations being reduced accordingly.

Thus, by taking this comprehensive approach to the regression analyses it was possible to compare the results of both approaches for consistency, although it is necessary also to bear in mind the systematic variations in methodology that these two approaches have, both in terms of interpretability and the reduction in the number of observations when taking first differences and lagged values

6.4.1 Results for Infant mortality

The findings for infant mortality, shown in Table 6.2, reveal that only health expenditure and the number of doctors per head are significant explanatory variables, with the model explaining 74 percent of variation in this health outcome.

The signs of the coefficients are as expected, both having a negative impact (improving) on infant mortality. The individual impact of the explanatory variables can be quantified by examining the magnitudes of each. Thus, a 1 percent increase in *per capita* health expenditure would lead to a -0.497 percent (fall) change in infant mortality rate, and a 1 percent increase in the number of *per capita* doctors would result in a -0.38 percent (fall) change in the infant mortality rate.

Table 6.2 Regression equation for infant mortality

	Constant	X^h	DOC
im	4.348	-0.497	-0.380
(t value)	(11.2)	(8.428)	(2.2)
Shift dummies:			
A	+0.145		
	(2.555)		
B	+0.419		
	(6.083)		
D	+0.296		
	(3.502)		
E	+0.35		
	(3.746)		
FIN	-0.368		
	(4.566)		
GR	+0.375		
	(2.591)		
IRL	-0.145		
	(3.229)		
P	+0.588		
	(4.947)		
R^2 Buse	0.72		
R^2 Obs/pre	0.726		

Note: all coefficients significant at the $p<0.05$ level

The use of (shift) dummy variables reveals the countries that are significantly different from those that are contained within the main constant of the model. In terms of ranking it is possible to conclude from the results that, from worst to best, the ranking is: Portugal, Belgium, Greece, Spain, Germany, Austria, (countries forming the reference intercept: Denmark, France, Luxembourg, the Netherlands, Sweden and the UK) Ireland, Finland.

These values reveal, therefore, the degree of heterogeneity that exists in the EU with regard to infant mortality, with the shift dummy values being added to the model's constant to reveal country-specific equations.

Those that have positive shift dummy coefficients add to the main constant to produce values above the reference (relatively worse), while those with negative shift dummy coefficients indicate a lowering of the constant (improvement).

For the first differences analyses on infant mortality, after removing the non-significant variables and paying attention to economic and econometric criteria, the final model produced was as follows (t-values all >2, $p<0.05$):

$$\mathbf{Dim = -0.04 + 0.2DLOS - 0.04DUNEM + 0.15DALC}$$

In other words differences in infant mortality increase with length of in-patient stay, reduce with increasing levels of unemployment and increase with alcohol consumption, according to their respective coefficients. The explanatory power of this model, however, was low with an R^2 value of 34 percent (24.6 percent for antilogs) between observed and predicted values.

When latent variables were lagged (one year) and re-introduced into the model the signs of the coefficients were not supportable in terms of expected influences and the explanatory power of the revised model, in terms of the R^2 value was only 29.2 percent (16.5 percent using antilogs). Therefore the first differences model without lagged variables produced better results although their interpretation is rather difficult to defend and the model reported in Table 6.2, because of its much higher explanatory power, is the principal result for infant mortality.

6.4.2 Results for Life expectancy (females)

The results for female life expectancy are presented below in Table 6.3. The results using absolute (logged) values revealed only *per capita* health care expenditure and doctors *per capita* to be significant explanatory variables. However, when latent variables were lagged and introduced into the model alcohol consumption and pollution became significant with a higher explanatory (R^2) value, and this model was selected as being the most appropriate.

The signs and magnitudes of the significant coefficients reveal the relative impact each has on the dependent variable. Thus, *per capita* health care expenditure has a positive influence on female life expectancy in that a 1 percent increase its value would lead to a 0.018 percent increase in female life expectancy, a 1 percent increase in the number of doctors *per capita* would lead to a 0.032 percent increase, a 1 percent increase in alcohol consumption would result in a 0.004 percent increase, while a 1 percent increase in pollution would reduce female life expectancy by -0.005 percent. These results therefore reveal the factors, from the derived model, that explain variations in female life expectancy among the EU countries.

The R^2 value shows that the model in fact explains 86 percent of the observed variation, which is very high for this form of analysis. The results in rank order for the shift dummies show that Luxembourg and Italy have positive dummy values, followed by countries forming the constant (Spain, France, Greece, the Netherlands, Sweden and the UK) whilst the remainder; Ireland, Austria, Portugal, Belgium, Denmark, and Germany have statistically significant negative (worsening) influences on the constant.

Table 6.3 Regression equation for female life expectancy

	Constant	X^h	DOC	ALC_{t-1}	POL_{t-1}
LEF	4.16	0.018	0.032	0.004	-0.005
(t value)	(391.02)	(17.22)	(4.4)	(2.1)	(-5.6)
Shift dummies:					
A	-0.02				
	(-5.7)				
B	-0.03				
	(-10.57)				
D	-0.03				
	(-15.5)				
DK	-0.03				
	(-4.5)				
I	0.01				
	(3.76)				
IRL	-0.01				
	(-3.2)				
L	+0.02				
	(-7.9)				
P	-0.02				
	(-19.2)				
R^2 Buse	0.86				
R^2 Obs/pre	1.0				

Note: all coefficients significant at the $p<0.05$ level

For female life expectancy with first differences the only significant explanatory variable was TOB (tobacco), producing the following model:

$$\mathbf{DLEF = -0.002 - 0.006DTOB}$$

The R^2 value was 20 percent (18.3 percent using antilogs), indicating a low explanatory power for the first differences model. When the remaining non-significant variables were lagged by one year and added into the model TOB became non-significant and N_1 (fruit and vegetable intake) became significant. Therefore the most supportable results for first differences are without lags, with changes in tobacco expenditure seemingly having the most significant (and negative) impact on changes in female life expectancy.

Again, due to the higher explanatory power of the regression model of Table 6.3, it should be regarded as the principal finding for female life expectancy, but the first differences model indicates that expenditure on tobacco is also a significant factor in explaining variations in female life expectancy.

6.4.3 Results: Life expectancy (males)

The results for male life expectancy are shown in Table 6.4. The model with the highest explanatory power and meeting economic and econometric criteria was obtained without lagged latent variables.

Three explanatory variables are shown to have a positive impact on male life expectancy and quantifiable as follows: a 1 percent increase in *per capita* health care expenditure would result in a 0.022 percent increase, a 1 percent increase in the number of *per capita* doctors would result in a 0.029 percent increase, and a 1 percent increase in fruit and vegetable intake would result in a 0.006 percent increase in male life expectancy. Conversely, a 1 percent increase in pollution would result in a 0.007 percent decrease in male life expectancy. The only country with a statistically significant positive shift dummy is Greece (better outcome), followed by the countries making up the reference intercept (Spain, Italy, Ireland, the Netherlands, Sweden and the UK), followed by those with

Table 6.4 Regression equation for male life expectancy

	Constant	X^h	DOC	NUT_1	POL
LEM	4.048	0.022	0.029	0.006	-0.007
(t value)	(219.0)	(8.83)	(5.53)	(1.992)	(5.106)
Shift dummies:					
A	-0.033				
	(5.346)				
B	-0.033				
	(8.23)				
D	-0.036				
	(10.902)				
DK	-0.017				
	(2.731)				
F	-0.028				
	(8.635)				
FIN	-0.026				
	(5.629)				
GR	+0.017				
	(2.486)				
L	-0.03				
	(11.693)				
P	-0.038				
	(9.103)				
R^2 Buse	0.0.763				
R^2 Obs/pre	1.0				

Note: all coefficients significant at the $p<0.05$ level

negative shift dummy coefficients, Denmark, Finland, France, Luxembourg, Austria, Belgium, Germany and Portugal - indicating lower values of male longevity compared with the reference. The R^2 (Buse) value indicates that the model explains about 76% of the variation in male life expectancy, which again is relatively high in regression analysis.

For male life expectancy with first differences again only one explanatory variable, ALC (alcohol), was found to be significant, producing the following model:

$$\mathbf{DLEM = -0.002 - 0.008DALC}$$

The R^2 value was 28.3 percent (27 percent using antilogs), again indicating a low explanatory power for this model. When the remaining non-significant variables werelagged by one year and added into the model, ALC remained significant but N_1 (fruit and vegetable intake) N_2 (total protein intake), POL (pollution) and COV (percentage of population covered by national health care) became significant, producing the following model:

$$\mathbf{DLEM = 0.002 - 0.007DALC - 0.001DN_{2(t-1)} - 0.007D\,N_{1(t-1)} - 0.004D\,POL_{(t-1)} + 0.03DCOV_{(t-1)}}$$

The R^2 value was 41.4 percent (39.4 percent using antilogs). These results indicate that differences in male life expectancy reduce when alcohol consumption, intake of protein or fruit and vegetables increase, and differences increase when health care coverage increases.

In summary, the above analyses and findings reveal the significant associations between each health outcome and the chosen and available explanatory variables. In terms of economic regressors, all health outcomes are shown to be positively linked with health care expenditure, and for resources, the number of doctors has been revealed to be statistically significant in having a positive influence on all health outcomes. In terms of lifestyle the analyses have found cigarette smoking to be detrimental to female life expectancy, alcohol consumption to be beneficial to the female population and detrimental to males, intake of fruit and vegetables is significant in improving male longevity. In terms of the environmental impact of pollution, this was shown to be detrimental to the life expectancy of both females and males. The first differences analysis for male life expectancy also revealed protein intake and the coverage provided by health care systems to be significant.

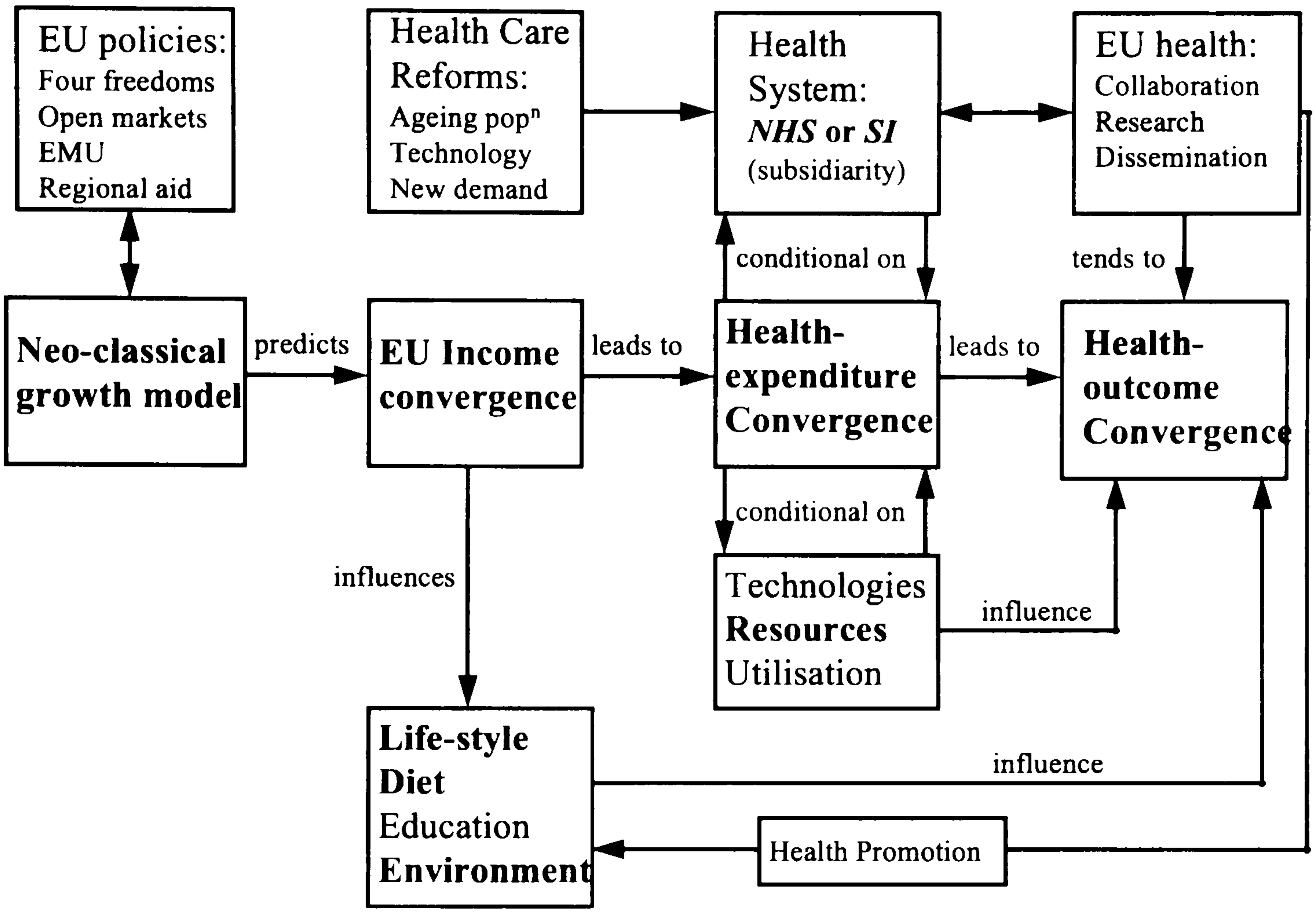
The main finding regarding the analyses using first differences is that applying this approach to the initial observations produces complementary results in comparison with the more conventional approach. Certainly none of the baseline results could be replicated in the first differences analyses and low explanatory values for these models were found, although the results for male life expectancy appear to be more informative and additional variables become significant consistent with *a priori* predictions. One possible explanation for this inconsistency is that many annual differences in the panel data are very low, following the same general trends, and variance in the transformed data using (logged) first differences will also be low. Moreover, each time differences are taken the number of available observations reduces and this process tends to limit the reliability of results

Based on the above results a conceptual model for the study of health and health care convergence can now be developed, as described in the following sections.

6.5. Convergence model

The aim of this section is to develop an illustrative framework for investigating and understanding associations and causal relationships that need to be considered in the study of health and health care convergence in the EU (and beyond). The model shows, in bold, the significant associations that were found from the results of 6.4, which are linked with the findings of earlier chapters of the thesis. The full model is given in Figure 6.2.

Figure 6.2 Convergence model for EU health care systems



Beginning the explanation from the left-hand side, the neo-classical growth model correctly predicts in this thesis that in countries such as those forming the EU, convergence of income will occur. This is enhanced by EU social, economic and political policies such as the four freedoms of the factors of production within the EU, the opening up of markets - including those for health care resources, EMU and the meeting of economic criteria to comply with its membership, and regional aid and investment in poorer regions in the EU. These influences, however, have not been empirically tested in this thesis and therefore remain at a theoretical level of influence.

Due to the well-established causal link between income and health expenditure, this in turn causes convergence in health care expenditure.

However, the results of Chapters Two and Three indicate that convergence is conditional on the type of system employed by member states, either NHS or SI, and the attributes of health care systems in terms of technologies, resources (in this thesis numbers of doctors and numbers of in-patient beds) and the utilisation rates for patients using the systems. In terms of causal links in this area, the number of practising doctors in a population has been shown to be significant in impacting on health outcomes.

The statistically significant association between health expenditure and health outcomes, although not found some previous studies, has been demonstrated to exist in the analysis of this chapter. This is one of the most important findings of the thesis as it enables the backbone of the conceptual model to be confirmed (neo-classical growth model ⇒ income convergence ⇒ health expenditure convergence ⇒ health outcome convergence). We might consider this finding to be based on higher marginal gains in (relatively low) health outcomes to have been possible due to increases in health expenditure in countries with initially low levels of health expenditure, such as Spain and Portugal. Conversely, the analysis of Chapter Four has shown that relative reductions in health care spending have resulted in a diminution of health outcome advantage in leading countries such as Sweden and Denmark.

Therefore, one may reasonably conclude that the stage of development and investment of a health care system is an important factor to consider when exploring the relationship between health care expenditure and health outcomes.

Linked also to health outcomes is the influence of EU health policies regarding joint medical and economic research, and dissemination of information from these and other studies such that information of optimal health care interventions is widely known in the EU. This information flow, to and from health care systems, may be passed on via a process of health promotion to have an impact on people's lifestyles, environment and education levels regarding health and health care interventions. In turn, this, along with the influence of income convergence on these social determinants of health, has its own influence on health outcomes. In this Chapter it has been shown that variables such as pollution, diet, expenditure on cigarettes, and alcohol consumption are all having a statistically significant influence on life expectancy in the EU. Due to the lack of available OECD data, the influence of education on health outcomes has not been tested empirically in the analyses of this chapter, but its influence has been well documented in previous studies as outlined in section 6.3.

The above findings, therefore, in conjunction with other studies summarised in this chapter lend support to the model in terms of its rationale and validity.

6.6. Is convergence dependent on EU membership?

The findings of this thesis are encapsulated in the above model, but the final question one would wish to investigate is whether or not the observed convergence is because of, or in spite of, EU membership.

To answer this question in a rigorous manner it would be necessary to take a matched sample (having the economic and social characteristics of the EU countries) of other countries which were not members of a group such as the EU, and test for comparable levels of convergence. If convergence is also found in such a sample it could be concluded that the pressures facing all OECD countries in relation to health care financing and convergence trends are common, and therefore EU membership would be largely irrelevant to the explanation. Conversely, if either no strong evidence of convergence is found or convergence is found to be statistically different from the EU it would be possible to conclude that membership of the EU is a principal driver of convergence in the areas examined.

To explore this question all other OECD countries were examined in terms of available data from the OECD Health Database (OECD/CREDES, 2000). However, as it is beyond the scope of the thesis to replicate all analyses undertaken, it was decided to limit the variables to be examined to the backbone of Figure 6.2, namely *per capita* GDP income, *per capita* health care expenditure, and health outcomes - infant mortality, life expectancy (females) and life expectancy (males). The type of analysis considered reasonable to offer an answer to this question is σ-*convergence* and both forms of β-*convergence* analysis (absolute and conditional) according to the methodology applied in the thesis.

The countries for which data were available are: Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland, Turkey and the USA. However, as it is known *a priori* that Turkey and the USA are not comparable with the countries of the EU in either economic or social welfare terms, they were removed from the sample to leave seven countries for comparison.

Initially, σ-*convergence* analyses were conducted over the same period of 1960-95 using one year intervals.

The hypotheses to be tested were those of the analyses conducted in Chapters Three, Four and Five, for each variable tested:

$$\mathbf{H_o}: \sigma^2_{60} = \sigma^2_{95}$$

$$\mathbf{H_A}: \sigma^2_{60} > \sigma^2_{95}$$

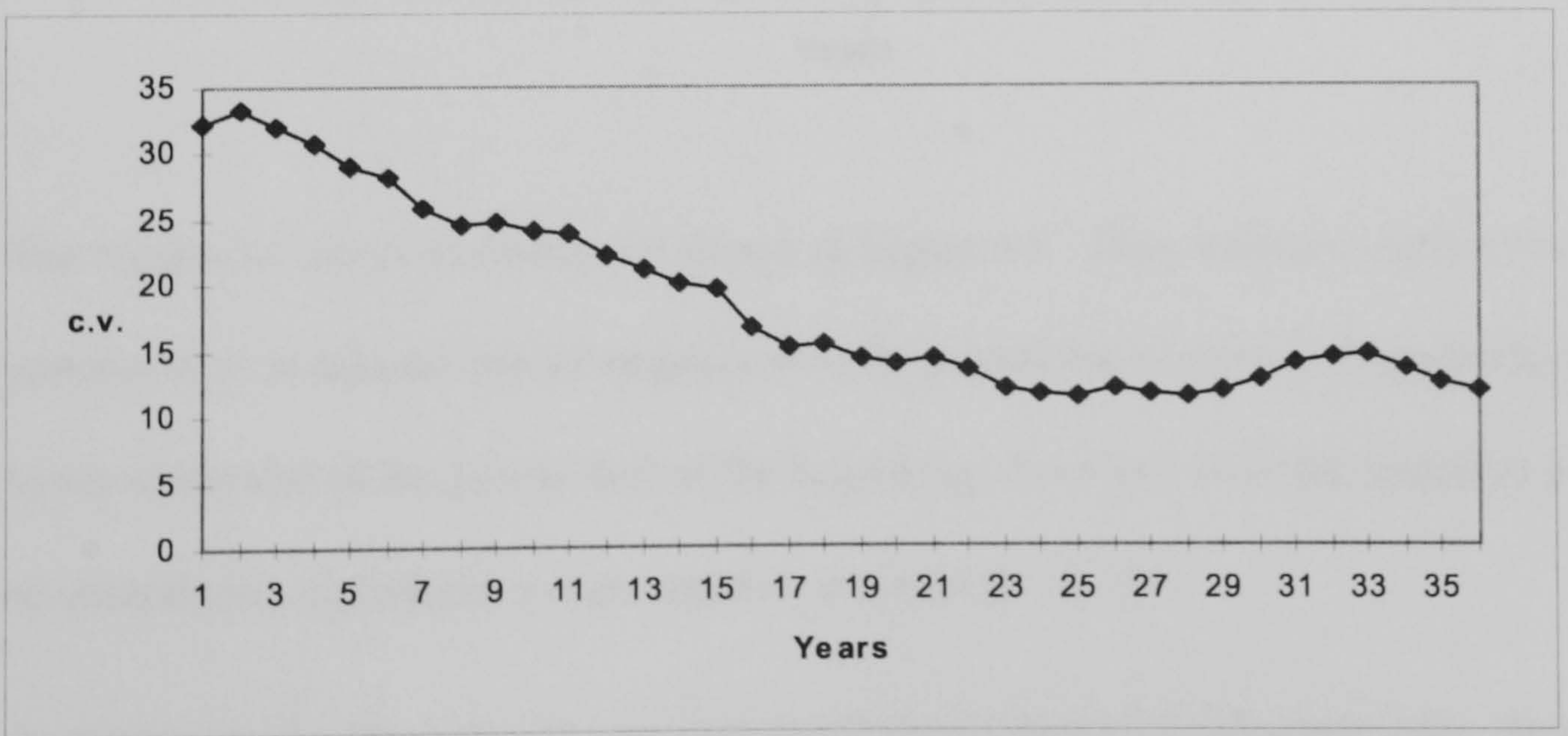
at the a = 5% level of significance with observations n = 7. The rejection rule is to reject the null hypothesis if F>F(n-1, a) and accept the alternative hypothesis of σ-*convergence*. The data were converted to the coefficient of variation (c.v.) according to the criteria outlined in Chapter Three (section 3.5), and the F-test was conducted on the standardised data (mean of 100) for 1960 and 1995. The results of the Shapiro-Wilk test confirm all data are normally distributed ($p<0.05$).

Following this both conditional and absolute convergence were tested for according to the methods of Chapter Three over the period 1980-95. The conditional variable used in the sample was *per capita* income and the number of observations achieved was 112 (7x16).

6.6.1 Results for σ- analysis in non-EU OECD countries

The results for σ-*convergence* analysis and *per capita* GDP income are shown diagramatically in Figure 6.3.

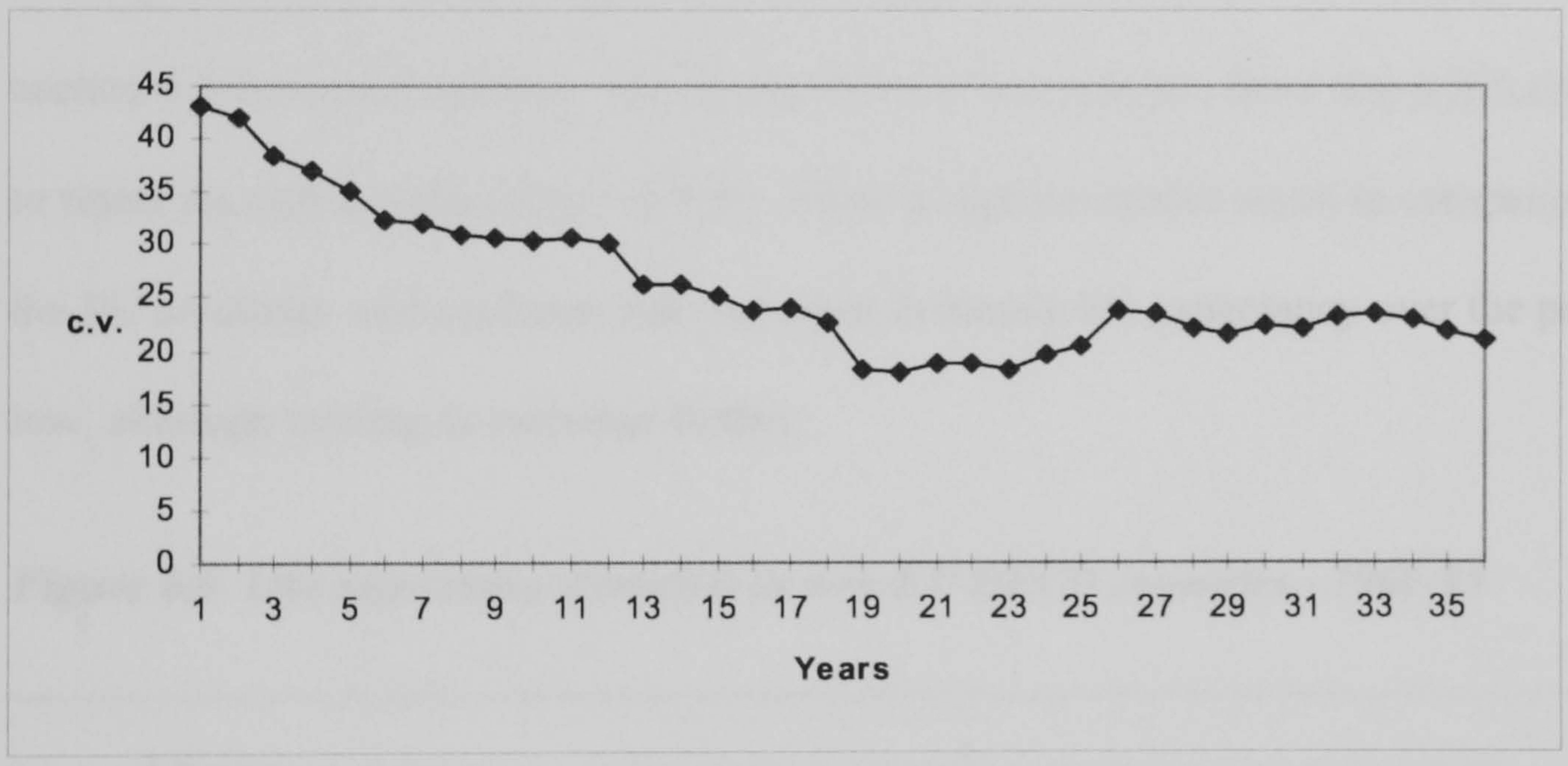
Figure 6.3 Per capita GDP income for non-EU OECD countries - 1960-95



The trend is for the coefficient of variation to reduce over the period 1960-95 from approximately 32 in 1960 to approximately 14 in 1995, which tells us that convergence did occur in the sample. The results of the F-test also showed that this occurred at a significant level (p = 0.01) and the alternative hypothesis of σ-*convergence* should be accepted.

For *per capita* health care expenditure, as shown in Figure 6.4, the trend from 1960 to 1980 was for steady convergence but this tended to level off over the remaining period. Again, the results of the F-test show the null hypothesis can be rejected (p = 0.05) and the alternative hypothesis of σ-*convergence* accepted at a statistically significant level over the period examined.

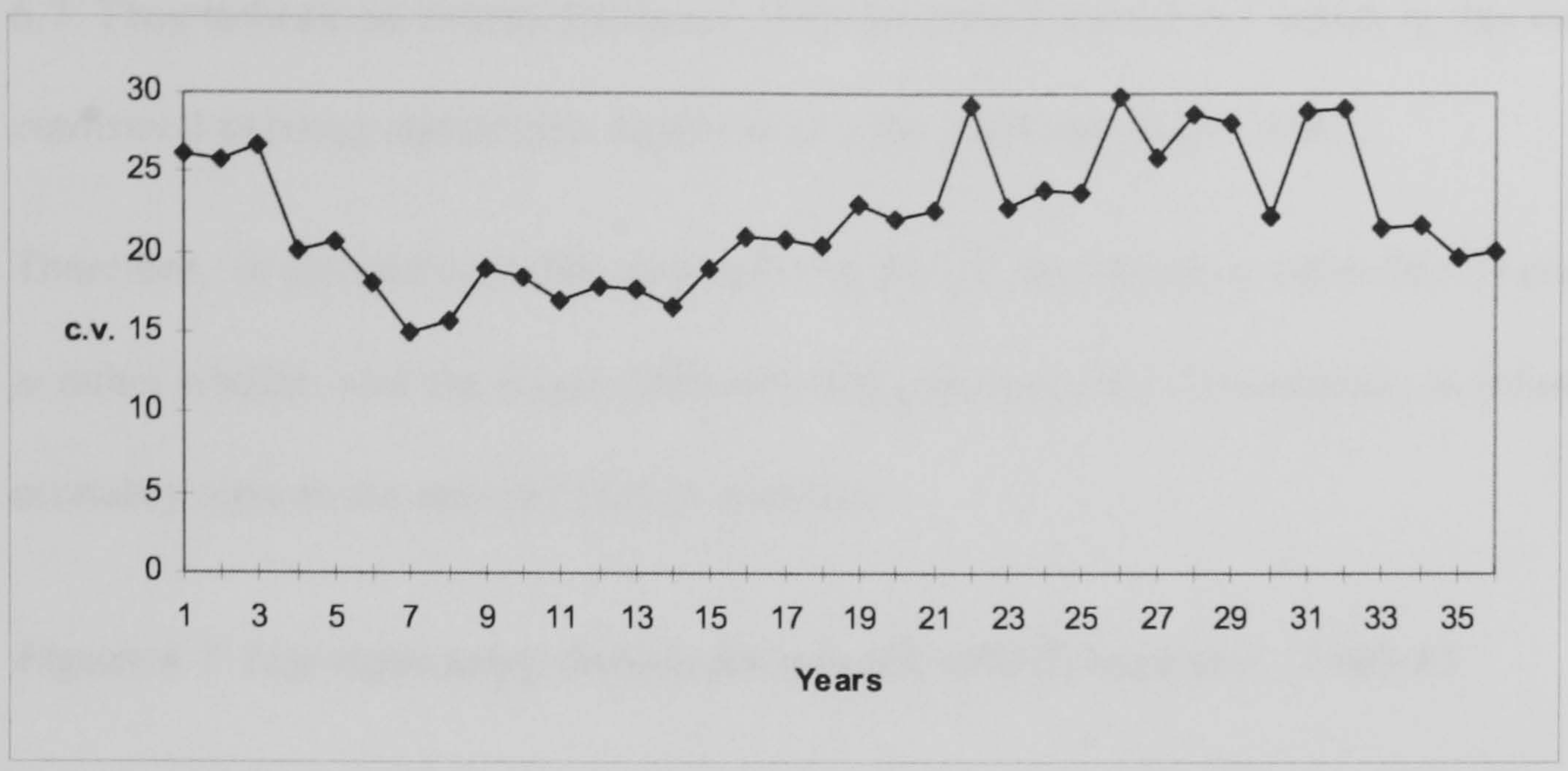
Figure 6.4 Per capita health expenditure for non-EU OECD countries - 1960-95



The results for infant mortality are shown in Figure 6.5. They indicate a rather random process of convergence and divergence over the period but in an overall sense the c.v. is lower at the end of the period than at the beginning. However, over the period as a whole no statistically significant σ-convergence occurred (p = 0.19).

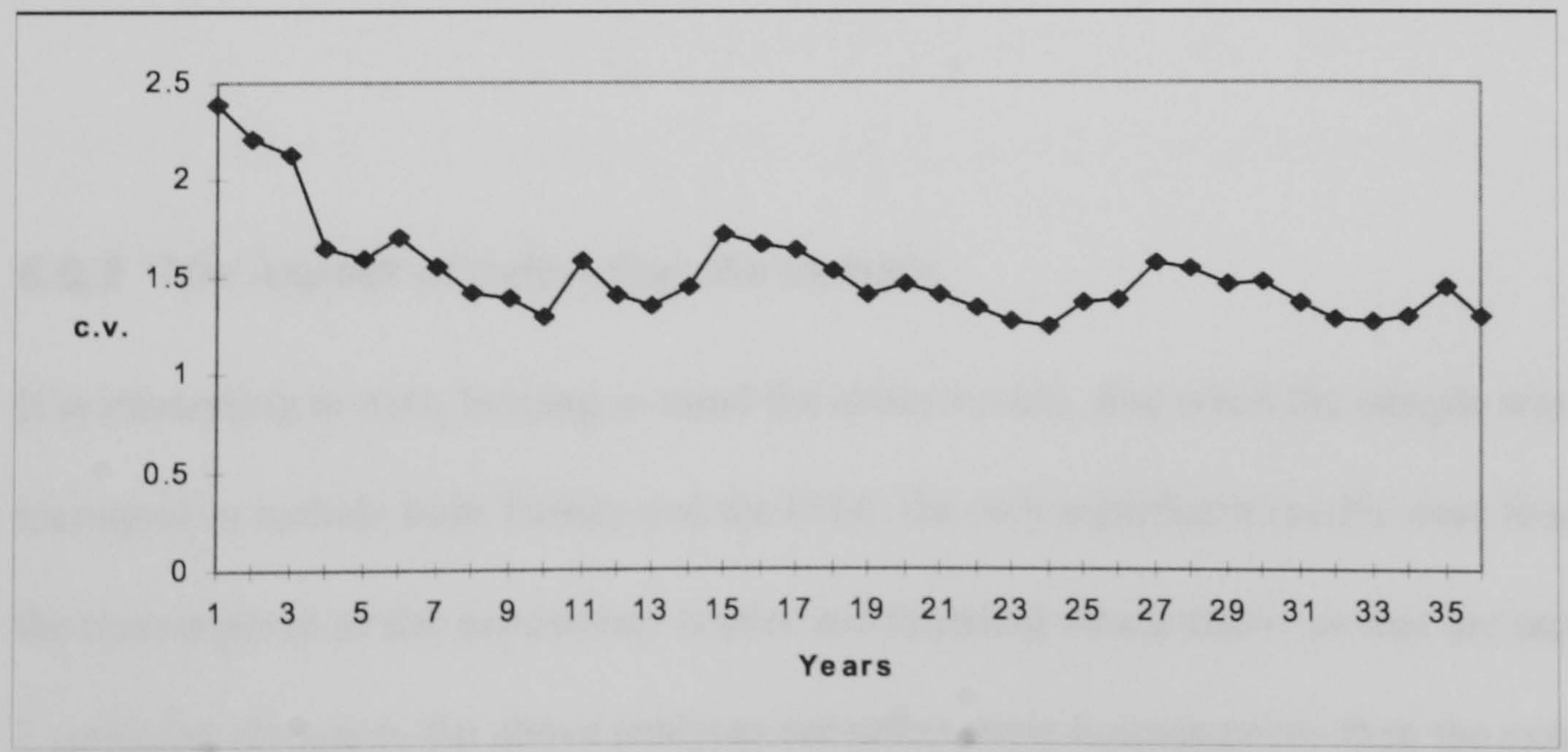
In contrast to the above health outcome result the analyses for life expectancy show strong evidence for convergence. For life expectancy in females Figure 6.6 shows that the c.v. fell from 2.5 in 1960 to 1.2 in 1995.

Figure 6.5 Infant mortality for non-EU OECD countries - 1960-95



In comparison with the EU countries this variation is rather similar (*c.f.* Chapter Four, section 4.3.1) over the period. The results of the F-test analysis show that it is not possible to reject the null hypothesis ($p = 0.059$), which is again a similar result in comparison with the EU countries and confirms that variations in female life expectancy over the period are low, although tending to converge further.

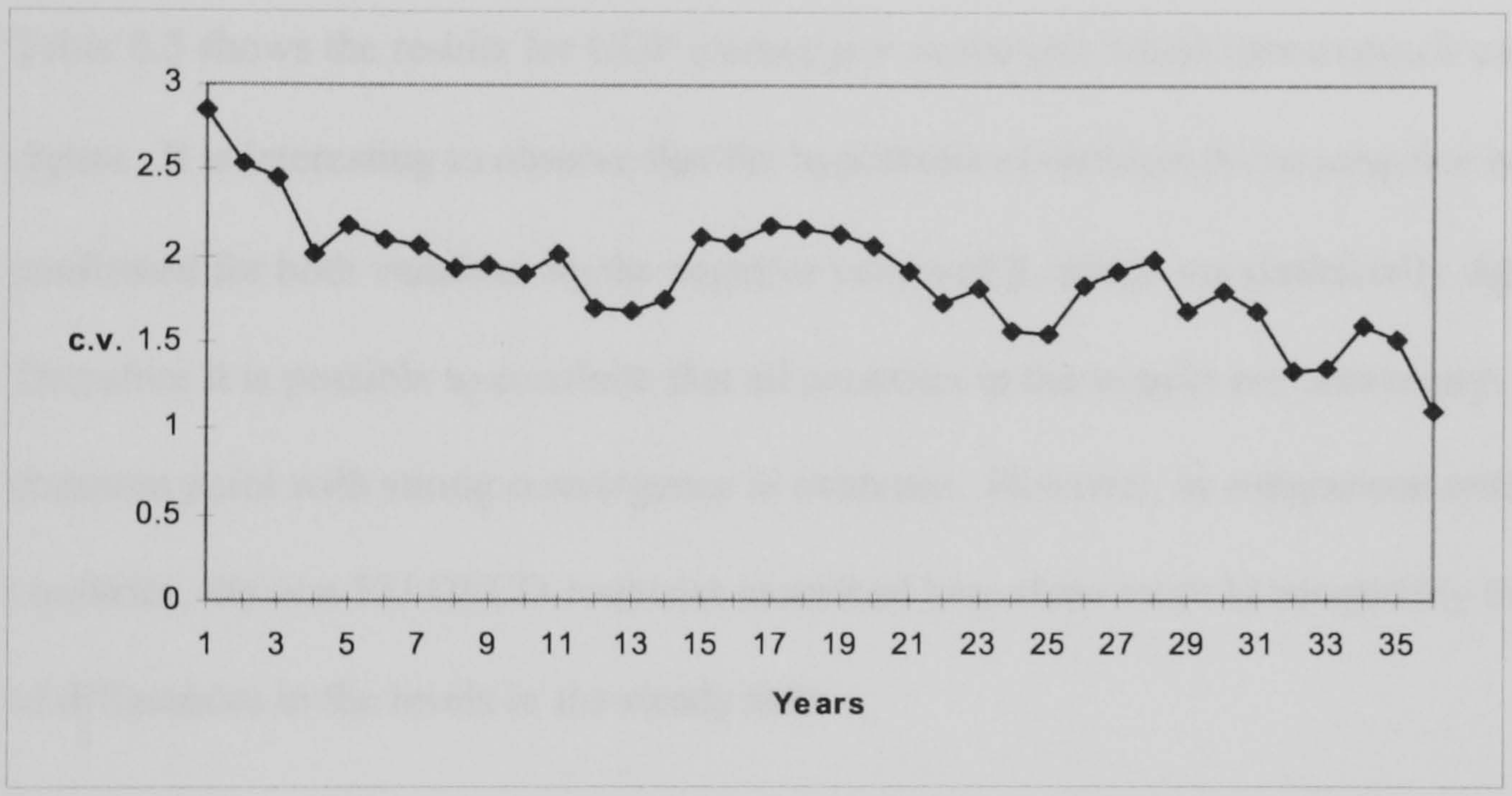
Figure 6.6 Life expectancy (females) in non-EU OECD countries - 1960-95



The results for male life expectancy are similar to those for females, as shown in Figure 6.7. They indicate an overall fall in c.v. over the period from 3 to 1 which in this case is confirmed as being statistically significant by the F-test result (p = 0.02).

Therefore, in comparison with the results for the EU the picture in other OECD countries is rather similar, with the major difference being the lack of σ-*convergence* in infant mortality rates in the non-EU OECD countries.

Figure 6 7 Life expectancy (males) for non-EU OECD countries - 1960-95



6.6.2 The impact of extending the sample

It is interesting to note, bearing in mind the above results, that when the sample was increased to include both Turkey and the USA, the only significant results were found in the convergence of life expectancy (males and females) which shows us that the sample of 7 countries chosen in the above analyses are rather more homogeneous than the extended sample and similar to the EU, thus broadly following the tenets of the neo-classical growth model as in the case of the EU. This result is consistent with other empirical studies of economic convergence (see Appendix A).

6.6.3 Results of β-analysis for non-EU OECD countries

The testing for conditional convergence, using GDP *per capita* income revealed non-significant results. The following findings, therefore, relate to absolute β-*convergence* only, with Switzerland being used as the reference country for the shift and slope dummy analyses.

Table 6.5 shows the results for GDP income *per capita* and health care expenditure *per capita*. It is interesting to observe that the hypothesis of absolute β-*convergence* is confirmed for both variables by the negative values of β, which are statistically significant. Therefore it is possible to conclude that all countries in the sample are converging to a common point with strong convergence in evidence. However, in comparison with the EU countries, the non-EU OECD countries examined here show more heterogeneity in terms of differences in the levels in the steady state.

This is revealed in the statistically significant shift dummies which show that they are all different (in fact lower, as shown by the negative values for each country) in comparison with the reference country, Switzerland.

The results for health outcomes are summarised in Table 6.6. The β coefficients for infant mortality, female life expectancy and male life expectancy confirm the hypothesis of absolute convergence and indicate that these values are converging to a common level in this selected sample non-EU OECD countries.

Table 6.5 β-convergence results for income and health expenditure - OECD countries

Coefficient	(1) GDP^h	(2) X^h
constant α	0.036	0.082
	(0.013)	(0.019)
coefficient (1+β)	0.773	0.692
	(0.062)	(0.071)
Dummy variables	-0.042 Au	-0.090 Au
	(0.014)	(0.021)
	-0.028 Ca	-0.022 Ca
	(0.011)	(0.010)
	-0.038 Ice	-0.078 Ice
	(0.015)	(0.024)
	-0.040 Jap	-0.135 Ice
	(0.019)	(0.033)
	-0.091 Nz	-0.208 Nz
	(0.027)	(0.048)
	-0.031 Nor	-0.084 Nor
	(0.015)	(0.021)
R^2 (Buse)	0.613	0.497
R^2 (observed/predicted)	0.956	0.979
β-coefficient	- 0.227	- 0.308
	(0.062)	(0.071)
Wald $\chi^2_{(1)}$ test for β=0	13.208	19.038

Notes: GDP^h = *per capita* income, X^h = *per capita* health care expenditure. Standard errors are shown in parentheses. Country abbreviations: Au = Australia, Ca = Canada, Ice = Iceland, Jap = Japan, Nz = New Zealand, Nor = Norway. All values are significant at the $p<0.05$ level.

However, once again a good deal of heterogeneity exists in the steady state. In infant mortality it can be seen that Australia, Canada and New Zealand all have positive shift dummies, meaning that their values are significantly above the reference country of Switzerland. In contrast, Iceland and Japan have negative shift dummies, indicating they are statistically significantly lower (better) infant mortality rates, while Norway is not statistically different from Switzerland.

For female life expectancy, the sample exhibits significant levels of heterogeneity as all countries are statistically different from the reference country, with Japan being statistically significantly above Switzerland (positive shift) and all others in the sample below the reference (negative shifts).

In the case of male life expectancy, a more homogeneous picture emerges with only Iceland and Japan having shift dummies statistically significantly above (better than) the reference, while New Zealand and Norway have values below (worse) the reference country.

The results of the β analyses thus confirm that convergence extends to other countries outside the EU which have similar levels of economic growth and developed health care systems. The results for the non-EU OECD countries examined here, suggest that the neo-classical growth model is equally applicable and that these countries share a good degree of commonality in economic growth terms, and are facing the same pressures as those facing EU countries in terms of health expenditure expectations and controls, albeit with greater degrees of heterogeneity as shown by the shift dummy results.

This analysis, although not as detailed in comparison with the tests applied to the EU countries, provides evidence to support the view that the EU is not exceptional in experiencing convergence in the variables examined and, with the exception of infant

Table 6.6 β-convergence results for health outcomes - OECD countries

Coefficient	(1) H^{im}	(2) H^{LEF}	(3) H^{LEM}
constant α	0.037	0.002	-0.0008
	(0.017)	(0.0006)	(0.0005)
coefficient (1+β)	0.404	0.778	0.679
	(0.101)	(0.052)	(0.061)
Dummy variables	0.116 Au	-0.002 Au	0.006 Ice
	(0.027)	(0.0009)	(0.002)
	0.067 Ca	-0.001 Ca	0.007 Jap
	(0.031)	(0.0007)	(0.002)
	-0.100 Ice	-0.002 Ice	-0.006 Nz
	(0.037)	(0.001)	(0.002)
	-0.139 Jap	0.003 Jap	-0.002 Nor
	(0.045)	(0.0009)	(0.0007)
	0.218 Nz	-0.007 Nz	
	(0.043)	(0.002)	
		-0.003 Nor	
		(0.0008)	
R^2 (Buse)	0.128	0.704	0.478
R^2 (observed/predicted)	0.892	0.982	0.0943
β-coefficient	- 0.596	-0.212	- 0.321
	(0.062)	(0.052)	(0.061)
Wald $\chi^2_{(1)}$ test for β=0	34.682	16.680	27.274

Notes: H^{im} = infant mortality, H^{LEF}= female life expectancy, H^{LEM} = male life expectancy. Standard errors are shown in parentheses. Country abbreviations are those shown in Table 6.6. All values are significant at the $p<0.05$ level.

mortality for σ-*convergence*, non-EU OECD countries are also associated with a diminution of differences both at the economic and social welfare levels.

6.7. Discussion and Conclusions

The aim of this chapter has been to explore significant relationships and associations that enable the findings of convergence in the previous chapters of the thesis to be brought to a coherent conclusion. This was achieved by developing regression models that employed the three thesis health outcomes as dependent variables, with explanatory variables being used according to the literature, but focusing on studies and methodologies employing production functions using aggregate-level data. As such, although Grossman-type models were briefly examined and were useful in identifying some key determinants of health, their emphasis on individual-level data limited their relevance to this thesis. The findings of the regression analyses, which utilised two approaches to dealing with fixed differences in EU countries and econometric modelling issues, facilitated the development of a conceptual model for the study of convergence in the EU and beyond. The final association analysed was the influence of EU membership on the convergence results and this was addressed by testing for convergence in the non-EU OECD countries which have economic, social and political characteristics similar to countries of the EU.

The regression analyses revealed the statistically significant variables, that were available from a potentially larger array, which explain variations in each of the health outcomes. Of particular interest to this thesis was that health care expenditure was shown to be significant for all health outcomes, leading to the conclusion that increasing health expenditure improves all the health outcomes examined. This was also the cases for one of the resource variables used in the thesis, namely number of doctors. The dummy variable analyses also revealed a good degree of heterogeneity in health outcomes within the EU, which confirms the work undertaken in Chapter Four.

The first differences analyses, which offered an alternative approach to identifying significant variables, showed for infant mortality that increasing length of stay and alcohol consumption increases differences, while unemployment reduces differences.

In terms of female life expectancy, the best results were obtained using lagged latent variables (expenditure on cigarettes, alcohol consumption and pollution). In addition to expenditure on health care and the number of doctors, alcohol consumption was also found to have a positive impact, while pollution was found the have a detrimental effect on female life expectancy. The first differences analysis also found expenditure on cigarettes to have a significant and detrimental effect on female life expectancy (reducing year on year differences which are usually positive, therefore restricting gains in life expectancy).

The findings for male life expectancy, as well as expenditure on health care and the number of doctors, consumption of fruit and vegetables has a positive impact, while pollution – as in the case of female life expectancy – has a detrimental effect. When lagged variables were introduced to the first differences analysis additional variables became significant, with alcohol consumption, consumption of fruit and vegetables, consumption of protein and pollution tending to diminish differences (gains), and the amount of coverage a health care system increasing differences (gains).

The conclusion regarding the analyses using first differences is that applying this approach produces complementary results in comparison with the more conventional approach. Certainly none of the baseline results could be replicated in the first differences analyses and low explanatory values for these models were found, although the results for male life expectancy using first differences were much more informative. Possible explanations for this inconsistency are that many annual differences in the panel data are very low, and in some cases zero and associated logs and their variance are very small, and differences between successive years are even smaller. Moreover, each time differences are taken the number of available observations reduces. Woldridge (2002) indicates that non-identical results between the two techniques are possible, especially when the time period being considered is greater than two years, and provides a wider discussion on the topic but states that 'the truth is likely to lie somewhere inbetween' (*ibid,* p. 284).

In terms of alternative methodological approaches it would be possible to consider doing first differences using the original data and not convert them to logs. However, in pooled time-series, cross-sectional analyses of this nature it is standard practice to transform to logs in order to increase the linearity between the dependent and explanatory variables (Norusis, 2000), with the coefficients of the significant explanatory variables being elasticities. These then represent and quantify the impact on the dependent variables. By taking differences of logs it is more problematic to interpret the rate of a rate results that are produced in this form of analysis.

Therefore whilst first differences may be an alternative approach to addressing the issue of fixed effects and may reduce the risks of errors due to modelling problems and mis-specifications, the results have been used to complement rather than substitute the more standard approach using dummy variables.

It is also recognised that the issue of latency in effect on outcomes for some lifestyle variables, such as expenditure on cigarette smoking and alcohol consumption, is a limitation of the regressions undertaken and a longer time-series of data would be necessary if the disadvantage of reduced observations due to lagging is to be adequately addressed.

In this regard, the modelling for life expectancy in particular has produced some results that perhaps warrant further discussion. For example, for the variable 'expenditure on cigarettes' there is the expectation that this should have a detrimental impact on life expectancy due to the associated increased risks to health. This was shown to be the case only in the differences analyses for female life expectancy but there are three principal points that are relevant in explaining the results.

Firstly, for expenditure on cigarettes the correlation matrix of Table 6.1 shows a weak association between this variable and life expectancy, the figures being -0.02 and 0.13 for females and males, respectively. Therefore when this variables is entered into the models it is not unreasonable to expect non-significant results.

Secondly, as revealed in the literature review at the start of this chapter, a number of other studies of this nature also produced non-significant results when using tobacco consumption as an explanatory variable (e.g. Wolfe (1986), Wolfe and Gaby (1987) and Cochrane *et al.,* (1978)). However, it is true that a significant relationship has been found in many studies, but these have usually employed individual-level data, and producing an impact using aggregate, macro-type data, appears to be more elusive. Moreover, in lifestyle variables such as expenditure on smoking, there is also the issue of latency in effect, which is almost certain to be different for each variable. When lagged variables are introduced into the modelling process, observations for the sample are lost each time and this has an impact on the predictive power of the model.

Thirdly, the explanatory variable used for tobacco was expenditure rather than volume consumption of cigarettes. Even though these values were expressed in PPP, which should deal with the issue of comparability, it has to be borne in mind that the data used do not represent true tobacco consumption. In this respect it would have been better to utilise *per* *capita* consumption, but there were too many missing observations in the OECD health data set and therefore the variable chosen may be a less than perfect proxy. Prevalence data for smoking may also offer better results and where these data are available future studies should employ them.

There is also the issue of the type of association that exists between the dependent variables and many lifestyle variables, i.e. the commonly found inverted U shape - indicating that moderate consumption of certain products may be beneficial, while excessive consumption may be harmful. The linearity between the health outcome variables used such explanatory variables may be somewhat compromised, partly explaining the non-significance of some variables when entered into the models.

In terms of further limitations regarding the regression models developed in this chapter, a small percentage of missing data were estimated using the extrapolation method, and some of the data used from the OECD (for non-medical determinants of health variables) suffer from a degree of unreliability due to differences in data definition for member states within the EU (OECD/CREDES, 2000). This issue is discussed more in Chapter Seven (section 7.5).

Using the statistically significant results of this chapter, in conjunction with the previous chapters' results, it was possible to construct a conceptual model for the study of convergence in the EU. On a cautionary note, however, the validity of the model, as outlined above, is clearly predicated on the reliability and availability of data to investigate these links, and further refinements to the quality of data suitable for cross-national analyses may assist in validating and expanding on the significant associations depicted in Figure 6.2. The conceptual model does, however, provide a succinct and clear overview of the findings of this thesis and lays the foundation for further research in this area.

In seeking to determine if the observed convergence in this thesis is explained by membership of the EU, the results of the convergence analyses have largely suggested otherwise although this point requires some clarification. That is, if one takes all the remaining OECD countries which are not members of the EU the levels of convergence to be found are minimal, extending only to life expectancy. However, by removing Turkey and the USA a sample more similar to the EU countries in terms of economic status, technological development and health care provision, was formed as a control group. Although greater heterogeneity was found in terms of levels in the steady state, this sample exhibited reasonably similar levels of convergence to the EU. Thus, it is possible to argue with a fair degree of confidence that EU membership, on its own, is not a primary driver of the observed convergence, apart from the point that in order to obtain membership to the EU 'club' countries have to have achieved a broadly similar degree of economic growth and social welfare provision. In this respect, the aspiration of joining the EU and maintaining a 'comparable' position in that club may be the point to focus on in encouraging greater convergence, with implications for budding new members in future enlargement programmes for the EU.

The conclusion to be drawn from the analyses of this chapter is that the backbone framework of the conceptual model (neo-classical growth model, income convergence, health expenditure convergence, health outcomes convergence) is applicable to the study of convergence for any group of countries with similar levels of economic and social development. Common research, economic and public health policies, specific to the EU, may accelerate the process of convergence in the EU but convergence can and has taken place in other groups of countries with similar levels of economic development and health care provision.

Chapter Seven

Discussion and Conclusions

7.1. Thesis overview

This thesis has sought to answer the question of whether or not convergence in the health care systems of the EU has taken place over the period 1960-95, using a framework of key variables which encompass health care expenditure, health outcomes, health care resources, and health care utilisation rates.

The applied empirical analyses have involved the use of a range of statistical techniques which progressively investigated the data to determine the presence, or otherwise, of groupings and trends in convergence. In order to tie the findings of each chapter together in a coherent and informative relationship, regression analyses were conducted using health outcomes as the dependent variable to investigate associations and relationships within the chosen framework, augmented by OECD data on the determinants of health.

The findings of each chapter enabled a conceptual model to be developed that is appropriate for the study of convergence in the health care systems of the EU and beyond, particularly for countries with a high degree of economic and social welfare homogeneity.

The final question of whether or not membership of the EU in itself was instrumental in driving the observed convergence in the backbone of the conceptual model (neo-classical growth model ⇒ income convergence ⇒ health care expenditure convergence ⇒ health outcomes convergence), a similar sample of non-EU OECD countries was subjected to convergence analyses according to the thesis convergence methodology.

In this thesis the theoretical foundation is the neo-classical growth model which, as demonstrated in the findings, is the trigger that initiates the subsequent convergence in income, health expenditure and health outcomes. Coupled with this, however, are a number of related theoretical issues that will tend to increase the tendency for EU countries to converge. The neo-classical growth model is relevant to the EU as it predicts that economies with similar tastes, technologies, and meeting specific economic criteria, tend to converge to the same income levels or growth rates in the steady state. Moreover, economies which start out proportionally below their steady states tend to grow faster than rich ones, regional convergence within countries is more easily achieved than across countries due to the presence of homogeneity of culture, religion, language, law, economics and politics. The latter points in particular have a controlling effect on the mobility of capital and labour and the principle of relevance to the EU is that the allowance of migration within the framework of the neo-classical growth model tends to accelerate the process of convergence.

Continuing with the underlying theoretical foundations of the thesis, the principles of the neo-classical growth model of economics have applicability to the study of convergence in health care expenditure as many studies, including this thesis, have demonstrated that there is a strong correlation between the latter and GDP income. The findings of the analyses, coming from the five chapters which formulate the main body of this thesis, have given support to the tenets of the neo-classical growth model and its applicability to the EU as a group of countries striving to achieve common goals and provision for its citizens.

Before its conception, former EU/EEC countries were far more closed and heterogeneous, and lacked the means to achieve greater convergence as independent states. However, EU membership not only allows for, but actively encourages, barriers to convergence to be broken down. Many aspects of EU social and agricultural policy, as described in Chapter One, encourage re-distribution of wealth by offering subsidies and financial assistance to poorer regions of the EU. The principles of worker mobility and free trade as laid out in the 'four freedoms' of the 1985 Single European Act and the 1991 Maastricht Treaty increasingly mean that citizens of the EU have, through increased knowledge, education and mobility, come and continue to expect similar rights and provision in terms of social and economic opportunities.

Other relevant factors in encouraging convergence in the health care systems of the EU, as identified in Chapter One, were technology diffusion, EU research initiatives in health technology, economic evaluations of health technologies, information dissemination regarding effectiveness and cost-effectiveness, and the health care reforms and policy initiatives that were introduced over the period examined. Additionally, even though subsidiarity is the guiding principle in EU health care systems, common initiatives in the area of public health and the facing of common health care challenges brought about by the ageing populations of the EU and new medical technologies, were anticipated by the European Commission to generate similar long-term solutions.

In terms of the statistical approach adopted throughout the thesis, largely non-parametric methods were initially used to determine if patterns existed and if sufficient evidence could be found to warrant further in-depth analyses using the more rigorous panel data methods, and other explanatory variables where necessary. The results were also supported by suitable graphical representations to provide visual explanations, based on standardisation of the data to ensure relative changes could be observed.

The following sections provide a reminder of the principal findings of each chapter before going on to discuss emerging influences for greater convergence, the limitations and potential for further research, and the policy implications of the thesis. Finally, the concluding comments of the thesis are presented.

7.2. Summary of results

Table 7.1 provides an overall summary of the findings of the thesis according to the forms of convergence analysis utilised and the variables that reached statistical significance. Where appropriate, suitable explanatory comments are given in the final column. However, prior to embarking on the core topic of the thesis, the first substantial chapter sought to gain an overview of how health care systems clustered or grouped according to the thesis framework of variables.

7.2.1 Cluster analysis

In Chapter Two hierarchical cluster analysis was employed to address the first research question of **what current variations exist between the member states of the EU in terms of health care**. Although not widely used in the study of economics or health economics, this statistical method was found to be extremely useful in determining country-specific groupings within the thesis framework. The essence of this chapter was to determine the degree of 'achieved' convergence and, by implication, areas that could potentially converge more in the future.

The principal finding was that countries are often grouped according to the way in which health care is organised within the EU. This was especially prominent for the health care expenditure variables which revealed that there are wide variations in the achieved expenditure on health care within the EU, particularly in *per capita* terms. SI countries were predominantly found to fall within the high spending groups and NHS countries in the lower spending groups. It was also noted from the results that countries of the South, namely Greece, Portugal and Spain (but also Ireland), tended to cluster below other NHS countries. However, it should be noted that lower expenditure does not necessarily imply inferiority in the delivery of health care as NHS countries are more centralised and are more able to benefit from economies of scale and health outcomes were not found to be similarly associated in this respect.

For analysis of health outcomes it was found that the countries of Scandinavia (in particular Sweden) enjoyed high life expectancy and low infant mortality in comparison with the other groups, while countries of the South were associated with higher infant mortality rates. In the middle ranges there was no strong association with health care system typology and groups were not homogeneous in this respect. The results therefore suggested that other factors may have a significant influence on such global health indicators, including lifestyle, diet and environment rather than the type of health care system employed by member states.

When examining health care resources it was clear from the results that a strong division exists between SI countries and NHS countries in terms of number of beds. SI countries had much higher resources in this respect although for number of physicians the differences were not great except for the UK. Italy and Ireland, which have a considerably lower number of physicians per head of population compared with other countries of the EU. On the other hand, countries such as Greece and Spain in particular, have an exceptionally high number of physicians per head of population. In general, system typology was relevant in the health care resource variables examined and influenced the resulting groupings.

When subjecting cluster analysis to utilisation rates the general finding was that NHS countries are associated with lower admission rates (also the Netherlands) with the countries of the South and Ireland having lower rates than other NHS countries. The SI countries, along with Finland and the UK, had the highest admission rates and SI countries generally had longer lengths of stay. With the caveat of data definition inconsistencies, with one or two exceptions the cluster analysis for utilisation rates was associated with health care typology.

The composite solution using all nine variables showed that, with the exception of Finland (appearing in the SI group) and the Netherlands on its own, there was a clear grouping of NHS and SI countries. In other words, system typology appeared to be playing a role in determining the grouping of countries which had similar characteristics according to the category they belonged to. Within the composite analysis, sub-groups were found to exist in that, for example, Portugal, Greece and Spain formed a geographical cluster, as did Sweden and Denmark, as did the UK, Ireland (and Italy). In other words, geographical location (in broad terms) was also a relevant factor in the clustering of countries.

The policy implications of the hierarchical cluster analysis are that discrete groupings can be found and there is thus room for future convergence in a number of areas of health care and this may be dependent, amongst other things such a geographical location and lifestyle, on a process of harmonisation in the way in which health care is organised within the EU.

7.2.2 Methods and convergence analysis of health expenditure

In Chapter Three the methods necessary to answer the second research question of '**what degree of convergence has occurred over the period of analysis in relation to a reliable point of reference?'** were developed. Initially, the analysis was applied to the first element of the framework, namely health care expenditure. Subsequently, all other elements in the framework were tested using the methods developed in Chapter Three. In addition, through the development of the chosen techniques, along with Chapters Four and Five, the third research question of the thesis, namely **'what are the relevant factors that explain the observed convergence?'** was addressed.

Having reviewed the literature a number of methods emerged which could be applied to the chosen framework of variables, and subsequently selections appropriate for the neo-classical growth model, were made.

Graphical representations of the various hypotheses and scenarios (Leonardi, 1995) associated with convergence initially provided an intuitive insight into the required analysis. Following this the method of examining variability in the data in the form of variance, standard deviation or coefficient of variation were found to offer a means of applying statistical methods to the data with convergence being present if either of these methods of dispersion measurement could be shown to be diminishing over time, namely *σ-convergence*. However, in order to determine if the observed diminution of variation in the data was statistically significant and thus allow for hypothesis testing, the F-test was employed as it is calculated by dividing the variance of two sets of similar cross-sectional data for two periods of time. This was a new development in the study of *σ-convergence*.

The 'reliable' point of reference to test for convergence was determined as the EU mean for each of the years examined. Previous convergence analyses, applied to GDP growth, had often used one particular country as a reference point or benchmark for other countries. However, when one is examining convergence within fifteen countries the situation will always be dynamic over time and the choice of one, perhaps leading country, seemed not to offer the required stability from which trends could be observed. For this reason the EU mean for each variable and year of analysis was adopted as the reference from which to determine convergence. This approach had also been used and advocated as being appropriate by other researchers (See Appendix A).

The final aspect which helped to analyse the relative changes that may have been occurring over time was that all data were standardised around an EU mean of 100 (or 1 in some instances). This was of particular benefit in the production of histograms and line diagrams which could show visually the hypotheses and scenarios associated with *σ-convergence*. Thus, relative changes around the standardised mean for individual countries could be immediately identified. This form of analysis, however, still remained largely in the non-parametric category but showed that for both measures of health care expenditure statistically significant convergence occurred between 1960 and 1995 for the present 15 members of the EU.

During this analysis it also became clearer that NHS countries spent, on average, statistically less than SI countries. The histograms produced indicated that the observed convergence was due to upward convergence, predominantly by countries of the South, whilst the Scandinavian countries of Sweden and Denmark had been converging downwards towards or even below the EU mean.

It was also evident that the position with respect to the mean for health expenditure as a share of GDP was not always reflected in the position with respect to the mean for *per capita* spending. In this regard some countries, such as Portugal, Spain, and Ireland, were allocating financial resources at similar percentages of their GDPs to other countries in the EU, but this was being translated into a position well below the mean for *per capita* spending. In contrast, the opposite was being achieved in wealthier countries such as Luxembourg which allocates well below the EU mean in terms of share of GDP, but this is translated into *per capita* values well above the EU mean. This aspect of the analysis showed that the GDP income of a country in relation to its population was having, as might be expected, a marked impact on achieved *per capita* spending. A number of countries, on the other hand, achieved close to parity in terms of their positions relative to the mean for both share of GDP and *per capita* health spending. Greece, in terms of health care expenditure for both share of GDP and *per capita* spending, was found to be lagging behind all other countries in the EU although for the latter periods of the analysis was beginning to converge upwards toward the mean.

The second part of Chapter Three involved the use of panel data covering the period 1980-95 and more rigorous econometric methods using β-*convergence* analysis, also grounded in the neo-classical growth model. Unlike the cross-sectional σ-*convergence* analysis for the years 1960, 1970, 1980, 1990 and 1995, the parametric method utilised data for consecutive years over the period of analysis and was therefore able to take into consideration possible contradictions in the intervening years of σ-*convergence*. This analysis determined if 'regression to the mean' was occurring rather than simply testing for a diminution in the coefficient of variation.

In order to achieve this two regression models were developed to test for the two forms of β-*convergence*, namely absolute (unconditional) and conditional convergence. The first does not consider explanatory variables but examines if the coefficient, β, of a bivariate equation, which should be less than zero if convergence is present. For conditional convergence, other explanatory variables are included in the regression model and in Chapter Three GDP income was used, as was population dependency ratio although this latter variable was excluded from the model as it was not statistically significant. The model was also adapted to test for the presence of convergence according to health care system, namely SI countries, low income (LI) NHS countries and all other NHS countries. In this way, the inferences coming from the hierarchical cluster analysis chapter could be investigated further using a more rigorous approach.

The findings of the β-*analysis* confirmed the presence of statistically significant convergence in health expenditure and that heterogeneity is a feature with SI countries sharing similar characteristics, being above the NHS countries in both measures of health care expenditure, while two sub-groups within the NHS category (LI and all others) exist in the context of north-south divide based on GDP income. However, the countries of the South (Portugal, Spain and Greece) are all converging towards the EU mean.

The graphical representations of these results confirmed the presence of upward convergence, as described above, and downward convergence for other countries such as Sweden and Denmark, while some other countries such as the Netherlands and France, maintained a more stable position with respect to the EU mean. All countries with SI systems were confirmed by this analysis to be above the EU mean for *per capita* health expenditure. The findings also indicated that the majority of the observed convergence in the EU as a whole was in fact taking place because of the upward and downward convergence achieved by NHS countries.

The methods for convergence analysis were now well formulated and tested, and produced good results for health care expenditure. Moreover, a logical and coherent approach was established which could now be applied to the remaining elements of the framework.

7.2.3 Other methods of convergence analysis

A number of other methods were considered but it was clearly not feasible to test all of them on the data. However, the Gap approach (Chatterji, 1992), which examines if the gap between the reference country and another in the sample is reducing over time, was tested on health care expenditure variables. This tests for the existence of clubs but it was found that the method produced similar results (in fact concluding that in economic terms the EU countries would converge towards one club only) to those adopted in the thesis and therefore re-inforced the choice of approach (see Appendix B).

In terms of recent studies of health expenditure convergence, Comas-Herrera (1999) discussed this question for the EU and the likely factors that would influence it. Although making observations about the coefficient of variation approach (and its susceptibility to shocks), her methods to test for convergence involved structural time-series models and an intersection test to obtain a matrix showing '1' whenever an intersection exists between countries (otherwise '0'). The number of intersections was then added for each year, which was normalised to obtain a convergence indicator. A time series for the convergence indicator was then generated with a positive slope being taken as evidence of convergence (increasing intersections) and a negative slope as evidence of divergence. In concept if not in technique, this is rather similar to the testing of regression to the mean within absolute β-*convergence* analysis.

The results of the above approach did not produce evidence of statistically significant convergence (although the slope determined was positive), unlike the results of this thesis. When examining the approach of Comas-Herrera (*ibid*) it is apparent that a form of proximity test is being adopted which, as shown in the various hypotheses and scenarios for convergence examined in this thesis, would not take into account the dynamics of relative movement (reversal of roles, in particular). regression to the mean analysis, or be able to detect the existence of conditional convergence (and therefore the existence of clubs).

A number of other approaches are discussed in Appendix A, but in summarising the methodology of convergence analysis, it is fair to say that some debate exists about the relative merits of available tests, but two well accepted tests within the context of the neo-classical growth model, have been adapted and appropriately utilised in this thesis. Other recent studies have also utilised the principal methods of this thesis (Alonso *et al.*, 1998) within the area of EU social welfare, and argue in favour of the appropriateness of σ and β convergence analysis.

7.2.4 Health outcomes

The results from Chapter Four showed that major improvements in infant mortality rates relative to the EU mean had been achieved, particularly by Portugal, and to a lesser extent by Italy and Spain, whilst other countries experienced worsening positions relative to the mean, exemplified by countries such as Belgium, Denmark, Sweden and the UK. The net result showed that statistically significant σ-*convergence* occurred between 1970 and 1995 for infant mortality.

For life expectancy the results were less dramatic, indicating that for females in particular no statistically significant σ-*convergence* occurred between 1960 and 1995 but this was because only small variations existed across the EU. However, Austria, Greece, Finland and Portugal achieved improvements with respect to the EU mean, while Denmark, the Netherlands, Sweden and the UK experienced worsening positions with respect to the EU mean. For males, statistically significant σ-*convergence* did occur between 1960 and 1995.

with Austria, Finland, Italy and Portugal improving their positions with respect to the EU mean, and Denmark, Spain, Ireland, the Netherlands and Sweden experiencing worsening trends with respect to the EU mean.

These results clearly indicated that differences in health outcomes diminished over the period 1960-95, but that much higher differences in scale between infant mortality and life expectancy were in evidence.

In establishing a potential link between chapter Three (health care expenditure) and chapter Four (health outcomes) the results were examined to determine if increasing levels of expenditure with respect to the EU mean had resulted in improved health outcomes over the period, and conversely whether decreasing expenditure had resulted in a worsening position with reference to the mean. At this stage the analysis was exploratory and formed the basis of discussion without rigorous testing being applied. However, clear relationships were observed to show that several countries which had been increasing their expenditure between 1960 and 1995 were bettering their health outcomes, in particular this was shown to be the case for Italy, Luxembourg and Portugal in all health outcomes examined, improvements in both life expectancy indicators for Greece, and improvements in life expectancy for females as well as infant mortality in Spain. However, for some countries increasing levels of expenditure were associated with worsening outcomes relative to the mean, in this case Belgium and Ireland.

The countries that had been reducing their expenditures relative to the EU mean were found to be Austria, Germany, Denmark, Finland, the Netherlands, Sweden and the UK. It is notable that all the EU countries of Scandinavia are in this group. Decreased *per capita* expenditure was associated with a worsening of all three health outcome measures relative to the standardised mean in Denmark, the Netherlands, the UK and Sweden. Finland had worsening infant mortality rates and Germany had a slight worsening in its life expectancy for males.

These findings suggested that it might be reasonable to suspect that a significant association between health expenditure levels and health outcomes exists, and that convergence is coming about in the countries of the EU due to downward and effective pressure to control health expenditure from some countries, which may result in a worsening position with respect to the EU mean, and efforts to improve health care expenditure in others, associated with improving health outcomes. These possibilities were taken into account in the exploration of potential causal links and addressed fully by means of regression analysis in chapter Six.

The β-*convergence* analysis supported the above in that statistically significant results were found for absolute convergence, predicting that EU countries were tending to converge to a common point, but with some diversity in the steady state in evidence. Germany, Finland and Sweden were associated with superior and Greece and Portugal inferior infant mortality rates in the steady state. A similar finding of strong convergence for female life expectancy predicted that Spain, France, Finland, Greece, the Netherlands and Sweden having higher life expectancies in the steady state, with poorer outcomes for Denmark, Ireland and Portugal. For male life expectancy a similar prediction was produced with Finland, Greece, the Netherlands and Sweden having higher values, and Denmark and Portugal statistically below the reference country, which in all cases above was the UK. In this respect the UK does not appear in any of the results relating to the shift dummies.

Thus the findings from Chapter Four revealed that health outcomes in the EU are not only improving, they are converging, with an expected association with health expenditure.

However, a large degree of heterogeneity was in evidence with regard to the steady state levels associated with the analyses.

7.2.5 Resources and utilisation rates

The results for the σ-*convergence* analysis of chapter Five showed that only in-patient utilisation rate achieved a diminution in coefficient of variation, and that this did not achieve statistical significance. In fact the only significant result was achieved for in-patient length of stay, which exhibited a high degree of *divergence* over the period 1960-95. The general theme coming from this form of convergence analysis was that differences in the *per capita* number of doctors, *per capita* number of beds and length of in-patient stay were increasing across the EU.

The results of the β-*convergence* analysis provided more illuminating information in support of the σ-*convergence* analyses. Absolute convergence was predicted for both *per capita* number of doctors and *per capita* number of beds, but diversity in the steady state was in evidence as several countries had statistically significant shift dummies. In neither utilisation rate variables of in-patient length of stay nor admission rate was absolute convergence found. However, for admission rate, conditional convergence was found to be occurring, suggesting the eventual formation of clubs based on the variable *per capita* income.

Although the agreement between the convergence analyses results for this chapter was not as clear cut as for health expenditure and health outcomes, the general theme coming from this chapter is that EU countries have generally been increasing numbers of physicians, decreasing the number of in-patient beds, increasing admission rates, and reducing in-patient lengths of stay.

Table 7.1 Summary of convergence analyses

Variable	σ	β_{ABS}	β_{CON}	Comments
Health expenditure per capita	*	*	*	SI countries spend significantly more than NHS countries. Evidence of clubs.
Health expenditure per capita LI, NHS and SI.	N/A	*	*	Confirmation that SI countries spend more than NHS countries. No difference between LI and NHS countries.
Health expenditure (% of GDP)	*	*		EU countries are converging.
Health expenditure (% of GDP) LI, NHS and SI.	N/A	*		EU countries are converging.
Infant mortality	*	*		EU countries are converging but variation remains high across EU countries.
Life expectancy (females)		*		EU countries are converging. σ-convergence occurred but at NS levels. Variation across the EU is low.
Life expectancy (males)	*	*		EU countries are converging. Variation across the EU is low.
Doctors per capita		*		EU countries are converging.
Beds per capita		*		EU countries are converging. SI and NHS countries have statistically significant differences.
Length of stay	†			Evidence of divergence
Utilisation rate			*	Countries will converge to different levels (in effect clubs).

Notes: * = significant convergence at $p<0.5$ level. † = significant divergence at $p<0.5$ level. β_{ABS} = absolute convergence, β_{CON} = conditional convergence. All variables are those used throughout the thesis as defined in Chapter Two (section 2.3).

From a policy perspective these measures reflect the thrust towards the achievement of micro efficiency in the delivery of health care in response to ever-increasing demands and the influence of new interventions which enable length of in-patient stay to be reduced. The finding that divergence in length of stay occurred is deserving of particular note as it confirms variations in clinical practice and incentives to traet across the countries of the EU. Many new health technologies are evaluated using length of stay as an economic outcome measure and it is clear from the evidence of Chapter Five that these moves towards efficiency in the delivery of health care are not pursued equally across the countries of the EU. If one were to focus of system typology, for example, the general trend observed is that NHS countries are generally decreasing in terms of length of stay, while SI countries are generally increasing length of stay with respect to the standardised mean. The influence of supplier-induced demand for SI countries is clearly of relevance to this issue as SI countries are cleary more susceptible to its influence than NHS countries, where incentives are more likely to be on increasing efficiency by reducing length of stay and increasing admission rate. The issue of definition of in-patient length of stay and changes in this, as illustrated for the Netherlands in Chapter Five, is also a relevant factor. This topic, however, would clearly benefit from further research and clarification.

7.3. The convergence model

The results of the empirical analyses and relevant explanatory variables enabled the research questions of '**what economic, social and political influences exist to encourage convergence?**' '**Can a generic model for the study of convergence be developed?**' and '**is there evidence of convergence in non-EU OECD countries?**' to be addressed.

These questions were pursued in Chapter Six, the aim being to explore significant relationships that would enable the findings of the previous chapters of the thesis to be encapsulated within a conceptual model by using health outcomes as dependent variables, with suitable explanatory variables being chosen in the derivation of pooled regression equations.

Examination of the literature revealed two broad approaches to investigate the determinants of health, oneusing individual-level data and based on the work of Grossman, and other production function work based on aggregate data. Although both were important in determining relevant explanatory variables, the latter was used as the basis of the work in this chapter with an emphasis on studies that had sought to establish a statistical link with health care expenditure. In this regard, although the link between health care expenditure and health outcomes had shown itself to be an elusive one in many previous studies, the findings of recent work had shown more promising results, and qualified the caveats associated with international analyses of this nature. Among these, heterogeneity in data definitions and consistency in measurement were cited as key limitations.

The statistically significant findings regarding associations between the variables enabled the construction of the model, suitable for the study of convergence in the health care systems of the EU, and possibly beyond. The model illustrates the appropriateness of the neo-classical growth in that convergence of income will occur for the countries of the EU, enhanced (in theory) by EU social, economic and political policies. The well-established correlation between income and health expenditure leads to convergence in health care expenditure, conditional on the type of system employed by member states, in conjunction with the technologies, resources, and the utilisation rates for patients using the systems. The link between health expenditure and health outcomes was shown to be statistically significant in the regression analyses. For countries with initially low levels of health expenditure, such as Spain and Portugal, greater marginal increases in health benefit were shown to occur for additional health care spending. Therefore, the stage of development and investment health is an important factor to consider when exploring the relationship between health care expenditure and health outcomes, and may well have been a major factor in creating the significant association between health care expenditure and health outcomes.

Linked also to health outcomes is the influence of EU health policies regarding joint medical and economic research, and dissemination of information such that knowledge of optimal health care interventions is widely known in the EU. This information flow, to and from health care systems, may be passed on via a process of health promotion to have an impact on people's lifestyles, environment and education levels regarding health and health care interventions. In turn, this, along with the influence of income convergence on these social determinants of health, has its own influence on health outcomes. However, although alcohol consumption, expenditure on cigarettes, diet and pollution were found to be statistically significant influences on health outcomes, education was not empirically tested due to the lack of available OECD data but has been shown to be significant in many studies (Grossman, 2000). The model thus provided a useful overview of the findings of this thesis and lays the foundation for further research.

In relation to the question of how EU membership impacts on the results, the analyses undertaken on a selected sample of OECD countries who are not members of the EU indicated that this was not necessarily the case as convergence in income, health expenditure and health outcomes was also occurring for these countries. However, an interesting finding was that when *all* the remaining OECD countries which are not members of the EU were analysed, the levels of convergence are minimal, and extend only to life expectancy. By removing Turkey and the USA a sample more similar to the EU countries, in terms of economic status, technological development and health care provision, was formed.

Although more heterogeneity was found in the steady state, this smaller sample exhibited reasonably similar levels of convergence to the EU. Thus, the implication is that EU membership, on its own, is not the only driver of the observed convergence.

The conclusion to be drawn from the analyses of this chapter is that the backbone framework of the conceptual model (neo-classical growth model, income convergence, health expenditure convergence, health outcomes convergence) is applicable to the study of convergence for any group of countries with similar levels of economic and social development. Common economic and public health policies, specific to the EU, may help the process of convergence in the EU but convergence can and has taken place in other groups of countries with similar levels of economic development and health care provision.

7.4. Developing influences

Although not tested empirically in this thesis, some recent and developing influences on EU health and health care system convergence, touched upon in Chapter One, are considered. These include:

- The micro-macro link in health expenditure and health outcomes brought about by economic evaluations of health technologies;
- New collaboration initiatives in medical research;

- Mechanisms and organisations charged with disseminating information on clinical and cost-effectiveness, available to EU countries;
- The influence of the political nature of governments on health care reforms in the EU;
- The emergence of new legal cases of cross-border consumption of health care in the EU.

In terms of the micro-macro link brought by economic evaluations of health care interventions, a recent study from the Netherlands illustrated how incremental cost-effectiveness ratios can vary according to location and system typology. The study (van Erkel *et al.*, 1999), examined international differences for an optimal diagnostic strategy for detecting and treating pulmonary embolisms (PE) using first ultrasound followed by helical CT scan. Costs were converted to PPP ECUs which eliminated the differences in general price levels between the countries assessed. The findings revealed that the lowest incremental cost per life saved was obtained in the UK (6,600 ECU), then the Netherlands (13,600 ECU), Switzerland (15,000 ECU), Austria (16,600 ECU) and France (18,000 ECU). For the United States the figure was an order of magnitude above the European countries' results, at 63,900 ECU. The sample in each country was too small to generalise these findings according to typology, but it can be seen that the NHS country (UK) was less than half that of the SI countries of the EU (the Netherlands, Austria and France) included in the comparison, and one tenth that of the private insurance system of the United States. These findings are, however, consistent with the results and analyses of this thesis in adding weight to the view that harmonisation of health system typology should act as a force for convergence in health expenditure.

The literature on economic evaluations is in fact abundant and ever-increasing (NHS Centre for Reviews and Dissemination, 2001), and effective ways of disseminating the findings of such economic evaluations are necessary if the positive and equalising effects they offer are to have an impact on convergence in health care and the ways in which it is delivered, although making information on the effectiveness and effectiveness of health technologies will clearly not eliminate variations in medical practice (Andersen and Mooney, 1990).

In addition to common EU research initiatives, as outlined in Chapter One, significant ongoing and new developments have occurred to encourage greater collaboration among EU partners in the area of health research and policy. For example, in February 2000 the European Commission signed an agreement to establish the European Collaboration for Assessment of Health Interventions - Health Technology Assessment (the ECAHI or ECHTA project) as an enhancement of the International Network of Agencies for Health Technology Assessment (INHATA). The aim of the new project is to 'develop systems to improve the generation and communication of evidence based information on the value of different interventions' (INHATA, 2000, p.1). The EU will sponsor this project, which will have six working groups covering; HTA of health promotion and disease prevention, joint assessments, best practice, education and training, exchange of information and linking HTA to policy making.

The project is a step forward from two former projects; HTA EUROPE (1997-1999) which focused on four areas: emerging technologies, internationally co-ordinated assessments, the future of health care systems in Europe, and health outcomes measurement; and EURO-ASSESS (1994-1996) which also had four sub-divisions of methodology, priority setting, dissemination and impact and coverage. The main goal of the ECAHI/ECHTA project will be to evaluate model systems and methods that will promote co-operation in HTA. The project also aims to stimulate the continuing advancement of HTA in the EU by providing an overview of the present situation. and in exploring opportunities to strengthen networks through which the dissemination of best practice throughout Member States can take place.

International collaborative projects such as these clearly have and will continue to have an influence on optimal choices in terms of health care interventions and therefore act as a positive influence on convergence in the EU.

As outlined in Chapter One, dissemination is a function performed by a number of organisations such as the Cochrane Library, ADIS, the Office of Health Economics (OHE) and the NHS Centre for Reviews and Dissemination.

These organisations are also rapidly expanding. Illustrative of this expansion of on-line databases is the setting up, in 2001, of a French database (Base Collège des Economistes de la Santé (CODECS), Département de l'Information Scientifique et de la Communication de l'Inserm) of cost-effectiveness studies conducted in France which will perform a similar role to that of NHS EED for French researchers and decision-makers. There is also a proposal with the EU for the setting up of a European network of similar databases which has now been funded[1]. and when implemented will extend the availability and applicability to European countries of information on cost-effectiveness.

Therefore, as facilities such as these become more widely known about and utilised, they are expected to provide a force for convergence within the EU as optimal solutions (subject to the caveats outlined above) will be sought based on the information that is disseminated.

As outlined in Chapter One, the OECD Project on the Reforms of Health Care Systems (OECD, 1994a) identified a number of key issues and characteristics which will have an

[1] Personal communication from Philippe Ulmann, Collège des Economistes de la Santé, Paris. June, 2002.

impact on the possibility of convergence. Although the first three objectives of 'adequate services for all', 'equity of access' and 'protection of income' were not examined in this thesis, it is evident that the objectives of 'macroeconomic efficiency (cost containment)', 'microeconomic efficiency (health outcome maximisation', 'patient satisfaction maximisation and cost containment', 'consumer choice' and 'provider autonomy') are likely to have influenced the level of convergence revealed in the results of this thesis.

The policy analysis conducted in Chapter Three also indicated that there have been three possible approaches to reforming EU health care systems depending on the political make-up of a member state and the way in which it delivers health care. The rapid reform of health delivery and financing in some countries in the EU, such as the UK, is possible due to what has been labelled the 'big bang' approach. This is feasible with strong, first past the post majority governments, particularly with NHS modes of delivering health care which can be more centrally controlled through global budgets and capping mechanisms. An alternative political response has been the bottom up approach adopted in Sweden in contrast to the more top down policies adopted by some countries. Finally, in countries with consensus governments (common in SI countries), a more incremental approach is followed within which reforms are introduced over a much longer period of time. Thus the political make-up of a government is instrumental in relation to the feasibility and time-scale regarding the introduction of convergence-enhancing reforms, with 'big bang'-type reforms not sitting easy with particular political systems.

In terms of general trends in the way health care is delivered, a recent article in *The Economist*[2] points out that health care systems appear to be converging due to common approaches to a position of 'managed care.' Within this new approach doctors, hospitals,

[2] Entitled 'Health international.' June 24th - 30th, 2000.

and other providers operate within certain budget constraints and there is effort to foster both consumer choice and producer competition. However, this is indicative perhaps of an emerging philosophy that could be applied across the board irrespective of system typology but has not been addressed in the context of the thesis.

In Chapter Two the influence of cross-border health care within the EU was also briefly touched upon as a potential driver of convergence in EU health care provision. Some recent developments and test cases have occurred which shed new light on this topic.

Mountford (2000) reports on the April 1998 Kohll and Decker rulings of the European Court of Justice (ECJ) which appeared, initially, to be a step towards a single European health care market. The ECJ upheld the rights of EU citizens to seek non-emergency health care in other EU member states apart from their own in acquiring reimbursements on the same basis as if they had received care in their own country. The Kohll case related to orthodontic treatment received in Germany by the daughter of a resident of Luxembourg. Mr Kohll had applied to a Luxembourg insurance fund (*Caisse de Maladie*) for reimbursement at Luxembourg rates, but was refused. In the Decker case, another Luxembourger wanted his *Caisse de Maladie* to reimburse the costs of a pair of spectacles purchased in Belgium.

As Mountford relates, governments and health care insurers within the EU saw this development as a possible prelude to an explosion of cross-border health care activity, which until the rulings had been very limited.

Among the reasons for arguing that such an explosion is not likely to materialise, however, are the issues of language difficulties, unfamiliarity with a different health care system, unwillingness of local doctors to refer patients to other countries, and travel time and costs. From a policy point of view, such a cross-border explosion of patient flows would weaken member states' ability to control health care expenditures by weakening the gatekeeping function, reducing the effectiveness of waiting as a rationing device, and constraining the ability of member states to exclude particular services from offer.

The pre and post-Kohll and Decker experiences show that cross-border health care remains at a low figure of 0.3-0.5% of total EU health care expenditure and movements are expected to remain restricted to only the most specialised fields of medical care. However, more cases are before the ECJ and the situation may change as more cross-border movements occur in the general EU population. Certainly, this aspect of EU health care might be a sleeping giant as a driver of future health care convergence in the EU but clearly relates more to SI models with a fee-for-service reimbursement mode of operation. NHS models within the EU, and also some SI models which offer benefits-in-kind to some patients (applicable to some sub-groups within the health care system of those such as the Netherlands) would not be as affected (if at all) by such cross-border activity[3].

Mountford (2000) goes on to reveal that further cases have been referred to the ECJ by the Dutch courts specifically to determine whether the Kohll and Decker rulings apply to the Dutch Health Care system. The objective pursued under this action is to determine if a two-track system might develop within the EU whereby some systems (fee-for-service reimbursement) might offer opportunities for cross-border health care for some and not others in the EU.

The most likely solution to this development will be a political one, possibly brokered by the European Commission rather than the ECJ. Recent evidence (*ibid*) suggests that such a political solution will be undertaken with reference to an assessment of the costs and

[3] This situation is, however, changing rapidly with the UK NHS, for example, piloting schemes to allow UK citizens to be treated in other countries such as France and Greece. This is aimed at reducing waiting lists for NHS patients.

benefits of an increase in cross-border health care delivery. In this regard it will be possible to draw on existing attempts to encourage cross-border health care in the so-called Euregios (border regions) of the EU.

This potential force for further convergence may be conditional on the breaking down of those factors, outlined earlier, which limit current cross-border activity (language differences, differences in health care systems, lack of willingness to refer patients to other countries' health services, travel time and costs, among others).

7.5. Limitations and future research

Like any other scientific research, there are a number of limitations which should be taken into account when considering the validity of the thesis findings and future research in this field of study. These are addressed in the following sub-sections which discuss the issues surrounding the choice of variables, the validity of the data used, the limitations in the statistical tests applied to test for convergence, the limitations of the modelling exercises of Chapter Six, and finally the political influences that have had a bearing on the findings.

To begin with, although the rationale for choosing particular variables is fully described in Chapter One, it is acknowledged to be somewhat subjective and is deserving of more elaboration and discussion.

The economic 'input' variables were total health care expenditure, expressed both in *per capita* and percentage of GDP terms, measured in PPP$. There are two aspects to this choice, namely the unit of measurement and the degree of coverage as either total, public, private, or permutations of these.

With regard to the first issue, Kanavos and Mossialos (1996) point out that international comparisons of health expenditure require a process of conversion into a common currency, either by the use of exchange rates or PPP. The debate concerning which approach to use is essentially about which is more suitable (Parkin *et al.*, 1987; Gerdtham and Joensson, 1991a, 1991b). Parkin *et al. (ibid)*, through a study of OECD countries in 1980, showed that the use of either exchange rates or PPP lead to different results with respect to the estimated income elasticity of health expenditure, with PPP values producing a value below unity. Gerdtham and Joensson *(ibid)* used a similar sample of OECD countries for 1985 and found that the estimated value of income elasticity is invariant to the use of GDP of health care PPP, and that the use of exchange rates leads to a slight fall in the estimated elasticity. In regard to health care income elasticity, however, Gerdtham and Joensson found no real evidence of conversion factor instability for exchange rates, GDP PPPs, and health PPPs to deflate *per capita* expenditure.

In terms of the limitations of using exchange rates there are two principal arguments. Firstly, the equilibrium set of international exchange rates can only reflect the equalisation of internationally traded goods, which clearly does not reflect health care as it consumed internally within countries. Labour is also relatively more abundant and less costly in low income countries, resulting in differences in prices between countries included in international comparisons. This means that exchange rates cannot reflect the relative purchasing powers across countries and international comparisons of commodities such as health care are in effect approximations. Secondly, it should be borne in mind that exchange rates are principally used by governments as a means of influencing capital movements to maintain a country's competitiveness with respect to its trading partners, for example in lowering its exchange rate in order to make domestic goods cheaper and imports more expensive. As international competitors may also make adjustments in a flexible exchange rate regime it is clear that the volatility of such a system makes comparative studies in health care expenditure unreliable.

The use of PPP values, on the other hand, enables international comparisons to be made based upon real volume measures and does not suffer from the limitations of exchange rates. There are, however, some limitations with PPP values due to problems associated with price calculation, the resulting effect being to narrow the differential in health expenditure between high and low income countries. Moreover, the 'basket' of goods used as the benchmark for comparison, may have some variation in the value attached to different components within the 'basket.'

On balance, however, 'international comparisons based upon PPPs have significant conceptual advantages' (Kanavos and Mossialos, 1996, p. 28) and their use in this thesis, therefore, is supported.

Turning to the second issue, the decision to use total *per capita* health care expenditure, as opposed to public expenditure on health, is based on the principle that health outcomes (which are 'global') are also being used in the thesis framework of variables. In this sense, impacts on variations in health outcomes are the result of all expenditure efforts to improve health outcomes. Thus, if only public expenditure were to be used, from a theoretical perspective it would be necessary to separate out only the public expenditure effects on health outcomes, which is a methodologically and conceptually different approach in comparison with that adopted in this thesis. However, from the perspective of EU governments, the finding of this thesis that health care expenditure *per se* is statistically significantly linked with health outcomes is highly relevant and this knowledge should be used to guide decisions on how much to spend on health care.

Turning now to the health outcomes used it is reasonable to point out that life expectancy and infant mortality have some limitations as output indicators (Zweifel and Breyer, 1997) as they relate to the recording of deaths and do not reflect illnesses or quality of life. In this sense, however, there are few other available indicators that are able to describe aggregate health output and the use of health-related quality of life (HRQOL) measures to derive QALYs is controversial, and their use is normally applied to economic evaluations of health technologies at a micro level (Drummond *et al.*, 1993; Bosch and Hunink, 1996).

Life expectancy at birth, used in this thesis, is considered to be an optimal choice as it is an aggregate of all possible states of health with the exception of death. It is therefore a summation of time that an individual finds himself in regarding health states and associated survival probabilities since birth.

In terms of infant mortality the choice can be justified in the fact that infants are more homogeneous than older members of the population, and are not therefore subject to the same degree of variability caused by lifestyle, environment and other socio-economic factors that affect life expectancy. Therefore, the use of infant mortality 'for comparing the performance of health care systems is not entirely unjustified.' (*ibid*, p. 92)

Thus, although there are well recognised limitations surrounding the use of the chosen outcome measures, their choice is mitigated as they are the most commonly used in international comparisons and may be for some time due to the lack of methodologically sound and consistent measures of quality of life.

With regard to the validity of the thesis findings it has also to be acknowledged that the results are predicated on the reliability and consistency of the data used. Indeed, this is the case for all research and in this regard the OECD (OECD/CREDES, 2001) states the following concerning the scope and limitations of the Health database:

> *'All users of cross-national comparisons of health care data are advised that there are still important gaps with respect to international agreements on statistical methods. The same term can refer to very different things among the 30 OECD countries. Despite efforts to develop homogeneity, standardised health statistics is still a goal, not a reality. The statistics contained in OECD Health Data .... reflect the situation at the time of release: they have been refined and improved year after year. The aim of the files and the accompanying sources and methods is to provide an objective working tool: the co-operation and, indeed, the criticism of the various national data providers and users will enable improvements in the future.'*

This limitation may manifest itself in the chosen thesis variables due to a wide range of influences. For example, the results for health expenditure in Sweden indicate that this fell consistently over the whole period of analysis (1960-95), but this may partly be due to shifts in the early 1990s, when expenditure on long-term care for the elderly was removed from the health budget. In some countries health expenditure may also be underestimated due to factors such as 'under the table' payments to health care professionals. In a similar way, the number of doctors that are actually practising medicine may be higher than recorded, as the OECD data on doctors refers to 'registered doctors' and there are likely to be practicing doctors that are not registered in EU member states, or registered doctors who are unemployed. Some of the changes in health expenditure may be a reflection of changes in growth rates (i.e. in Ireland health care expenditure increased markedly in the 1990s but its GDP growth was much higher). Therefore the observed convergence in this thesis reflects the influences on the data that underpin it, and it is clearly the case that convergence analyses of this nature will become more valid over time as data sources improve in terms of consistency and homogeneity of definition and country-specific sources.

In a similar manner, the OECD data set used contains missing data which meant that less frequent data were used in the cross-sectional σ-*convergence* analyses. In this regard the OECD data set showed much evidence of missing values for the earlier periods of 1960-1980, but in fact data were complete at the ten-year intervals. However, this limitation was mitigated in that a more rigorous approach, namely β-*convergence* analysis, was to follow using panel data over a shorter period (1980-95) and the initial analyses can be regarded as a means of achieving an overview which is designed to obtain an early indication of the presence, or otherwise, of convergence in the chosen variables. The more rigorous panel data approach enabled the potential for inconsistent trends in the data to be revealed. For the non-EU OECD countries, as a shorter period was used for both analytical approaches the 10-year time intervals were replaced by annual data. Therefore, even though the cross-sectional analyses had some limitations they had to be viewed in the wider context of data gaps and subsequent analyses which limited their impact.

Another potential limitation of the findings in relation to system typology relates to the possibility of further sub-divisions of EU health care systems. In this thesis the principal division has been based on an NHS/SI split, with the NHS countries being further sub-divided into low and high income classifications to determine the effect of health care system on health expenditure (Chapter Three). As such the SI countries have always been treated as a generic group. This clearly has some limitations as the way in which health care and reimbursements are managed is not consistent throughout the EU. For example the Netherlands has a split based on income in which some patients receive services 'in kind' and others follow a fee-for-service procedure. The rationale for retaining these major classifications of NHS/SI, however, is that it enables reasonable sample sizes to be used in the generation of statistical comparisons. The findings according to this split have been informative and shed light on variations according to the overriding typologies used. However, continuing research in this area would benefit from a closer examination of further sub-divisions if they can be formulated into meaningful categories.

In terms of measuring and representing trends in convergence analyses the thesis has used the EU mean. An alternative approach would have been to use one 'leading' country in order to quantify if others were converging towards or diverging away from it. The use of the mean is considered, however, to provide a more stable platform as it clearly will not fluctuate as much as one particular country. It is recognised, however, that the limitation of this choice is that countries being compared with the mean have themselves contributed to the calculated mean, and therefore some errors will be present in the results. However, this approach, as shown in the review of Annex A, has been adopted and recommended by other researchers and is considered in this thesis to be the best compromise given the possible alternative approaches. The EU mean is also a commonly used yardstick with which to judge the characteristics of one's own health care system, as has been cited many times in this thesis.

Continuing with methodological issues, as part of the β-*convergence* analyses carried out in chapters Three to Five, shift dummies were introduced to test for country-specific differences within the overall process of testing for this form of convergence. In many cases significant shift dummies were found and the question one might wish to pose is whether or not this conflicts with the finding of statistically significant β-*convergence*. In order to answer this point it is necessary to distinguish between the pooled result for the sample, indicated by the value of β in the convergence equations, and country-specific differences. Thus it is possible to have the sample exhibiting convergence as a whole but to also find that some countries are predicted to have values either above or below the reference. Therefore the two are not mutually exclusive and countries may converge to their own steady state or the steady states of other members of the sample. However, the fewer the number of statistically significant dummies, the more homogeneous is the sample steady state. This point can be seen in the results for the non-EU OECD countries which, for health care expenditure, found that all shift dummies were significant even though *β-convergence* was occurring for the sample. These differences were less pronounced in the EU countries, indicating more homogeneity (and by implication more achieved convergence) in the EU.

One of the limitations of conducting macro-level analyses is that country-specific aggregate data are used. They thus provide an 'overview' of a country's performance with respect to other countries in the sample, and may mask what is going on 'within' each country. This point comes down to the choice of unit of measurement, in this case EU member state, but evidence from many single country studies on convergence (see Appendix A) shows variations in economic performance and health status based on regional factors. However, the benefit of the findings of this thesis is that similar studies, at a lower level of analysis, can be performed in order to inform governments of the differences that exist, their trends and finally how greater convergence can be achieved by targeting resources and introducing policies to compensate for differences in economic performance. Indeed, as outlined in Chapter One, a number of EU initiatives already exist to achieve this but greater awareness of internal variations within EU countries will increase the effectiveness of such policies.

In terms of potential 'causal' links the analyses of Chapter Six have revealed statistically significant relationships between the dependent variables (health outcomes) and a number of explanatory variables, including some that form the thesis framework (health expenditure and resources in particular). However, it is perhaps difficult to argue that these are 'causal' in nature as many health, lifestyle variables and health expenditure are statistically strongly linked to income. In this regard it is worth recalling that many studies (see 6.1) have shown an inverted U shape for income in explaining changes in health status, with high levels of income leading to riskier behaviour and poorer outcomes. In the case of health expenditure the observed relationship is one of diminishing returns to health for increasing levels of expenditure and it is this facet which is of more relevance to the convergence hypothesis. This issue, however, would clearly benefit from further study if a wider explanation would be informative.

The reasons as to why convergence is also occurring in the reduced sample of non-EU OECD countries are worthy of note but are thought to be grounded in the predictions of the neo-classical growth model, consistent with the finding of convergence clubs in advanced nations of the world (see Appendix A). These countries - which formed the control group for comparison; Canada, Australia, New Zealand, Norway, Iceland and Japan, all have access to similar technologies, have advanced and comprehensive health care systems, good education systems, modern democracies and political stability, and share common trade links that are comparable with countries of the EU. The neo-classical growth model, which is relevant for countries even with closed economies but similar levels of development, appropriately predicts economic convergence to occur and this is further enhanced by the above influences and factors such as technology diffusion and access to common information on health care interventions and health promotion. In other words, EU social, economic and health care policies aside, these countries have a high degree of homogeneity and convergence among them is a reasonable expectation, which has been confirmed in a number of empirical studies. This was corroborated by the lack of evidence of convergence in the complete sample of non-EU OECD countries, which as a whole exhibits much more heterogeneity.

One of the difficulties raised by the wide scope of related topics associated with convergence analysis, touched upon in this thesis, is the problem of how one treats these topics. In this thesis this principal body of literature has been identified as those studies that outline the methodology, and those conducting empirical economic analyses, of convergence. However, in Chapter Six a more detailed look at the literature was also necessary in order to inform the construction of a health production model using the aggregate data used in the thesis, as well as other explanatory variables. This, and other topics, it could be argued, should also have received the same level of attention in reviewing the literature (for example, health care reforms, European Union health policy, European Union health care systems, the neo-classical growth model, choice of variables used in the thesis, the validity of the OECD health data set, amongst others). These topics have in fact been given, what is considered, adequate attention in order to permit their relevance to be assessed and used within the context of the thesis, but the need to fully address the methodological and empirical issues of the convergence hypothesis has naturally required a trade-off with regard to fully exploring all relevant literature. Future studies ought, therefore, to single out these issues such that they can be given more weight in terms of explaining the results and informing the convergence debate.

Finally, a number of political issues are relevant to the potential for increased convergence in the health care systems of the EU. These have been outlined in Chapter One but additionally it is the case that, over the period examined (1960-95) not all of the present fifteen countries of the EU have been members, and therefore the impact of being part of this group has perhaps been variable. Indeed, the findings have shown the countries of the

South (which joined the EU late in comparison with others) to be catching up with the more established countries of the EU, and this process will undoubtedly continue to have an effect on achieved levels of convergence. Also, many potentially influential policies, key among these being the recent introduction of EMU, have not been relevant to the period studied in this thesis but the impact of such changes should be significant in the future in encouraging greater convergence. The use of a common currency will also greatly help in increasing the comparability of future cross-national studies on health expenditure.

7.6. Policy implications

The findings of this thesis, therefore, are that convergence has occurred in many aspects of the health care systems of the EU between 1960 and 1995. Although no explicit policy exists to encourage health and health care convergence and the principles of subsidiarity lie at the heart of this area of social policy, the findings of this thesis show that greater convergence will result when and if:

- Further economic integration continues to be achieved in the EU;
- *Per capita* GDP continues to converge such that the current differences are reduced;
- Greater mobility of the factors of production occurs;
- A reduction of restrictions in EU markets occurs;
- Greater harmonisation in the way in which health care is financed and delivered occurs;
- Differences in the level of health care resources diminish;
- Technology diffusion and common research projects continues to expand;

- Macro and micro-economic efficiencies in health care provision continue to be pursued along common grounds;
- Information and guidelines concerning clinical and cost-effectiveness is more widely disseminated;
- EU governments address areas they are lagging in, as illustrated in the findings of this thesis.

The findings of each of the chapters of this thesis enable trends for each country in the EU to be assessed such that appropriate responses can be made, both at the national and EU policy level. The analyses have shown a significant relationship between health care expenditure and resources, and health outcomes, which some countries need to be cognisant of in future policies on funding.

Other independent forces for convergence will continue to have an impact on health care policy, and these include demographic changes in the populations of the EU, the development of new health care technologies and convergence of lifestyles.

Policy responses, however, are taken in the light of prevailing political climates within individual countries and these may either facilitate or constrain the actions of individual member-state governments.

7.7. Concluding comments

The methods developed in this thesis have provided answers to the research questions posed in chapter One, and have provided a means of assessing differences in health care systems and how convergence may be analysed. The methods further offer a means of conducting convergence analysis in any field of Economics or Social Policy, which can be applied both within and across countries.

In conclusion, this thesis has shown that being a member state of the European Union has been associated with convergence, at least in the parameters of health care systems examined here. However, although the shared levels of economic integration, research and policy initiatives may accelerate this process, convergence can occur in groups of countries outside the EU with similar economic and health care characteristics. The observed convergence has occurred with very limited adoptions of specific EU policies in health care that would formally facilitate it. The logical progression is for further integration at some point in the future by means of structural mechanisms that would result in more similar health care provision and standards for all EU citizens. Indeed, without a certain level of achieved convergence in social welfare systems as exists within individual EU member-states, undue and sub-optimal levels of cross-border movements, to acquire social and economic benefits afforded in other countries, would act as a destabilising force within the EU itself. In this respect one could argue that convergence is a good development as its presence is indicative of a diminution in differentials of the sort examined in this thesis. Moreover, the aspiration of joining the EU through the anticipated enlargement processes, shared by many countries from the old Eastern Bloc, may be the point of focus in encouraging greater further convergence and more equality in health care among the wider European countries.

Appendix A

Review of Empirical Studies of Economic Convergence

A.1. Introduction

The methods selected and adapted to test for convergence in the thesis are developed and fully described in chapters One and Three by reference to relevant literature, and are then utilised within the chapters that apply the analyses. An important element of the convergence debate is empirical in nature and stems from various analyses of the evolution of income levels or growth rates.

The aim of this appendix, therefore, is to provide a review of empirical studies of convergence in the field of economics and briefly summarise their principal findings and key methodological concepts that have emerged. The appendix is thus divided into three sections: a summary of key principles emanating from empirical studies of convergence, a summary of studies either exclusively outside the EU or with some EU elements, and studies of convergence conducted for the EU as a whole, EU regions or within specific countries of the EU.

A.2. Key principles from empirical studies

Early theoretical work on macroeconomic convergence was done by Kaldor (1961) who identified a number of similarities in national economies' long-run growth behaviour.

Romer (1989) updated this work with a number of observations from empirical analyses. These included the issue of selection bias in samples used in convergence testing; in samples free of selection bias, regressing subsequent growth on initial income levels is more likely to yield *positive* coefficients (i.e. divergence) than the negative ones that would be expected if poor countries did catch up with richer ones (β-*convergence*); population growth rates, saving rates, educational levels and policy variables are relevant to subsequent growth rates in economically significant ways (Barro, 1991; Levine and Renelt, 1992); estimates of conditional convergence rates are similar in a variety of cross-country and cross-region regressions, which predict that about 2 per cent *ceteris paribus* of income differentials vanish every year (Barro and Sala-i-Martin, 1992; Mankiw *et al.,* 1992; Sala-i-Martin, 1995, 1996). A similar figure for convergence within the regions of Finland was found by Kangasharju (1998a, 1998b).

In relation to the influence of worker mobility, available to all EU workers now, Taylor and Williamson (1994) found evidence of strong convergence in income per worker over the period 1870-1913, when unrestrained and intense migration tended to arbitrage away wage differentials and equalise GDP *per capita.*

In exploring the concept of conditional convergence through the use of a range of parametric and non-parametric, time-series and cross-sectional, methods Durlauf and Johnson (1994), Miller (1995), Ben-David (1994), Canova and Marcet (1995), Quah (1996a, 1996b) found that permanent income differentials are much more relevant than temporary, self-correcting ones. This finding is consistent with the first of Kaldor's assertions that growth rates and capital-output ratios are roughly constant over time for individual countries and the world as a whole. Quah (1993) argues that income levels do not tend towards unconditional equality, and when empirical techniques allow, the data give evidence of the 'twin peaks' or 'convergence club' phenomenon whereby income levels within relatively rich or relatively poor countries gravitate towards each other, leading to divergence across such groups.

Sachs and Warner (1995b) provide a comprehensive overview of the growth behaviour of many countries over a long time span, arguing that poor countries grow fast (and therefore converge) when they implement economic policies which open them up to international markets, while moves towards economic closeness (in particular restrictive trade) are associated with divergence. Sachs and Warner (1995a) found that policies that protect private property are likely to be implemented by countries that choose a liberal trade policy, both of which lead to convergence for relatively poor countries. Later empirical work by Sachs and Warner (1997), however, tended to support the view that openness in terms of trade liberalisation accelerates the process of convergence, a view supported by the findings of this thesis. Again, in considering the impact on clubs or 'coalitions,' convergence occurs simply because countries form themselves into groups (Quah, 1994), and do not act in isolation as is commonly assumed in various forms of growth analyses. This point is clearly applicable to the countries of the EU.

In terms of the methodology of testing for convergence, a recent paper by Goddard and Wilson (2001) examined the issue of cross sectional estimations of convergence regressions regarding the presence of heterogeneity in steady state values. They found that if heterogeneity does exist, a panel estimator outperforms both the unconditional and conditional cross sectional and pooled OLS estimators.

Anyone undertaking an in-depth study of convergence cannot avoid uncovering a degree of disharmony regarding the validity of the methods used. Boyle and McCarthy (1997) comment on the spate of papers that have been published using 'Barro regressions' which are criticised by Friedman (1992) and Quah (1993) as being subject to Galton's Fallacy. with a tracking of the intertemporal change in coefficient of variation (c.v.) being offered as a means of overcoming this limitation (adopted in this thesis with further enhancements as part of the applied methodology).

These themes have often been reflected in the EU health-related variables analysed in this thesis. The following section summarises the results of studies principally conducted outside the EU.

A.3. Non-EU empirical studies on convergence

The first serious investigation of convergence appears to have been conducted by Baumol (1986) for over the period 1870-1979, using data provided by Maddison (1982). Baumol's hypothesis of convergence was tested by simply running a cross-section regression equation in which the growth rate over the 110 year period was regressed against the initial (1870) level of labour productivity. His finding was that convergence was in evidence and significant for 16 major industrialised countries, indicating that the fast growing countries were those which initially had a low level of productivity and conversely for others. To give examples of this, in 1870 the output per worker-hour in Australia (the leader) was eight times that of Japan (the laggard), whilst in 1979 the ratio of the leader (the USA) to Japan (the laggard) was only two. Convergence was found to be occurring at an annual rate of 0.9%. These results indicated what Baumol (1986) referred to as 'the convergence phenomenon and its pervasiveness.' However, an interesting point to emerge from this influential study was that when the sample was increased to 72 countries, evidence of convergence disappeared but sub-groups or clubs emerged for relatively poorer countries.

Subsequent empirical work of a similar nature was conducted by Summers and Heston (1988), De Long (1988) and Romer (1989).

Baumol and Wolff (1988) also examined a large sample of 72 countries over the period 1950-80. Their results showed that middle income countries had grown fastest and the poorest countries had diverged from the others. According to their findings on convergence, a group of 17 countries formed a 'superior' club. Later studies have also confirmed the existence of convergence clubs (Oxley and Greasley, 1995; Quah, 1995; Taylor, 1996).

Chatterji (1992), however, refuted this finding, his own results showing this club to be empty, and undertook Gap analyses on 109 countries over the period 1960-85. Using the USA as the world leader and reference in order to determine *per capita* GDP gaps for individual countries, he found evidence of two mutually exclusive clubs. The first related to countries with income levels more that 17% of the USA had converged on the USA, while countries with income levels below this threshold diverged - but had also converged to another stable equilibrium, defined as 3% of the USA's *per capita* GDP in 1960. The assertion made by Chatterji was that in fact a superior club of 45 countries existed, and an inferior club of 60 countries.

Using methods applied to international studies of convergence, several studies of the US states have found strong evidence of regional income convergence (Barro and Sala-i-Martin, 1991 being the leading work in this area but also studies by Carlino and Mills. 1993; 1996a, 1996b; Crown and Wheat. 1995; Bernard and Jones, 1996, Vohra, 1996). Similar studies on regional convergence processes for Canadian provinces have also been performed (Coulombe and Lee, 1995), for Colombian departments (Cardenas and Ponton, 1995), and for Mexican states (Mallick and Carayannis, 1994).

In order to test the predictions of conditional convergence for the neo-classical growth model within regions of a country, Barro and Sala-i-Martin (1995) undertook empirical analyses across the US states (1880-1990), the Japanese prefectures (1930-90) and also among 90 regions in eight countries of the EU (11 in Germany, 11 in the UK, 20 in Italy, 21 in France, 4 in the Netherlands, 3 in Belgium, 3 in Denmark, and 17 in Spain) between 1950 and 1990. The measures they used were β and σ-*convergence*. Also, within this study, they assessed the impact of net migration on convergence. In summary, they found that β-*convergence* was the norm for regional economies - that is, poor regions of these countries tend to grow faster *per capita* than rich ones. Moreover, the convergence found was absolute as no explanatory variables other than the initial *per capita* product or income is held constant. The findings, as in the case of this thesis, support the predictions of the neo-classical growth model in that regions or countries which have roughly similar tastes, technologies and political institutions, move towards similar steady-states. The influence of technology diffusion and technology imitation is also confirmed as a positive influence in achieving convergence, supported by the earlier work of several other authors (Gerschenkron, 1962; Gomulka, 1971; Baumol, 1986). The findings regarding net migration show a stronger effect in the US than the European regions, but in both migration is found to play only a minor role in the 'convergence story.'

Using methods which Boyle and McCarthy (*ibid*) argue to be consistent with Sala-i-Martin's (1994) concept of β-*convergence*, they apply two tests that capture the change in rankings of income levels using Kendal's index of *rank concordance* (Siegal, 1956). β-

convergence is present, according to this method, if the index is less than unity. To illustrate their methods Boyle and McCarthy analysed convergence in GDP *per capita in* the OECD countries for each year over the period 1950-88. Over the full period they found σ-*convergence* to be 1.3% up to 1972, concluding that β-*convergence* was also present (though not tested for as they argue it is present due to the presence of σ-*convergence*. Using their two Kendall rank tests to represent β-*convergence* they find that this measure was not statistically significant following 1972.

This latter finding is in contrast to the work of Barro and Sala-i-Martin (1992a), covering the period 1960-85 for the 20 original OECD countries, who find evidence of unconditional β-*convergence*. This disparity is argued by Boyle and McCarthy (*ibid*) to be due to the point that Sala-i-Martin's (1994) requirement that $\beta<0$ is perplexing as this condition excludes the possibility of leapfrogging (the changes of role scenarios identified by Leonardi (1995) as explained in Chapter Three of this thesis) which they argue is the very essence of the finding of β-*convergence* in the absence of σ-*convergence*.

This latter methodological point is useful in explaining some of the findings of the analyses of this thesis in that the finding of β-*convergence* was not always accompanied by the finding of σ-*convergence* in some of the variables tested (see Chapters Four and Five).

Quah (1993b) undertook Markov chain analysis for 118 countries over the period 1962-85, categorising the countries into income levels of 1/4, 1/2, 1 and 2 relative to the world average. Observing only moderate mobility, he concluded that two convergence clubs existed with cross-country incomes tending towards the extremes at high and low endpoints.

Quah (1996a) also estimated Markov chains for the US federal states from 1948 to 1989, his results suggesting that there was greater mobility and attending convergence for the US states than the 118 countries he analysed. Moreover, the results for the US suggested that only one club exists rather than the bimodality observed in the sample of countries he analysed.

In terms of more recent studies and perhaps more progressive methods, Rey and Montouri (1999) analysed regional income convergence from a spatial econometric perspective over the period 1929-94. Their standpoint is that geographical dimensions of spill-overs have largely been ignored in studies of regional convergence and conduct analyses of relative income *σ-convergence* (measured by c.v.) and spatial autocorrelation, and repeat for *β-convergence* analysis. Their results generally corroborate the findings of previous studies confirming convergence in the US regions but they offer what they argue to be new and challenging insights as to the geographical dimensions of state income growth, as well as evidence regarding the role of spatial effects in the formal econometric analysis of regional income convergence.

The above summaries provide an insight into the literature either exclusively outside the EU regions or with some European elements. The published material on economic convergence is in fact vast in nature and beyond the scope of this thesis to cover in its entirety. However, the above-summarised results show evidence of recurring themes which have relevance for the findings of this thesis.

A.4. Studies specific to the EU

In relation to the concept of convergence within the EU at the political level, Bertola (1999) highlights that the designers of its institutions were aware of the 'potential inequality-enhancing effects' of free goods and factors of mobility of goods and factors, and introduced structural funds (see chapters One and Seven) to support peripheral regions. This perhaps captures the essence of why convergence analyses are important material upon which to formulate policies that are aimed at reducing income differentials, and therefore increasing equality of opportunity in the EU. This process, as revealed by the findings of this thesis, has knock-on effects in the provision and convergence of health care expenditure, health care resources and health outcomes.

In terms of empirical studies within the EU, Armstrong (1995) conducted convergence analysis across the 85 regions of the EU during two periods of economic growth; 1950-70 and 1970-90. He found that the Ile de France was the leading region in both periods, with results suggesting that in fact all other regions of the EU had diverged from this leading region, converging instead to an equilibrium of 84% of the Ile de France in 1990, and 66% in 1970. Armstrong's findings were therefore supportive of two clubs in the EU context.

Button and Pentecost (1995) undertook an analysis of EU regional economies similar to the work of Barro and Sala-i.Martin (1991) using a data set of *per capita* GDP growth for level one regions of the EU. They argue that the Eurostat data set they used, which covered cross sectional data for 1975, 1981 and 1988, is more reliable than the disparate sources (and regions - not all were level one) used by Barro and Sala-i-Martin. This is because Button and Pentecost's data are based on output per head at market prices in purchasing power parities standard, it is based only on 51 level one regions across nine countries (including 11 from the UK, 11 from West Germany, 8 from France, 4 from the Netherlands, 4 from Belgium and one from Denmark, Luxembourg and Ireland - 3 regions from Greece were also added from 1981), and convergence was measured with respect to the EU average so that convergence was measured across the EU as a whole which is in contrast to Barro and Sala-i-Martin's approach. This approach, which has many of the methodological features adopted in this thesis, enables the results to be interpreted for the EU rather than a specific country. The methods applied by Button and Pentecost (*ibid*) also sought to overcome the problems of convergence models' sensitivity to mis-specification, as identified by work on the US states (Coughlin and Mandelbaum (1988) and cross-country comparisons (Levine and Renelt, 1992). The results of Button and Pentecost using more traditionally simplified models confirmed the presence of convergence. However, when testing using a more comprehensively specified model which included structural variables, country dummies and an ERM dummy, the results showed no significant convergence across the EU's regions in the 1980s.

Chatterji and Dewhurst (1996), examined British regional convergence in growth periods between 1977 and 1991 using Gap equations. They found that London was the leading region for the overall period, with divergence from London being experienced to a level of 56% of *per capita* GDP by the rest of the country. Their results further showed that 55 other regions, with smaller gaps in comparison with London, tended to diverge from London, whereas the remaining 6 regions and counties with larger initial gaps, grew faster than London. Their final conclusion from this study was that convergence occurred more strongly during periods of slow national growth than when the national economy is booming.

In terms of regional studies on convergence in Europe, Kangasharju (1999) examined relative regional economic performance in Finland over the period 1934-93, using *σ-convergence* as defined by the Gap approach (Chatterji, 1992) and Markov chain matrices. The study examined convergence in relative income over a number of sub-periods within 88 Finish sub-regions, finding that convergence was confirmed for this sample. The study also revealed that convergence was non-linear with poorer regions catching up during periods of growth, with the rate at which they catch up being faster the smaller their initial income level. The results also confirmed the presence of one convergence club, with no inferior group in evidence.

In the study of convergence analysis it is clearly the case that researchers seek explanatory variables and influences that help to account for empirical confirmations of convergence. In this regard Chatterji and McKaig (1995) looked at the world's economies in terms of real *per capita* income and the role of education as a determinant of growth and an accelerator of convergence. Their results suggest that convergence is happening more quickly that had previously thought to be the case and that education, particularly higher education, has a major role to play in this process. This work indicates that there are a wide variety of explanatory variables that could impact positively on economic growth and therefore convergence, and that the full story may only be revealed through further studies of this nature.

Convergence in *per capita* income and the influence of migration was also examined across the Swedish counties over the period 1906-1990, with confirmation of convergence also in evidence (Personn, 1995).

Using the techniques of *σ-convergence* analysis and Markov chain modelling Dewhurst (1996) reports an exploratory analysis of regional household income per head in the UK over the short period of 1984-93. His findings tend to give support to the point that regions in the UK tend to diverge during times of boom (found to be occurring in the periods 1984-88 and 1992-93) and converge during slumps in the economy (1988-92). These trends are accounted for by the findings that during times of boom the richer regions grow faster than poorer ones, but in times of slump the poorer regions tend to outperform richer ones. These findings are broadly in line with those of Chatterji and Dewhurst (1996), with the policy implication being, as they argue, that regional policy is likely to be more important when the national economy is performing well, in other words when differentials in income are being generated. It is interesting to note, however, that this conclusion is at odds with the findings of Kangasharju (1999) for the regions of Finland, which were found to converge during times of economic growth.

The above literature review of empirical studies within the EU, whilst not exhaustive, provides a good insight into the available material on convergence. Again, similar concepts emerge from these empirical studies that confirm many of the findings of this thesis and the work conducted outside of the EU area. Further reading on EU empirical studies is provided by Armstrong and Vickerman (1995).

A.5. Conclusions

This review has identified and summarised the findings of a wide range of empirical studies of convergence. This exercise has revealed the explosion of work in this area of economics and undoubtedly there are more studies that have not been uncovered here.

However, the above offers support to the findings of the thesis, which were largely determined independently through empirical analyses using techniques appropriate to the EU as a group of relatively homogeneous countries. The general thrust of the findings of empirical studies is that convergence clubs can be found in both regional and international contexts, but the driving feature in determining more than one club is the degree of heterogeneity that exists in the sample. In more homogeneous samples, such as in the case of the US regions, the regions of Finland, the UK and Europe, a high degree of convergence in *per capita* GDP income is in evidence although Europe as a whole tends to throw up two clubs due to the existence of leading regions. The findings from Finland and Sweden, however, suggest more homogeneity and the existence of only one club. The influence of diffusion of technology, the free movement of the factors of production, open markets, and spill-overs are strong determinants of economic convergence with strong applicability to the EU. However, the caveat one might wish to introduce is that the findings of convergence analyses are clearly influenced by the adopted methodology and time-frame of analysis.

In this sense the literature throws up two general approaches to the study of convergence. On the one hand there is the Barro-type regression approach which tests for the presence of *β-convergence* to determine if poorer countries are catching up with richer ones through higher rates of economic growth. In contrast there is the thesis that countries form natural groups according to their degree of association and economic development, forming clubs as exemplified by Quah's twin peaks findings. To a large degree these respective positions are predicated on the chosen methodology to study convergence, and whether or not restrictive samples of countries are used. The Barro approach is to undertake regression analysis to determine if the sample is approaching a steady state at a diminishing rate of growth, while the approach associated with researchers such as Quah is to use the coefficient of variation to determine if variation in the sample is diminishing with time. Both approaches, however, are informative and have been applied in this thesis to explore and utilise the relative merits of each.

Appendix B

Convergence Analysis using the Gap Approach

Although not used as a principal tool during this thesis, the Gap approach offers an alternative method which seeks to detect the presence of 'convergence clubs,' namely groups of countries that follow similar patterns of convergence (Chatterji, 1992).

This is achieved by the application of the following function:

$$G = A_1 G_{-1} + A_2 G^2_{-1} + A_3 G^3_{-1} \tag{1}$$

Where G ln $(X_{t,m} - X_{t,i})$ is the gap for a given variable to be tested of a country i from the mean of the EU countries and G_{-1} is the same gap of the previous period. The quadratic and cubic terms in the equation allow for testing different specifications of convergence. For example, if $A_1 < 1$ and $A_2 = A_3 = 0$, then the countries in the sample converge together and form a single convergence club. If all three coefficients are non-zero, then three clubs can be identified which diverge from each other, one with a low gap and ($A_1 \neq 0$) leading the convergence, another with ($A_2 \neq 0$) diverging, and a third club converging but to an inferior steady state ($A_3 \neq 0$).

Equation (1) was estimated for both health care expenditure as a percentage of GDP and *per capita*. The results, shown in Table B.1, confirm that all three groups of the EU converge monotonically with $A_1 < 1$ and $A_2 = A_3 = 0$, in other words a single convergence club.

However, the shift dummies for SI and LI groups (defined in Chapter Three) of countries are significant in equation (2), and the former in equation (4) as well.

Table B.1 Health expenditure results for the Gap equations

Coefficient	**(1)** G^y	**(2)** G^y	**(3)** G^h	**(4)** G^h
constant α	- 0.013	- 0.010	0.008	0.006
	(0.005)	(0.004)	(0.004)	(0.003)
coefficient G_{-1}	0.943	0.960	0.933	0.957
	(0.021)	(0.018)	(0.025)	(0.013)
coefficient G^2_{-1}	-0.106*		-0.043	0.079
	(0.118)		(0.040)	(0.019)
coefficient G^3_{-1}	0.221*		0.067*	
	(0.238)		(0.048)	
Social Insurance Dummy, SI	- 0.017	- 0.015	0.020	- 0.016 (0.006)
	(0.006)	(0.006)	(0.007)	
Lower Income	-0.019F	-0.019	0.007*	
Dummy, LI	(0.009)	(0.008)	(0.018)	
R^2 **(Buse)**	0.594	0.557	0.660	0.652
R^2 **(observed/predicted)**	0.958	0.957	0.987	0.987

Notes: standard errors in parentheses. Estimates with a * indicate non-significance at the 0.05 level. Equations (1) and (2) refer to the gap of health care expenditure as a share of GDP, G^y; equations (3) and (4) refer to the gap of health care expenditure *per capita,* G^h. The shift dummies stand for SI = Social Insurance countries; and LI = low income countries.

Similar results are obtained when countries are inserted in the estimated equation individually and not as members of groups: the square and cubic terms of equation (1) are non-significant.

Although this reporting of the Gap approach is rather brief, it provides an insight into other statistical tests and approaches that can be utilised in convergence analyses in contrast to those adopted in this thesis (Chapter Three).

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