

ASSESSING
THE BENEFITS
OF PRICE STABILITY:
THE INTERNATIONAL
EXPERIENCE

Javier Andrés, Ignacio Hernando
and J. David López-Salido

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CONTENTS

	<i>Páginas</i>
INTRODUCTION	9
I. THE COSTS OF INFLATION: THEORY AND EVIDENCE.	13
I.1. Theoretical considerations	13
I.2. International evidence	18
I.2.1. Model-based estimates of the welfare costs of inflation	18
I.2.2. Econometric estimates of the overall impact of inflation on economic activity.....	19
I.3. Inflation and growth in the OECD: Descriptive statis- tics.....	26
II. THE COSTS OF INFLATION IN CONVERGENCE EQUA- TIONS.....	35
II.1. Theoretical framework: The effect of inflation in con- vergence equations.....	36
II.2. Estimation of the effect of inflation: main results	39
II.3. Country-specific effects and the cost of inflation	43
II.4. Causality analysis	50
II.5. The role of the financial system in the growth-inflation link	57
II.5.1. Theoretical and empirical backgrounds	59
II.5.2. Indicators of financial development.....	61
II.5.3. Results	66
II.6. Concluding remarks	70
III. THE DYNAMIC EFFECTS OF PERMANENT DISINFLA- TIONS.....	73
III.1. The analysis of the long-run effects of disinflations: a SVAR approach	74

	<u>Páginas</u>
III.2. Inflation, output and unemployment	76
III.2.1. The model	76
III.2.2. Alternative Identifying restrictions	79
III.3. The disinflation in Spain: 1976-1996.....	81
III.4. International Evidence.....	85
III.5. Concluding remarks.....	90
Appendix III.1. Econometric setup	92
CONCLUSIONS.....	105
REFERENCES.....	107

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INTRODUCTION

The dynamic interaction between inflation and output has always been a matter of concern for central bankers and for macroeconomists at large. While the proximate causes of inflation are well known, its effects both in the short run and over the medium term are less so. The failure of the international monetary system and a series of supply shocks are at the root of the upsurge of inflation during the seventies. The initial reaction of monetary policies to these events was aimed at preventing the most negative consequences of the recession, and must share the blame for the increased price instability. Since the mid eighties, things have changed and price stability has become the main goal of monetary policies. That this change of strategy has been successful in the inflation front nobody can deny. What is less widely accepted is that this new environment of low inflation has also contributed to bring about the high growth rates that we witness today in most industrialised countries.

Admittedly, the link between stable prices and future growth is blurred. Most of the theoretical analysis of the trade-off among inflation and growth takes on a short-run perspective, whereas growth models have been more concerned with the role of factors such as investment, schooling or innovation. However, it is also true that price stability as a policy objective can only be justified on the basis of the welfare or output costs of high inflation.

A great deal of research effort has been devoted in recent years to assess these costs. Many of these studies have come up with a similar conclusion: the costs of inflation are small but non-negligible. This is also the main theme of this book, but our approach has several features that depart somewhat from other published work. For one thing, we focus on a sample of industrialised economies: the OECD. This is partly justified on the basis of homogeneous data availability, but the main reason to do that is that we are interested in testing whether or not inflation is costly even at moderate rates, as the ones that characterise the OECD countries during the sample period (1960-1996). Most economists would agree on the harmful effect of very high inflation rates, which simply de-

stroy the environment in which productive activities take place. However, it is not that clear why production and trade can be so significantly damaged by inflation rates around, say, 5-10 %. Also working with a sample of few countries makes it possible to control for some variables that may bias the estimated long run correlation among inflation and income.

The focus on how to solve the issue of causality among inflation and output is the second specific feature of our work. Gathering evidence on the correlation among inflation and output at different time horizons is not enough to draw monetary policy conclusions. Before that, it must be established that causality is running from the former to the latter, i.e. that it is current inflation what is lowering the prospects of future growth of an economy. To do that, we follow several avenues. Standard instrumental variable methods and causality tests give a strong hint about that it is indeed inflation what causes lower growth, rather than the other way round. A more detailed analysis of this issue is pursued also by means of Structural Vector Autorregresion models (SVAR). This approach turns out to be very adequate for the purpose at hand and uncovers a significant long-run negative effect of nominal shocks on output. This is the effect that might be behind the estimated negative correlation and is the one that generates a long-run cost of inadequate monetary policies.

The rest of the book is organised as follows. Chapter 1 discussed the main theoretical issues regarding the correlation between inflation and growth and presents some descriptive statistics of the macroeconomic performance of the OECD economies during the sample period. Chapter 2 provides an estimation of the long-run effect of inflation on growth within the framework of convergence equations. The main advantage of these equations are that they can be derived from a theoretical model of economic growth and that allow for a clear distinction between level and rate of growth effects of inflation. Chapter 3 presents a joint analysis of both the short and long-run real effects of the disinflation processes in some major OECD countries using a SVAR analysis. We seek to identify the innovations behind the joint dynamics of output and inflation to see what is the permanent effect of nominal shocks on them. The model here is enlarged with the unemployment rate and the approach is mostly empirical, although the restrictions invoked to identify alternative sources of fluctuations can be justified on the basis of a fairly general macroeconomic model.

All the evidence presented in this book points in the same direction: even low or moderate inflation rates have a negative *temporary impact* upon current or future *growth rates*; this effect is significant and generates a *permanent reduction in the level of per capita income*. The estimated benefit of a permanent reduction in the inflation rate by a percentage point is an increase in the steady-state level of per capita income

which ranges from 0.5 % to 1 %. The estimated correlation among current inflation and future income is robust, in an econometric sense, to changes in the information set as well as to a number of improvements in the specification of econometric models. In particular, the joint dynamics of these two variables suggests that such correlation is driven by a genuine negative effect running from truly exogenous innovations to inflation (i.e. innovations to the rate of money growth) to the long-run component of output. The book concludes with a more detailed account of the main results.

THE COSTS OF INFLATION: THEORY AND EVIDENCE

I.1. Theoretical Considerations

Business cycle theory offers different explanations for the positive correlation between short-run fluctuations in output and inflation, i.e. the co-movements between the deviations of output and inflation from their respective trends. These explanations differ at least in three respects. The first relates to the theoretical explanation of this empirical regularity. Also economists disagree on the persistence of the Phillips curve with a negative slope beyond the very short term. Finally, there is the question of to what extent the economic authorities can use this negative correlation to reduce unemployment in recessions, even at the expense of higher inflation. In sum, the main discrepancy in this field is between those authors who defend inflation as a necessary evil that accompanies expansions and those who argue that higher or lower inflation has no real effect (1).

However, inflation, even when fully anticipated, has effects that manifest essentially in the long run and that affect the productive capacity and potential income of economies. The theoretical discussion and formalisation of this relationship have been unnoticed by business cycle models, which do not address either the main cause of the lasting effects of inflation or its influence on the accumulation of productive factors and on the efficiency with which such factors are applied to producing goods and services. It is rather economic growth theory which tackles these aspects yielding an unequivocal verdict on the harmful effect of inflation in the long run.

One notable exception is given by multiple equilibria and hysteresis models. Under this approach, there is not a unique equilibrium in the

(1) At least when it is fully anticipated by economic agents.

economy but many levels of activity that may be considered as such in the sense that the economy remains therein unless it undergoes some exogenous shock. In these models, even a transitory shock (associated, for example, with a temporary slowdown in the rate of money growth) can shift the economy from a low unemployment equilibrium to one of high unemployment, around which it stabilises. The existence of these diverse equilibria is due to the presence of some type of strategic complementarity or of increasing returns in production or trade technology [Mortensen (1989)]. It is in these models that many authors find the essential explanation for the high persistence of unemployment in many European countries [Blanchard and Summers (1987)], compared with what has happened in other developed economies. In accordance with this approach, disinflation may have given rise to lasting effects on output and employment. Thus, a simplistic reading of these models would lead us to think of a Phillips curve whose long-run slope was negative. This conclusion is, however, hasty since it may not be inferred from these models that inflation will necessarily have positive effects (2). A more qualified interpretation would be that the way in which disinflation processes are tackled is not neutral in the medium run and that an erroneous inflation-control strategy may contribute to exacerbating the costs of inflation (3).

The adverse effects of expected inflation on output have generally been studied in growth models, both with constant returns and absence of externalities [Orphanides and Solow (1990)] and in some endogenous growth models [De Gregorio (1993)]. The structure of these models is relatively simple. In them, per capita income growth is the outcome of the accumulation of productive factors and of the ongoing improvement in the efficiency with which such factors are used. Inflation may affect growth through either channel, or through both at the same time. In fact, early attempts to introduce money in growth models concluded that since money and capital are rival assets in households' portfolios, higher inflation, which makes money holding less attractive, encourages capital accumulation resulting in higher per capita income. This is the Mundell-Tobin effect.

However, this effect is not robust to the way money is introduced in general equilibrium models. When money is taken to be a necessary device to carry out transactions (cash-in-advance constraint) or as a good whose services yield some utility (money in the utility function), the effect

(2) In general, although the theoretical literature does not particularly stress the subject, it is not clear that the shift between differing equilibria is symmetrical. Although a temporary decline in demand may lead an economy to a worse equilibrium situation, there is not sufficient evidence in favour of a counter-movement in response to an expansionary policy.

(3) Specifically, hysteresis or persistence models infer that a gradualist disinflationary strategy may, under certain conditions, be less costly than a more drastic strategy.

of anticipated inflation may be very different. As Walsh (1998) shows, except for some particular set of preferences, the steady-state level of labour supply, output and consumption, are not independent of the steady-state (fully anticipated) inflation rate, in many well defined stochastic general equilibrium dynamic macroeconomic models. More often than not, money is non-superneutral, in these models but, unlike the Mundell-Tobin effect, in this case higher inflation is associated with lower levels of per capita income, consumption and utility.

These effects have been found to be empirically relevant [Bruno (1993)]. In association with unexpected or volatile inflation, the effects of uncertainty on investment returns are well known [Bruno (1993) and Pindyck and Solimano (1993)]. Moreover, high inflation prompts uncertainty over the future course of monetary policy, which exerts negative effects on domestic investment and on foreign capital inflows. But even perfectly anticipated inflation reduces profitability because of the nominal rigidity in the tax structure (e.g. tax allowances established in nominal terms), whereby when inflation increases, the tax allowances in relative terms diminish and the actual cost of investment increases [Jones and Manuelli (1995), and Cohen, Hasset and Hubbard (1999)]. Feldstein (1997, 1999) discusses alternative channels through which inflation can have a substantial impact on economic welfare by increasing the tax-induced distortions that would exist even with zero inflation. He concludes that the effects arising from the interaction between the tax system and inflation are sizeable (4).

Inflation also has a bearing on certain other determinants of long-term growth. In particular, the accumulation of human capital may be harmed by a prolonged period of inflation for reasons linked to the deterioration in income distribution and tighter liquidity restrictions. For Galor and Zeira (1994) the existence of an imperfect capital market tends to perpetuate the differences in income distribution owing to the borrowing difficulties faced by the poorest households to finance their education. If inflation should adversely affect the distribution of income, the effects on potential income may be significant [see, e.g. Alesina and Rodrik (1992)]. The differential impact of inflation on different agents is harmful for creditors and for recipients of non-indexed income, and may distort the allocation of resources and effort. In this respect, the change in relative consumer and leisure prices may distort the choice between income and leisure, shifting labour supply away from its optimum level [De Gregorio, (1993)].

(4) In his own words, "the deadweight loss associated with inflation is therefore not the traditional small triangle that would result from distorting a first-best equilibrium but is the much larger trapezoid that results from increasing a large initial distortion" (Feldstein, 1999, p. 10).

When inflation negatively affects some of the so-called engines of growth, such as those mentioned above, this effect will only be detected in empirical growth equations in the absence of such variables. Nonetheless, most empirical models of economic growth already take into account the influence of these variables through the inclusion of the rate of accumulation of physical capital, that of human capital, the growth rate of labour supply or R+D spending, as additional regressors in the equations. The presence of inflation, with a significant coefficient, in these models is indicative of an effect which goes beyond that of a reduction in the accumulation of productive factors (accumulation effect) and which is associated with the impact of macroeconomic instability on total factor productivity. Although this presence may be due to poor specification owing to the omission of relevant variables, there is no shortage of arguments to justify the relevance of this transmission channel (efficiency effect) for the negative effects of inflation.

Although there has been little theoretical formalisation of these effects, a set of arguments has been recurrently used in most papers that have attempted to justify the harmful effect of inflation in the long run (5). Among the costs arising from inflation are those associated with changes in prices («menu costs») or with the increase in the number of transactions needed to reduce average holdings of liquid balances («shoe-leather costs»). Further, inflation distorts price signals [Smyth, (1994)], inducing greater and more frequent prediction errors that hamper the optimal allocation of resources. Inflation blurs the distinction between rises in the general level of prices and changes in relative prices. Generally, the increase in uncertainty about the future course of inflation and the difficulty of identifying changes in relative prices act as incentives for economic agents to assign more resources to protect themselves from inflation and fewer resources to be efficient and competitive in the production of goods and services [De Gregorio (1996)].

Inflation causes rises in interest rates that likewise become more volatile as the risk premium increases. Uncertainty in turn jeopardises the maintenance of the monetary authority's credibility in terms of its economic policy strategy. It should be borne in mind that the degree of uncertainty about the future design and implementation of monetary policy is related to the central bank's level of independence. The recent theoretical literature coincides in that central bank independence contributes favourably to controlling inflation (6). The pursuit by economic

(5) As Briault (1995) indicates, it is very difficult to derive a direct effect of inflation on factor productivity from general equilibrium models.

(6) The papers by Repullo (1993) or Fischer (1995) are cases in point. Consensus on this point goes beyond academic circles and, in this respect, legal reforms have been enacted since 1989 to endow the central banks in many countries with greater independence (see Cukierman, 1996).

authorities of various objectives generates an inflationary bias [Barro and Gordon (1983)]. One possible solution to this is to delegate responsibility for monetary policy decisions to a central bank not subject to government authority and with price stability as its primary goal [Rogoff (1985), Persson and Tabellini (1993) and Walsh (1995)] (7). Inflation that is high and out of control gives off a negative signal to financial markets regarding the monetary authority's degree of independence and/or of commitment in fighting for nominal stability, which diminishes its credibility and, by extension, the effectiveness of its actions. Last but not least, inflation reduces the effectiveness with which the different productive sectors operate, particularly the financial sector. This phenomenon is especially harmful for economic growth, as King and Levine (1993b) have recently argued (8). These authors also present convincing empirical evidence on the existence of positive causality running in a direction from the level of development of the financial system (approximated by a series of aggregate indicators) to the economic growth rate.

Finally, while the belief that the long-run costs of inflation are significant is widely shared by most economists and policymakers for countries with moderate or high average inflation rates, its validity for economies with low inflation rates is a question that remains open. Some recent theoretical models predict that inflation has potential benefits as it "greases the wheels" of the labour market as well as potential costs induced by its disruption ("add sand to") of wage and price adjustments. The grease effect arises from downward rigid wages in economies facing negative supply shocks. Inflation facilitates relative price adjustments reducing the extent to which nominal rigidities distort employment and output. The sand effect arises from the existence of nominal rigidities (due to menu costs or informational problems). Then, a pure nominal shock will change relative prices and wages, which misdirects resources and lowers output below potential (9).

(7) Notwithstanding the virtual unanimity with respect to the favourable effect of the monetary authority's independence on inflation, contradictory positions are held as regards the effect on the volatility of output (Pollard, 1993, Debelle and Fischer, 1995 and Alesina and Gatti, 1995).

(8) Certain authors (Pagano, 1993 and Japelli and Pagano, 1994) have pointed out that the liquidity restrictions associated with a relatively undeveloped financial system and with unequal income distribution may encourage saving. Although a more uncertain environment may possibly be conducive to precautionary saving, it is not clear whether the uncertainty associated with a relatively undeveloped financial system eases the channelling of these funds towards increased investment.

(9) See Akerlof, Dickens and Perry (1996) and Groshen and Schweitzer (1999) for a formalization of these arguments and for an estimation of the grease and sand effects in the U.S. economy. See King (1999) for a skeptical view on the importance of nominal stickiness, in a low inflation environment, as an argument to abandon the pursuit of price stability.

1.2. International Evidence

The empirical literature on the costs of inflation is extensive and it includes studies covering a wide variety of methodologies (10). This empirical work may be classified in two categories. A first strand of the empirical literature deals with the measurement of the welfare costs of inflation arising from specific channels. This model-based empirical literature, using either a partial equilibrium or a general equilibrium approach, attempts to provide a direct measure of some of the costs associated to inflation. On the other hand, some papers provide econometric estimates of the impact of inflation on the level (or growth rate) of economic activity (measured by output, productivity or per capita income). This approach, that includes both cross-country and single country time-series analyses, provides an overall assessment of inflation's effect on economic activity without making explicit the precise channels through which inflation operates.

1.2.1. *Model-based estimates of the welfare costs of inflation*

The model-based empirical literature deals with some specific channels through which inflation reduces welfare. It has mainly focussed on two types of costs associated to inflation: first, those arising from considering inflation as a tax on real balances (shoe-leather costs), and, second, those resulting from the interaction of inflation and the tax system. Partial equilibrium and general equilibrium models have been used to obtain estimates of both types of welfare costs. In short, these calculations make use on previous empirical work on money demand equations or other demand equations to compute deadweight loss areas. These partial equilibrium studies attempt to measure how these areas change in response to inflation changes or, in other words, how inflation exacerbates existing distortions (11). Similarly, general equilibrium papers draw on previous empirical literature modelling inflation distortions to obtain their key parameters. The models are calibrated – to take into account the salient features of the tax system and other characteristics of the economy – and

(10) Briault (1995), Black et al. (1998), O'Reilly (1998) and Viñals(1998) survey the literature on the benefits of price stability.

(11) Howitt (1990) provides an example of this type of approach to estimate the shoe-leather costs of inflation. Similarly, a set of recent papers – Feldstein (1999), Bakhsi, Haldane and Hatch (1999), Dolado, González-Páramo and Viñals (1999) and Tödter and Ziebarth (1999) – estimates the deadweight losses that result from the interaction of inflation and the tax system in four countries: United States, United Kingdom, Spain and Germany. These studies, developed within the framework of the NBER project on "The Costs and Benefits of Achieving Price Stability", show how differences in national tax systems imply differences in the costs of disinflation.

simulated to provide comparisons – in terms of welfare or steady-state output – under different inflation assumptions (12).

1.2.2. Econometric estimates of the overall impact of inflation on economic activity

Table I.1 draws together the most significant characteristics of some of the papers addressing the measurement of the overall long-run effect of inflation. Panel A of Table I.1 presents studies using time-series data and methods for a particular country or group of countries, whereas Panel B presents some of the cross-country analyses that explicitly take into account the cross-country dimension of the data.

Single-country evidence from time-series analysis

A first look at the empirical evidence based on single-country time-series analysis shows a lack of consensus regarding the sign and size of the long-run relationship between inflation and growth. Grimes (1991) considers a simple specification in which the growth rate of output is explained by various indicators of the inflation rate for the OECD countries. The results point towards a negative association for most of the countries, although this correlation is not robust to changes in the estimation method. Likewise, Smyth (1994) obtains a negative effect of inflation and its first difference on the growth of US private-sector output. However, Stanners (1993) for a sample of 9 industrialised countries does not find any significant correlation between inflation and output growth.

Rudebusch and Wilcox (1994) use time series from single countries (G-7) to estimate the influence of inflation on productivity growth. They observe a negative relationship between these two variables. In addition, they find that inflation Granger-causes productivity growth. However, these results are only significant for Canada, United Kingdom and United States. And, in general, the significance of the estimated relationship depends, to a large extent, on the statistical method used to disentangle the cyclical and long-run relationship between inflation and productivity growth. Similar results are found in Sbordone and Kuttner (1994) for the U.S. economy. These authors find that inflation Granger-causes productivity growth, but this result is not robust to the inclusion of additional vari-

(12) Lucas (2000) surveys recent research on the welfare costs of inflation and provides new estimates based on US data. See also O'Reilly (1998) for an overview of general-equilibrium estimates of the costs of inflation.

ECONOMETRIC ESTIMATES OF THE IMPACT OF INFLATION ON ECONOMIC ACTIVITY

<i>PANEL A. SINGLE-COUNTRY TIME-SERIES ESTIMATES</i>			
Authors	Samples	Methodology	Main findings
Grimes (1991)	21 industrialized countries	Linear regressions of GDP growth on inflation.	Negative long-run relationship between inflation and output growth.
Stanners (1993)	9 industrialized countries	Correlations	No significant correlation between inflation and output.
Rudebusch and Wilcox (1994)	G-7 countries (special attention paid to the U.S.)	Linear regressions of productivity growth on inflation	Negative effect. Specially significant for Canada, U.K. and U.S. Non-significant for Japan and Germany
Sbordone and Kuttner (1994)	U.S.	Granger causality tests and time-series models for productivity growth and inflation	Negative correlation between productivity growth and inflation. Size heavily dependent on the identifying assumptions
Bullard and Keating (1995)	58 countries	SVAR Inflation is a monetary phenomenon	Inflation has no significant long-run effect on the level of output for most countries

PANEL B. CROSS-COUNTRY TIME-SERIES EVIDENCE

Authors	Samples	Methodology	Main findings
Kormendi and Meguire (1985)	47 countries Cross-section 1950-77	Reduced-form equation	Negative effect of inflation on growth.
Fischer (1993)	68 countries Pooling annual data 1961-88	Growth accounting	Negative effect of inflation on growth. Significant investment and efficiency channels.
De Gregorio (1993)	12 Latin American countries 6-year averages 1950-85	Reduced-form equation	Negative effect of inflation on growth. Predominance of the efficiency channel.
Motley (1994)	21 to 78 countries 10-year averages 1960-90	Convergence equations	Negative effect of inflation on growth. Higher effect for samples of low-inflation countries.
Barro (1995)	89 countries 5- and 10-year averages 1965-1990	Convergence equations	Temporary growth rate effect. Higher coefficient for high-inflation countries.

PANEL B. CROSS-COUNTRY TIME-SERIES EVIDENCE (continued)

Judson and Orphanides (1996)	69 to 142 countries Annual data 1959-1992	Reduced-form equations	Inflation volatility negatively related to growth. The level of inflation is negatively correlated with growth (but only significantly for inflation higher than 10 %)
Gylfason and Herbertsson (1996)	94 to 170 countries 5-year averages 1960-1993	Growth equations from an endogenous growth model	Negative link between inflation and growth. Non-linear link: the growth effect of inflation is higher at low rates of inflation.
Bruno and Easterly (1998)	High inflation episodes 1961-1994	Growth rates before and after high (>40 %) and moderate (20-40 %) inflation episodes	Negative inflation-growth correlation is only present for high inflation episodes.
Ghosh and Phillips (1998)	145 countries Annual data 1960-1996	Non-linear reduced-form equations	Negative inflation-growth link with two non-linearities: 1. Higher effect for lower inflation rates; 2. But positive effect at very low rates (<2-3 %).

ables. Using a bivariate time series model, they also show that the size and sign of the estimated effect on productivity of a permanent shock to inflation depends on the identifying scheme used to distinguish inflation shocks from productivity shocks. Finally, Bullard and Keating (1995), using a structural vector autoregression (SVAR) approach for fifty-eight countries, do not find a systematic long-run relationship between inflation and the level of output (13). Nevertheless, their results are heavily dependent on the way nominal shocks are identified. As we will see in chapter 3, alternative identification schemes lead to a remarkably different pattern of results.

The ambiguity of the results of the single-country approaches is far from surprising given the serious limitations that face most of these studies when trying to capture the long-run impact of inflation on economic activity. First, as predicted by business cycle theory, there is a positive short-run relationship between inflation and growth, with the direction of causality going from growth to inflation, that may bias the estimation of the long-run effect of inflation on growth. Second, it is difficult to disentangle the genuine effect of inflation from the effect that is induced by the response of economic policy; for instance, high inflation may provoke a monetary tightening which in turn will reduce output growth. Finally, the observed negative correlation between inflation and output growth might be driven by the presence of supply shocks. In fact, excluding the years immediately after the oil shocks of 1972-73 and 1979, reduces the significance of the results [see, for instance, Rudebusch and Wilcox (1994)].

Cross-country evidence

The use of cross-country data helps to avoid some, though certainly not all, of the problems associated to single-country time series analyses. By averaging the data for each country over a number of years it is possible to get rid of the problems that are associated with the use of high frequency data, namely the short-run correlation between inflation and growth, arising from business cycle or policy reaction considerations. This is the main reason behind the extensive use of cross-section databases in the burgeoning empirical literature estimating the overall long-run impact of inflation on economic activity.

Thus, Kormendi and Meguire (1985) estimate a growth equation with cross-section data in which the effect of the initial income is controlled along with a series of macroeconomic indicators, including inflation. The

(13) See Bullard (1999) for a survey on this sort of time series evidence.

effect of this variable on the growth rate is negative, but it loses explanatory power when other regressors are included, in particular the rate of investment. That would denote that the effect of inflation mainly shows itself by reducing investment but not total factor productivity. Grier and Tullock (1989) estimate a model that excludes the investment rate and includes various measures of nominal instability (inflation rate, price acceleration and standard deviation of inflation). The results differ across country groupings, but for the OECD sample the variability of inflation appears to have a significant and adverse effect on growth.

Further to these seminal papers, the study of the long-term influence of inflation has been mainly undertaken within the framework of convergence equations derived from economic growth theory (14). Some exceptions, however, are the papers by Cardoso and Fishlow (1989), Burdekin, Goodwin, Salamun and Willett (1994) and Bruno (1993). Cardoso and Fishlow (1989), using a panel of five-year averages for 18 Latin-American countries, encounter a negative impact of inflation on the growth rate of per capita income, conditioned on high-inflation countries being included in the sample. This same negative effect is found by Burdekin *et al.* (1994), that also find it more significant in the case of the developed countries. In a more complete study, Bruno (1993) identifies an association between inflation and growth in the industrialised countries which, however, has not remained unchanged during the period he looks at. Bruno finds that the main channel of influence through which macroeconomic shocks bear on long-term growth is their effect on the rate of capital accumulation, a finding that matches that obtained by Pindyck and Solimano (1993) in the estimation of investment equations for a broad group of countries.

Fischer (1991, 1993) detects a most sizeable influence exerted by various short-term macroeconomic indicators on the growth rate, both through an exercise of growth accounting and through the estimation of convergence equations. Inflation (like other indicators of macroeconomic instability) reduces both capital accumulation and total factor productivity. Cozier and Selody (1992) estimate the effect of inflation on the level and growth rate of output per worker by means of a cross-section regression in which the observations are averages of the different variables between 1960 and 1985. The specification chosen is derived from the exogenous growth model augmented with the level and variance of the inflation rate. For the sub-sample of OECD countries, the effects of inflation are more appreciable in the level than in the growth rate of productivity, while the variability of inflation does not appear to have a significant effect. For a broader sample, including less industrialised countries, the effects are

(14) These equations are derived and their properties discussed in the following chapter.

more significant (and always negative), both in the short and the long run. This result coincides with that obtained more recently by Barro (1995) in a sample of over 100 countries. Barro found that inflation has a negative albeit not very considerable effect on long-term growth while the effect of inflation variability is not robust to alternative specifications. The adverse impact of inflation is particularly unfavourable for relatively high levels of inflation, denoting the presence of some non-linearity in the effect considered. The general conclusion of these and other studies [De Gregorio (1992a, 1992b and 1996), Motley (1994)] is consistent with the negative correlation between inflation and long-term income suggested by the theoretical literature.

Some authors have criticised these results owing to the lack of a sufficiently developed theoretical framework in which to interpret them and, in particular, to the lack of robustness to changes in the econometric specification. This latter argument is developed in Clark (1997), who finds that minor alterations in the sample period, whether in the group of countries or in the econometric specification, substantially alter the estimated effect of inflation in the context of convergence equations. Levine and Zervos (1993) and, in particular, Levine and Renelt (1992) further develop this line of reasoning. These authors conduct an exhaustive sensitivity analysis of the set of explanatory variables found in the literature on economic growth. They show how most of these variables are not robust to changes in the conditioning information set (15). This is true for the inflation rate, but also for the rest of the variables approximating nominal stability in the economies of the sample. Nonetheless, these findings are not free from criticism either. Sala-i-Martin (1994) argues that the difficulty of finding a macroeconomic indicator whose effect is robust to alternative specifications of the convergence equation should not be interpreted as an absence of this influence but rather as the difficulty of finding indicators that can adequately capture this effect for any period and group of countries. Andrés, Doménech and Molinas (1996) show that, for the OECD as a whole, the macroeconomic policy variables are even more robust than the accumulation rates in the explanation of economic growth.

Other authors argue that inflation only affects output insofar inflation goes beyond some certain threshold; thus, it would be the inclusion of high inflation countries in the sample what really drives the estimated correlation. However, the evidence regarding this criticism is not conclusive. First, the threshold below which the effects of inflation become insignificant differs across studies. This threshold is 8 % in Sarel (1996), 10 % in Judson and Orphanides (1996), 15 % in Barro (1995) and 40 % in Bruno and Easterly (1998). The picture may be even more complex. Ghosh and

(15) McCandless and Weber (1995) conclude also that the cross-country correlation between inflation and growth is zero.

Phillips (1998) find a negative growth-inflation relationship with two non-linearities: the negative effect is higher for lower inflation rates, but at very low inflation rates (less than 2-3 percent) inflation and growth are positively related. Second, in the framework of cross-country convergence equations, a significant long-run cost of inflation is also found for samples including more stable economies (for instance, OECD excluding high inflation countries). Moreover, in this same framework, when non-linearities in the effect of inflation are allowed the results suggest that, if anything, it pays more in the case of a low inflation country than in a high-inflation one to reduce the inflation rate by a given amount (16). Equivalently, it is more costly for a low-inflation country to concede an additional (and permanent) point of inflation than it is for a country with a higher starting rate.

Summing up, the whole endeavour of uncovering a causal relationship among current inflation and future output (growth) has proved to be a difficult one. A fair summary of this literature would conclude that current high inflation is never associated with faster future growth, although the existence of a negative correlation among these variables is still an open issue. The most compelling criticisms on the estimated negative correlation are related to the likely simultaneity bias that may arise since both are endogenous variables in a macroeconomic system. As it has been already mentioned, there are many authors that find that such correlation is spurious and driven by some sort of misspecification in the empirical models (endogeneity, fixed effects and omitted relevant variables) or by the inclusion of high inflation countries in the sample. Even among those who do not dispute that negative correlation as an empirical regularity, there are some that do not give it a particular relevance for policy purposes arguing that it is generated by reverse causality (running from low growth to high inflation) caused by the predominance of supply shocks during the sample period. In chapters 2 and 3 of this book, all this criticisms are taken into account with the aim of answering, using alternative methodologies, two questions: first, is there a significant long-run correlation among output and inflation?; second, is that correlation usable for monetary policy purposes?, or do sound monetary policies aimed at achieving low inflation have a bearing on the long run path of output in advanced economies?.

I.3. Inflation and Growth in the OECD: Descriptive Statistics

Table I.2 draws together the key statistics on macroeconomic performance in the OECD countries during the sample period, in terms of out-

(16) See, for instance, Fischer (1993), Motley (1994), Gylfasson and Herbertsson (1996) and Andrés and Hernando (1999).

put, output growth and inflation (17). On average, the OECD countries have grown at an annual rate of 2.7 % over the past 36 years, with annual per capita income rising to \$21,600 in 1996. The differences in the rate of growth are highly significant. The 12 countries with the lowest average per capita income in the period 1961-1996 have grown 0.6 % more rapidly (in annual average terms) than the richest countries. Setting aside the extreme cases, most countries attained an annual growth rate of between 2 % and 3 % on average, except for the poorest countries, whose growth rates have been higher than 3 % per annum. Despite a tendency for these income disparities to narrow, they were still very substantial between countries in 1996 (18). For example, the per capita income of the richest country was more than five times larger than that of the poorest country.

Among the determinants of economic growth, the accumulation of productive factors plays a decisive role. Thus, the sustained growth of the OECD countries has been based on a high and relatively stable rate of investment (22.2 % on average). In general, the countries with the higher rates of investment are among those which have exhibited the highest growth rates. Conversely, among the countries that have grown less are some with very low rates of investment. Nonetheless, this preliminary look at the data does not reveal a very clear pattern as far as the relationship between the level of per capita income and the rate of investment is concerned. Indeed, the rate of investment of the group of OECD countries with lower-than-average per capita income is not significantly different from that observed for the group of the richest OECD countries.

A simple examination of the data does not offer much clarification either of the sign of the effect of inflation on economic growth. Columns 4 and 5 of Table I.2 summarise the behaviour of two indicators of price evolution for the set of countries considered: the average rate of inflation of each country, for the entire sample period, and the variability of inflation, measured by the coefficient of variation. Set against the relative uniformity of the per capita GDP growth rates, a notable dispersion in inflation rates is seen. The relationship between inflation and growth is not immediate. Grouping the countries on the basis of the level of their average per capita income over the period 1961-1996, the poorest countries have suffered an average inflation rate almost four points higher than that in the richest countries. However, from the standpoint of the rate of growth, the evidence is more ambiguous. The 12 countries that have most grown

(17) Unless stated otherwise, most of our data are taken from the OECD data base elaborated by Dabán, Doménech and Molinas (1997).

(18) Some of the exercises in the book have been extended up to 1998 without significant changes in the results. Notwithstanding, to maintain a homogeneous sample period in all three chapters we present the results obtained for this slightly shorter time span.

TABLE I.2

BASIC STATISTICS 1961-1996

	<i>Growth rate of real per capita income</i> (a)	<i>Real per capita income in 1996</i> (b)	<i>Investment (% of GDP)</i> (a)	<i>Inflation rate</i> (a)	<i>Volatility of inflation</i> (c)
European	2.8	21.1	21.7	7.0	0.63
Union G-7	2.8	23.3	23.3	5.7	0.85
OECD	2.7	21.6	22.2	8.5	0.72
High income	2.4	24.9	22.3	6.6	0.75
Low income	3.0	18.3	22.2	10.4	0.69
High growth	3.3	21.6	23.8	8.6	0.69
Low growth	2.1	21.5	20.7	8.3	0.75
High inflation	2.8	18.8	21.4	12.0	0.80
Low inflation	2.7	24.4	23.1	5.0	0.64

Source: OECD.

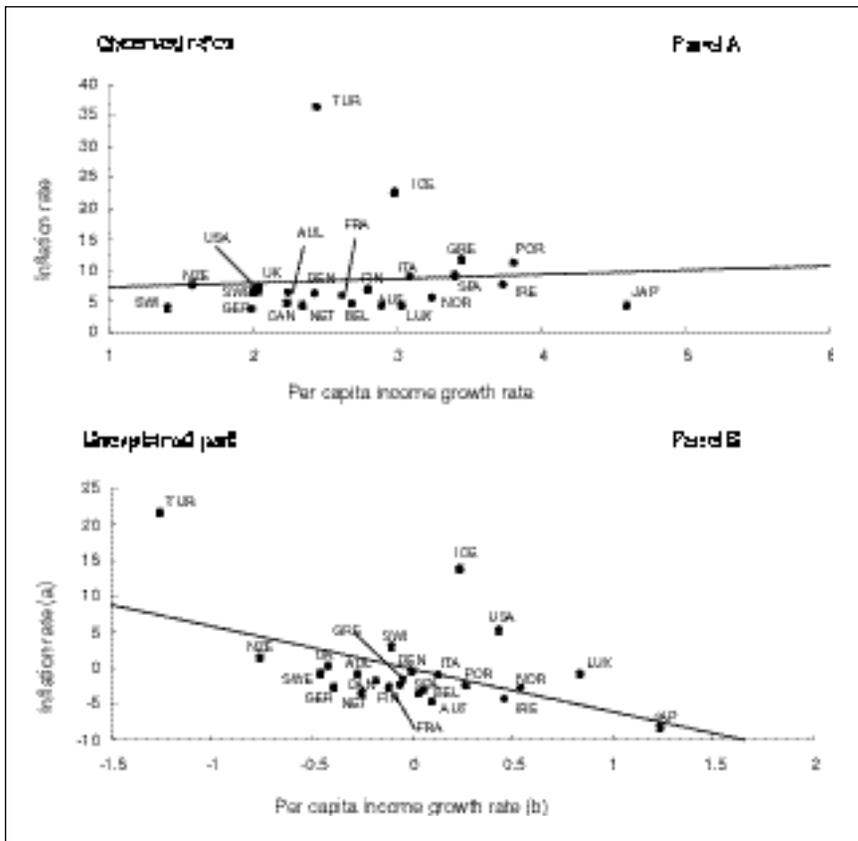
- (a) Average 1961-1996.
 (b) In thousands of 1993 US \$.
 (c) Coefficient of variation.

during the sample period do not exhibit an average inflation rate substantially different from that of the OECD as a whole (8.6 % compared with 8.3 %). Consequently, the simple correlation analysis (Panel A of Figure I.1) shows a rather imprecise relationship between inflation and the growth rate of per capita income. It must be borne in mind, however, that this correlation does not consider other determinants of an economy's growth rate, which are incorporated into the subsequent econometric analysis (in the other chapters of this book). Panel B of Figure I.1 shows that controlling for the effect of the initial income of each country in 1960, the partial correlation between the inflation rate and the growth rate becomes unambiguously negative. Moreover, there does appear to be a negative relationship between the inflation rate and the investment rate. Specifically, the average of the investment rate for the countries with lower inflation is almost two percentage points higher than that of the high-inflation countries.

The characteristics reflected in Table I.2 show very long-term trends that have not held stable throughout the period. In the period spanning 1960 to 1996, the OECD economies have experienced different periods of expansion and recession, during which time the relationship between the macroeconomic magnitudes may have changed. A more time-detailed analysis may cast some additional light on the inflation/growth relationship. This can be seen splitting the sample to three periods of similar length; these coincide with three clearly distinct phases: sustained growth (1961-1972), recession (1973-1984) and disinflation (1985-1996). The decline in growth rates since the mid-seventies is appreciable not only for the OECD as a whole (see Figure I.2) but also for the different groups of

FIGURE I.1

PER CAPITA INCOME AND INFLATION GROWTH (1961-1996)



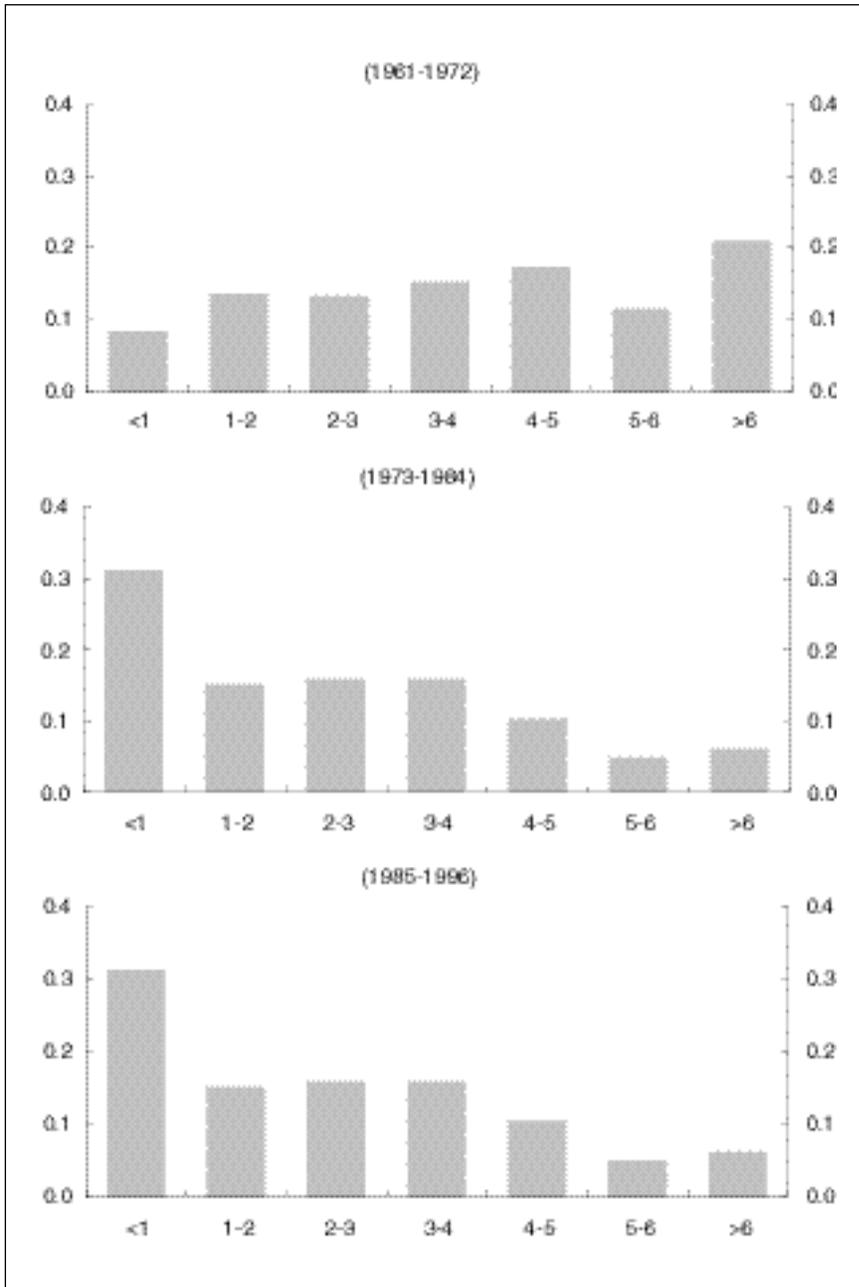
- (a) Residuals from the regression of the inflation rate on initial per capita income.
- (b) Residuals from the regression of the per capita income growth rate initial per capita income.

countries considered. The average rate is virtually halved (from 4.1 % to 2 %) between the first period considered and the other two and it is the consequence of widely differing developments within the OECD. Taken as a whole, the OECD countries have seen their investment rate gradually diminish (see Figure I.3). Thus, during the phase of sustained growth (1961-1972), the average rate of investment stood at 23.6 %, falling to 22.3 % in the period of recession (1973-1984) and to 20.8 % in the period of disinflation (1985-1993). Once again, this overall behaviour hides widely differing individual behaviour.

As can be seen in Figures I.2 and I.4, cyclical developments in the OECD economies react in a complex fashion to the behaviour of inflation.

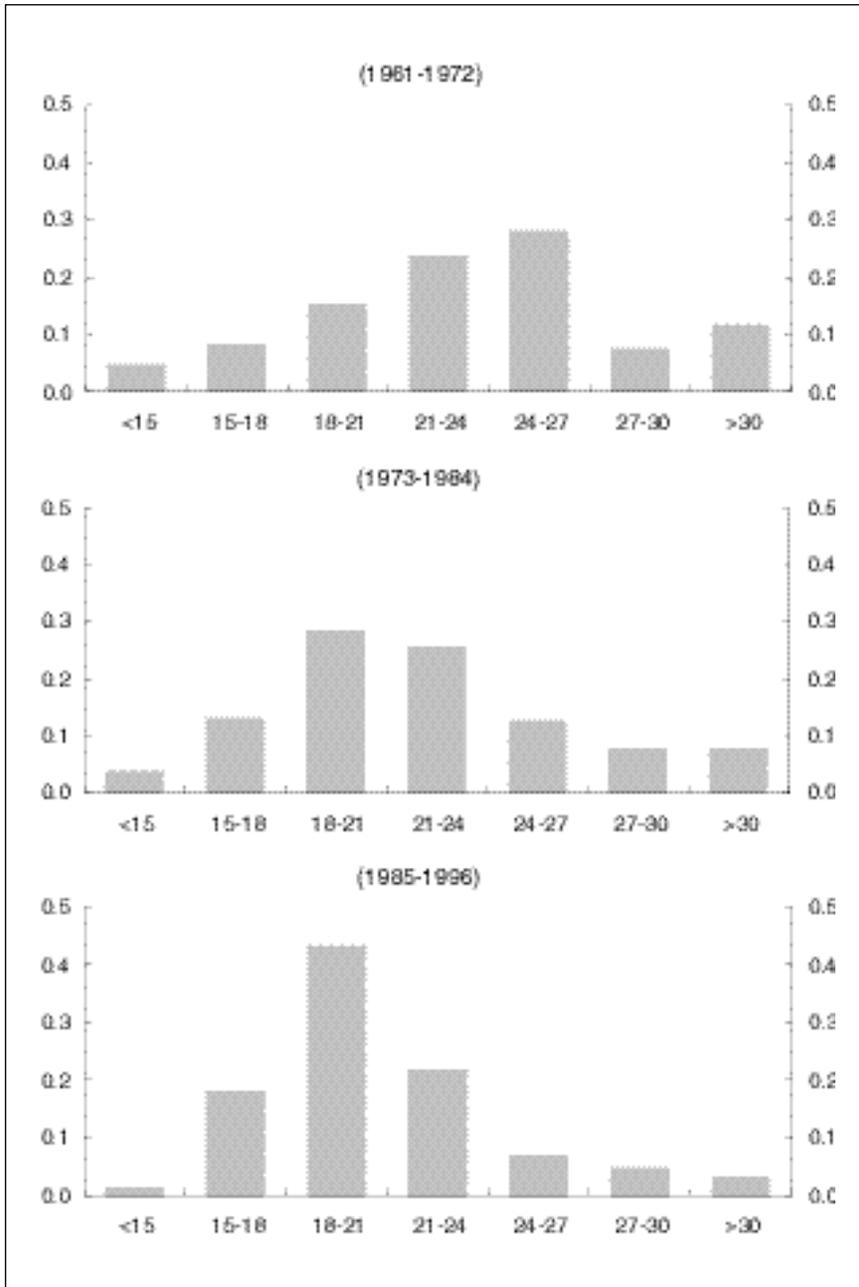
FIGURE I.2

FREQUENCY DISTRIBUTION OF PER CAPITA
INCOME GROWTH RATES (a)



(a) In percent per year. 288 observations in each panel.

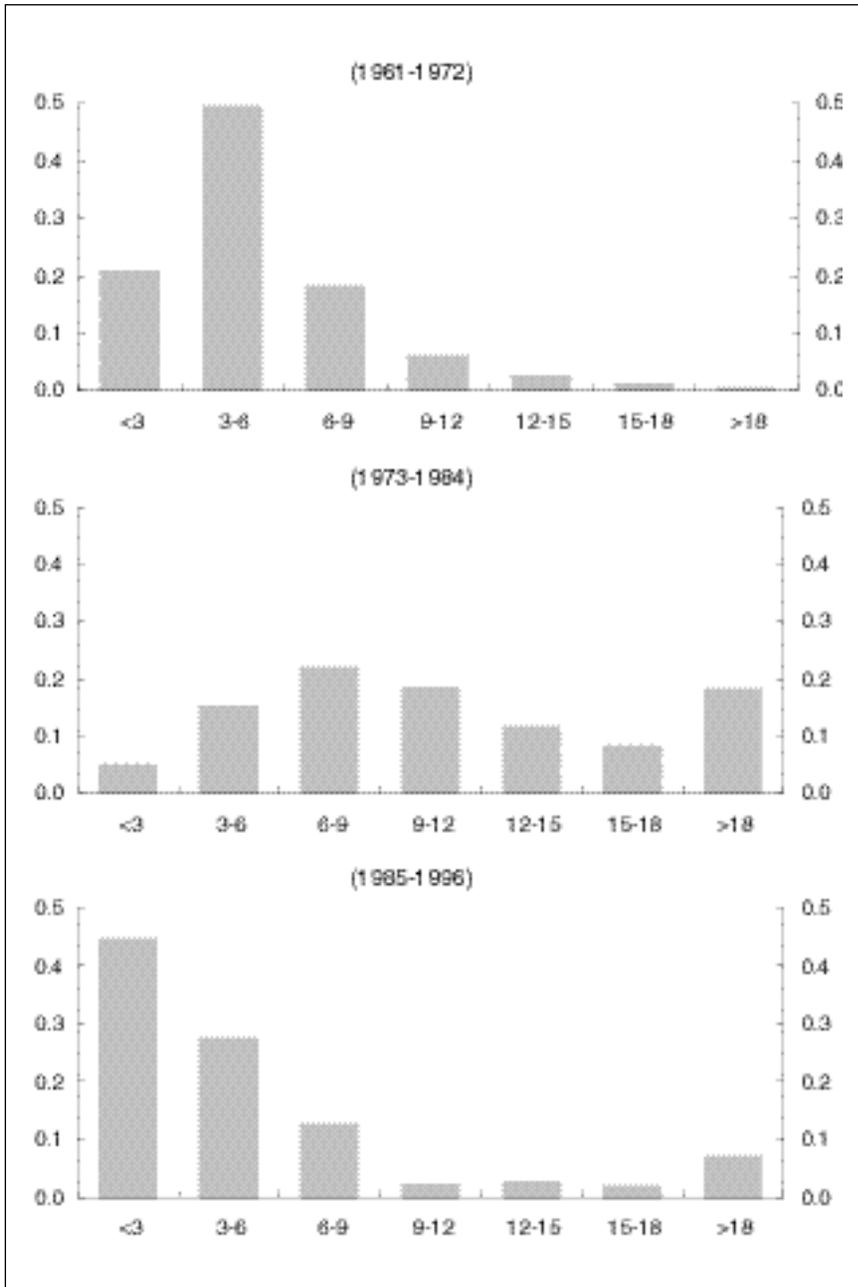
FREQUENCY DISTRIBUTION OF INVESTMENT RATES (a)



(a) In percent per year. 288 observations in each panel.

FIGURE I.4

FREQUENCY DISTRIBUTION OF INFLATION RATES (a)



(a) In percent per year. 288 observations in each panel.

Following an initial period in which nominal growth was equally distributed between growth of prices (5.3 % in annual average terms) and output (4.1 %), was one in which the inflation rate was almost sevenfold the real growth rate (12.9 % compared with 2 %). It has not been possible in the period 1985-1996 fully to restore the situation prior to 1973; during these years, and despite the ongoing efforts to keep inflation under control, inflation has still been far higher than the average growth rate of per capita output (7.3 % against 2 %). There are also significant differences across countries in this case. The richest countries were better able initially to control the inflation shock, and subsequently managed to restore pre-1973 levels. Thus, the inflation rate for G7 or for the twelve richest OECD countries has, in the 1985-1996 period, been even lower than that of the pre-recession period. Conversely, the least advanced OECD countries have, in recent years, exhibited an inflation rate almost twice as high as the one which they achieved during the period 1960-1972.

Overall, OECD economies have attained considerable growth rates, and pivotal in this connection has been the maintenance of high investment rates and the catching-up or convergence process. That said, the description of the empirical evidence given in this section is only a partial approximation to the analysis of the inflation/growth relationship, since we do not consider other determinants of growth whose incorporation into the study requires a regression analysis. Moreover, the combining of periods with differing macroeconomic results indicates that a mere cross-section analysis of broad historical averages may be insufficient to study the relationship between growth and inflation. Further, the evidence generally indicates that the richest OECD countries have grown less than the OECD-wide average, whereby the correlation between inflation and the long-term level of per capita income differs perforce from the correlation with the growth rate. This distinction points to the advisability of an analytical framework that allows an explicit distinction to be drawn between effects on the level and on the growth rate. All these issues are borne in mind in the analysis addressed in the following chapters.

II

THE COSTS OF INFLATION IN CONVERGENCE EQUATIONS

This chapter provides an estimation of the correlation among the inflation rate and some measure of the macroeconomic performance across OECD countries, within the framework of the empirical analysis based in standard models of economic growth. A series of recent papers have tried to assess the overall long run impact of current inflation within the framework of the so-called convergence equations. These equations can be derived from a theoretical model of economic growth and have several advantages for the purposes at hand. First, and foremost, an explicit model reduces the risk of omitting relevant variables. Second, convergence equations allow for a variety of effects of inflation, including those that reduce accumulation rates and those that undermine the efficiency with which productive factors operate. Finally, in this framework a clear distinction can be made between level and rate of growth effects of inflation; this difference matters as regards the size and the timing of the costs of inflation. This approach has some shortcomings too. First, the precise channels through which inflation affects growth are not made explicit and alternative channels can only be disentangled in a very rough manner. Also, growth models focus on long run issues, disregarding the short run costs associated to disinflation (the sacrifice ratio). Third, convergence equations rely heavily on the use of multi-country data sets to prevent a shortage of degrees of freedom at the cost of imposing untested restrictions in the parameter set. Finally, the direction of causality among the variables included in convergence equations is not unambiguous. Causality is a crucial issue in this field and will be discussed at length both in this chapter and in the next one.

The main results of the chapter can be summarised as follows. Even low or moderate inflation rates (as the ones that characterise the recent experience of most OECD countries) have a negative *temporary impact* upon current or future *growth rates*; this effect is significant and generates a *permanent reduction in the level of per capita income*. Inflation not

only reduces the level of investment but also the efficiency with which productive factors are used. The estimated benefit of a permanent reduction in the inflation rate by a percentage point is an increase in the steady-state level of per capita income which ranges from 0.5 % to 1 %. Although the size varies somewhat across specifications, the correlation among inflation and future income is never found positive. This result holds across different sub-samples (even excluding high-inflation countries) and is also robust to alternative econometric specifications, to the inclusion of country-specific effects and to the presence of indicators of financial development.

The rest of the chapter is organised as follows. Section II.1 describes the model. In section II.2 we present the estimated convergence equations augmented with the rate of inflation, whereas in section II.3 the empirical model is further augmented to allow for cross-country heterogeneity. In these two sections, we test the sensitivity of the results to the exclusion of high-inflation countries. Moreover, in section II.3 we estimate the long run benefits of a permanent disinflation and address the issue of whether the cost of inflation varies with the level of inflation or not. In section II.4 standard causality tests are applied to the inflation-growth relationship. In section II.5 we jointly estimate the effects of financial development and inflation on growth, to ascertain whether the estimated negative long-run effect of inflation on growth withstands the presence of banking and stock market indicators. Section II.6 concludes with some additional remarks.

II.1. Theoretical framework: The effect of inflation in convergence equations

In many growth models, money is non superneutral, so that changes in anticipated inflation reduces income. These models have proper microeconomic foundations and are easily interpretable. However, since most of the modern work on the long run relationship between inflation and income is cast in the framework of the convergence equations, we follow this path to make our results comparable with those obtained in other studies. Thus, in this section, the correlation between inflation and growth is approached within the framework of the convergence equations as proposed by Barro and Sala-i-Martin (1991), which represent the main empirical proposition of growth models with constant returns (1). In doing so, however, we do not intend to test any particular model of economic growth since, as Gylfason and Herbertsson (1996) have pointed out,

(1) De Gregorio (1993) and Roubini and Sala-i-Martin (1995) provide more elaborate models of the interaction between inflation and growth.

these equations might encompass the empirical implications of different (endogenous) growth models. The main advantage of this specification is that it systematically captures most of the factors that have been usually considered as determinants of growth, reducing the risk of omitting relevant regressors entailed in *ad hoc* specifications (2). The technology is represented by the following production function of constant returns [Mankiw, Romer and Weil (1992)],

$$Y_t = (A_t L_t)^\beta K_t^\alpha H_t^\gamma \quad [\text{II.1}]$$

Total factor productivity (A_t) grows at the constant exogenous rate ϕ , whereas fixed capital (K) and human capital (H) grow in proportion to the output assigned for their accumulation (3). Assuming that the depreciation rates of both factors are the same, it is possible to derive the following equation of growth between two moments in time (T and T + τ):

$$y_{T+\tau} - y_T = \phi\tau + (1 - e^{-\lambda\tau}) [\Omega^c + y_T^* - y_T] \quad [\text{II.2}]$$

where y_t represents the logarithm of per capita income in the period indicated by the subscript, and y_t^* represents its steady-state value. Expression [II.2] indicates that the growth rate of an economy will have a component determined by the growth in total factor productivity, ϕ , and another resulting from the economy's propensity to move to its steady-state level if, for some reason (shocks, initial conditions, etc.), it lies away from it. The rate at which the economy closes the gap between its current income and its potential or steady-state level is represented by λ (4). The steady-state level is, in turn, determined by the parameters of the production function and by the rates of accumulation of the productive factors:

$$y_{T+\tau} - y_T = \Omega^s + \phi T + \beta^{-1} [\alpha s_{Tk}^* + \gamma s_{Th}^* - (\alpha + \gamma) \log(n_T^* + \phi + \delta)] \quad [\text{II.3}]$$

where s_k^* is the logarithm of the rate of investment, s_h^* represents the logarithm of the rate of accumulation of human capital, and n^* is the growth rate of the population, all evaluated at their steady-state level; δ is the depreciation rate of capital which will be assumed equal to 3 %, while the two constants combine different parameters of the model and the starting level of technology (A_T).

This structure allows us to test the different hypotheses considered in this chapter. First, the presence of the rates of factor accumulation in

(2) In particular, unlike those equations that do not include the catching-up component, the convergence equation provides a way of controlling the level of per capita income when analyzing the determinants of its growth rate. This turns out to be of crucial importance to obtain a significant correlation between growth and inflation.

(3) In the original formulation of Solow (1956), the rate of technological progress is exogenous, although in more recent models it can be explained by the set of resources assigned to research, market size, learning-by-doing, etc.

(4) This rate can be written as: $\lambda = (1 - \alpha - \gamma) (\phi + \delta + n^*)$.

[II.3] is useful to discriminate between the two channels through which macroeconomic imbalances can affect the growth rate. If inflation reduces total factor productivity, we could expect a significant coefficient of the rate of inflation in equation [II.5]. In this case, the productivity index (A_t) might be assumed to evolve as in [II.4] (Cozier and Selody (1992)), which reflects the influence of both the inflation rate (π) and its variability (σ):

$$A_t = A_0 \exp(\phi t) \exp(\mu_1 \pi_t) \exp(\mu_2 \sigma_t) \quad [\text{II.4}]$$

The empirical specification is then given by:

$$\begin{aligned} y_{T+\tau} - y_T &= \phi\tau + (1 - e^{-\lambda\tau}) \\ &[\Omega - y_T + \phi T + \mu_1 \pi_T + \mu_2 \sigma_T + \\ &+ \beta^{-1} (\alpha s_{Tk}^* + \gamma s_{Th}^* - (\alpha + \gamma) \log(n_T^* + \phi + \delta))] \end{aligned} \quad [\text{II.5}]$$

If inflation affects growth solely through its impact on investment (s_k), the rate of inflation should be non significant in a model like [II.5] (5). Unless when necessary we shall not impose the parametric restrictions in the previous equations and we shall focus in the linear version [II.5'] instead,

$$\begin{aligned} y_{T+t} - y_T &= \Psi_0 + \Psi_1 T + \Psi_2 y_T + \Psi_3 s_{Tk}^* + \Psi_4 s_{Th}^* + \\ &+ \Psi_5 \log(n_T^* + \phi + \delta) + \Psi_6 \pi_T + \Psi_7 \sigma_T \end{aligned} \quad [\text{II.5}']$$

Second, the exogenous growth model specifies the determinants of both the long-run level of per capita income and of the sustained growth rate. Inflation can affect one and/or the other, although the implications in terms of welfare are different (6). According to the specification of equation [II.4], the impact of inflation basically impinges on the potential level of income, but not on sustained growth (represented by ϕ). To examine the latter possibility, we shall also consider an alternative specification, [II.4'], which allows for the influence of inflation on the long-run growth rate (7):

$$A_t = A_0 \exp[(\phi + \phi' \pi) t] \exp[\mu_1 \pi] \quad [\text{II.4}']$$

such that the equation to be estimated would be represented by:

(5) In this case, the impact of inflation on growth in the long run should be evaluated by estimating investment equations.

(6) See Thornton (1996) for a discussion of this issue.

(7) This is the specification proposed by Motley (1994). The variability of inflation is excluded in order to simplify the expression.

$$\begin{aligned}
y_{T+\tau} - y_T &= (\phi + \phi'\pi)\tau + (1 - e^{-\lambda\tau}) \\
&[\Omega - y_T + (\phi + \phi'\pi)T + \mu_1\pi_T + \\
&+ \beta^{-1}(\alpha s_{Tk}^* + \gamma s_{Th}^* - (\alpha + \gamma) \log(n_T^* + \phi + \delta))]
\end{aligned}
\tag{II.6}$$

In next section we estimate the elasticity of growth with respect to inflation in models [II.5], [II.5'] and [II.6].

II.2. Estimation of the effect of inflation: main results

Table II.1 displays the cross-section estimates of model [II.5] for the sample period, which imposes the restrictions implied by the technology of constant returns to scale. As a first approximation to the long-run performance of each country we proceed to take sample averages of the relevant variables for each country. Thus we are left with 24 observations, in which $T = 1960$, and $\tau = 36$. The standard model in column 1 displays a non-significant coefficient for the human capital proxy as well as a rate of convergence along the lines of those usually estimated for the OECD countries ($\lambda = 2.1$) [Mankiw, Romer and Weil (1992)]. When the model is augmented with the inflation rate (column 2), the technological parameters remain largely unchanged, and the inflation effect is found to be negative and significant ($\mu = -0.028$, $t = 3.87$) (8).

Although 36 years averages are useful to capture long-run correlations, they leave us with a severe limitation of degrees of freedom that may induce spurious results driven by the presence of some outliers in the sample. To assess the importance of this effect the model has been estimated excluding the countries with higher average inflation during the sample period: Spain, Greece, Portugal, Iceland, and Turkey (ranging from 9 % to 30 %). The only significant change is found when Iceland is excluded (column 3). This country has experienced a very high average inflation (the second in the sample, with values above 40 % in some years) but it has also achieved a high growth rate, despite its modest 1960 per capita income. These features generate a downward bias in the estimated convergence rate and inflation effect (in absolute value), which turns out to be non-negligible in a small sample as the one we are dealing with. Excluding Iceland from the sample the effect of inflation is significantly larger ($\mu = -0.042$, $t = 6.96$)

The cross-section estimates of Table II.1 give us a hint about the long-run correlation among income and inflation, but a closer inspection of the robustness of this correlation requires taking into account the time series

(8) The variability of inflation is never significant.

TABLE II.1

NON-LINEAR CROSS-SECTION MODELS

	(1)	(2)	(3) (*)
Dependent Variable	Δy	Δy	Δy
α	0.55 (3.82)	0.41 (2.73)	0.28 (1.70)
γ	0.08 (0.64)	0.04 (0.32)	-0.10 (0.71)
μ	—	-0.028 (3.87)	-0.042 (6.96)
λ021	.031	.104
R^2	0.60	0.73	0.82
σ	0.179	0.150	0.126

Notes: Non linear least squares.

(*) Excluding Iceland.

dimension of the sample. To do that, and still smooth cyclical variations, a pooled sample of four years averages of the variables of interest is used in what follows. Tables II.2 and II.3 display the estimated steady-state and convergence equations, using one and two-periods-lagged regressors as instruments. The effect of inflation is negative and significant in most specifications. The models in columns 1 and 2 of Table II.2 represent different linear versions (equation [II.5']) of the convergence equation. As predicted by the neoclassical model, the parameter of initial per capita income is negative and highly significant, both when steady-state variables are included (conditional convergence) and when they are not (unconditional convergence). In column 2, the coefficients of the input accumulation rates have the expected sign, although all of them are non-significant (9). The estimated parameter of the trend, which according to the theoretical model is approximating the rate of technological progress, has an unexpected negative sign (10). On the other hand, the trend coefficient has the expected positive sign in the steady-state equation (columns 3 and 4), but the values of the coefficients of the accumulation rates suggest a far too large

(9) This result is common to many other papers in the growth literature using cross-sections.

(10) A possible interpretation for this result is that the trend may be capturing the process of sustained reduction in the rate of growth of per capita income suffered by OECD countries during part of the sample period. We have tried alternative characterizations of technological progress: first, including time dummies instead of the linear trend and, second, imposing a rate of technological progress of 2 %. The estimated coefficients, including that of inflation, do not change significantly. These results are not reported to save space.

LINEAR MODELS
Equation [II.5']

	(1)	(2)	(3)	(4)
Dependent variable	y	y	y*	y*
1	-0.006 (2.44)	-0.005 (1.96)	0.067 (6.21)	0.051 (4.41)
2	-0.082 (4.63)	-0.092 (4.79)	—	—
3	—	0.029 (1.02)	—	0.053 (0.41)
4	—	0.012 (0.57)	—	0.401 (4.36)
5	—	-0.070 (0.80)	—	-0.629 (1.73)
6	-0.0021 (3.53)	-0.0020 (3.18)	-0.022 (10.85)	-0.018 (7.95)
R ²	0.25	0.29	0.47	0.54
.	0.058	0.057	0.275	0.260

Notes: Estimation method: instrumental variables. Instruments: constant, trend and first and second order lags of the regressors and second lag of the dependent variable. Absolute t-ratios in parentheses.

share of human capital in the production function. The coefficient of the inflation rate is negative and significant, both in the convergence and in the steady-state equation, whereas no significant effect is found from the variability of inflation (11). When the factor accumulation rates are included (columns 2 and 4) the size of the inflation effect is slightly smaller than when they are omitted (columns 1 and 3), but it is still significant. These results suggest that there are two channels by which inflation influences growth: first, through a reduction in the propensity to invest, and second, through a reduction in the efficiency in the use of inputs.

Non-linear versions of the convergence equation [II.5] in Table II.3 confirm the negative correlation among inflation and the rate of growth of economies across the OECD. The estimated parameters of the accumulation rates in the steady-state equation (column 1) are quite far from the usually obtained in the empirical literature. The effect of inflation is negative and significant. The estimated coefficients in the convergence equa-

(11) As in the cross-section models, this is a feature of all specifications tried and, thus, the equations presented hereafter exclude this variable.

TABLE II.3

NON-LINEAR MODELS
Equation [II.5]

	(1)	(2)	(3)	(4)
Dependent variable	y^*	Δy	Δy	Δy
Ω^s	-0.14 (0.20)	—	—	—
Ω^c	—	-2.01 (1.71)	-0.49 (0.52)	-0.02 (0.71)
α	0.05 (0.71)	0.30 (2.99)	0.27 (2.78)	0.30 (2.83)
γ	0.28 (5.19)	0.17 (2.11)	0.10 (1.28)	0.14 (1.59)
ϕ_{ss}	0.05 (4.58)	—	—	—
ϕ_c	—	-0.03 (1.10)	-0.00 (0.12)	-0.03 (1.41)
ϕ'	—	—	—	0.003 (2.07)
μ_1	-0.019 (9.10)	-0.019 (5.46)	-0.025 (7.77)	-0.13 (2.29)
λ	—	0.031	0.035	0.032
R_{ss}^2	0.55	—	—	—
R_c^2	—	0.26	0.29	0.26
σ_{ss}	0.256	—	—	—
σ_c	—	0.058	0.055	0.058

Notes:

- Estimation method: see notes in Table II.2
- Absolute *t*-ratios in parentheses.

tion (column 2) look similar to those found in the cross-section with an implicit rate of convergence around 3.1 %. Again, the effect of inflation is negative and significant.

Multi-country pooling estimates, in which typically the number of countries is not very large, are very often criticised on the basis of the large influence of a few extreme values. In particular, the estimated negative correlation among inflation and income might well stem from the experience of some high inflation countries. As a first approximation to this issue we have carried out some tests of the sensitivity of the inflation coefficient to the sample definition. The most noticeable change in the esti-

mated coefficient takes place when Iceland is excluded from the sample. In such case (column 3 of Table II.3) the correlation among inflation and growth is significantly higher than when it is included. This is not surprising since Iceland being the country with the second highest average inflation within the OECD, is also a high-income fast-growth economy which may be generating a downwards bias (in the absolute value of) the growth-inflation correlation.

The negative effect of inflation on per capita income seems to be robust both in the steady-state and in the convergence equation. This however does not settle an important issue, namely whether high inflation rates lead to a permanent fall in the *rate of growth* of income per capita or if this effect is just permanent on the *level* of that variable, but temporary on the rate of growth. To discriminate between these effects we have estimated equation [II.6], allowing for an effect of inflation both on the steady-state level of income (μ) and on the permanent component of the growth rate (ϕ'). Both these coefficients are negative and significant when they are introduced individually, but when they are jointly included in the model (column 4) the effect on the trend component takes an unexpected positive sign. This would indicate that the negative effect of inflation impinges upon the level of per capita income but not on the sustainable rate of growth of the economy. Thus, the impact on the growth rate is transitory, as long as convergence is under way.

Summing up, the analysis in this section, in accordance with other studies, supports the evidence of an adverse influence of inflation on growth. As regards the size of this effect, if we take the coefficient in column 3 of Table II.3 as a reliable estimate of the long-run effect of inflation upon growth, an increase in average inflation by one percentage point reduces per capita growth by 0.08 points per year. This fall in the growth rate is not permanent but it lasts for a long period leading to a permanent reduction in steady-state per capita income of 2.5 % (12). However, before drawing any policy implication out of these figures it is convenient to take a closer look at the relationship between inflation and growth, trying to correct for some biases that might arise in specifications like the ones studied so far.

II.3. Country-specific effects and the cost of inflation

The use of information for wide groups of countries in empirical analyses of economic growth makes it possible to focus on the low-frequency

(12) To make these computations we use model [II.5]. The short run increase in the rate of growth is obtained as $[100(1 - e^{-\lambda T})\mu_1/4] = 0.08$, whereas the long run increase in per capita income is simply $[100\mu_1] = 2.5$. When Iceland is included in the sample, these figures are 0.05 and 1,9 % respectively.

properties of the data. This requires taking time series averages and, thus, having information about different countries or regions prevents from running in a severe shortage of degrees of freedom. However, this approach imposes a very strong restriction, namely that the data for all the economies of the sample stem from the same theoretical distribution, i.e. the technological parameters are homogeneous across countries. This assumption is seldom explicitly tested, although its empirical implications may be very important [see Pesaran and Smith (1995)]. The existence of technological differences in the rates of technical progress or, as it is more likely, in the initial conditions of each country, goes against that assumption and might render lagged regressors inappropriate as instruments in growth equations, generating biased estimates of the parameters of interest (13).

In this section, we test whether the estimated negative effect of inflation on growth is biased due to the omission of these country-specific (time-invariant) effects. The main results are summarised in Table II.4. In column (1), the linear model (equation [II.5']) has been estimated under the assumption that the omitted individual effects are not correlated with the regressors. The random effects estimates, and in particular the coefficient of the inflation rate, resemble very much those of the basic model depicted in column (2) of Table II.2. Nevertheless, the reasons to include country-specific effects in the model suggest that the assumption of lack of correlation among these and the regressors might not be appropriate in this setting. Thus, in what follows we focus on the fixed effect estimates, which we compute including dummies in the linear convergence equation. All the models have been estimated by instrumental variables (see note of Table II.4, for details). When we add a dummy variable for each country (column 2) the explanatory power of most regressors changes, as compared with the models in the previous section. In particular, while inflation still has a negative effect on income its t-statistic is now lower (-0.75). The changes in the rest of the model are far more radical though. First, whereas the negative trend coefficient was an unappealing feature of the models in section II.3, this coefficient now becomes positive and significant, with a reasonable point estimate of 0.03. Second, the point estimates of the technological coefficients are now either non-significant or wrongly signed. In fact, excluding the accumulation rates from the equations, the negative correlation between growth and inflation becomes significant with a t-statistic of -2.06 (column 3). Finally, several country dummies are not different from zero, which means that the model might be over-parameterised.

(13) For a discussion of the importance of individual effects in the constant term of convergence equations see Knight, Loayza and Villanueva (1993), Islam (1995), Barro (1996) and Andrés and Boscá (2000), among others.

CONVERGENCE EQUATION WITH INDIVIDUAL EFFECTS
Equation [II.5']. Dependent variable Δy

	(1)	(2)	(3)	(4)	(5)
Ψ_1	-0.01 (1.80)	0.03 (2.87)	0.03 (3.57)	0.01 (1.77)	0.02 (3.31)
Ψ_2	-0.08 (4.43)	-0.57 (4.67)	-0.45 (5.56)	-0.29 (4.30)	-0.38 (5.99)
Ψ_3	0.06 (2.34)	-0.16 (1.58)	—	0.05 (1.58)	0.03 (1.16)
Ψ_4	0.01 (0.24)	0.05 (0.69)	—	0.04 (1.00)	0.04 (1.81)
Ψ_5	-0.03 (0.45)	0.02 (0.09)	—	-0.10 (1.08)	-0.11 (1.43)
Ψ_6	-0.0018 (3.23)	-0.0009 (0.75)	-0.0016 (2.06)	-0.0026 (3.34)	-0.0025 (3.34)
R^2	0.31	0.35	0.47	0.46	0.43
σ	0.056	0.059	0.053	0.052	0.052
Ψ_6 (LI)		-0.0077 (1.70)		-0.0119 (4.61)	
Ψ_6 (HI)		-0.0016 (2.05)		-0.0022 (2.50)	
Ψ_6 (HI-ICL)		-0.0013 (1.33)		-0.0020 (2.27)	

Notes:

— HI: sample of 6 countries with the inflation rate above the OECD average; LI: OECD excluding HI countries; HI-ICL: as HI, excluding Iceland.

— Estimation method col. (1): random effects; Instruments: lags of the regressors.

— Estimation method cols. (2)-(5): Country-dummies; Instruments: as in Table II.2 plus country dummies and inflation variability.

— Dummy variables included:

— Columns (2) and (3): one for each country except Australia.

— Column (4): one for: each of the following countries: Canada, Switzerland, Germany, Spain, United Kingdom, Greece, Ireland, Iceland, Luxembourg, New Zealand, Portugal, Iceland, Turkey and United States.

— Column (5), one for each of the following countries: Spain, Greece and Turkey and one for each of the following country groups: Ireland and Portugal; Canada and Germany; Switzerland, Luxembourg, Iceland and United States; and Finland, New Zealand and United Kingdom.

The search for a more parsimonious specification proceeds along the following steps. Starting from the model with a dummy variable for each country, the non-significant dummy variables have been removed, setting aside the one with the lowest t-statistic each time. As a second step, these excluded variables have been added again, one at a time,

retaining those with a t-ratio greater than 1.5 (14). Every time a dummy variable is added back into the model, the process is reinitiated. This procedure does not involve the analysis of every single possible specification according to all the combinations of country-specific constants. However, it provides a model selection procedure that allows us to test, at least twice, the marginal significance of each dummy variable: first, against a more general model (with all the country-specific dummies) and next against a more restricted one. The model in column 4 summarises the final outcome of this specification process. The results do not change very much with respect to those in column 1, except in that now the coefficient of the inflation rate is negative and significant and its size is larger than that obtained for the model without individual effects. Furthermore, this result is quite robust to the set of country-specific dummies included in the regression. The same search process has been also carried out for different sub-samples with different average inflation rates. The point estimates of the inflation coefficient, along with its confidence interval, are depicted in Figure II.1. The coefficient of inflation turns out to be larger and more significant whenever high inflation countries are not considered. Hence, the estimated correlation between inflation and growth (or income) does not depend on the presence of high inflation countries in the sample.

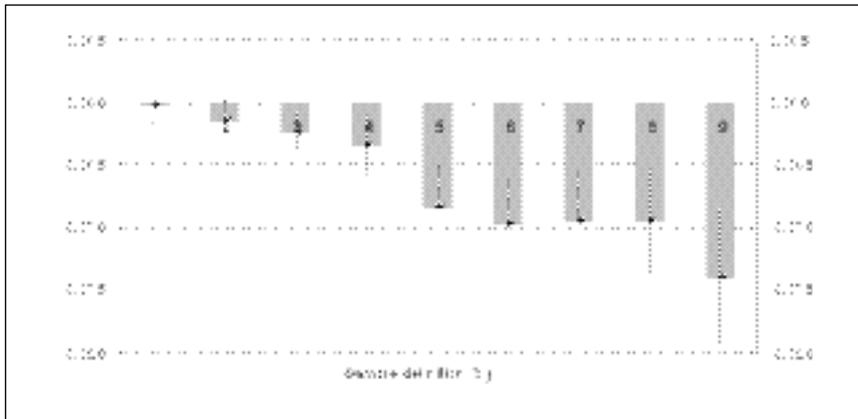
Taking column 4 as a starting point, in the model in column 5 individual dummies are clustered into country-group dummy variables. The t-statistic of the inflation rate is still very high in absolute value (-3.34) (15). The country groups in column 5 have been defined according to the size of the individual effect. Turkey's individual effect is negative (-0.34) as compared with the excluded countries, followed by Greece (-0.15), Ireland and Portugal (-0.14), Spain (-0.13), New Zealand, Finland and the United Kingdom (-0.05). On the other hand, Canada and Germany (0.02), Iceland (0.07) and Switzerland, Luxembourg and the United States (0.10) display a positive individual effect on the growth rate (16). The estimated individual effects reveal a systematic pattern which, if ignored, could have led to a bias in the estimated effect of inflation. The individual effect is strongly correlated with the level of per capita income achieved at the end of the sample period. Thus, omitting the individual effect, the model would underestimate the growth of the richest countries overestimating that of

(14) If the threshold level of the t-ratio is 2.0, the final specification is more parsimonious. Nevertheless, the estimated long run coefficient of inflation does not depart very much from that in column 4.

(15) As in column 2, the coefficients for the input accumulation rates are not significant. The exclusion of these variables does not worsen substantially the fit of the equation and further increases the significance level of the inflation rate.

(16) The omitted countries are Australia, Austria, Belgium, Denmark, France, Netherlands, Italy, Japan, Norway and Sweden.

SENSITIVITY OF THE INFLATION COEFFICIENT TO THE SAMPLE DEFINITION (a)



Notes:

(a) The figure depicts the estimated coefficient for inflation in model [II.5] (bars) as well as the 95 % confidence intervals (lines) for different sample definitions.

(b) Sample definition:

1. High inflation countries (above OECD average).
2. High inflation countries (excluding Iceland).
3. OECD.
4. OECD excluding Turkey.
5. OECD excluding Turkey and Iceland.
6. OECD excluding Turkey, Iceland and Portugal.
7. OECD excluding Turkey, Iceland, Portugal and Greece.
8. OECD excluding Turkey, Iceland, Portugal, Greece and Spain.
9. Low inflation countries (below OECD average).

the poorest countries. Since there is a negative correlation, at the OECD level, between per capita income in 1993 and the average inflation rate, excluding the individual effects is a source of potential upwards bias in the estimation of the effect of inflation. Indeed, although the estimated coefficient of inflation remains largely unchanged, as compared with that in Table II.2, there is, nevertheless a significant change in the point estimate of the long-run effect of inflation once country-specific dummies are included in the model. The coefficient of initial GDP is now almost five times larger than the one in Table II.2, thus the estimated long-run cost of inflation is now lower. A permanent increase in one percentage point leads to a 0.9 % permanent fall in output. This time, though, the transition period is much shorter since a higher coefficient of initial GDP means that convergence to the steady-state is much faster too.

Although OECD economies share certain common institutional features, their inflation performances are rather different. Once we have a more accurate estimate of the long-run cost of inflation we can address the issue of whether this cost varies according to the level of inflation or not.

The different perspectives adopted to analyse the linearity of the inflation effect have led to contradictory results. For instance, Barro (1995), estimating different coefficients for different levels of inflation, finds a greater effect of inflation on growth the greater the inflation level (17). Motley (1994), estimates the growth model for different sub-samples and concludes the opposite. We have tried these two approaches in equation [II.5'] and found that they also yield somewhat different results for the OECD, although the coefficients of inflation in different sub-samples were not very precisely estimated. In general, though, the coefficient corresponding to lower inflation rates tends to be higher although, in some cases, with a lower t ratio. This would indicate that the benefits of lower inflation are indeed higher at low rates, although the functional form might be inappropriate to capture this result. As an alternative, we have estimated the basic model allowing for a non-linear effect of inflation on growth. Including π and π^2 , both coefficients are significant while the positive coefficient on π^2 indicates that the marginal cost of inflation is positive but decreasing with its level. Two alternative specifications that allow for a falling marginal cost of inflation have also been tried. In these, inflation is represented by $\log(\pi)$ and the ratio $(\pi / (1 + \pi))$, respectively (18). In all these specifications the fit is better than in the models with the level of inflation.

A further test of linearity has been carried out in the model in which inflation enters in logs. In panel A of Table II.5, a different coefficient is allowed for $\log(\pi)$ depending on the level of inflation. These coefficients are always negative and significant but not statistically different. As an alternative approach, the homogeneity assumption may be relaxed by estimating the convergence equation for different sub-samples. This approach allows all the parameters, and not only the coefficient of inflation, to vary across sub-samples. The results are summarised in panel B of Table II.5. The effect of inflation is negative and significant for low (although not for very low) as well as for high (and very high) inflation countries and the coefficient of $\log(\pi)$ is similar across different sub-sample specifications (19). The results of these two approaches lead us to conclude that the elasticity of income with respect to inflation does not change significantly with the level of inflation. If anything, this tells us that it may be more costly for a low-inflation country to concede an additional (and permanent) point of inflation than it would be for a country with a higher starting rate (20).

(17) Although the null of linearity cannot be rejected [see also Barro (1996)].

(18) Gylfason and Herbertsson (1996) propose this nonlinear transformation.

(19) The coefficient of initial GDP is also similar across the specifications in panel B of Table II.4. Thus, the hypothesis of homogeneity in the long-run elasticity cannot be rejected either.

(20) The exercises on Table II.5 have been carried out for different inflation regimes and also for different specifications of the equation and the inflation term. The overall picture

LINEARITY OF THE INFLATION EFFECT
Elasticities of income with respect to inflation in estimates of the linear
version of the convergence equation

A. Whole sample estimates with specific inflation coefficients	
Low inflation (a)	-0.098 (2.64)
Medium inflation (a)	-0.071 (3.71)
High inflation (a)	-0.074 (4.97)
B. Sub-sample estimates	
Low inflation (b)	-0.064 (2.93)
High inflation (b)	-0.058 (4.88)
Very low inflation (c)	-0.046 (1.45)
Very high inflation (c)	-0.063 (4.37)

Notes:

— Estimation method: see notes in Table II.2.

— Absolute t-ratios in parentheses.

(a) Low inflation: observations with inflation lower than 6%; Medium inflation: observations with inflation between 6% and 12%; High inflation: observations with inflation greater than 12%.

(b) Low inflation: countries with average inflation lower than the median; High inflation: countries with average inflation greater than the median.

(c) Very low inflation: eight countries with the lowest inflation. Very high inflation: eight countries with the highest inflation.

Table II.6 shows the long-run impact on income of one percentage point permanent reduction of inflation, for a variety of specifications of the effect of inflation (21). When using the whole sample of OECD countries, the estimated long-run benefit of a reduction of inflation from 20 % to 19 % varies from 0.30 % to 0.80 %, with an average value of 0.5 %. At lower in-

that comes out of these exercises is the same. The coefficient of the inflation term is negative in most cases and it tends to be bigger (in absolute value) at low inflation rates, although with lower t-statistics as well. In a few specifications the coefficient for very low inflation rates (below 3-4 %) is positive, although never significant. This issue deserves a more careful scrutiny, since it might well be that inflation ceases to be costly at all at very low levels. Since we have very few data points with inflation under 3 % in our sample, we have not been able to pursue this further. Sarel (1996) concludes that the cut-off point might be at an 8 % rate of inflation. However, both the model and the data used differ from ours in several respects.

(21) All models include country-specific constants.

TABLE II.6

LONG RUN EFFECT OF INFLATION ON PER CAPITA INCOME (a)

Model ^(b)	OECD		OECD (Ex. Iceland)	
	Low π ^(c)	High π ^(d)	Low π ^(c)	High π ^(d)
π, π	1.60 %	0.80 %	2.10 %	1.25 %
$\pi/(1 + \pi)$	0.50 %	0.40 %	0.95 %	0.70 %
Log(π)	1.40 %	0.30 %	2.10 %	0.40 %
π	0.30 %	0.30 %	0.55 %	0.55 %

Notes:

(a) The long run effect is calculated as the partial derivative of income per capita with respect to inflation in the long-run solution of the model. In the linear case (last row) this is simply the coefficient of inflation divided by the coefficient on initial income. In the other cases there is an additional term which depends on average inflation. The model has been estimated including all country dummies, which make the results of the linear case slightly different from other reported in this chapter.

(b) The variables in the first column indicate the way in which inflation enters in each model.

(c) Low π : reducing inflation from 4 % to 3 %

(d) High π : reducing inflation from 20 % to 19 %

— Initial GDP non instrumented.

flation levels (from 4 % to 3 %), the benefit of the same reduction in inflation is higher, with an average 1 % increase in steady-state income. These estimated values are all rather similar except for the specification in logarithms, which overrates the benefits of disinflation at low inflation levels.

These benefits are not large, but it must be noticed the estimated convergence rate is higher than the usual 2-3 %. This means that the transition period until the increase in GDP actually takes place is shorter; thus, it would not take the representative economy much time to reap the full benefits of a sustained disinflation. In Table II.7 we compare the cost of inflation estimated in the basic model (column 2, Table II.2) with the one obtained in the model with country specific effects (column 4, Table II.4). The estimated benefit from a permanent reduction in the inflation rate by one percentage point is higher in the former (2.2 % versus 0.9 %). Nevertheless, since this is a steady-state effect and the convergence rates also differ across models (2.4 % versus 8.6 %), the relevant comparison should be made in present value terms, which makes the outcome dependent on the discount rate. According to the figures in this example, for discount rates slightly above 4 % the benefit of disinflation is larger in models with faster dynamics, despite the lower per capita income gain in the steady-state. Hence, the present value of the per capita income gain might well be within the range of those found in other studies.

II.4. Causality analysis

The models studied in previous sections focus on the contemporaneous correlation between inflation and growth, while the literature presents

TABLE II.7

**PER CAPITA INCOME GAIN FROM REDUCING INFLATION:
STEADY-STATE AND PRESENT VALUE**

	<i>Basic model</i>	<i>Country effects</i>
Steady-state per capita income gain (a)	2.2 %	0.9 %
(b)	2.4 %	8.6 %
Half-life per capita income gain	1.1 % (28 years)	0.45 % (8 years)
Present value: discount rate 4 % (c)	0.37 %	0.33 %
Present value: discount rate 5 % (c)	0.28 %	0.30 %

Notes:

(a) Computed as the coefficient of inflation (β_6) divided by the coefficient on initial income (β_2) in the converge equation augmented with country dummies (equation [II.5']). From equations [II.5] and [II.5'], $\beta_2 = -(1 - e^{-\mu_1})$ and $\beta_6 = -(1 - e^{-\mu_1})\mu_1$. Thus, $\mu_1 = -\beta_6 / \beta_2$.

(b) From equations [II.5] and [II.5'], $\beta_2 = -(1 - e^{-\mu_1})$, i.e. $\mu_1 = -0.25 \ln(1 + \beta_2)$.

(c) Discounted present value of half-life gain (expressed in percentage points of steady-state per capita income).

arguments in favour of causality in both directions. This might generate a non-negligible bias in the estimation of the magnitude of costs associated with high inflation. The correlation between inflation and growth depends on the nature of the shocks that hit an economy; hence, the estimated negative correlation between inflation and growth might well be driven by the predominance of negative supply shocks during the sample period. To test this possibility we have estimated the convergence equation for two periods: one in which demand shocks predominated (1961-1972 and 1989-1996), and the other in which supply shocks have been probably more significant (1973-1988) (22). The results of this split are shown in Table II.8, where we present only the coefficient on inflation for both the OLS and the instrumental variable (IV) estimation. As expected, the IV coefficient is higher, in absolute value, than the OLS coefficient for the first period given the nature of the expected bias. Both coefficients are similar for the second period. But in all cases, the coefficients are negative and significant, meaning that the negative supply shocks that hit the OECD economies during most of the second half of the sample period are not primarily responsible for the estimated negative correlation association between inflation and growth. If this had been the case, we ought to find a positive coefficient for the first period, at least in the OLS estimation. The finding of negative coefficients for both periods strengthens the view that

(22) Similar results were obtained when we split the period up in other two parts: 1961-1976, for demand shocks predominance, and 1977-1996, for supply shocks predominance.

INFLATION EFFECT FOR DIFFERENT PERIODS
Coefficients of inflation in a linear version of the convergence equation (a)

A. Demand shocks predominance period (b)		
OLS		-0.002 (2.66)
IV (c)		-0.003 (3.36)
B. Supply shocks predominance period (b)		
OLS		-0.005 (4.82)
IV (c)		-0.005 (3.09)

Notes:

- (a) Equation [II.5'] excluding the trend.
 (b) Demand shocks predominance period: 1961-1972 and 1989-1996. Supply shocks predominance period: 1973-1988.
 (c) Instruments: constant, first and second order lags of the regressors and second lag of the dependent variable.
 — Absolute t-ratios in parentheses.

there is indeed a genuine negative effect of inflation upon growth that does not rely on the influence of supply shocks on inflation and growth.

In order to pursue this issue more thoroughly, this section analyses the statistical causality, as formulated by Granger, of inflation to growth and vice-versa. This perspective is broader than that of convergence equations in several ways. First, the analysis of causality focuses on the study of non-contemporaneous effects of one variable on the other. Second, using a more flexible specification, we avoid the imposition of the parametric restrictions of the neo-classical growth model, which might make the correlation that concerns us here less clear. The analysis of causality carried out in this section does not put theoretical growth models aside though. Economic theory suggests a series of growth determinants that can be incorporated into the information set in the tests of causality.

To analyse the causality running from the rate of inflation to the level of per capita income, a test is run on the joint significance of $\{d_1, \dots, d_p\}$ in the model (23):

(23) Testing the causality from the rate of inflation to the growth rate only entails adding a linear restriction on the coefficients in C(L), and writing per capita income in first differences. The results of the causality tests to the growth rate are quite similar to those of the causality tests to the level of per capita income and will not be reported here to save space.

$$y_t = A + C(L)y_t + D(L)\pi_t + G(L)X_t + \mu_t \quad [II.7]$$

where y_t , π_t are vectors (24 x 1) of current observations of the logarithm of per capita GDP and of the rate of inflation, respectively, for 24 member countries of the OECD, X_t is a vector of additional regressors, suggested by growth theory and A is a vector (24 x 1) of constants. $C(L)$, $D(L)$ and $G(L)$ are matrices of order (24 x 24) in which the elements outside the main diagonal are zero and the element within the main diagonal is a lagged polynomial of order p such as (for $D(L)$, for example):

$$d_1L + d_2L^2 + d_3L^3 + \dots + d_pL^p$$

The rejection of the null hypothesis that the d_j 's are zero indicates that current inflation helps to reduce the mean-squared error in the prediction of per capita income and, therefore, that π causes y in the Granger sense. Likewise, the causality from the growth rate to inflation is tested through the joint significance of $\{e_1, \dots, e_p\}$ in:

$$\pi_t = B + E(L)\Delta y_t + F(L)\pi_t + H(L)X_t + \varepsilon_t \quad [II.8]$$

where $E(L)$, $F(L)$ and $H(L)$ are matrices of a structure similar to $C(L)$ and B is a vector (24 x 1) of constants. The rejection of the null hypothesis that the coefficients e_j are zero indicates that Δy causes π .

The elements of the matrices A and B , as well as the coefficients of the lagged polynomials (in $C(L)$, $D(L)$, $E(L)$, $F(L)$, $G(L)$ and $H(L)$), will be assumed to be homogeneous among countries unless expressly stated otherwise (24). The estimation of [II.7] and [II.8] raises several methodological issues, the most important one being the possibility that some variables are non-stationary, in which case exclusion tests do not have a standard distribution. There are several ways in which the hypothesis of causality between integrated variables can be tested, making use of statistics with asymptotic standard distribution. These procedures basically consist of a re-parameterisation of the model in order to obtain stationary regressors (25). The method proposed by Dolado and Lütkepohl (1996) does not require a search for possible cointegration vectors which is quite often a hazardous task in panel data models. These authors propose the estimation of a VAR in levels of order $p + 1$. The exclusion test

(24) Since this section applies annual data relating to the variables of interest for 24 OECD countries, it departs from the traditional approach in the empirical literature on growth, which avoids using annual information. Nevertheless, an increasing number of studies tend to use raw annual data. Moreover, in the dynamic analysis of causality, models based on time averages can be considered as restricted versions of models that use annual data. As regards the role of individual effects in multi-country regressions, we shall take them into account in this section by considering several specifications in which vectors A and B include a different constant for each country (a_i , b_i).

(25) See Sims, Stock and Watson (1990).

performed on the p first lags is thus distributed asymptotically as an F , while the efficiency loss is compensated by the simplicity of the test (26). The application of this method requires knowing the true order p ; rather than discussing the lag structure in detail, we present results for a sufficiently broad range of lags that ensure the stationarity of the residuals.

Table II.9 displays the results of the causality tests from the rate of inflation to the level of per capita income. It summarises the significance level for the null hypothesis that the inflation coefficients are jointly non-significant in alternative specifications for [II.7]. In addition, it gives the t -statistic for the sum of these coefficients. The exclusion test in [II.7] has been performed for six different structures of lags (p going from 3 to 8) and for five sets of additional regressors (X_i). Model 1 includes neither additional regressors ($g_j = 0$) nor constant individual effects. Model 2 includes individual constant effects so that A is a vector of different constants, one for each country. Model 3 incorporates, in addition to individual effects, several other regressors such as a linear trend, the savings ratio, the rate of schooling and the growth rate of the population, all of them contemporaneous. Model 4 is similar to the previous model, but with the first lag (instead of the current) accumulation rates. Finally, model 5 incorporates, in addition to the regressors of model 4, the first lag of money growth, exports growth and public spending as a percentage of GDP. The results in Table II.9 may be summarised as follows. In 22 out of the 30 considered cases, the null hypothesis that the inflation coefficients are jointly non-significant, and hence that inflation does not cause income, can be rejected at the 10 % level. Furthermore, the sum of the lagged coefficients of inflation is negative in 29 out of the 30 cases. This would imply that higher inflation today anticipates lower income in the future. However, the evidence of a long run effect of inflation upon income is not unequivocal since the sum of the coefficients of the inflation lags is significantly different from zero (at the 10 % level) in just a half of the cases. This is worrisome since a non-significant long run coefficient can be interpreted as if the effect of inflation on the long run level of income is not permanent, casting some doubts on the validity of the correlation found in previous sections.

The last two columns of Table II.9 indicate the results for the model with the largest set of additional regressors: individual effects, lagged accumulation rates and several macroeconomic variables. Many authors have studied the relationship between long-term growth and the short-term performance of economies (27). The main argument on which this

(26) For an application of this method, see Andrés, Boscá and Doménech (1996).

(27) See Levine and Renelt (1992), Fischer (1993) and Andrés, Doménech and Molinas (1996), among others, for alternative views of the influence of macroeconomic shocks on growth.

TABLE II.9

CAUSALITY FROM INFLATION TO PER CAPITA INCOME

p	Model 1		Model 2		Model 3		Model 4		Model 5	
	χ^2	t								
3	4	-2.75	9	-2.43	5	-2.58	23	-1.78	2	-2.93
4	11	-1.34	27	-0.93	15	-1.12	30	-0.01	4	-1.29
5	0	-2.97	3	-2.38	1	-2.69	10	-1.62	1	-2.52
6	0	-1.93	3	-1.73	2	-1.50	19	-1.01	1	-2.15
7	0	-0.40	2	-0.27	2	-0.48	6	0.24	1	-0.81
8	2	-1.11	5	-0.98	16	-1.50	23	-0.54	6	-1.68

Notes:

χ^2 denotes the significance level for the null hypothesis that the inflation coefficients are jointly non-significant.

Model 1: Basic model with no individual effects nor additional regressors.

Model 2: Model with individual effects.

Model 3: Model with individual effects, a trend and accumulation rates (investment rate, schooling, rate of growth of population).

Model 4: Model with individual effects, a trend and lagged (t-1) accumulation rates.

Model 5: As in model 4 including some lagged (t-1) macroeconomic indicators (money growth, exports growth and public spending as a percentage of GDP).

relationship rests is that the shocks hitting an economy or the way economic policy is conducted influence the agents' accumulation decisions and the way markets operate. Thus, a succession of negative shocks or an inadequately designed fiscal or monetary policy may have effects that go beyond the short term, affecting potential output and sustained growth. If this argument is correct, the causal interpretation of the estimated correlation between inflation and growth could be called into question. The estimated correlation between growth and inflation could be due simply to the fact that inflation approximates the impact of other macroeconomic variables with which it is strongly correlated. Including these macroeconomic variables in the model makes it possible to isolate the influence of inflation on growth from the effect of other shocks. The results indicate that after taking into account the effect of fiscal and monetary policy and the export performance, the existence of causality of a negative sign from inflation to economic growth becomes more apparent. The null hypothesis that inflation does not help to improve the prediction of the future growth rate is clearly rejected in all cases. The statistic associated with the sum of the coefficients of the inflation lags is negative in all cases and statistically significant in most of them (28).

Although the results of these causality tests are not fully conclusive, their importance is enhanced if we compare them with some similar tests

(28) In four out of ten cases, at a 10 % significance level, and in three of them at the 5 % level.

relating growth to other variables such as investment in physical and human capital or public spending. Blömstrom, Lipsey and Zejan (1996) show that growth always precedes investment, rather than the other way round. Carrol and Weil (1993) obtain a similar result for the OECD sample. What these authors find is that most of the observed positive correlation among investment and growth (or income) can be attributed to reverse causation. Reasoning on similar grounds, many authors suspect that something of this kind might be behind the correlation among inflation and growth [Kocherlakota (1996)].

Interestingly enough, unlike what happens with investment and schooling, in this case the causality running from income growth to inflation is indeed significant but with a sign that weakens, rather than strengthens, the case for reverse causality. Table II.10 displays the results of the causality tests from growth to the rate of inflation. The exclusion test in [II.8] has also been performed for six different structures of lags (p going from 3 to 8) and for five sets of additional regressors (X_t). As can be seen in Table II.10, causality from growth to inflation is not rejected in any of the 30 specifications analysed, thus we may conclude that current growth rates help to explain the future course of the inflation rate. The t-statistic of the long-run coefficient is always positive and significant (at the 5 per cent significance level). Economic theory proposes several explanations why rapid growth is associated with higher inflation in the more or less immediate future. On the one hand, it could be a movement along a negatively sloped Phillips curve, as prices respond after a period of rapid expansion in demand. Another interpretation is derived from the so-called Balassa-Samuelson effect (29). According to these authors, rapid economic growth is associated with rapid expansion in the productivity of a country's tradable goods sector, leading to an appreciation of its currency. Insofar as the nominal exchange rate is not adjusted to produce this appreciation, domestic prices will grow faster. This leading correlation of a positive sign indicates that the risk of a simultaneity downward bias in the estimation of inflation costs is considerable (30). As a result, the contemporaneous correlation in the convergence equations could be regarded as a lower bound of the costs of inflation, which would have to be adjusted upwards in absolute value.

In the light of this evidence, the results presented in this section have an unequivocal interpretation. The current rate of inflation provides relevant information on income prospects in OECD countries. In particular,

(29) Balassa (1964) and Samuelson (1964).

(30) Andrés, Hernando and Krüger (1996) show that when observations under fixed exchange rates are excluded from the sample, the size and the significance level of the coefficient of inflation in OECD convergence equations increase substantially.

TABLE II.10

CAUSALITY FROM GROWTH TO INFLATION

p	Model 1		Model 2		Model 3		Model 4		Model 5	
	χ^2	t								
3	0	3.72	0	4.26	0	4.06	0	4.15	0	3.74
4	0	5.92	0	6.00	0	5.10	0	5.37	0	4.81
5	0	5.40	0	5.51	0	4.75	0	4.81	0	4.35
6	0	5.30	0	5.41	0	4.75	0	4.94	0	4.61
7	0	4.35	0	5.06	0	4.37	0	4.38	0	4.14
8	0	4.53	0	4.87	0	4.60	0	4.60	0	4.32

Notes: see Table II.9.

cæteris paribus, higher inflation never anticipates a higher level of income in the medium and long run. This effect is robust to alternative specifications and, most notably, survives even when accumulation rates and individual effects are included among the set of regressors. Moreover, it can be rejected that this leading correlation between inflation and income is spurious and produced by the coincidence of inflationary tendencies and slow growth in some economies. Even though the magnitude of the negative effect of inflation might be questioned, the results of this section tell us that inflation does not appear to be neutral in the long run and that in no case does the persistence of inflation favours rapid economic growth in the future.

II.5. The role of the financial system in the growth-inflation link

As last section has emphasised, the joint evolution of inflation and the rate of growth of an economy is the outcome of the decisions made by private agents, the policy actions carried out by the public sector and the shocks hitting each economy during a given period. Among the potential candidates contributing to explain this joint determination, it is worth focussing in the potential role of the development of the financial system in shaping the growth-inflation link for, at least, two reasons. First, the process of financial liberalisation and innovation in the last two decades has highlighted the importance of the financial system in the monetary policy transmission mechanism by underscoring the ability of the financial intermediaries to issue liquid assets, thereby, taking an active role in the process of money creation. To this extent, the establishment of a stable financial environment is an essential ingredient in the commitment of monetary authorities in western economies to price stability.

The second reason to focus on the role of the development of the financial system in understanding the growth-inflation link is the renewed attention paid to this potential role by recent theoretical research. On the one hand, some models indicate that policies of “financial repression” have adverse effects on long-run growth and are also associated to high inflation rates (31). In particular, high inflation rates are usually considered as indicators of the intensity of such repression. According to the implications of this class of models, the negative medium-term correlation among inflation and growth might be driven by a third variable, namely by the extent to which the public sector seeks to finance large deficits by imposing unwarranted regulations to the banking system. On the other hand, another strand of the literature stresses the long-run effect of inflation that comes through its interaction with the financial system. This sort of models claims that high inflation exacerbates informational frictions affecting financial markets, which play a crucial role to understand the link between inflation and growth. If either of these were relevant channels through which inflation affects growth, the coefficient of the inflation rate in convergence equations should be affected in a significant manner by the inclusion of measures of financial development.

In this section we jointly estimate the effects of financial development and inflation on growth in order to ascertain whether the estimated negative long-run effect of inflation on growth withstands the presence of banking and stock market indicators in otherwise standard convergence regressions. Our results indicate, first, that the long-run costs of inflation are not explained by policies of financial repression, and second, that if inflation affects growth through its interaction with the financial market, this is not the only (nor the most important) channel.

These results must be interpreted with caution. We have made use of the set of proxies for financial development that is standard in the empirical literature. This choice is justified in order to make comparisons with other empirical work easier. However, this choice is far from being unquestionable. On the one hand, these standard indicators do not cover all the agents or institutions that provide financial services (for instance, bond markets or insurance companies are not represented in these indicators). On the other hand, these indicators are mainly measuring the size of the institution or market, but it would also be desirable to use measures of efficiency of the financial system as well. We believe that these shortcomings are behind the weakness of the finance-growth relationship we have found for our sample of OECD countries.

(31) “Financial repression” policies include inflationary taxation, mandatory purchases of public debt, ceilings on interest rates and other regulations of the financial system. See Roubini and Sala-i-Martin (1995) for details.

This section starts with a brief survey of the theoretical results linking inflation, growth and financial system development. The banking and stock market indicators used in the analysis are discussed in subsection II.5.2, whereas subsection II.5.3 presents the estimated effects of jointly including inflation and financial variables in otherwise standard growth equations.

II.5.1. Theoretical and empirical backgrounds

Before surveying the recent literature dealing with the joint evolution of inflation, financial development and economic growth, it is worth briefly mentioning the main results of the literature on the relationship between financial development and growth. This strand of the literature is as extensive as that connecting inflation and growth (surveyed in chapter I). Most of the theoretical work in this field deals with the potential impact of financial development on growth assuming the former to be exogenous (32). McKinnon (1973) and Shaw (1973) were among the first to provide theoretical foundations for the fact that the liberalisation and development of financial markets favour economic growth (33). Subsequent theoretical work has studied in depth this direction of causality running from financial development to economic growth [Pagano (1993), Levine (1997)]. The different mechanisms which explain how financial intermediation can affect growth may be classified in three groups: effects on the saving rate, effects on the proportion of saving funnelled to investment and effects on the efficiency in the allocation of capital.

Since the seminal work by Goldsmith (1969), numerous empirical studies have analysed the relationship between the level of financial markets development and the rate of growth making use of large cross-country data sets. A strong positive correlation between growth and indicators of financial development has been recurrently obtained, even after controlling for most of the factors that have been usually considered as determinants of growth (34).

In contrast to the previous models that focus on genuine effects of financial development on economic growth and to the models described in

(32) Greenwood and Jovanovic (1990) is one remarkable exception.

(33) In his pioneering *Theory of Economic Development*, Schumpeter argued that the services provided by financial intermediaries play a decisive role enhancing productivity and fostering growth.

(34) The empirical literature has focused either on measures of banking activity [King and Levine (1993a,b)] or on measures of stock market development [Atje and Jovanovic (1993) and Levine and Zervos (1998)]. In both cases the statistical association between the growth rate and the financial indicators seems to be equally robust.

chapter I analysing the effects of inflation on growth, two classes of models deal simultaneously with the role of these two variables in the process of growth. On the one hand, a recent wave of theoretical articles has focused on the effects of inflation on growth that arise through its interaction with financial markets. These papers show different channels whereby high inflation exacerbates informational frictions afflicting financial markets, thus, depressing the level of activity and generating a significant cost in terms of future growth rates. De Gregorio and Sturzenegger (1994a,b) present models in which the ability of financial intermediaries to distinguish among heterogeneous firms is reduced as inflation rises leading to a larger share of credit allocated to less efficient firms. In contrast, in the paper by Choi, Smith and Boyd (1996) inflation reduces real returns to savings and makes more severe the adverse selection problems in capital markets inducing a higher degree of credit rationing. Finally, Huybens and Smith (1999) present a monetary growth model with a different kind of informational friction. In their model, there are multiple technologies for producing capital and some of them are subject to a standard costly state verification problem. They show that higher rates of money creation reduce the real return on all assets and, under certain conditions, lead to a reduction in the volume of trading in equity markets. All of these papers show to what extent financial market frictions may play a crucial role to understand the relationship between inflation and growth.

On the other hand, recent theoretical work provides an alternative explanation for the pattern of correlations among inflation, growth and financial markets development. This line of research argues that government strategies of financing large deficits resorting to policies of financial repression explains the negative correlation between inflation and the level of activity in financial markets. First, the repression of the financial system increases the transaction costs of converting illiquid to liquid assets and, as a consequence, expands money demand. This expansion raises the inflation tax base, generating incentives to inflate (35). Moreover, these models predict that financial repression will also have adverse real effects to the extent that a badly functioning financial sector decreases the efficiency in the allocation of savings. As a consequence, these models suggest that the negative effect of inflation on growth is spurious as both high inflation and low economic growth are caused by policies of financial re-

(35) However, Espinosa and Yip (1996) present a model that generates a "Laffer curve" type relation between inflation and repression. Thus, in some cases (when financial repression is severe enough so that an informal financial sector emerges) liberalization may be inflationary. Roubini and Sala-i-Martin (1995) argue that policies of financial repression have two different effects: an increase in the inflation tax base (due to the increase in money demand) and a decrease in the income-tax base (implied by a reduction in income). Thus, these authors suggest it is more likely that a government choose to repress the financial sector if tax evasion is large because in such a case the increase in the inflation tax base is not offset by a substantial reduction in the income-tax base.

pression. In related theoretical research, Chari, Jones and Manuelli (1996) compare the implications of several quantitative models to explain the growth effects of inflation found in the literature. They conclude that inflation *per se* does not have significant effects on growth, but financial regulations and their interaction with inflation have substantial effects on growth.

Summing up, these models indicate that policies of financial repression have adverse effects on long-run growth and are also associated to high inflation rates. Thus, the negative correlation among these two variables is driven by a third one. On the other hand, according to the models stressing financial market frictions, the real effects of inflation come through its interaction with the financial system, reducing the efficiency with which this sector operates and, thus, harming growth. If either of these were relevant channels through which inflation affects growth, the coefficient of the inflation rate in convergence equations should be dramatically affected by the inclusion of measures of financial development. Before we test this hypothesis, next section is devoted to study the causality relationships among these variables.

II.5.2. Indicators of financial development

The construction of synthetic indicators of the volume of services provided by the financial system is not an easy task. First, because the services provided are very diverse (management of the payment system, mobilisation of savings, information gathering, risk diversification, exerting corporate control), and second, because the agents that provide these financial services are also heterogeneous (banks, securities markets, insurance companies, among others). As a result, there is a wide spectrum of indicators of financial development used in this field (36). In this paper, we use the set of proxies for banking development proposed by King and Levine (1993a,b) that has been recurrently used in most of the subsequent empirical work. Additionally, we consider market capitalisation as a measure of stock market development [Levine and Zervos (1998)]. Thus, the data set includes annual variables for 21 OECD countries over the sample period 1961-1996 with the only exception of market capitalisation that is available for 16 countries and only over the 1971-1996 period (37).

(36) See De Gregorio and Guidotti (1995) for a discussion of the advantages and shortcomings of different indicators of financial development.

(37) The countries included in the analysis are the following: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, Greece, United Kingdom, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, Sweden and USA. MKTCAP is not available for Finland, Greece, Ireland, Portugal and New Zealand.

The data set incorporates four measures of banking system development (BTOT, DCPY, QLLY and RESERVES) and one indicator of stock market development (MKTCAP) (38). The variable labelled QLLY is defined as the ratio of liquid liabilities (excluding currency in circulation and demand deposits) of the financial system to GDP. We consider this variable, as it is usual in the literature, as a proxy of financial depth since it represents the size of the formal financial intermediary sector. The implicit assumption is that the size of the financial system is positively related to the provision of financial services. DCPY is defined as the ratio of claims on the non-financial private sector to GDP. This measure tries to proxy the amount of credit available to the private sector through the banking sector. Implicitly we are assuming that the credit granted to the public sector may respond to different criteria from those used to grant credit to private agents. BTOT is defined as the ratio of deposit money bank domestic assets to deposit money bank domestic assets plus central bank domestic assets. It tries to capture the importance of banks relative to the central bank. The idea behind the use of such variable is that deposit banks are more likely to provide risk sharing and information services than central banks. We have also constructed a variable labelled RESERVES, which is defined as the ratio of claims on monetary authorities to demand deposits plus other deposits of banking institutions. We consider that this variable, even reflecting a policy instrument –the reserve requirement ratio–, can be also described as a proxy of the degree of financial development. The implicit hypothesis here is that countries with high reserve ratios have less developed financial systems than countries with low reserve ratios (in particular, Haslag and Koo (1999) have found evidence in favour of this hypothesis). Finally, we label MKTCAP to the ratio of domestic shares on domestic exchanges in a year divided by GDP. It measures the size of the stock market and it is the usual indicator of market development. This variable captures the fact that the stock markets provide financial services that are different from those provided by banks.

Table II.11 presents descriptive statistics on the five financial indicators, growth and inflation. When observations are divided in four quartiles defined in terms of the growth rate (Panel A) we first observe that contemporaneous financial indicators are weakly correlated with growth rates. Second, as we move from observations with lower growth to observations with higher growth we see a sizeable decrease in the average inflation rate. When observations are divided in four quartiles defined in terms of the inflation rate (Panel B) we observe that financial indicators

(38) Financial indicators were drawn from the IMF International Financial Statistics [BTOT, lines (22a + 22d) / (12a + 22a + 22d), DCPY, lines 32d / 99, QLLY, lines 35/99 and RESERVES, lines 20 / (24 + 25)] and Morgan Stanley Capital International (MKTCAP).

DESCRIPTIVE STATISTICS (a)

PANEL A AVERAGE LEVEL OF FINANCIAL INDICATORS AND INFLATION BY SUBSAMPLES DEFINED IN TERMS OF GROWTH					
	<i>Very low</i>	<i>Low</i>	<i>High</i>	<i>Very high</i>	<i>Correlation with growth</i>
Output growth . . .	-0.5	2.0	3.4	6.0	—
Inflation	7.9	6.7	6.0	5.7	-0.18
DCPY	62	57	54	48	-0.16
QLLY	43	44	40	35	-0.15
BTOT	92	92	91	91	0.01
RESERVES	6.5	7.0	7.0	7.9	0.04
MKTCAP (b)	29	28	30	31	-0.01
PANEL B AVERAGE LEVEL OF FINANCIAL INDICATORS AND GROWTH BY SUBSAMPLES DEFINED IN TERMS OF INFLATION					
	<i>Very low</i>	<i>Low</i>	<i>High</i>	<i>Very high</i>	<i>Correlation with growth</i>
Inflation	1.9	4.1	6.7	13.7	—
Output growth . . .	2.8	3.3	2.9	1.9	-0.18
DCPY	68	54	54	45	-0.21
QLLY	45	39	40	38	-0.05
BTOT	93	92	93	88	-0.29
RESERVES	5.7	6.4	6.5	9.9	0.30
MKTCAP (b)	44	30	26	17	-0.37
PANEL C CONTEMPORANEOUS CORRELATIONS AMONG FINANCIAL INDICATORS					
	<i>MKTCAP (b)</i>	<i>QLLY</i>	<i>DCPY</i>	<i>BTOT</i>	<i>RESERVES</i>
MKTCAP (b)	—	0.57	0.51	0.19	-0.24
QLLY		—	0.78	0.31	-0.11
DCPY			—	0.52	-0.18
BTOT				—	-0.45
RESERVES					—

(a) The whole sample includes 21 countries over the 1961-1993 period.

(b) MKTCAP is only available for 16 countries over the 1971-1993 period.

are negatively, and in some cases significantly, correlated with inflation. Finally, Panel C shows that financial indicators are highly and significantly correlated with each other. This is specially the case for the measures of banking development excluding RESERVES. Notice that while variables QLLY, DCPY and BTOT are aimed to proxy banking development, the variable RESERVES measures reserve requirements as an indicator of financial repression and it is negatively correlated with the proxies of financial development. For the later variables, the correlation coefficient among banking indicators ranges between 0.31 and 0.78 in the whole sample.

To analyse causality relationships among inflation, growth and financial system developments, we follow a similar approach to that described in section II.4. Now, we estimate the following unrestricted VAR model:

$$Y_{it} = C_i + A(L)Y_{it-1} + B(L)X_{it} + U_{it} \quad [II.9]$$

where Y_{it} is a vector including the logarithm of per capita GDP, the rate of inflation (π_{it}) and a financial variable (F_{it}), C_i is a constant (which we allow to differ among countries) and U_{it} is a vector of error terms i.i.d. with constant variance and zero mean. The vector X_{it} includes additional regressors usually suggested by growth theory. Details on the causality tests performed in this subsection are more extensively described in section II.4.

The results are presented in Table II.12 and may be summarised as follows. First, current inflation provides relevant information on output prospects in OECD countries. The null of non-causality can be rejected in all cases at the 5 % level of significance. As for the sum of the coefficients of lagged inflation in the output equation it is always negative and significant. Moreover, current output developments also help to explain the future course of the inflation rate. The t-statistic is in this case always positive and in most cases significant. These effects are robust to alternative financial variables being included in the VAR and to different lag-structures. Second, things are different when analysing causality relationships from financial variables to output and the other way round. Causality from QLLY and RESERVES to output is easily rejected at the 10 % significance level. The tests of causality from BTOT and DCPY to output are less conclusive but the t-statistics are hardly significant. Only the variable of market capitalisation helps to forecast future output with a positive and significant t-statistic. Causality from output to financial variables is overwhelmingly rejected. Finally, the causality relationships between financial variables and inflation are also far from conclusive. On the one hand, inflation does not help to predict future financial variable dynamics. This result is in contrast with a recent paper by Boyd, Levine and Smith (1996) who present evidence in favour of a strong negative association between inflation and financial market performance. On the other hand,

TABLE II.12

CAUSALITY RESULTS

PANEL A												
p	Causality from inflation to				Causality from output to				Causality from BTOT to			
	Output		BTOT		Inflation		BTOT		Output		Inflation	
	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t
3	0	-3.52	51	-0.91	0	2.16	68	0.94	6	1.23	11	-0.70
5	0	-2.56	64	-0.60	0	4.08	62	0.66	2	-0.59	5	0.51
PANEL B												
p	Causality from inflation to				Causality from output to				Causality from QLLY to			
	Output		QLLY		Inflation		QLLY		Output		Inflation	
	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t
3	0	-4.28	4	-1.57	0	2.10	15	0.23	62	0.72	3	1.13
5	0	-4.12	8	-0.43	0	3.89	15	-1.25	66	0.25	3	0.76
PANEL C												
p	Causality from inflation to				Causality from output to				Causality from DCPY to			
	Output		DCPY		Inflation		DCPY		Output		Inflation	
	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t
3	0	-4.34	33	-0.81	0	2.32	1	0.01	2	-1.02	1	1.94
5	0	-3.45	46	0.07	0	4.05	2	-0.80	12	-1.01	7	0.51
PANEL D												
p	Causality from inflation to				Causality from output to				Causality from RESERVES to			
	Output		RESERVES		Inflation		RESERVES		Output		Inflation	
	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t
3	0	-3.87	13	0.68	0	1.90	46	-0.90	55	-1.26	46	1.02
5	0	-3.39	32	0.90	0	3.92	12	-2.24	70	-0.37	47	0.70
PANEL E												
p	Causality from inflation to				Causality from output to				Causality from MKTCAP to			
	Output		MKTCAP		Inflation		MKTCAP		Output		Inflation	
	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t	F (%)	t
3	0	-3.22	23	-1.36	7	0.85	1	-2.55	0	2.37	8	-0.55
5	0	-3.70	43	-1.05	3	2.47	5	-1.06	0	1.90	10	0.11

Notes: The model includes individual effects, accumulation rates (investment rate –lagged 1 period–, schooling, rate of growth of population and a trend) and some macroeconomic indicators lagged 1 period (money growth, exports growth and public spending as a percentage of GDP). F (%) indicates the p-value of the F exclusion test described in the text. t indicates the t-statistic for the sum of the coefficients of the logs of the variable of interest. p indicates the number of lags of the model.

two out of the five financial variables considered help (at least for some lag-structures) to predict future inflation. However, this result is not very robust to the lag structure. Moreover, the sum of the coefficients of past financial variables in the inflation equation differs also considerably across models: it is positive, and in some cases significant, for QLLY, DCPY and RESERVES and it changes signs for the different models including BTOT and MKTCAP. These results give weak support to the link among finance development and growth, whereas they confirm that running from inflation to growth. Moreover, the causality results are not in favour of the close relationship between inflation and financial development suggested by the models stressing financial market frictions (39).

II.5.3. Results

We turn our attention to more standard convergence equations, suitably augmented to include both the inflation rate as well as some indicators of financial development. We take as a benchmark the linear versions of the convergence equations estimated in section II.2 making use of four-year averages of the raw annual data (expressed in logs) covering the period 1961-1996. More precisely, in this specification the growth rate of per capita income is regressed on the initial level of per capita income, the rate of investment, the rate of schooling, the growth rate of population, a linear trend and a constant. In order to test the effects of interest, we augment these equations with the inflation rate and with some indicators of financial development.

Table II.13 shows the OLS estimates of the convergence equation augmented with inflation and/or financial system indicators. To save space, we only present the coefficient estimates for inflation and financial development indicators. The coefficients of the other explanatory variables are not significantly different from those obtained in column (2) of Table II.2. Regarding the effects of interest, the coefficient of the inflation rate is negative and significant when excluding financial system indicators. The size of the coefficient does not change significantly when these indicators are included. The coefficients of the proxies of financial development have the expected sign, but only BTOT and RESERVES are significant at the 5 % level of significance (MKTCAP is so at 10 %). This evidence is not fully consistent with the standard results obtained in cross-section regressions with larger samples of countries [see, for instance,

(39) As an alternative to the OLS with country dummies procedure used, we also tried the strategy followed by Rousseau and Wachtel (1998). This strategy consists in estimating equation [II.9] in first differences by the Generalized Method of Moments (GMM). Using this procedure yields a much lower the level of significance of the causality tests.

TABLE II.13

CONVERGENCE EQUATION WITH INFLATION AND FINANCIAL INDICATORS (OLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation.....	—	—	—	—	—	-0.0044 (5.58)	-0.0041 (5.01)	-0.0043 (5.46)	-0.0040 (4.93)	-0.0032 (1.97)
QLLY	0.003 (0.13)	—	—	—	—	0.005 (0.25)	—	—	—	—
BTOT	—	0.123 (2.52)	—	—	—	—	0.046 (0.94)	—	—	—
DCPY.....	—	—	0.018 (1.17)	—	—	—	—	0.005 (0.37)	—	—
RESERVES .	—	—	—	-0.191 (2.97)	—	—	—	—	-0.103 (1.63)	—
MKTCAP ...	—	—	—	—	0.035 (1.94)	—	—	—	—	0.031 (1.74)
R ²	0.50	0.52	0.51	0.52	0.32	0.57	0.58	0.58	0.58	0.35
σ	0.051	0.050	0.051	0.050	0.039	0.048	0.047	0.047	0.047	0.039

Notes: (i) Estimation method: OLS. Absolute t-ratios in parentheses. (ii) Other explanatory variables included in the regressions: initial level of per capita income, rate of investment, rate of schooling, growth rate of population, a linear trend and a constant. (iii) The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY and RESERVES is 0.02 (0.59) in an equation excluding (including) the inflation rate. The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY, RESERVES and MKTCAP is 0.01 (0.00) in an equation excluding (including) the inflation rate.

King and Levine (1993a)]. When inflation is included among the right-hand side variables two results are worth noting. First, the coefficients of the financial development indicators keep their sign although none of them is significant at the 5 % level (40); second, the coefficient of inflation is always negative and significant and is not dramatically affected by the presence of either QLLY, BTOT, DCPY or RESERVES in the model (41).

Overall, these results indicate, first, that it seems to be a genuine effect of inflation on growth and, second, that the development of the financial system could favour economic growth. Both effects are apparently not related, although, if any, the former seems to be stronger. However, before to draw any conclusion out of these estimates it is convenient to take a closer look at these relationships, trying to correct for some biases that might arise in these specifications. In particular, we address two of

(40) When the financial development indicators are simultaneously included their significance is jointly rejected. The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY and RESERVES is 0.06 (0.51) in an equation excluding (including) the inflation rate. The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY, RESERVES and MKTCAP is 0.19 (0.12) in an equation excluding (including) the inflation rate.

(41) The fall in the coefficient of inflation in column (10) has more to do with the reduced sample in this equation than with the presence of MKTCAP on it.

the most common criticisms to the empirical framework adopted: country-specific time invariant effects and simultaneity biases (42). In order to deal with these two sources of potential biases, we augment the empirical model to allow for cross-country heterogeneity and we estimate by instrumental variables to take into account the simultaneity among the considered variables.

Table II.14 presents the results of the IV estimates of models with country-specific effects. Again, to save space, we only present the coefficient estimates for inflation and financial development indicators. Comparing results in Tables II.13 and II.14 (OLS without country-specific effects and IV with country-specific effects) some interesting results arise (43). First, the coefficient of inflation is negative and significant and its size is significantly larger than that obtained in the OLS estimation. This result is consistent with the causality tests in which a positive causality running from income to inflation was detected, thus leading to a simultaneity downward bias in the OLS estimation of the inflation costs. Again, the inflation rate stands as the only additional regression in the convergence equation, which keeps a reasonable explanatory power of growth rates in OECD economies (44). Second, in the IV estimation the coefficients of financial development proxies are not significant; only BTOT is close to the 10 % level of significance when inflation is not included in the specification (column 2 of Table II.14) (45). This might imply that the observed positive effect of financial development on growth could be attributed, in our sample, to reverse causation (from growth to financial development). This would suggest that, for our sample of industrialised economies, the interaction of inflation with financial market variables is not a relevant mechanism to explain the effects of inflation on long-run growth. This result is consistent with that of De Gregorio and Guidotti (1995). These authors show that the positive correlation between finan-

(42) As discussed by Harris (1997) the standard procedure of choosing the initial value of a variable as the instrument of its value throughout the period may lead to misleading results. In particular, in the context of financial and growth models, it can overstate the statistical significance of financial indicators. To avoid this, Harris proposes to run 2SLS using lagged values as instruments for the endogenous ones.

(43) Andrés, Hernando and López-Salido (1999) present both OLS estimates with country dummies and IV estimates without these country-specific effects for a slightly shorter sample period. In both types of models, the coefficients of the indicators of financial development become non-significant and the coefficient of the inflation rate remains negative and significant. The OLS estimate of the coefficient of the inflation rate is smaller when including country-dummies. On the other hand, the IV estimate of the coefficient of the inflation rate in the model without country-dummies is larger than the OLS estimate.

(44) In column (10) the t-ratio of the inflation rate is 1.50. Nevertheless, this low value is not only caused by the presence of MKTCAP in the regression, but also by the short sample used to estimate this model (16 countries and a shorter period, further reduced by the use of instruments).

(45) In Table II.14, when the financial development proxies are simultaneously included they are jointly rejected at the 10 per cent level.

**CONVERGENCE EQUATION WITH INFLATION AND FINANCIAL INDICATORS
(IV WITH COUNTRY EFFECTS)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation.....	—	—	—	—	—	-0.0076 (4.10)	-0.0086 (3.76)	-0.0075 (4.17)	-0.0078 (3.76)	-0.0064 (1.50)
QLLY.....	-0.047 (0.87)	—	—	—	—	-0.016 (0.34)	—	—	—	—
BTOT.....	—	0.192 (1.74)	—	—	—	—	-0.086 (0.70)	—	—	—
DCPY.....	—	—	0.023 (0.71)	—	—	—	—	-0.009 (0.32)	—	—
RESERVES..	—	—	—	-0.222 (1.53)	—	—	—	—	-0.024 (0.18)	—
MKTCAP...	—	—	—	—	-0.072 (0.87)	—	—	—	—	-0.035 (0.49)
R ²	0.41	0.46	0.41	0.45	0.15	0.57	0.56	0.56	0.57	0.46
σ.....	0.056	0.054	0.056	0.054	0.051	0.048	0.048	0.048	0.048	0.041

Notes: (i) Estimation method: IV. Instruments: constant, country dummies and first and second order lags of the regressors and second lag of the dependent variable. Absolute t-ratios in parentheses. (ii) Other explanatory variables included in the regressions: initial level of per capita income, rate of investment, rate of schooling, growth rate of population, country dummies and a constant. (iii) The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY and RESERVES is 0.20 (0.66) in an equation excluding (including) the inflation rate. The p-value for the F-test of the joint exclusion of QLLY, BTOT, DCPY, RESERVES and MKTCAP is 0.16 (0.37) in an equation excluding (including) the inflation rate.

cial indicators and growth is considerably weaker for industrialised countries, suggesting that the positive effect of financial development is especially relevant in the early stages of the development process. These results are also consistent with those of Harris (1997) who finds only a weak significance of stock markets indicators in growth regressions for developed countries (MKTCAP in our model).

Summing up, our analysis shows that the negative effect of inflation in growth equations remains significant even after including financial market variables. Additionally, the link between proxies of financial market performance and growth is found to be weak, vanishing when country-dummies are included and endogeneity is accounted for using instrumental variables. Also, controlling for inflation reduces the significance of those indicators. Overall, these results indicate, first, that the long-run costs of inflation are genuine and not explained by a sort of omitted variable bias. These costs are not explained by policies of financial repression and although they may stem from the interconnection among inflation and financial market conditions, this is not the only (nor the most important) channel.

In addition, our analysis has not found a significant positive growth-financial development link. There are three potential reasons for the lack of

significance of this relationship in our analysis. First, the finance-growth link might be less relevant for industrialised countries with already highly developed financial systems. Second, the standard analysis of the finance-growth link does not correct the specification biases that might arise when cross-country heterogeneity and simultaneity among the considered variables are not taken into account. Finally, the proxies for financial development used in our analysis –which are the standard indicators in the empirical literature- might be adequate when analysing large samples of countries, but might be too rough when focussing in a smaller and more homogeneous sample of countries, like our panel of OECD countries. In particular, we believe that the impact of financial markets on economic growth is more sophisticated than what these standard variables capture. On the one hand, these standard indicators do not cover all the agents or institutions that provide financial services. On the other hand, these indicators are mainly measuring the size of the institution or market without properly capturing the efficiency of the financial system. In our view, the construction of indicators of the efficiency of the financial system and the analysis of its impact on the process of economic growth are issues that deserve further research.

II.6. Concluding remarks

In this chapter we have tried to assess the long-run costs of inflation, within an explicit theoretical framework stemming from the growth literature: the convergence equation. Despite its shortcomings, this approach is well suited to test the robustness of the correlation between growth and inflation in low inflation economies with reasonably well working markets, such as the OECD countries during the 1960-1996 period. The specific results are described at length in each section and will not be repeated here. The main finding is that current inflation is not positively correlated with income per capita over the long run.

In fact, in most specifications tried we obtained a significant negative correlation between inflation and income growth during rather long periods. This negative correlation survives the presence of additional regressors, such as the investment rate, population growth and schooling rates, and the imposition of the theoretical restrictions implied by the constant returns of technology. Moreover, our analysis shows that the negative effect of inflation in growth equations remains significant even after including financial market variables. This result suggests that the long-run costs of inflation are not explained by policies of financial repression and although they may stem from the interconnection among inflation and financial market conditions, this is not the only (nor the most important) channel.

What is most remarkable is that the negative coefficient of inflation in growth equations remains significant even after allowing for country-specific time-invariant effects in the equations. This is striking since, as it is well known in the empirical growth literature, few regressors in convergence equations withstand the explanatory power of country dummies. The analysis of causality gives less clear-cut results, but it is also noteworthy that causality from inflation to growth is always significant and never positive. Again, this result shows up more clearly whenever the influence of country dummies, accumulation rates and the effect of other macroeconomic variables is controlled for.

Inflation not only reduces the level of investment but also the efficiency with which productive factors are used. It has a negative temporary impact upon long-term growth rates, which, in turn, generates a permanent fall of income per capita. Our results suggest that the marginal cost of inflation diminishes as the inflation rate becomes higher. The estimated benefit of a permanent reduction of inflation by one percentage point depends on the starting level of inflation. Thus, reducing the inflation rate from (say) 20 % to 19 % may increase output by 0.5 % in the long-run. This benefit increases with further reductions in inflation and might be twice as large when inflation reaches a low 5 %. These benefits seem to be lower than others reported in the literature, but some evidence suggests that they might be underestimated since there is a positive causation running from growth to inflation, in particular for economies with fixed exchange rates. It must also be noticed that these estimates are obtained in models displaying a high convergence rate, so that the present value of the benefits of disinflation might be quite sizeable. Overall, these results indicate that the long-run costs of inflation are non-negligible and that efforts to keep inflation under control will sooner or later pay off in terms of better long-run performance and higher per capita income.

III

THE DYNAMIC EFFECTS OF PERMANENT DISINFLATIONS

In the previous chapter we presented evidence that shed some light on the effects of inflation on per capita income in the context of convergence regressions. Instrumental variable estimates, fixed effects models and Granger causality tests suggest that the estimated correlation can be interpreted as a genuine harmful effect of inflation on income which indicates that the way monetary policy is conducted has permanent real effects. Unfortunately, the econometric methods used there do not fully settle the issue of causality among the two variables involved. Since inflation and output are endogenous variables their joint evolution might reflect non-monetary shocks, for instance technology shocks, affecting both variables. That is, the sign of that correlation may be negative because high growth tends to generate low inflation as a result of (exogenous) technological progress [see, for instance, Kocherlakota (1996) and Sims (1996)]. This chapter approaches this issue using an alternative econometric approach.

The dynamic relationship among inflation and growth is further complicated by the fact that the sign and size of the correlation among these two variables is likely to differ sharply depending on whether a short-run or a long-run perspective is adopted. Most of the business cycle literature explains a positive correlation among inflation and output on the grounds of nominal price or wage rigidities, relative price misperceptions, credit rationing and the like. Thus, monetary policy actions, undertaken with the aim of reducing the inflation rate, are likely to result in significant short-run increases in unemployment and output losses. The combination of continuous market clearing and rational expectations in macroeconomic models reduces the significance of the trade-off between inflation and unemployment to the very short-run. But, the performance of the labour market may play a special role relating business cycle fluctuations with long-run growth.

In this chapter we undertake a joint analysis of both the short and long-run real effects of disinflationary processes. Our approach is mostly empirical although the restrictions invoked to identify alternative sources of fluctuations can be justified on the basis of a fairly general macroeconomic model. We do so for two reasons. First, because it is not easy to portray all these long-run and short-run features in a simple dynamic macroeconomic model which captures what we consider the most salient feature of a process of disinflation: the changing pattern from the short-run negative correlation between inflation and unemployment to the long-run negative one between inflation and output. Second, because even if one succeeds in constructing a general equilibrium model displaying such a pattern, it would hardly account for more than a few out the many channels through which inflation is related to unemployment and output (1).

The rest of the chapter is organised as follows. Section III.1 describes the endogeneity problem, introducing the Structural Vector Autoregression (SVAR) literature as a suitable device to deal with the problem. In section III.2 we introduce the role of unemployment in order to describe alternative identifying restrictions, which allow us to assess costs and benefits of disinflation at different horizons. In section III.3 we present the empirical results for Spain. These results are also extended to several major OECD countries in section III.4. Finally, section III.5 summarises the main results of the analysis.

III.1. The analysis of the long-run effects of disinflation: a SVAR approach

No matter how elaborated they might be, cross-country convergence regressions do not fully settle the issue of endogeneity in the correlation among inflation and growth (2). This issue is of crucial importance to assess the beneficial effects of sound monetary policies. The argument goes as follows. Let us assume that output and inflation are non stationary variables whose unit roots can be explained by J orthogonal shocks $\{\varepsilon^j\}$,

$$\pi_t = \pi[b_1(L)\varepsilon^1, b_2(L)\varepsilon^2, b_3(L)\varepsilon^3, \dots]$$

$$y_t = y[d_1(L)\varepsilon^1, d_2(L)\varepsilon^2, d_3(L)\varepsilon^3, \dots]$$

if ε^1 represents money growth, the estimated long-run correlation among inflation and income is relevant for the monetary authority if it is the inap-

(1) In particular, the hysteresis-like mechanisms could explain the dependence of the long-run growth from the short-run movements in activity [see Blanchard and Summers (1986)].

(2) See Kocherlakota (1996) and Sims (1996), among others.

appropriate control of money growth what is causing today inflation and tomorrow's output losses. In terms of the previous equations this requires that;

$$\text{Corr} [\pi(b_1(1)\varepsilon^1), \gamma(d_1(1)\varepsilon^1)] < 0$$

where $b(1)$ and $d(1)$ represent the long-run multipliers of the lagged polynomials $d(L)$ and $b(L)$ respectively. But for this correlation to be negative it is a necessary condition that $d_1(1)$ is strictly different from zero or, in other words, that money has a genuine negative influence on output. Critics of the results obtained estimating inflation augmented convergence equations argue that the negative correlation estimated in convergence equations might be driven by other, non-monetary, shock(s), thus rendering it useless for monetary policy purposes. Thus, since all shocks are exogenous, the right approach to deal with the risk of causality is to estimate the ultimate source of fluctuations (i.e. the ε 's) and to test the sign of $d_1(1)$.

When the issue of causality is thought of as running from shocks to variables rather than from one variable to another variables, VAR models are the most appropriate framework. For one thing, in a VAR all variables involved are endogenous thus avoiding the flaws of many empirical models relating inflation with output growth that do not deal properly with the problems raised by the endogeneity of inflation. Moreover, the analysis of the relationship between inflation and growth is often blamed by not discriminating among different types of shocks behind inflation. The SVAR methodology makes it possible to identify different structural shocks driving the variables during the sample period and thus, to focus on the correlation among monetary policy shocks and output, which is our primary interest. Last but not least, since the theoretical foundations of empirical models relating inflation and growth is often weak, it is necessary to be careful as to which theoretical restrictions are imposed on the data; the SVAR methodology has the advantage of making explicit the identifying assumptions.

Bullard and Keating (1995) were among the first to approach the long-run effect of inflation in this way. They assume that the J set can be split in two groups: those shocks which exert a permanent effect on inflation (ε^P) and those with a purely temporary effect on it (ε^T). Thus the long-run representation of the $\{\pi, y\}$ process is:

$$\begin{aligned}\Delta\pi_t &= \gamma_{11}(1)\varepsilon_t^P \\ \Delta y_t &= \gamma_{21}(1)\varepsilon_t^P + \gamma_{22}(1)\varepsilon_t^T\end{aligned}$$

(where $\gamma_{ij}(1)$ represent the long-run multipliers of the dynamic model). To obtain an estimate of the ε 's, Bullard and Keating invoke an *extreme monetarist assumption*, namely that *inflation is always and everywhere a*

monetary phenomenon. Under this assumption, ε^P can be identified as the only shock behind the unit root of inflation directly linked to the rate of growth of the monetary base, without contamination from supply side disturbances, to be found in ε^T . Thus, the interpretation of the estimated long run correlation among inflation and income boils down to a test of the sign of $\gamma_{21}(1)$. Bullard and Keating apply their model to several countries and find that the sign of $\gamma_{21}(1)$ is positive in most cases and significant in some of them, meaning that inflation is costless over the long run. If disinflations, as it is broadly accepted, are costly in the short-run, the case for price stability is undermined. Thus, while cross-country regressions come up with a negative relationship between inflation and output, the SVAR approach, aimed at eliminating supply side influences on inflation, yields opposite results.

Nevertheless, the model identified under the *extreme monetarist* assumption might still yield a biased estimate of the long-run output effect of the monetary shock. To see how this may happen let us assume that permanent inflation has a real component (say ε^2), so that the true long-run VAR model is:

$$\Delta\pi = b_1(1)\varepsilon^1 + b_2(1)\varepsilon^2$$

$$\Delta y = d_1(1)\varepsilon^1 + d_2(1)\varepsilon^2 + d_3(1)\varepsilon^3 + d_4(1)\varepsilon^4 + \dots$$

Under this assumption it is clear that the estimated ε^P in the *monetarist* model would not be an adequate estimate of ε^1 and ε^2 (whose effect may even go in opposite directions). For this to happen, it does not matter how small the contribution of ε^2 to the long-run fluctuations of π is. As long as it is significant, what really matters is the size of $d_2(1)$; if this multiplier is positive and large, an estimated positive $\gamma_{21}(1)$ might be compatible with a negative influence of monetary shocks on output [i.e. a negative $d_1(1)$]. Unfortunately, the additional source of long-run inflation cannot be identified in the bivariate system if we want to make use of long-run identification restrictions.

III.2. Inflation, output and unemployment

III.2.1. The model

To identify additional (non-nominal) sources of fluctuations of inflation, thus isolating the true nominal component, we need to enlarge previous analysis with a third variable. Unemployment turns out to be a good candidate for such purpose and, thus, the model is specified as a stationary vector in the first differences of unemployment (u), inflation (π) and

the log of output (y). This system will be driven by three orthogonal shocks: ε^N containing the nominal source of fluctuations and ε^Z , ε^* which are real and, that for reasons explained below, are called productivity and natural rate-velocity shocks, respectively.

There are a number of advantages in enlarging the SVAR models with the unemployment rate. First, unemployment has been over the last two decades very much a non-stationary variable that it is bound to contain useful information about the long-run features of the economies in our sample (3). Second, most macroeconomic models come up with clear-cut predictions about the long-run determinants of unemployment (NAIRU), thus providing structural restrictions for identification purposes. Finally, but not least, a joint consideration of output and unemployment seems the natural approach to the costs of inflation since the SVAR approach permits a clear distinction between short-run and long-run responses to particular shocks. Any process of disinflation is expected to impinge upon the economy some costs and to yield some benefits. The expected time pattern of these is one in which costs, in terms of higher unemployment and output foregone, come first whereas the eventual beneficial effects take much longer to show up. The presence of such pattern in the dynamics of our model might be taken as some sort of informal overidentifying restrictions.

The structural innovations might be compounded of a larger set of innovations, so they are loosely defined. However, what is crucial for our purposes is the ability of the model to isolate the nominal shock, whose long-run real effect is what we are interested in. Since the structural innovations are by definition orthogonal, purely nominal shocks (i.e. shocks to monetary growth) may pertain to any of the three ε 's but only to one of them. Thus, a more precise definition of ε^Z and ε^* is not necessary, as long as the identifying restrictions provide an unbiased estimate of the nominal shock behind inflation. The structural model in matrix form can be represented as:

$$\begin{bmatrix} y \\ u \end{bmatrix} = \begin{bmatrix} c_{11}(1) & c_{12}(1) & c_{13}(1) \\ c_{21}(1) & c_{22}(1) & c_{23}(1) \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{bmatrix} \begin{bmatrix} N \\ Z \\ * \end{bmatrix} \quad \text{[III.1]}$$

where $c_{ij}(1)$ represents the long-run multiplier of the j_{th} shock on the i_{th} variable. In order to identify the shocks we impose some restrictions de-

(3) See, for instance, King and Watson (1994), Alogouskofis and Manning (1988) and Hall (1999).

rived from the long run implications of a large class of macroeconomic models that can be cast in terms of the following simple framework:

$$\pi = \Delta m + \Delta \nu - \Delta y \quad [III.2]$$

$$y_t = a_t + \alpha k_t + (1 - \alpha)l_t^S - (1 - \alpha)u_t \quad [III.3]$$

$$\Delta y_t^P = \tau_1(L)\varepsilon_t^* + \tau_2(L)\varepsilon_t^N + \tau_3(L)\varepsilon_t^Z \quad [III.4]$$

$$u_t = u_t^* - \beta(\pi_t - \pi_t^e) + \varepsilon_t^Z \quad [III.5]$$

$$\Delta u_t^* = \delta_1(L)\varepsilon_t^* + \delta_2(L)\varepsilon_t^N + \delta_3(L)\varepsilon_t^Z \quad [III.6]$$

The inflation process is represented in [III.2] by a simple quantitative theory equation, where m and ν are logs of money supply and velocity respectively. Notice that we are allowing the monetary authority to respond in a systematic way to real shocks. This process is motivated by monetary rules aimed at smoothing inflation and output (4). Expressions [III.3] and [III.4] represent the determinants of current output, derived from a constant returns to scale production function, and potential (y^P) output; a , k and l^S represent the total factor productivity, the capital stock and the labour supply respectively. Equation [III.5] is a standard *Phillips curve*, in which deviations of unemployment from its *natural level* (u^*) depend on temporary nominal and real shocks. Finally, expression [III.6] represents the process of u^* as a function of the structural shocks.

The process of inflation can also be written as an unrestricted function of the structural innovations as,

$$\Delta \pi_t = c_{11}(L)\varepsilon_t^N + c_{12}(L)\varepsilon_t^Z + c_{13}(L)\varepsilon_t^* \quad [III.7]$$

and taking first differences in [III.5],

$$\Delta u_t = \Delta u_t^* - \beta[c_{11}(0)(\varepsilon_t^N - \varepsilon_{t-1}^N) + (c_{12}(0) + 1)(\varepsilon_t^Z - \varepsilon_{t-1}^Z) + c_{13}(0)(\varepsilon_t^* - \varepsilon_{t-1}^*)] \quad [III.8]$$

where $c_{ij}(0)$ are the associated short-run multipliers of the $c_{ij}(L)$ polynomial lag matrices. Similarly, the output process (*Okun's Law*) can be written as follows:

$$\Delta y_t = \Delta y_t^P - (1 - \alpha) (\Delta u_t - \Delta u_t^*) \quad [III.9]$$

(4) See, among others, Galí (1999) and Clarida, Galí and Gertler (2000).

III.2.2. Alternative Identifying Restrictions

Inflation is a monetary phenomenon

From equation [III.8] we see that the effect of any shock on unemployment is purely transitory, unless it affects the natural rate u^* directly. Most theories of the *natural rate* predict that nominal shocks do not have a permanent effect on unemployment. Similarly, according to these theories the effect of productivity shocks on the supply and the demand for labour cancel out in the long run, so that these shocks have no effect upon u^* either (5). If we identify ε^Z as those real shocks with no permanent effect on u^* , the process [III.6] incorporates the following long-run restrictions: $\delta_2(1) = \delta_3(1) = 0$. Thus, the structural long-run multipliers $c_{31}(1)$ and $c_{32}(1)$ are both set to zero.

The process of y^P is not restricted. According to equation [III.9] the sources of long-run output fluctuations are those of potential output, i.e. those behind permanent changes in the savings rate, population growth and the total factor productivity. These variables are jointly driven by all shocks: ε^Z , ε^N and ε^* . The effect of purely nominal shocks on potential output is questionable; however we allow for such an effect in the model since the significance and sign of such effect is the main hypothesis we are interested in (6).

The remaining long-run restrictions must be found in the determinants of the unit root of inflation. First, the monetarist assumption of inflation being a monetary phenomenon in the long run, implies that the unit root of inflation is just money growth providing two restrictions in the matrix of long run multipliers: $c_{12}(1) = c_{13}(1) = 0$ [see Roberts (1993) for a similar strategy]. This set of assumptions provides four identifying restrictions and, consequently, the model is overidentified (7). The data does not support this scheme and the overidentification restrictions are clearly rejected; thus, in order to reconcile the model with the facts, we can consider two alternative sets of identification schemes (8).

Retaining the monetarist assumption but allowing for a long-run negatively sloped Phillips curve (i.e. removing $c_{31}(1) = 0$), the nominal shock is

(5) This has been established by Layard, Nickell and Jackman (1991) as a consistent empirical feature of modern economies and it has been recently stressed by Blanchard and Katz (1997).

(6) Notice that both ε^Z and ε^* are real determinants of output, the difference among them being that the former does not exert a permanent influence upon unemployment.

(7) The econometrics of SVAR is devoted to Appendix III.1.

(8) With data for the Spanish economy, the statistic ($\chi^2(1)=23.67$) is not significant at the 5%. Table III.3 shows this statistic for the cases of other OECD countries.

the only responsible of the common trend between inflation and unemployment. This identifying scheme may be labelled as *monetarist-full hysteresis*, meaning that part of the observed upward trend of unemployment might have a nominal origin. However, full hysteresis is helpless in our framework, since it relies on models which explain that any temporary shock might have permanent effects on unemployment and in such a case, $c_{32}(1) = 0$ would not be a feasible restriction, thus rendering the model underidentified (9).

Real shocks behind inflation

Alternatively, we can keep the assumption of a long-run vertical Phillips curve but considering the possibility of more than one shock driving the process of inflation in the long-run (i.e. removing either $c_{12}(1) = 0$ or $c_{13}(1) = 0$ or both). In such a case, the low frequency relationship between inflation and unemployment is due to real shocks, but this raises the issue of how a non-monetary source of long-run inflation can be rationalised. Although differences in money growth must account for most of the cross-country differences in inflation, many authors argue that the influence of other, non-monetary, factors cannot be denied. A strand of the literature of international trade suggests that relative inflation is partially explained by structural differences both on the demand and on the supply side of the economy (10). The argument relies in the different pricing behaviour of firms in sectors exposed to the international competition as compared with that of firms specialised in the production of nontradable goods. If productivity in the tradables sector grows faster than that in the nontradables, the productivity gain leads to higher wages and labour demand. This in turn produces an across-the-board increase in wages that is translated into higher prices in those sectors with monopolistic power and slow productivity growth. Similar effects can result from increases in public spending (11). An alternative approach is represented by Ball and Mankiw (1995) who show that if the distribution of relative prices present skewness, due to menu costs, real shocks may have an effect upon the general price level. What these theories of inflation have in common is that shocks which do not have a monetary origin might exert a lasting influence on the inflation rate (12).

More formally, the existence of a non-monetary source of inflation may be also rationalised making use of equation [III.2]. In this general

(9) Furthermore, the theoretical conditions under which full hysteresis takes place are very demanding [Blanchard (1997)]. Dolado and López-Salido (1996) use real wages instead of inflation to test the importance of full-hysteresis in the Spanish economy.

(10) See, among others, Balassa (1964), Samuelson (1964) or, more recently, De Gregorio, Giovannini and Wolf (1994) and Campillo and Miron (1997).

(11) See Rogoff (1992) and Martín Moreno (1996).

(12) Balke and Wynne (1996) show how inflation may occur even without money growth, merely as a consequence of real shocks.

set-up, since velocity is usually taken as a residual, the non-monetary shock might be considered as a shock to this component that, while affecting inflation permanently does lead neither to a long-run shift in the growth rate of the economy nor to changes on money growth. More precisely, the shocks considered by most real theories of inflation operate through stochastic movements in this residual, thus exerting a long-lasting influence on inflation and on the level of output.

Many economists would argue that over and above these real shocks, persistent inflation requires monetary accommodation; if this is so, all models are monetarist and there is not a relevant distinction among real and monetarist theories of inflation in the very long run (13). Despite this ambiguity, there are reasons to allow for more than one source of long-run inflation movements (i.e. to remove either $c_{12}(1) = 0$ or $c_{13}(1) = 0$). First, from an econometric perspective, the time horizon at which money can be considered fully accommodated, and thus the only source of inflation, may be very long. If this is the case, extreme monetarism is an infinite horizon property and, as argued by Faust and Leeper (1997), it may be wise not imposing it as a long run restriction at finite horizons. Second, although allowing for more than one source of inflation is controversial, since it is by no means easy to give a precise interpretation to all of them, the orthogonality of shocks ensures that only one of these contains the nominal component (i.e. monetary growth), the one whose effect we are interested in. Third, removing this restriction makes the model less restricted so we have the chance of testing whether inflation has had a substantial non-monetary component.

There are different identification schemes in which inflation is allowed to be influenced by real shocks also over the long run, all of which are characterised by either $c_{13}(1)$ or $c_{12}(1)$ not being zero. The assumption of productivity shocks not having permanent effect on inflation is widely accepted, whereas most theories of the natural rate suggest that some supply shocks may result in higher unemployment and higher permanent inflation, which may be captured by allowing $c_{13}(1)$ to be different from zero. Thus, our preferred empirical model is identified under the restrictions: $c_{31}(1) = c_{32}(1) = c_{12}(1) = 0$ (14).

III.3. The disinflation in Spain: 1976-1996

The Spanish economy is characterised by a medium-high, but steadily subsiding, inflation over the sample period (1976 to 1996), as well as

(13) See, for instance, Ball (1993) for a discussion of this issue.

(14) The alternative identification scheme ($c_{31}(1)=c_{32}(1)=c_{13}(1)=0$) has the undesirable property of not allowing for a common long-term component of inflation and unemployment and will not be tried here.

by a very high and persistent aggregate unemployment. The growth rate has also suffered large fluctuations during this period. These features make of the Spanish macroeconomic performance a most adequate case study to analyse the dynamic interactions of the three variables of interest. As it was mentioned before, the overidentified model is clearly rejected so we go straight to discuss the results obtained under our preferred identification scheme that are summarised in Figure III.1 and Table III.1 (15).

The innovation ε^Z is well identified as a supply shock, with a short run influence on unemployment. Its short run effect on inflation is, as expected, countercyclical and it does not contribute to the forecast variance decomposition of inflation at any time horizon. The contribution of this type of innovation to explain the unit root of output is low (from 27 % in the short-run to 9 % in the long-run) as compared with the contribution of ε^* , which looks very much as a real demand shock, since it is associated with a permanent fall in inflation and in output. This is less surprising than it looks since ε^Z does not include all real shocks, but only those that do not exert a permanent influence upon inflation. This feature may reflect the importance of unemployment persistence in Spain in shaping the course of output and the fact that the restriction of demand shocks having no effect on long run output is difficult to maintain (16).

The assumption of two shocks driving inflation seems well accepted by the data. As can be seen from Table III.1, positive one-period impulses to ε^N and ε^* produce permanent changes in inflation. Even assuming that there are several forces of long-run inflation, to what extent does our identification scheme succeeds in allocating nominal and real components to ε^N and ε^* respectively? We interpret ε^* as an inflation shock that has a real component with permanent effects upon the natural rate of unemployment, whereas ε^N can be interpreted as a nominal shock. Notice that ε^* explains most of unemployment and a great deal of output too, which makes it hard to consider it a nominal shock. On the other hand ε^N behaves as a nominal demand shock. It is demand since the short-run correlation with unemployment displays a Phillips curve pattern: the increase in inflation leads to a rapid, although not very pronounced, fall in unemployment in the short run. As inflation reaches its steady-state level, unemployment subsides slowly returning to its previous level in about 20 quarters. Other features indicate that ε^N must collect the nominal determinants of inflation. First, although our identification scheme allows for non-monetary determinants of inflation,

(15) In Figures III.1 to III.4, thin lines depict approximate 90 % confidence intervals computed using 1000 bootstrap replications using the method proposed by Runkle (1987).

(16) See, for instance, Dolado and López-Salido (1996 and 2000) and Andrés, Mestre and Vallés (1999).

TABLE III.1

SPAIN FORECAST ERROR VARIANCE DECOMPOSITION

		ε^N	ε^Z	ε^*
Inflation	1	99(3)	0(0)	1(3)
.....	4	97(2)	1(0)	2(2)
.....	8	87(6)	1(0)	12(6)
.....	12	84(7)	1(0)	15(7)
.....	40	77(9)	0(0)	22(9)
Output	1	2(2)	27(6)	71(6)
.....	4	1(2)	16(4)	82(4)
.....	8	1(1)	12(3)	87(3)
.....	12	1(1)	11(2)	88(3)
.....	40	1(1)	9(2)	90(2)
Unemployment.....	1	1(3)	47(10)	53(11)
.....	4	2(2)	18(4)	81(5)
.....	8	1(1)	5(1)	94(2)
.....	12	1(0)	2(1)	97(1)
.....	40	0(0)	0(0)	100(0)

Note: Standard errors in brackets. They are calculated using Runkle's (1987) bootstrap method based on 1000 replications.

money is still expected to be the most important one, and ε^N accounts for most of the variance of the forecast error of inflation over the long run (77 %). Second, although the long run impact of both inflation shocks upon output is left free, the contribution of ε^N to the forecast variance decomposition of output is virtually nil (below 1 %).

Turning now to our main hypothesis of interest, we find that the response of output to impulses in ε^N is negative and strongly significant, especially in the long run. Thus, conditioned on our characterisation of ε^N being adequate, we have identified an effect of inflation on long term income, which is of the same sign to that found in the literature of growth. It is true that the other shock driving inflation (ε^*) displays a positive correlation with income, but this by no means, contradicts the claim that disinflation with a monetary origin generates beneficial effects in the long run. Indeed, what this result indicate is that our previous surmise of a misspecification bias in the *extreme monetarist* identifying scheme is right. If our scheme is correct the nominal shock estimated under the monetarist scheme is a composite of ε^N and ε^* ; even if the contribution of ε^* to inflation is small, a powerful long-run positive impact of ε^* on output generates the positive impulse response estimated under that scheme.

TABLE III.2

SENSITIVITY TO ALTERNATIVE IDENTIFICATION SCHEMES

Identification scheme (a)	Contribution to the long-run variance of output (b)			Contribution to the long-run variance of inflation		
	ε^N	ε^Z	ε^*	ε^N	ε^Z	ε^*
$C_{12}(1) = C_{31}(1) = C_{32}(1) = 0$	(+) [1]	(+) [9]	(-) [90]	77	0	22
$C_{13}(1) = C_{31}(1) = 0; C_{31}(0) = 0$	(+) [0]	(-) [73]	(+) [27]	75	24	1
$C_{13}(1) = C_{31}(1) = 0; C_{21}(0) = 0$	(+) [0]	(-) [56]	(+) [44]	72	27	1
$C_{12}(1) = C_{31}(1) = 0; C_{31}(0) = 0$	(+) [0]	(+) [27]	(-) [73]	75	1	24
$C_{12}(1) = C_{31}(1) = 0; C_{12}(0) = 0$	(+) [1]	(+) [8]	(-) [91]	78	0	22
$C_{12}(1) = C_{31}(1) = 0; C_{32}(0) = 0$	(-) [0]	(+) [74]	(-) [26]	55	2	43
$C_{12}(1) = C_{31}(1) = 0; C_{21}(0) = 0$	(+) [0]	(+) [44]	(-) [56]	72	1	27
$C_{12}(1) = C_{32}(1) = 0; C_{31}(0) = 0$	(+) [5]	(+) [9]	(-) [86]	67	0	33
$C_{12}(1) = C_{32}(1) = 0; C_{21}(0) = 0$	(-) [0]	(+) [9]	(-) [91]	88	0	12
$C_{13}(1) = 0; C_{12}(0) = C_{31}(0) = 0$	(+) [4]	(-) [85]	(+) [11]	68	31	0
$C_{13}(1) = 0; C_{21}(0) = C_{31}(0) = 0$	(+) [0]	(-) [64]	(+) [36]	77	21	1
$C_{12}(1) = 0; C_{31}(0) = C_{32}(0) = 0$	(-) [4]	(+) [74]	(-) [22]	79	3	18
$C_{12}(1) = 0; C_{12}(0) = C_{31}(0) = 0$	(+) [6]	(+) [8]	(-) [86]	66	0	34
$C_{12}(1) = 0; C_{21}(0) = C_{31}(0) = 0$	(+) [0]	(+) [36]	(-) [64]	77	1	21
$C_{12}(1) = 0; C_{21}(0) = C_{32}(0) = 0$	(+) [3]	(+) [74]	(-) [23]	13	3	84

Notes:

- (a) $C_{ij}(1) = 0$: long run restriction;
 $C_{ij}(0) = 0$: short run restriction.
(b) This shows the long run forecast error variance decomposition of output and the sign of the long run responses of output to the different shocks.

Thus, even for a high unemployment country like Spain, permanent reductions in the inflation rate, achieved through a permanent fall in monetary growth, might have significant short run unemployment costs, but end up having net beneficial permanent effects on output (17). Furthermore, the path following a permanent inflation fall is one of a initial increase in unemployment with a fall or modest increase in output followed by a long run stronger positive output effect. This path is consistent with the previous results in the literature: the main costs of disinflation come first, due to nominal rigidities; when all prices adjust, and the level of unemployment gets back to its previous level, output increases rapidly to achieve its new long run level. Additionally, our results show that the way disinflation is pursued matters. In particular, although the contribution of real factors to inflation is small, permanent reductions in inflation that are achieved through permanent cuts in real demand, impose upon the economy a permanent cost. What happens in this case is that the way in which the cut in inflation is obtained also generates long lasting unemployment effects which outweigh the efficiency gains.

(17) As an additional check on the robustness of this result we have tried many other identification schemes, based upon short-run as well as long-run identification restrictions. According to the results summarised in Table III.2, a negative long run output effect of impulses to ε^N is clearly predominant (in 70 % of the cases).

III.4. International Evidence

Most OECD countries have also successfully pursued policies aimed at lowering the rate of inflation from their peak during the eighties. Although inflation moderation has been less pronounced than in the Spanish case, price stability has often been taken as one of the reasons for fast growth during the mid and late nineties. In this section we analyse the disinflationary experience of the G7 (United States, Canada, Japan, Italy, France, United Kingdom, Germany) plus Australia. Since our aim is to focus in the recent macroeconomic experience the sample period is 1972:2-1996:3 (18).

Table III.3 shows that the overidentified ($c_{31}(1) = c_{32}(1) = c_{12}(1) = c_{13}(1) = 0$ in [III.1]) model is largely rejected by the data for all countries. Again, this might be interpreted as indicating that unemployment and inflation are not long-run orthogonal so that the unit root of inflation and unemployment must have a common component (19). As in the previous section we introduce such component as a second, non-nominal, source of inflation so that the identification scheme will not be discussed further (20).

The SVAR model under this set of restrictions is estimated for our sample of eight countries. Figures III.2-III.4 depict the response functions, for each country, of unemployment, output and inflation to each of the three shocks. The one year and the long-run forecast error variance decompositions are summarised in Tables III.4 and III.5. Although our primary aim is the identification of the nominal shock, a first glance to Figures III.2 and III.3 and Tables III.4-III.5 suggests that ε^* and ε^Z look as it would be expected according to our simple model. In particular, the response of all three variables to an innovation in ε^Z suggests that it can be interpreted as a productivity or supply shock. A positive productivity shock has a strong but short-lived effect on unemployment, which might be caused by a slow process of labour reallocation. This shock hardly contributes to the forecast variance decomposition of inflation at any time horizon. Notwithstanding, the contribution of such a supply shock to explain the unit root of output is slightly low as compared with the contribution of ε^* .

(18) On the grounds of homogeneous data availability, we use data of West Germany (1972:2-1994:4) instead of Germany, and the sample period is also different for Italy (1972:2-1995:3).

(19) See, for details on that evidence, King and Watson (1994) for the case of US.

(20) In Andrés, Hernando and López-Salido (1998) we summarise the results obtained under non monetarist identification schemes relying upon restrictions on the short run coefficients, $c_{ij}(L)$. Whereas short-run restrictions are less appealing than the long-run ones, these results confirm those obtained imposing $c_{32}(1)=c_{12}(1)=c_{13}(1)=0$.

TABLE III.3

TEST OF THE OVERIDENTIFYING RESTRICTION

	Chi-Squared (1 DF)	Significance Level
USA.....	14.87	0.000
CANADA.....	15.21	0.000
JAPAN.....	23.04	0.000
UNITED KINGDOM.....	20.88	0.000
FRANCE.....	4.77	0.029
GERMANY.....	26.61	0.000
ITALY.....	34.62	0.000
AUSTRALIA.....	12.13	0.000

The monetary root of inflation can only be in either ε^N or in ε^* , but not in both since these shocks are, by construction, orthogonal (21). There are several reasons to argue that the monetary component of inflation has to be in ε^N whereas ε^* is a non-nominal source of permanent inflation. First, the forecast variance decomposition of the model indicates that ε^* explains most of the short and long-run path of unemployment and a great deal of those of output too, which is not what could be expected from a nominal shock. Second, in most countries ε^N might be characterised as a *nominal demand shock*. It is demand since the short-run correlation with unemployment displays a Phillips curve pattern: the increase in inflation leads to a rapid fall in unemployment in the short run. As inflation reaches its steady-state level, unemployment returns slowly to its previous level. On the other hand, ε^N must be nominal since it accounts for most of the variance of the forecast error of inflation over the long run, whereas its contribution to the forecast variance decomposition of output and unemployment is negligible (Tables III.4 and III.5). These results are consistent with the widespread consensus among economists that the long run behaviour of real variables is basically driven by real shocks.

As regards the *long-run elasticity* of output with respect to nominal innovations, it is negative in five out of the eight cases. Actually, a permanent increase in inflation due to a nominal shock has a positive effect on output in France and Italy and negative in Japan, United States, Australia, United Kingdom and Canada (although in the later the effect is just weakly signifi-

(21) A common feature of the results obtained is the shape of the response of both inflation and output to innovations in the non-nominal source of long-run inflation dynamics (ε^*). A negative innovation in ε^* generates a permanent fall in inflation along with a permanent fall in output, thus explaining why the *extreme monetarist* identifying scheme may be wrong as well as the direction of the bias.

TABLE III.4

ONE-YEAR FORECAST ERROR VARIANCE DECOMPOSITION

		ε^N	ε^Z	ε^*
USA	Inflation	98(1)	0(0)	2(1)
	Output	4(1)	10(2)	86(3)
	Unemployment	6(2)	4(1)	90(2)
CANADA	Inflation	96(3)	2(1)	2(3)
	Output	1(2)	37(7)	62(7)
	Unemployment	3(1)	3(1)	94(1)
JAPAN	Inflation	71(11)	12(3)	17(13)
	Output	1(1)	30(8)	69(9)
	Unemployment	5(1)	19(3)	76(4)
UNITED KINGDOM	Inflation	78(9)	1(0)	21(9)
	Output	1(1)	36(5)	63(8)
	Unemployment	9(2)	1(0)	90(2)
FRANCE	Inflation	95(3)	3(1)	2(3)
	Output	13(5)	30(7)	57(8)
	Unemployment	0(0)	14(3)	85(3)
GERMANY	Inflation	90(6)	1(0)	9(6)
	Output	8(3)	24(5)	68(7)
	Unemployment	5(1)	1(0)	94(1)
ITALY	Inflation	55(7)	23(5)	22(8)
	Output	34(9)	49(9)	17(9)
	Unemployment	6(1)	4(1)	91(2)
AUSTRALIA	Inflation	97(2)	1(0)	1(2)
	Output	1(1)	24(5)	75(5)
	Unemployment	1(0)	5(1)	93(1)

Note: Standard errors in brackets. They are calculated using Runkle's (1987) bootstrap method based on 1000 replications.

cant) (22). This effect is non significant in the case of Germany. Finally, when the sample period is restricted to 1974:2-1996:3, 1976:3-1996:3 and 1980:1-1996:3 the negative response of output to innovations in ε^N becomes stronger and more significant in all cases. This is the main hypothesis we are interested in: positive ε^N that rise inflation permanently also have a permanent negative effect on real output. The pattern of response is also consistent with the central banker's view of disinflations: the main costs come first, in terms of higher unemployment and lower output, whereas a higher output is achieved in the medium term. Table III.6 summarises the discounted present value of costs and benefits arising from achieving two percentage points lower inflation rate, by means of an unanticipated nominal shock (23). Again,

(22) When the model includes a time trend, results are very similar, but the negative effect of nominal shocks in Canada becomes strongly significant.

(23) France and Italy are not included in the Table for reasons that we will discuss below. The short run output cost is calculated using an Okun law with coefficient 2.

TABLE III.5

LONG-RUN (TEN YEARS) FORECAST ERROR VARIANCE DECOMPOSITION

		ε^N	ε^Z	ε^*
USA	Inflation	86(7)	0(0)	14(7)
	Output	1(1)	16(3)	83(3)
	Unemployment	1(0)	0(0)	99(0)
CANADA	Inflation	84(7)	1(0)	15(7)
	Output	1(1)	68(8)	31(8)
	Unemployment	0(0)	0(0)	99(0)
JAPAN	Inflation	78(6)	2(0)	20(6)
	Output	2(1)	18(7)	80(8)
	Unemployment	0(0)	1(0)	99(0)
UNITED KINGDOM	Inflation	79(8)	0(0)	21(8)
	Output	2(1)	21(5)	77(5)
	Unemployment	0(0)	0(0)	100(0)
FRANCE	Inflation	94(4)	0(0)	5(4)
	Output	9(4)	40(9)	51(9)
	Unemployment	0(0)	1(0)	99(0)
GERMANY	Inflation	77(7)	0(0)	23(7)
	Output	1(0)	9(2)	90(2)
	Unemployment	0(0)	0(0)	100(0)
ITALY	Inflation	62(9)	4(1)	34(10)
	Output	30(10)	67(9)	3(3)
	Unemployment	1(0)	0(0)	99(0)
AUSTRALIA	Inflation	87(7)	0(0)	12(7)
	Output	2(2)	34(7)	64(7)
	Unemployment	0(0)	0(0)	99(0)

Note: Standard errors in brackets. They are calculated using Runkle's (1987) bootstrap method based on 1000 replications.

these results are consistent with the dynamics of the simple model sketched in the previous section. If the shock ε^N is predominantly associated with permanent changes in the rate of growth of money, the only way in which it can exert a permanent effect upon output is through its incidence on the accumulation of productive factors and/or on the level of total factor productivity. This is precisely what the literature on inflation and growth is about, and our results confirm that the negative correlation among inflation and output found in some of these studies cannot be explained solely on the basis of endogeneity or reverse causality (24).

(24) Since output is stationary in first differences in our sample, the effect of inflation is an effect upon the steady state level of output. This is consistent with the findings in the literature on growth empirics. See Andrés and Hernando (1999) for a detailed discussion on this issue.

TABLE III.6

**COSTS AND BENEFITS, AS ANNUALISED % OF GDP, ASSOCIATED WITH
A NOMINAL DISINFLATION OF TWO PERCENTAGE POINTS**

	<i>Costs</i>	<i>Benefits</i>	<i>Net benefits</i>
SPAIN	0.23	1.69	1.46
USA	0.07	0.54	0.47
CANADA	0.09	0.84	0.75
JAPAN	0.02	1.01	0.99
UNITED KINGDOM	0.07	0.92	0.85
FRANCE	—	—	—
GERMANY	0.07	-0.24	-0.31
ITALY	—	—	—
AUSTRALIA	0.04	0.90	0.86

Note: The discount factor is set to 4 %.

France and Italy are the only countries in the sample whose behaviour is at odds with these negative long-run elasticity results. A closer inspection of these cases reveals that perhaps the nominal component of inflation might not be properly identified in these cases. In these two countries, the estimated short-run responses of unemployment and output to ε^N do not exhibit the *Phillips curve* pattern common to all other countries. Also, whereas the average contribution of ε^* to the long-run forecast error variance of inflation, excluding France and Italy, ranges from 12 to 22 per cent, this value reaches a low 5 per cent in France and a high 34 per cent in Italy. This makes the identification of the nominal shock less reliable than in the rest of the countries. In France the identification is not satisfactory since the nominal shock explains a large proportion of the output variance (9 %), far larger than in other countries (excluding Italy). On the other hand, France is the only country for which inflation is almost fully explained by ε^N with no weight whatsoever for ε^* ; it is not surprising that the results are close to those obtained under the overidentified model which incorporates just one source of inflation (i.e.

(25) The p-value of the overidentifying restrictions is close to the level of non-rejection (Table III.3). This scheme, though, has the unpleasant feature that the nominal shock explains a great proportion of the forecast error variance of output (up to 10 per cent 10 years ahead).

the *extreme monetarist* assumption) (25). The identified ε^N shock also explains an unreasonably high proportion of long-run output in Italy: 30 per cent. Another unpleasant feature of the estimated model for this country is that inflation is explained almost in similar proportions by ε^N and ε^* , whereas the later shock explains almost nothing of output in the long run.

III.5. Concluding Remarks

Cross-country regressions aimed at identifying a long run correlation among inflation and growth have often been blamed for not solving the crucial issue of causality among these two endogenous variables. An economy may suffer a rise in inflation for different causes, some of which may also lead to a fall in output, thus producing a negative correlation among these variables. A supply shock is an example of this and, since OECD economies have suffered huge shocks of that kind during the seventies and eighties, it is difficult to give to the results of convergence equations a structural or causal interpretation. But such an interpretation is crucial for policy purposes since it tells us whether or not misleading monetary policies might have significant real costs.

In this chapter we have taken an alternative approach that should be considered as complementary to the one in chapter II. Instead of looking for causality from one variable to another, we have analysed that running from truly exogenous sources of fluctuations towards both inflation and output. Since a monetary policy component might be one of the shocks driving both variables, the aim of the exercise has been to identify such component and test whether it exerts permanent effects on inflation and output. The results crucially rely on the identification procedure that we chose to be based on long-run restrictions on the unit root of inflation, output and unemployment. The model is enlarged with the unemployment rate to estimate more than one source of inflation, but no role for nominal shocks on the unit root of unemployment is allowed for.

Our model is capable of explaining why other models that do not allow for a second (real) source of inflation (thus mixing all sources in one) may be misleading. The model has also other appealing features that make it a reasonable description of the joint dynamics of the three variables of interest during the sample period: inflation is mostly, although not exclusively, a monetary phenomenon; nominal shocks have very little influence on long-run output and unemployment. The results confirm, both for the Spanish case as well as for most of the other major OECD countries, that a nominal shock can be indeed identified and that it leads to opposite long-run movements in inflation and output, thus explaining the

negative correlation uncovered by the growth equations. Since the nominal component of the model must be in turn driven by the rate of growth of the money supply, what the results in this chapter indicate is that there is indeed a lasting influence of monetary policies beyond the business cycle. Also, the widespread central banker's view is confirmed: monetary policies aimed at achieving price stability may have non-negligible short run costs in terms of rising unemployment and foregone output, but they do pay-off in the longer term getting the economies onto a path of higher income.

APPENDIX III.1. ECONOMETRIC SET-UP

Let us assume that $X = \{\Delta\pi \ \Delta y \ \Delta u\}$ is a covariance stationary vector that can be represented as a moving average of current and past serially uncorrelated structural shocks ε 's. In matrix form (in Gali's (1992) notation) the structural model can be represented as follows:

$$X_t = C(L)\varepsilon_t \quad [A \text{ III.1}]$$

where $C(0) = I$. Let us also assume that X_t admits the following reduced form moving average representation:

$$X_t = E(L)v_t \quad [A \text{ III.2}]$$

where the v 's are the innovations in the elements of X , that are correlated with variance-covariance matrix,

$$\Sigma = E v v' \quad [A \text{ III.3}]$$

The autoregressive representation of the reduced-form is:

$$B(L) X_t = v_t \quad [A \text{ III.4}]$$

where $B(0) = I$, $B(L) = E(L)^{-1}$. A crucial assumption is that the vector of innovations, v_t , can be written as linear combination of the vector structural disturbances ε_t :

$$v = S\varepsilon \quad [A \text{ III.5}]$$

which means

$$C(L) = E(L)S \quad [A \text{ III.6}]$$

Under these assumptions, the autoregressive representation of the structural model is given by,

$$A(L) X_t = \varepsilon_t \quad [A \text{ III.7}]$$

where $A(0) = S^{-1}$.

The purpose of the exercise is to obtain an estimate of $C(L)$ and ε , so that the dynamics of X in response to structural disturbances can be traced out. Estimates of $B(L)$, v and the variance-covariance matrix of v can be obtained by OLS from the reduced-form autoregressive representation (expression [A III.4]). Then, $E(L)$ is obtained inverting $B(L)$. To obtain an estimate of S notice that under the assumption of orthogonality of

the ε 's and under the appropriate normalisation, $E\varepsilon\varepsilon' = I$. Thus the following relationship holds:

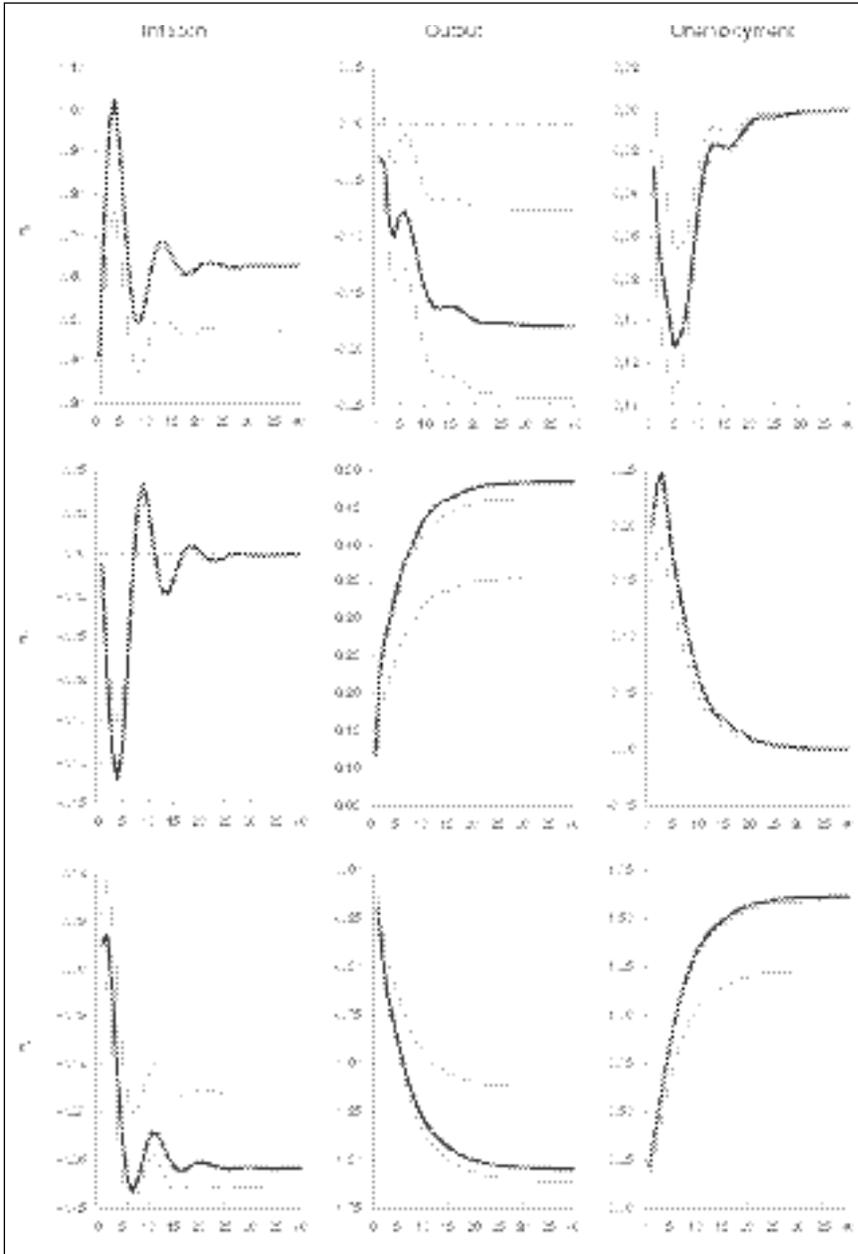
$$\Sigma = E\nu\nu' = E[S\varepsilon\varepsilon'S'] = SE[\varepsilon\varepsilon']S' = S'S \quad [A \text{ III.8}]$$

Since there are 6 different elements on the estimated variance-covariance matrix of ν 's we have 6 non linear equations involving the elements of S of the form:

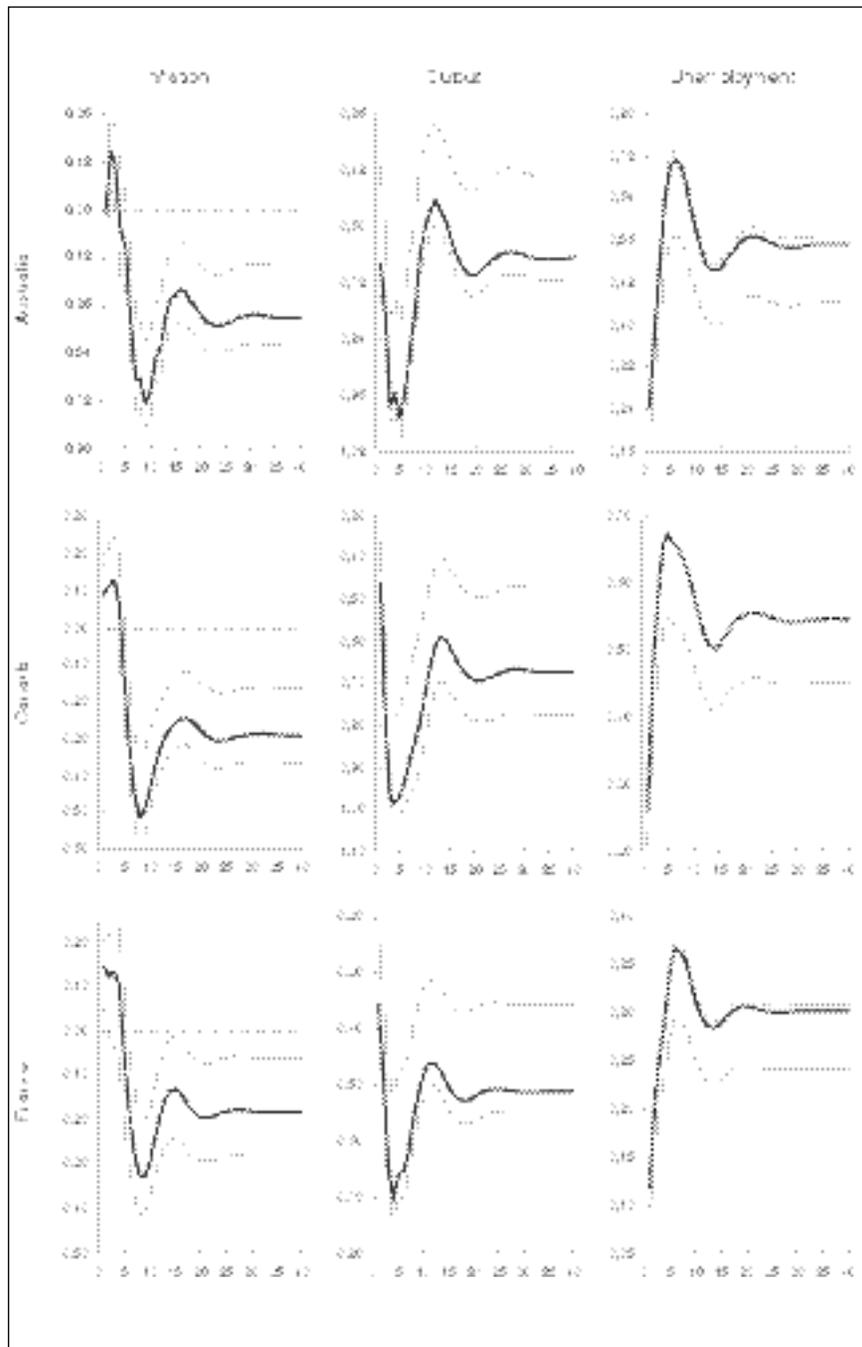
$$\sum_{k=1}^3 S_{ik}S_{kj} = \delta_{ij} \quad [A \text{ III.9}]$$

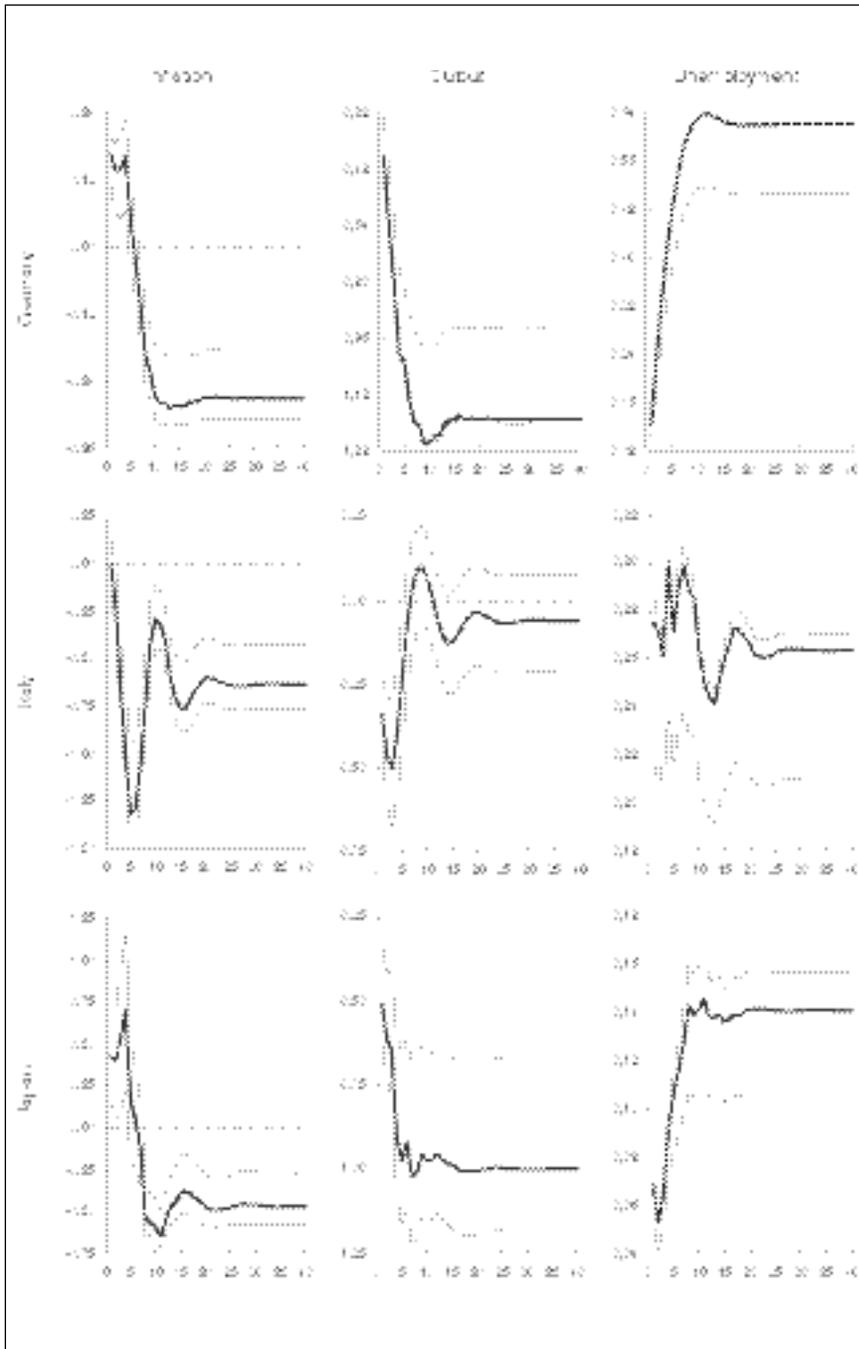
Thus, we still need 3 restrictions to estimate the 9 elements on S . Those elements ought to be obtained imposing additional restrictions in the model. For that purpose we proceed making use of the relations suggested by economic theory. In particular, we will mainly impose long-run restrictions —i.e. restrictions upon $C(1)$ —, and, in some cases, we will combine long and short-run restrictions —i.e. restrictions both upon $C(1)$ and S , respectively—.

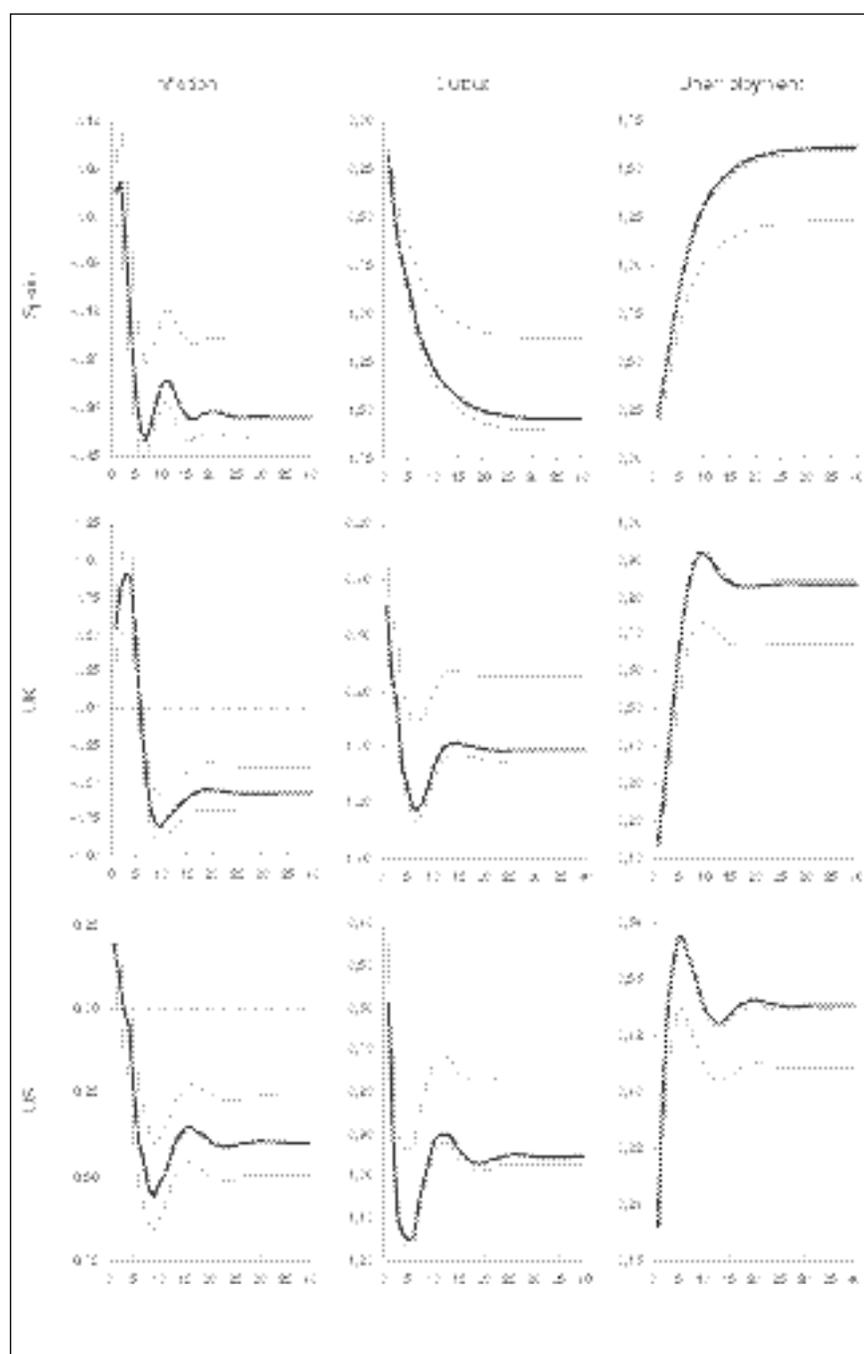
SPANISH IMPULSE-RESPONSE FUNCTIONS

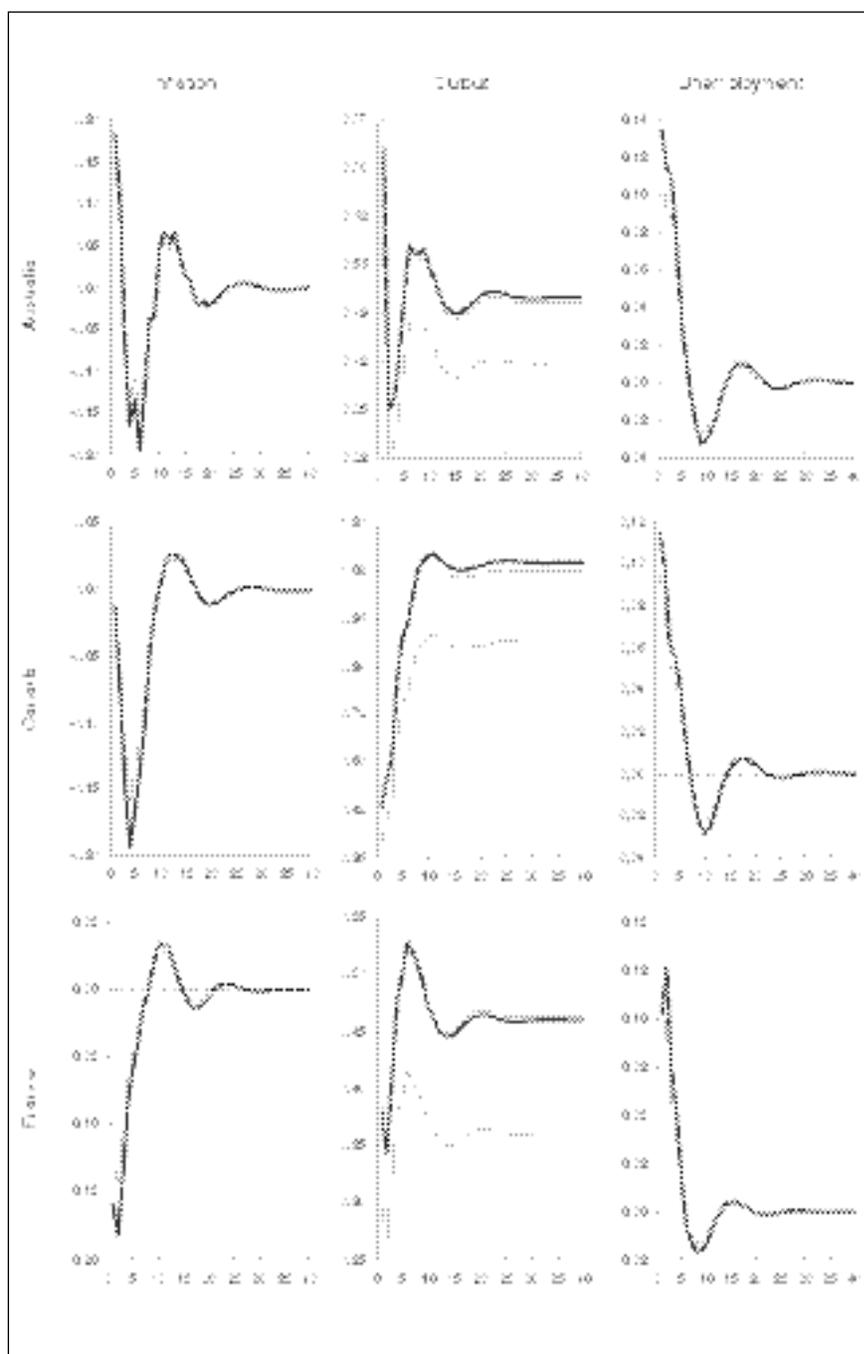


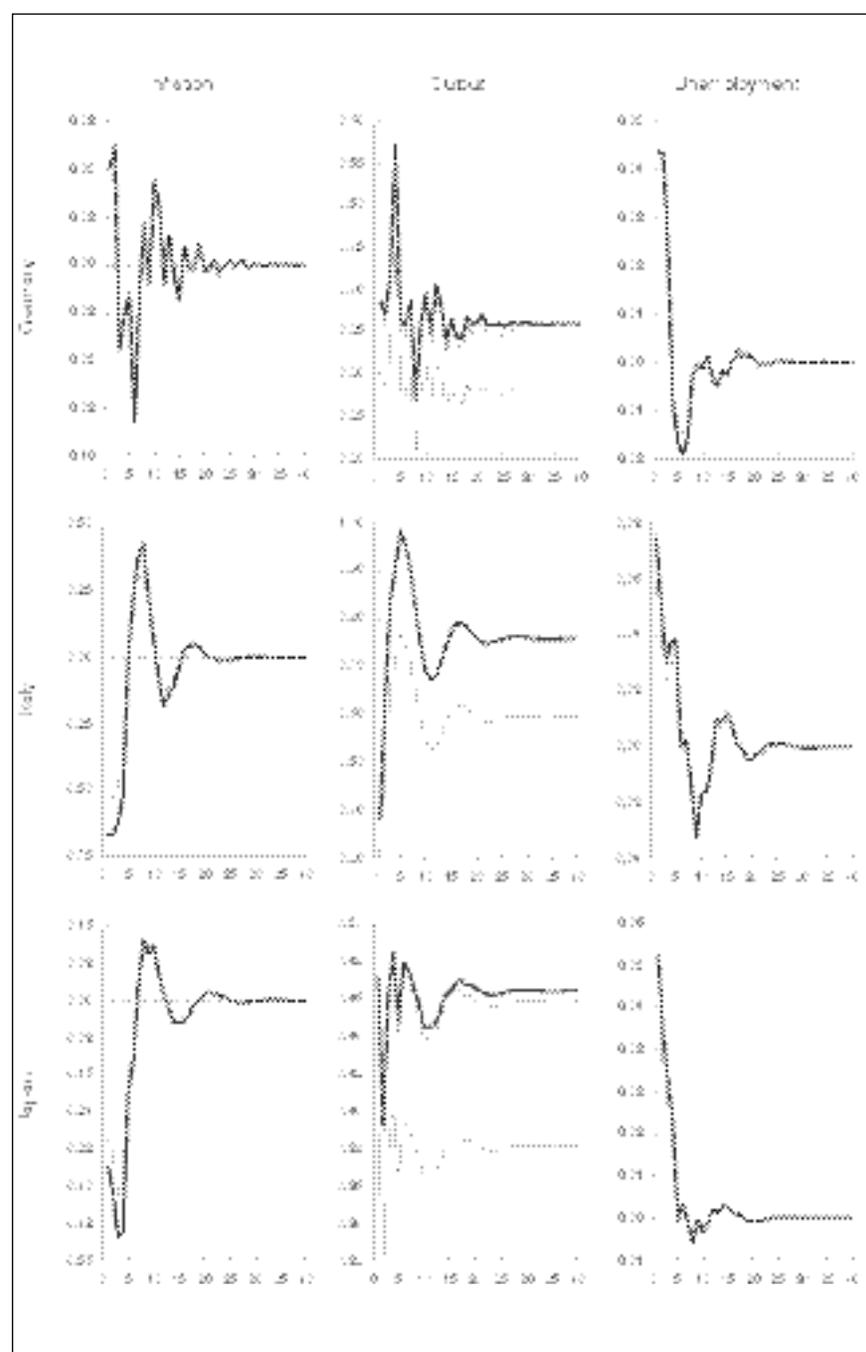
Notes: First row depicts the responses of inflation, output and unemployment to a nominal demand shock (ϵ^D); second row depicts the responses of inflation, output and unemployment to a productivity shock (ϵ^Z); and third row depicts the responses of inflation, output and unemployment to a natural rate shock (ϵ^*).

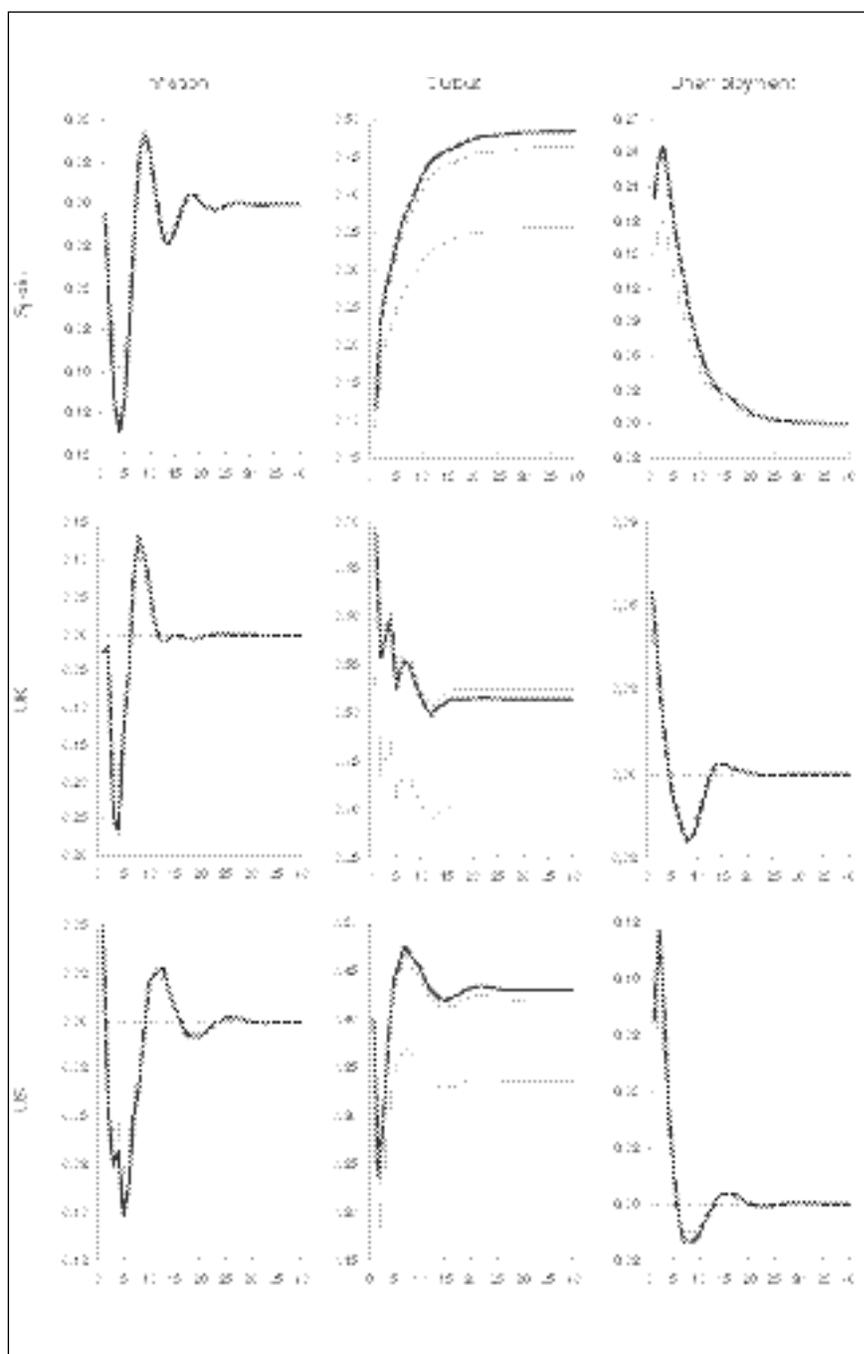
RESPONSES TO A NATURAL RATE SHOCK (ϵ^*)

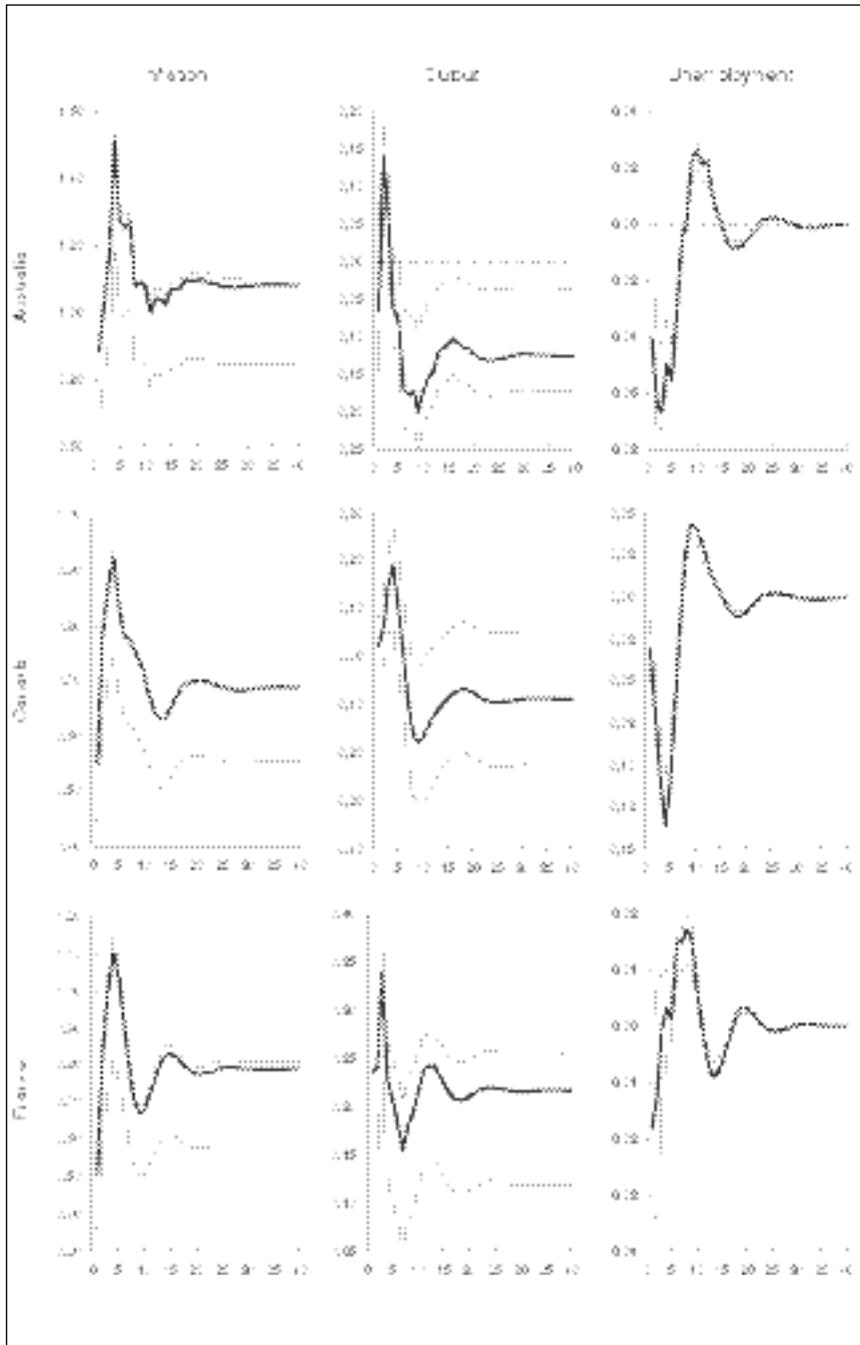
RESPONSES TO A NATURAL RATE SHOCK (ε^*)

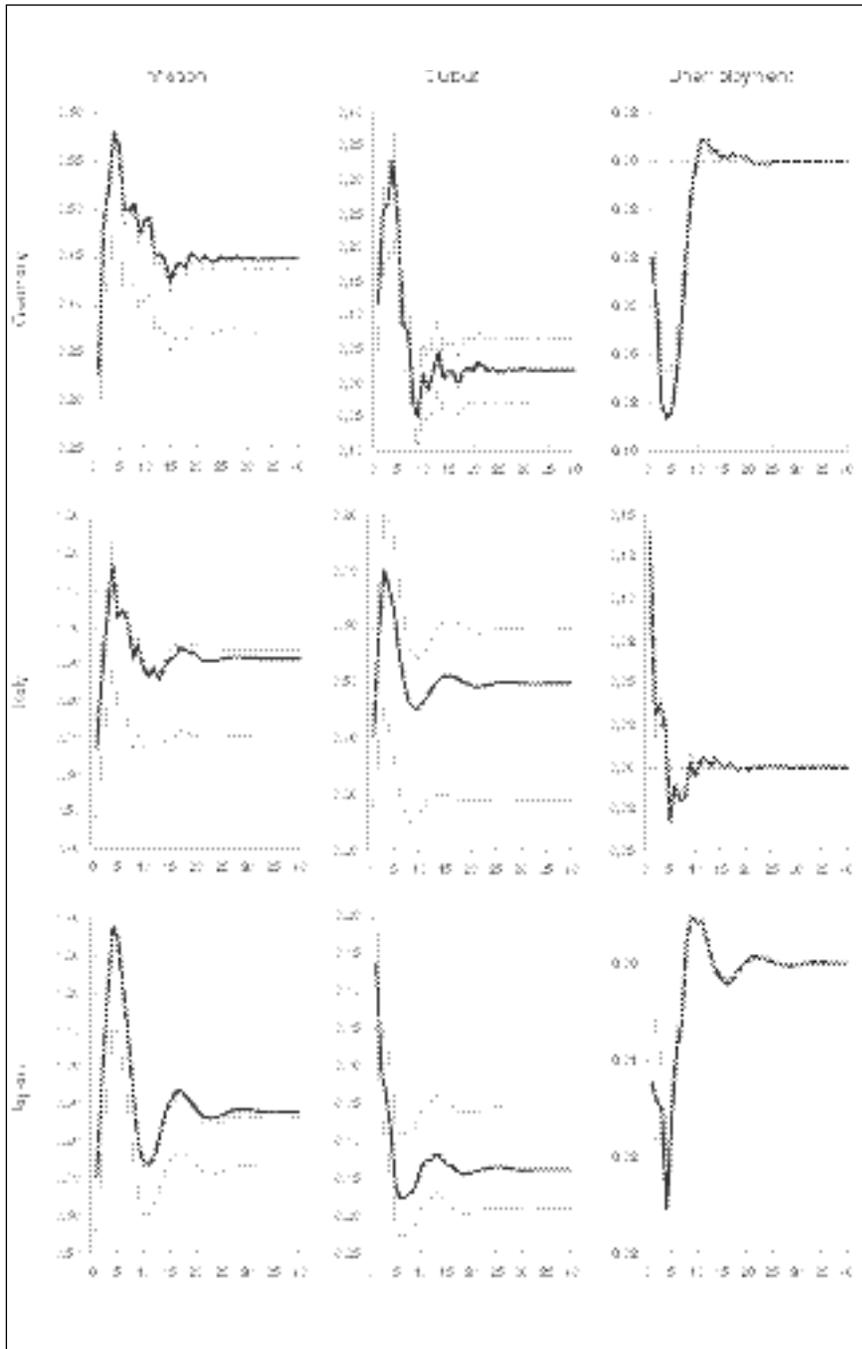
RESPONSES TO A NATURAL RATE SHOCK (ϵ^*)

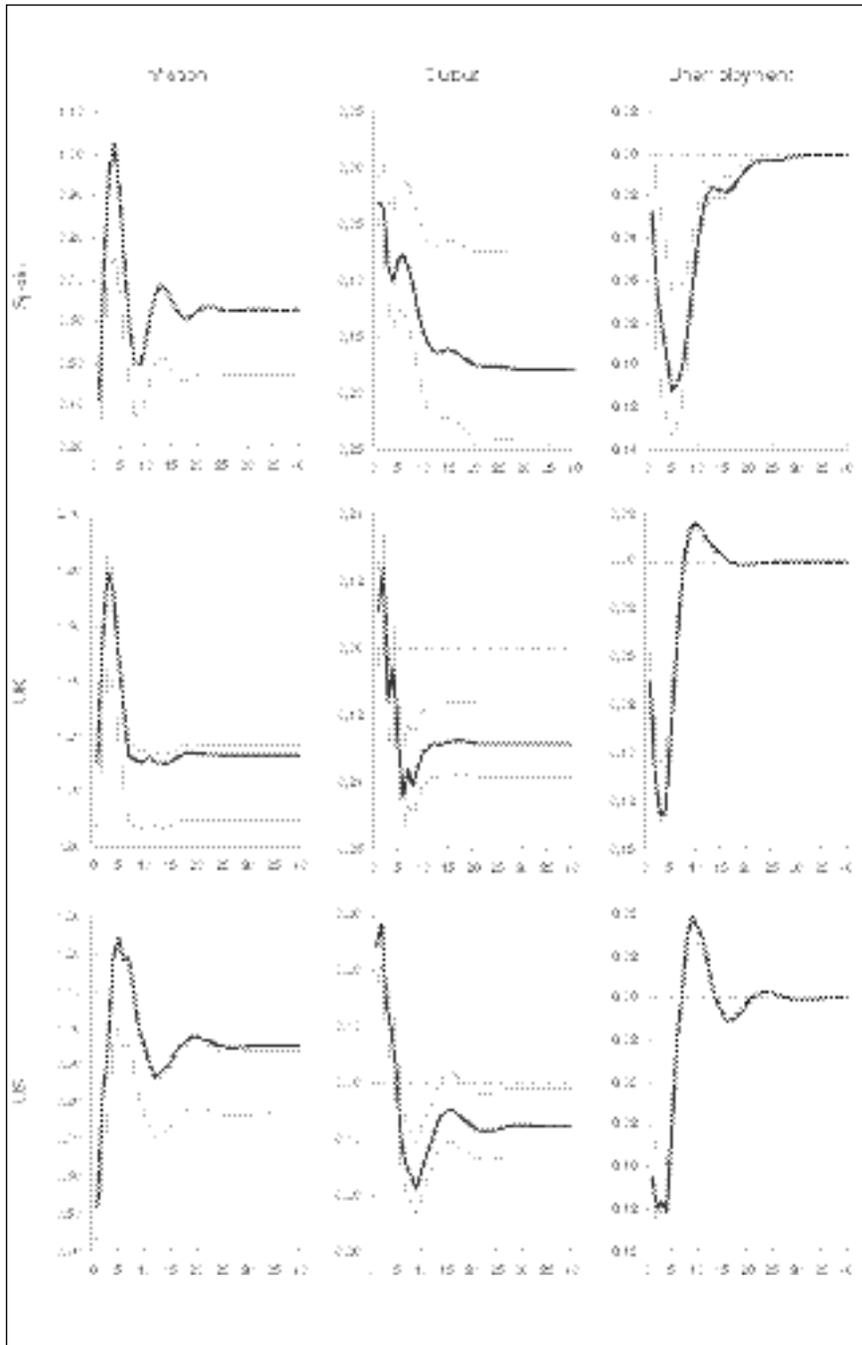
RESPONSES TO A PRODUCTIVITY SHOCK (ε^2)

RESPONSES TO A PRODUCTIVITY SHOCK (ε^2)

RESPONSES TO A PRODUCTIVITY SHOCK (ε^2)

RESPONSES TO A NOMINAL DEMAND SHOCK (ϵ^n)

RESPONSES TO A NOMINAL DEMAND SHOCK (ε^n)

RESPONSES TO A NOMINAL DEMAND SHOCK (ϵ^n)

CONCLUSIONS

The main finding of this book is that current inflation is not positively correlated with income per capita over the long run. On the contrary, inflation reduces the level of investment as well as the efficiency with which productive factors are used. It exerts a negative temporary impact upon long-term growth rates, which, in turn, generates a permanent fall of income per capita. Furthermore, our results suggest that the lower is the inflation rate, the higher is the marginal cost of inflation. The estimated benefit of a permanent reduction of inflation by one percentage point depends on the starting level of inflation, ranging from 0.5 % to 1 % of output. These benefits are not as large as others reported in the literature, but are obtained in models displaying a high convergence rate, which suggests that might be quite sizeable in present value terms.

This negative correlation is first estimated in standard convergence equations but survives a number of improvements in the econometric methods. Inflation is still significant in these equations even in presence of additional regressors, such as the investment rate, population growth and schooling rates. Also, the negative effect of inflation in growth equations remains significant after including financial market variables. This result suggests that the long-run costs of inflation are not merely explained by policies of financial repression.

Similarly, the estimated correlation cannot be explained on the basis of the experience of some countries with a particularly poor macroeconomic performance. When high-inflation countries, or episodes, are excluded from our sample, the negative coefficient of inflation in growth equation becomes more significant and even higher in absolute value. What is most remarkable is that such negative coefficient remains significant even allowing for country-specific time-invariant effects in the equations; actually this coefficient is among the few that remain significant in these specifications. Standard Granger-causality tests give less clear-cut results, but still causality from inflation to growth is always significant and never positive in models including country dummies, accumulation rates as well as other macroeconomic variables.

Cross-country or panel data models are often criticised on the basis of reverse causality among these two endogenous variables. Furthermore, inflation and output may be negatively correlated due to the predominance of adverse supply shocks during the sample period, which tend to move them in opposite directions. If this were the case, the implications of the previous econometric results would be of little relevance for monetary policy. What needs to be ascertained is whether nominal (monetary) shocks that have a permanent effect on the inflation rate also have a permanent effect on trend output and that these two effects have opposite sign.

To that end we have identified such nominal component of inflation in a SVAR model, and found that the response of output to an innovation on that component is indeed negative and significant for several major OECD economies. Since the nominal component of the model can only be driven by the rate of growth of the money supply, what we find is that monetary policies exert a small but significant influence beyond the short-run, i.e. on the potential output of these economies, thus explaining the negative correlation uncovered by the growth equations. Although a permanent rise in the rate of monetary growth may rise output and reduce unemployment in the short-run, for reasons familiar to the business cycle literature, these effects are reversed as time goes by and end up reducing the product capacity.

All in all, the results of this book, as we read them, confirm that monetary policies aimed at achieving price stability may have non-negligible short run costs in terms of rising unemployment and foregone output, but they do pay-off in the longer term getting the economies onto a path of higher output.

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