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ECONOMIC GROWTH: THE ROLE OF POLICIES AND INSTITUTIONS. PANEL DATA EVIDENCE FROM OECD COUNTRIES

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by
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ABSTRACT/RÉSUMÉ

This paper discusses links between policy settings, institutions and economic growth in OECD countries on the basis of cross-country time-series regressions. The econometric approach allows short-term adjustments and convergence speeds to vary across countries, imposing restrictions only on the long-run coefficients. In addition to the 'primary' influences of capital accumulation and skills embodied in the human capital, the results confirm the importance for growth of R&D activity, the macroeconomic environment, trade openness and well developed financial markets. They also confirm that many of the policy influences operate not only 'directly' on growth but also indirectly *via* the mobilisation of resources for fixed investment. The paper also reports some bivariate correlations between OECD indicators of product regulation and growth. They provide some supporting evidence that the negative impact of stringent regulations and administrative burden on the efficiency of product markets also results in a negative impact on overall economic growth.

JEL classification: N10, O40, O47
Keywords: economic growth, policy and institutions, panel data

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Ce document analyse les liens entre la croissance économique et les politiques et les institutions dans les pays de l'OCDE sur la base de régressions en coupe transversale et en séries temporelles. L'approche économétrique permet aux paramètres de court terme et à la vitesse de convergence de varier d'un pays à l'autre, alors que seuls les paramètres de long terme sont estimés communs. Au-delà du rôle "primaire" joué par l'accumulation du capital physique et humain, les résultats confirment l'importance pour la croissance de l'activité de R-D, du cadre macroéconomique, ainsi que de l'ouverture aux échanges et du développement des marchés financiers. Les résultats confirment que les variables politiques influencent la croissance économique non seulement directement, mais aussi indirectement par le biais de l'accumulation du capital. Le document montre enfin des corrélations bivariées entre des indicateurs de régulation sur les marchés des produits et la croissance économique dans les pays de l'OCDE. Celles-ci suggèrent que des régulations restrictives ont un impact négatif non seulement sur l'efficience des marchés des produits mais aussi sur la croissance économique.

Classification JEL : N10, O40, O47
Mots-Clés : croissance économique, politiques et institutions, données de panel

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ECONOMIC GROWTH: THE ROLE OF POLICIES AND INSTITUTIONS. PANEL DATA EVIDENCE FROM OECD COUNTRIES

Andrea Bassanini, Stefano Scarpetta and Philip Hemmings[1]

Introduction

This paper discusses links between policy settings, institutions and economic growth in OECD countries on the basis of the available literature, descriptive material and cross-country time-series regression analysis. In particular, the focus of the paper is on the possible influences of research and development activity, macroeconomic conditions and financial market conditions on both economic efficiency and the accumulation of physical capital.

The paper examines some of the empirical relationships found in the recent growth literature in order to evaluate the overall robustness of key policy-related results and their validity for the OECD countries. The pooled cross-country time-series data used in the econometric analysis allow for the explanation of both cross-country differences in growth performance as well as of the evolution of performance over time in each country. Moreover, in contrast with previous studies, the econometric approach reconciles growth model assumptions with the needs of panel data regressions by letting short-term adjustments and convergence speeds to vary across countries while imposing (and testing) restrictions only on long-run coefficients.

The first section of the paper briefly introduces the policies and institutional dimensions that are considered in the empirical investigation of the sources of economic growth. It focuses on the transmission mechanisms linking policy to growth as well as on cross-country differences in policy settings and their evolution over time. The second section of the paper presents multivariate growth regressions for 21 OECD countries over the 1971-1998 period. This permits an assessment of the specific role of each policy in influencing growth performance, while controlling for other factors influencing the growth process. The set of institutional and policy variables considered have three basic characteristics: *i)* they are largely macroeconomic in nature; *ii)* they yield testable implications for economic growth; and *iii)* they can be evaluated using available data across countries and over time. Needless to say, this set of variables is by no means exhaustive. The third section concludes.

1. We thank Jørgen Elmeskov, Michael Feiner, Dirk Pilat, Nicholas Vanston and Ignazio Visco for many helpful comments on a previous version of the paper and Catherine Chapuis-Grabiner for excellent statistical assistance. A previous version of this paper was presented at the “Séminaire d’Economie Monétaire Internationale”, Paris, 24 November 2000 (CEPREMAP, DELTA) and we acknowledge useful comments from participants. The opinions expressed in the paper are those of the authors and do not necessarily reflect those of the OECD or its Member countries.

I. An overview of policy influences on economic growth

I.1 The role of policy and institutions on growth

The empirical growth literature has developed substantially over the past two decades, drawing on larger and richer databases and exploiting better econometric tools to explain cross-country differences in growth performance (Table 1 summarises recent studies focusing on OECD countries; see also Ahn and Hemmings, 2000). This renewed interest in the empirics of growth has its counterpart in the political discussion. In particular, evidence has accumulated to suggest that traditional (fully-exogenous) growth models do not tie up with stylised macroeconomic facts. In a model with exogenous saving rates, population growth and technological progress combined with diminishing returns to reproducible factors, there is no role for policy and richer countries grow at a slower rate than poorer countries adjusted for demographic differences. However, evidence of this process of convergence has weakened amongst the OECD countries in the most recent decades (Figure 1). Thus, the concept of convergence can only be reconciled with the data if one moves to *conditional* convergence, that is to say, the relation between growth rate and initial conditions after holding constant other variables. In particular, countries may persistently show differences in living standards and growth rates because of differences in saving rates, framework conditions and technological progress, all of which could be influenced by policy and institutions.

Extended versions of the neoclassical model have relaxed the hypothesis of exogenous savings and capital formation, giving room for policy to affect growth in the short and medium-term via an impact on savings and investment. Moreover, some of these models allow the level of efficiency in the economy to be related to policy and institutional settings, reinforcing the notion that policy can change the level of the long-term growth path. On the other hand, the *slope* of the path remains determined by exogenous (but potentially different across countries) population growth and technical progress. Another class of models relaxes this latter assumption: postulating that production requires more than just direct investment in physical capital and basic labour but also investment in knowledge and human capital, research and development (R&D) and in infrastructure. With this extended concept of capital it is possible to relax the assumption of diminishing returns to capital. With constant (or increasing) returns to “broad” capital, the long-term rate of growth becomes endogenous, in the sense that it depends on investment decisions which, in turn, could be influenced by policy and institutions.[2]

While it is difficult to discriminate amongst these models on an *a priori* basis, the empirical analysis presented in section 2 sheds some light on the mechanisms operating in the growth process. By way of background, this first part of the paper spells out the possible mechanisms that relate a given policy or institutional factor to growth and looks at differences across OECD countries and over time in these policy and institutional settings.

2. Some of these endogenous growth models imply ‘conditional’ convergence, while others do not, depending on assumptions about the specification of the production function and the evolution of broad capital accumulation (see Barro and Sala-i-Martin, 1995; Durlauf and Quah, 1999).

Table 1. **Growth-regression studies based on OECD countries**

Topic	Author	Data period(s) and coverage	Dependent variable (s)	Comment
a-general	Cellini, 1997	Annual time series, 1960-1985. Regressions for the G7 and Europe are run alongside broader regressions.	Labour productivity.	The specification is derived from a basic model with error-correction terms used to deal with short-run variation.
a-general	Cellini *et al* 1999	Annual panel data, varying time periods. Regressions for OECD countries are run alongside other country groupings.	Labour productivity and change in investment share.	Augments the annual time-series panel approach taken in Cellini (1997) (see above) with variables indicating social and political stability.
a-general	De la Fuente (1995)	21 OECD countries, 5-year panel data 1963-1988.	Labour productivity.	Regressions are based on the model used by Mankiw, Romer and Weil (1992) with additional variables indicating R&D intensity and labour utilisation. Stresses the significance of R&D in the regressions and of rapid technological catch-up in the first half of the sample period.
a-general	Englander and Gurney (1994) (1)	19 OECD countries over 4 time periods between 1960s and 1990s.	Labour productivity growth. TFP growth.	Concludes that: -capital, schooling and labour force growth have robust links with growth. (positive); -some role played by catch-up, R&D spending and inflation; -no evidence from indicators of financial deepening or trade intensity; -regressions explaining TFP growth suggest no externalities through capital accumulation.
a-general	Englander and Gurney (1994) (2)	25 "high productivity" countries (including 16 OECD countries) over 3 time periods between 1960 and 1985.	Labour productivity growth.	Essentially a replication of De Long and Summers (1992) work on the role of different forms of investment. The equipment investment share produces a robust result whilst transport and investment is insignificant. However, it is pointed out that regressions explaining output per worker in the business sector show the equipment investment share to also be insignificant.
a-general	Englander and Gurney (1994) (3)	24 OECD countries.	Growth rate of real per capita GDP, 1960-1985.	This regression replicates the Barro (1991) regression for OECD countries. Notable in that the statistical performance is poor.
a-general	Lee (1995)	16 OECD countries, panel data.	Growth rates in GDP per capita.	Regressions suggest several important factors: private investment (positive), government consumption and debt (negative) and inflation (negative).
a-general	Mankiw, Romer and Weil (1992)	22 OECD countries.	GDP per person of working-age, 1985.	OECD regressions are run as part of their test of the augmented Solow model. The OECD regressions perform poorly in relation to wider samples of countries but show signs of stronger convergence compared to other samples of countries. It is hypothesised that this is due to the Second World War generating greater departures from steady states.
a-general	Vasudeva Murthy and Chien (1997)	OECD countries, cross-section data.	GDP per person of working age.	The paper tackles a similar issue that of Mankiw, Romer and Weil (1992) , further confirming the importance of human capital in an augmented Solow model context.

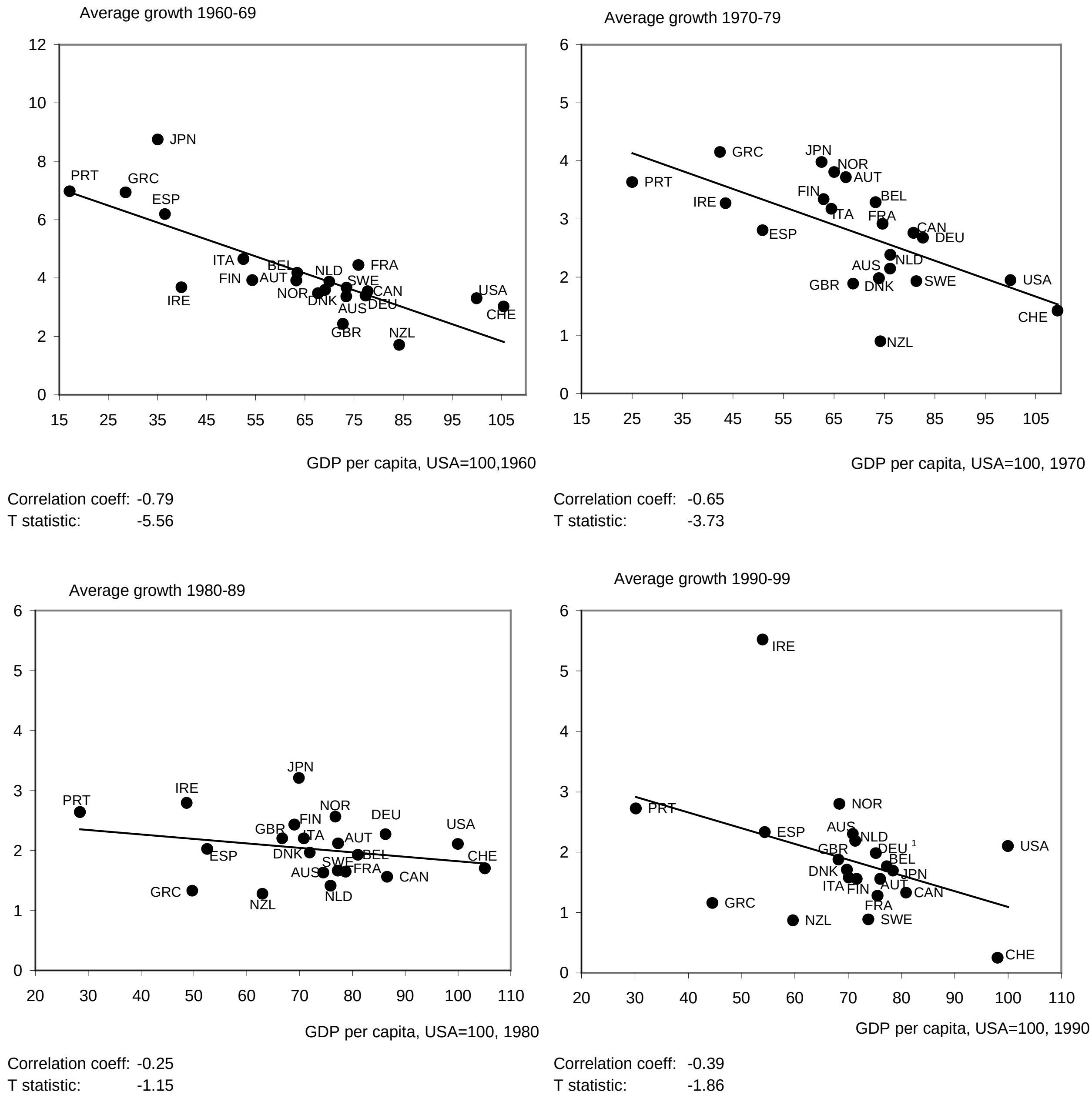
Table 1. **Growth-regression studies based on OECD countries** (cont.)

Topic	Author	Data period(s) and coverage	Dependent variable (s)	Comment
b-public capital	Ford and Poret (1991)	12 OECD countries, annual data from 1960s to 1980s.	TFP growth.	The paper questions the validity of the "Aschauer hypothesis" which argues the productivity returns to public infrastructure are high. The results of separate time-series regressions for each country fail to show infrastructure capital to important in explaining TFP growth.
b-public capital	Nourzad and Vrieze (1995)	7 OECD countries, panel data.	Labour productivity growth.	Finds public capital formation to have a positive influence on labour productivity growth. Conditioning variables include private-sector employment, private-sector investment and an indicator for the stock of natural resources.
b-public capital	Fowler and Richards (1995)	Annual panel data for 16 countries.	Growth rate in real GDP.	Finds little support for the view that the size of the public enterprise sector affects growth in growth regressions controlling for investment and human capital.
c-R&D	Fagerberg (1987)	25 countries, all OECD except 2. Panel data.	Growth rate in real GDP.	A patent index equal to the growth of patent applications made in other countries proves significant, alongside a catch-up and investment.
c-R&D	Park (1995)	10 OECD countries, panel data.	Growth rates in real GDP.	Main result is that private sector R &D appears more important than public sector R&D. It is suggested, however, that public-sector R&D acts to stimulate private-sector research. Conditioning variables cover catch-up, non-R&D investment and an indicator of capacity utilisation.
d-human capital	Domenech and de al Fuente, 2000	21 OECD countries.	Labour productivity.	The results are based on a revised version of the 'Barro-Lee' data on human capital and show that this adjusted data set appears to produce significant results not only where the level of human capital is used but also changes in human capital.
d-human capital	Wolff and Gittleman (1993)	19 industrial market economies.	Growth rates in real GDP per capita.	Runs regressions for a number of samples of countries and time periods, investigating the differences between education as measured by enrolment rates compared with attainment rates. For OECD countries only tertiary enrolment rates are significant, whilst attainment is always more significant for primary education. It is noted that inclusion of investment strongly affects the significance of the attainment variables.
e-inflation	Alexander (1997)	Small number of OECD countries, panel data.	Growth rate in real GDP.	Both levels of inflation and changes in inflation are significant.
e-inflation	Andres and Hernando (1997)	OECD countries, panel data.	Growth rates in GDP per capita.	In an analysis based on several econometric approaches, consistently finds inflation to be negatively correlated with growth. Conditioning variables include catch-up, investment, human capital and population growth.
e-inflation	De Gregorio (1996)	21 OECD countries.	Growth rate in real GDP per capita.	Runs regressions for a number of groups of countries and concludes a significant negative impact of inflation on growth. OECD regressions include catch-up, initial education levels and government consumption.
f-fiscal	Agell e*t al.* (1998)	23 OECD countries, panel data.	Growth rate in real GDP per capita.	A critique of Folster and Henrekson (1998) with replication of results and additional analysis to support their claim of there being no evidence to support a fiscal effect on growth.
f-fiscal	Agell *et al*. (1997)	23 OECD countries.	Growth rate in real GDP per capita.	Finds no support for significant influence of either the tax or expenditure share on growth. Conditioning variables include catch-up and shares of young and older cohorts in the population.

Table 1. **Growth-regression studies based on OECD countries** (cont.)

Topic	Author	Data period(s) and coverage	Dependent variable (s)	Comment
f-fiscal	Hansson and Henrekson (1994)	Industry-level data for 14 OECD countries.	Industry-level rate of growth.	The regressions examine the link between industry-level rates of growth and various components of government expenditure. The results find that government transfers, consumption and total outlays have a negative impact on growth whilst education expenditure has a positive impact and government investment is not significant.
f-fiscal	Folster and Henrekson (1999)	23 OECD countries, panel data.	Growth rate in real GDP per capita.	In response to the conclusion of Agell *at al.* (1997), claims that their conclusion is based on poor regression results. Perform some panel regressions and find a robust (negative) link between tax or expenditure shares and growth.
f-fiscal	Folster and Henrekson (2000)	23 OECD countries, cross country and panel regressions, 1960-75.	Growth rate in real GDP per capita.	Builds on Folster and Henrekson (1999) , and claims that the more econometric problems are address, the more clearly the data show a negative relationship between the ‘size’ of government and growth.
f-fiscal	Kneller *et al*. (1999)	22 OECD countries, panel data.	Growth rate in real GDP per capita.	Classifies tax revenue into ‘distortionary’ and ‘non-distortionary’ and classifies expenditure into “productive” and “non-productive”. Conditioning variables include catch-up, investment and labour force growth. Concludes from results that non-distortionary revenue and productive expenditure are a zero impact on growth. Furthermore suggests results imply an increase in productive expenditure, if financed from non-distortionary tax and non-productive expenditure has a positive impact on growth. Acknowledges that results are weakened by the finding that coefficients vary significantly depending on time period chosen.
f-fiscal	Medoza *at al.* (1997)	18 OECD countries, panel data.	Growth rate in real GDP per capita.	Introduces data on tax rates on consumption, labour, capital and personal taxation to growth regressions and finds that they are not statistically significant determinants of growth. Concludes that the evidence supports the Harberger hypothesis that in practice tax policy is an ineffective instrument to influence growth.
f-fiscal	Miller and Russek (1997)	16 countries, panel data.	Growth rate in real GDP per capita.	Disaggregates revenue and expenditure into different components and runs regressions for both OECD and developing countries. Conditioning variables include catch-up, population growth, investment, openness and inflation. For developed countries, concludes that debt-financing increases in expenditure have no effect on growth but that tax-financed increases do. In terms of expenditure, education expenditure is positively linked with growth whilst other forms of expenditure have no significant impact.

Figure 1. **Comparison of GDP per capita growth rates and initial conditions over four decades**



Note:
GDP per capita is based on the OECD 1993 purchasing power parities estimates, average growth rates are based on H-P cyclically-adjusted real GDP volumes.

Source: OECD.

I.2 The accumulation of physical and human capital

I.2.1 Investment and growth

The rate of accumulation of physical capital (typically proxied by the share of investment in GDP) is one of the main factors determining the level of real output per capita. In a neo-classical model, a one-time increase in the investment rate leads only to a transitional period of increased output growth. When growth reverts back to the steady state rate; the capital stock and output have risen to levels at which the new rate of gross investment is only sufficient to maintain a constant capital/labour ratio plus an amount to cover physical depreciation. Endogenous growth models allow for more permanent effects of increases in investment on the steady state growth rate of output per capita. First, technological progress could, to some extent, be embodied in the process of investment. Second, Arrow (1962) and Romer (1986) introduce externalities to capital whereby private returns to scale may be diminishing, but social returns - reflecting spillovers of knowledge or other externalities - can be constant or increasing.[3]

Government can influence the rate of investment in physical capital either directly (housing, urban infrastructure, transport and communication) or indirectly by affecting incentives to invest in the private sector. The fact that various policies can affect both the level of investment as well as influencing growth through other mechanisms creates some difficulties in evaluating their role. If policy variables are included along with investment as explanatory variables in growth regressions, the estimated coefficients pick up only part of the overall impact on growth.[4] For this reason, in the regression analysis presented in section 2 of the paper, the growth equation is complemented with an investment equation.[5] The growth equation aims at identifying the effect on output of a policy variable over and above its potential impact of investment, while the investment equation is intended to identify the impact of the policy variable on the level of investment. The investment rate is proxied by gross fixed capital formation in the business sector as a share of business sector GDP (see Figure 2 for a comparison across countries and over time). Public-sector investment share is also considered in extended regression equations to assess its independent impact on output, as suggested by Aschauer (1989), as well as its potential effect on the estimated coefficient of the business-sector investment rate.[6]

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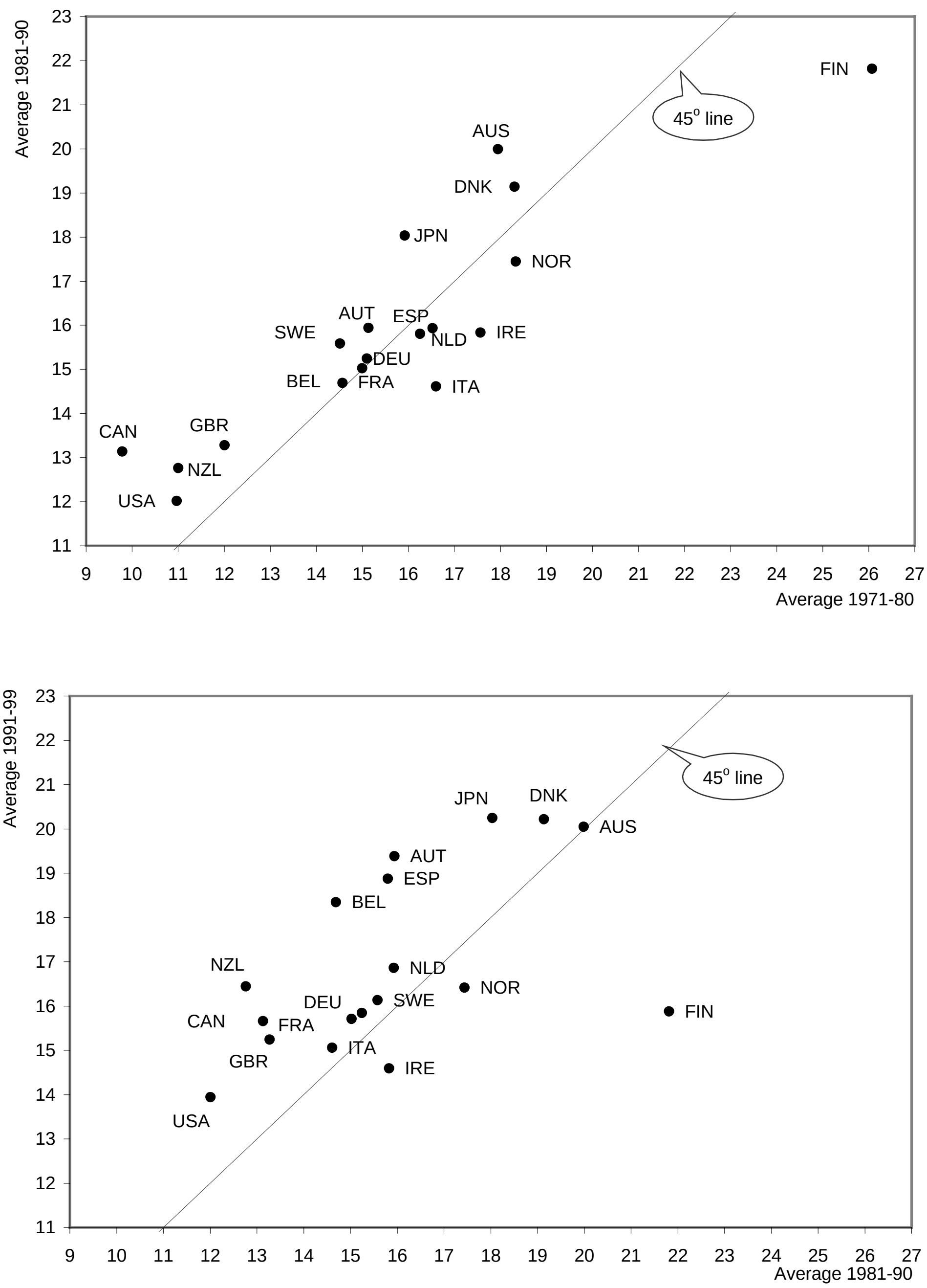
3. For example, the introduction of new capital may lead to better organisation and efficiency even if no new technology is incorporated in the capital equipment (Arrow 1962). It could also be assumed that the growth rate of labour productivity of workers operating on new machines could be related to investment in new technologies (Kaldor, 1957).

4. For example, if a variable has a positive bearing on output independently of its positive impact on investment, its estimated coefficient in a growth regression that includes on the right-hand side the investment rate will under-represent its total impact on output. Alternatively, if the policy variable has a positive independent effect on output growth but a negative effect on investment, the estimated coefficient in the growth regression will be biased upward.

5. An alternative approach pursued in the empirical literature is to omit the investment variable from the growth equation (Barro, 1991, amongst many others, takes this approach). This can be justified on the basis that researchers wish to reflect the full influence that policy variables may have on growth. However, leaving investment out of regressions requires some faith in *a priori* reasoning as well as confidence that the proxies used (say, for financial development) are not themselves driven by investment.

6. Specifying public capital as a separate factor input in the aggregate production function, Aschauer (1989) found the marginal productivity of public infrastructure spending to be two to four times higher than that of private investment spending. However, these results have been questioned by several researchers (*e.g.* Aaron, 1990; Schultze, 1990; Tatom, 1991) on the ground that they were implausibly high and affected by possible problems of misspecification and reverse causality. More recently, Duggal *et al.* (1999) found results consistent with the original predictions of Aschauer by specifying infrastructure as

Figure 2. **Business-sector investment share, 1970s-1990s[1]**



Note:

1. The ratio of real private non-residential fixed capital formation to real business-sector GDP. The figures are cyclically adjusted using an H-P filter.

Source: OECD.

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part of the technology index, as opposed to including infrastructure as a factor input in the production function.

I.2.2 Human capital and growth

One of the key extensions of the neo-classical growth model is to include human capital together with physical capital. This generally improves the fit of the model with real-world data and increases its plausibility. In these augmented models, the role of human capital is analogous to that of physical capital, insofar as its accumulation implies capital deepening with an associated period of accelerated growth towards a new steady state. However, investment in human capital (*e.g.* higher expenditures on education and training) might play a more persistent role in the growth process. Advances in technological progress often have strong links with education, especially at the higher level. Thus, education may not only make a contribution to 'embodied' improvements via increases in the skills of the workforce but also a contribution via innovation. Indeed, new-growth models that incorporate a knowledge-producing sector can be interpreted as incorporating the role that, for example, research universities may play in growth.[7]

Table 2. **Average years of education in OECD countries, 1970-98**

	Average years total[1] 1970	Average years total[1] 1980	Average years total[1] 1990	Average years total[1] 1998
Australia	11.02	11.58	12.14	12.34
Austria	9.72	10.42	11.27	11.77
Belgium	8.16	9.26	9.78	10.79
Canada	11.37	12.10	12.47	12.94
Denmark	9.85	10.60	11.04	11.43
Finland	8.63	9.60	10.40	11.21
France	8.75	9.51	9.96	10.60
Germany[2]	9.47	11.41	12.89	13.55
Greece	7.40	7.93	8.85	9.86
Ireland	7.84	8.49	9.38	10.26
Italy	6.64	7.32	8.36	9.79
Japan	9.37	10.21	11.24	..
Netherlands	9.00	10.11	11.21	11.85
New Zealand	10.24	10.92	11.35	11.77
Norway	9.78	10.74	11.59	11.96
Portugal	6.51	6.90	7.23	7.73
Spain	5.71	7.22	7.32	8.65
Sweden	9.10	10.10	11.07	11.65
Switzerland	10.47	11.49	12.58	12.90
United Kingdom	9.10	10.10	10.89	11.95
United States	11.57	12.23	12.59	12.71

Notes:

1. Average number of years of education in the working-age population based on data on highest level of education attained and assumptions about the number of years of education implied by different levels of education achievement.
2. Western Germany in 1970, 1980 and 1990.

Source: OECD.

7. An early example of this type of model was by Uzawa (1965), later examples by Lucas (1988), Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1998).

In this study, human capital is measured by estimates of the average number of years of education among the working-age population, based on figures on educational attainment and assumptions about how many years of education a particular level of education represents.[8] Table 1 shows that despite some convergence over time, there remain significant differences between countries in this measure. In 1970, the data range from 5.7 years (Spain) to 11.6 years (United States), whilst the most recent years still indicate a range from 7.7 to 13.6 years (Portugal and Germany, respectively).

I.3 Research and development

Technological development is at least partially an endogenous process, influenced by business and policy environments. For example, private-sector expenditure on research and development results in many significant technological developments. However, non-rivalry and less than full excludability of advances in knowledge mean that there are spillover effects which imply that without policy intervention the private sector would likely engage on less R&D than is socially optimal.[9] This can justify some government involvement in R&D, both through direct provision and funding, but also through indirect measures such as tax incentives and protection to intellectual property rights to encourage private-sector R&D (see Nadiri, 1993 and Cameron, 1998, for a review).

Overall expenditure on R&D as a share of GDP has risen somewhat since the 1980s in most countries (Figure 3, Panel A), partly reflecting increases in R&D in the business sector that accounts for the majority of expenditure in this area in most OECD countries (Figure 3, Panel B).[10] Interestingly, the increase in business-sector R&D intensity in the 1990s as compared to the 1980s has been driven by larger resources made available by private firms, rather than by governments: indeed the share of publicly financed business-sector R&D has declined over the past decade in most countries (Figure 3, Panel C).

An important policy consideration is whether the relationship between public and private R&D is one of complementarity or substitution. Available econometric evidence gives conflicting answers: a number of studies support the complementarity hypothesis, but others cite instances where publicly funded R&D displaces private investment.[11] A final consideration with respect to the role of public-sector R&D is that it is often directed at making improvements in areas not directly related to growth, such as defence and medical research, and any impact on output growth could be diffused and slow to come about (see OECD, 1998). All in all, these considerations suggest that any quantitative analysis of growth must take R&D

8. This variable is, of course, only a proxy for human capital, insofar as it does not consider on-the-job training, experience and other factors that could potentially influence human capital. However, it is an improvement with respect to the measures generally used in the literature. It relies on OECD data on education attainment and the revised Barro-Lee (1996) dataset based on the work of De la Fuente and Domenech (2000).

9. There has been a certain amount of conjecture as to the nature of the spillover effects from R&D. While most studies have pointed to positive spillover effects, some have hinted at possible negative spillovers. See OECD (2000*a*) for further discussion.

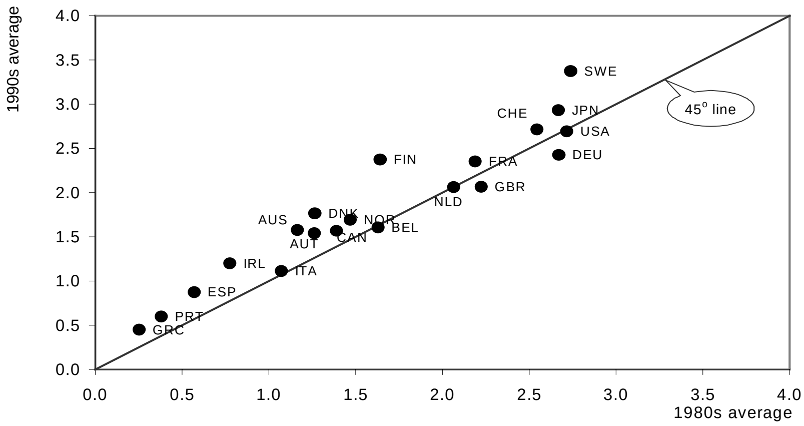
10. The forthcoming OECD (2000*a*) provides more details on recent trends in R&D intensity. In particular, the decline in government spending in R&D has been affected by the reduction in the military R&D budget in the aftermath of the end of the cold war. Moreover, government spending declined in the early 1990s as a result of the efforts to reduce fiscal imbalances.

11. For example, Guellec and Van Pottelsberghe, 1997 support the complementarity hypothesis, while, *e.g.* Lichtenberg (1984) finds that changes in company R&D had a consistently and significantly negative correlation with changes in public R&D in the United States. Lichtenberg (1988) also finds that non-competitive R&D procurement tends to crowd out private R&D investment, while competitive procurement stimulates private R&D investment. See David *et al.* (1999) for a survey.

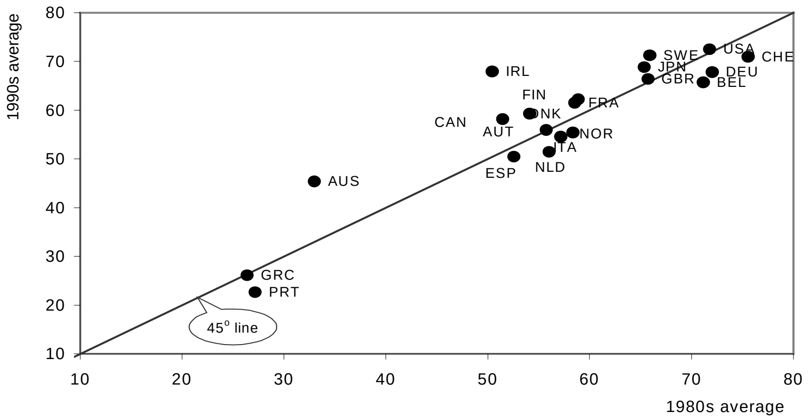
activity into account as an additional form of investment and consider possible interactions between different forms of R&D expenditure and different forms of financing. Given data availability, section 2 of the paper will consider total R&D expenditure (as a share of GDP), business sector R&D expenditure and the privately financed share of business sector R&D expenditure.

Figure 3. **Expenditure on R&D in the OECD countries, 1980s and 1990s**

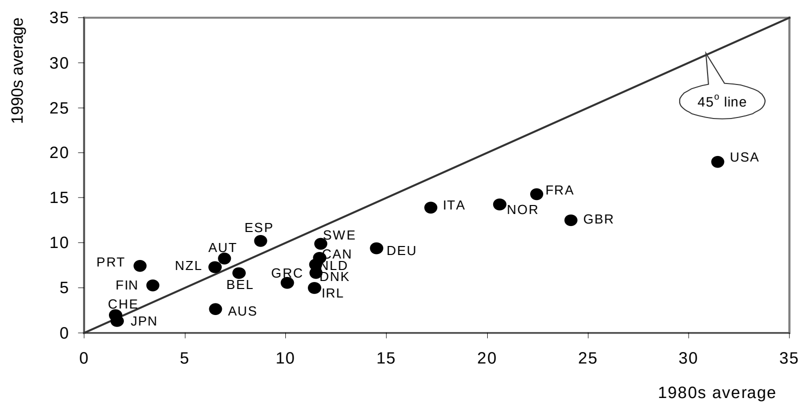
Panel A. **Total expenditure on R&D as a percentage of GDP, 1980s and 1990s**



Panel B. **Business enterprise expenditure on R&D as a share of total expenditure on R&D, 1980s and 1990s**



Panel C. **Share of government-financed business enterprise R&D, 1980s and 1990s**



Source: OECD, MSTI.

I.4 Monetary and fiscal policy and growth

In recent years most OECD countries have made significant steps towards low inflation and improved public finances. The broadest economic argument for the benefits of stability-oriented macroeconomic policy is that it reduces uncertainty in the economy.[12] The literature has focused on three issues; the benefits of maintaining low inflation, the impact of government deficits on private investment, and the possibility of negative impacts on growth stemming from a too-large government sector (with associated high tax pressure to finance high government expenditure).

I.4.1 Inflation and growth

In the context of the growth literature, two inflation-related factors have generally been considered, namely its level and its variability.[13]

– *Direct effect of inflation on investment:* It has been argued that inflation can be considered as a tax on investment and, thus, high levels of inflation would increase the profitability required to undertake an investment project with an overall negative impact on the accumulation of physical capital (see *e.g*. Stockman, 1981; De Gregorio, 1993; Jones and Manuelli, 1993).[14] However, others have pointed out that an increase in the rate of inflation results in a higher cost of holding money and a portfolio shift from money to capital, leading to an increase in investment and growth and a decline in the real interest rate (Mundell, 1963; Tobin, 1965).[15]

– *Inflation, uncertainty and growth*. Inflation could also have an impact on investment, the returns to investment and hence on growth via its impact on uncertainty. Uncertainty about inflation is likely to rise with the level of inflation (see *e.g.* Ball and Cecchetti, 1990). Moreover, inflation increases the amount of 'noise' in price signals (Barro, 1976, 1980).[16]

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12. Policy-induced uncertainty can reduce the efficiency of the price mechanism (Lucas, 1973). In addition, if investment or the choice of technology is irreversible, then increased volatility in output might lead to lower investment (*e.g.* Bernanke, 1983; Pindyck, 1991; and Ramey and Ramey, 1995) Not all links between output volatility and growth may be negative. Some have argued that there may be a choice between high-variance, high-expected-returns technologies and low-variance, low-expected-returns technologies (*e.g.* Black, 1987). Moreover, cross-country differences in the volatility of output may to some extent reflect differences in the 'size' of economies. Greater diversity of activities in larger economies implies that sector-specific shocks carry less weight in aggregate outcomes. In addition, 'large' economies are typically less exposed to external shocks as trade balances are relatively small compared with smaller economies.

13. See Temple (1998) for a comprehensive discussion of theories linking inflation with growth.

14. In the models developed by Stockman (1981) and De Gregorio (1993), money is required to buy capital goods, and thus the effective cost of capital increases with the inflation rate. Jones and Manuelli (1993) argue the case based on nominal rigidities in the tax structure, specifically, taxes include nominally-denominated allowances: in these cases, as inflation rises tax allowances (credits) decline and the effective cost of investment rises.

15. However, the potential for such an effect is limited since money balances are only a small fraction of the capital stock and, thus, the effect could at best be marginal.

16. Several studies show that the variability of prices across goods and the variability of prices of the same good across stores increases with inflation (see Lach and Tsiddon, 1992, for a survey). Moreover, Tommasi (1993) finds that price differences within markets, rather than between them, increase with inflation.

> The link between uncertainty and investment is less clear-cut: while the irreversible investment literature (*i.e.* once a machine has been put in place it has no alternative use) provides strong support to the idea that uncertainty is harmful for investment, its composition, and ultimately growth, other studies have raised some doubts about this negative association.[17]

Evidence on the relationship between inflation and growth is somewhat mixed: while the link is strong in cases of high inflation, it is less so in cases of moderate or low inflation (see *e.g.* Edey, 1994; Bruno and Eastely, 1998). As an illustration, Figure 4 plots annual growth rate of output against inflation on the basis of groups constructed from individual observations across the OECD countries and over the past three decades. The figure shows a negative relationship between average growth and median inflation. Moreover, a link between uncertainty, investment, efficiency in resource allocation and growth would suggest a relation between variation in inflation and growth even though, given the correlation between level and variability of inflation, this effect could be difficult to identify. Bearing this caveat in mind, bivariate correlations indeed suggest a negative relationship between the change in the variability of inflation and the change in output growth (Figure 5): countries with a significant reduction in the variability of inflation have not experienced the decline in growth that other countries have.

From the above discussion, two indicators of inflation are considered in the empirical analysis: the level of inflation and the variability of inflation. These indicators are included in the growth equation that includes the investment share, whereby the estimated impact on growth is via the effect of these variables on resource allocation and the ex-post return on investment. They are also included in the investment equation, which permits testing for an effect of both variables on the level of investment.

I.4.2 Fiscal policy and growth

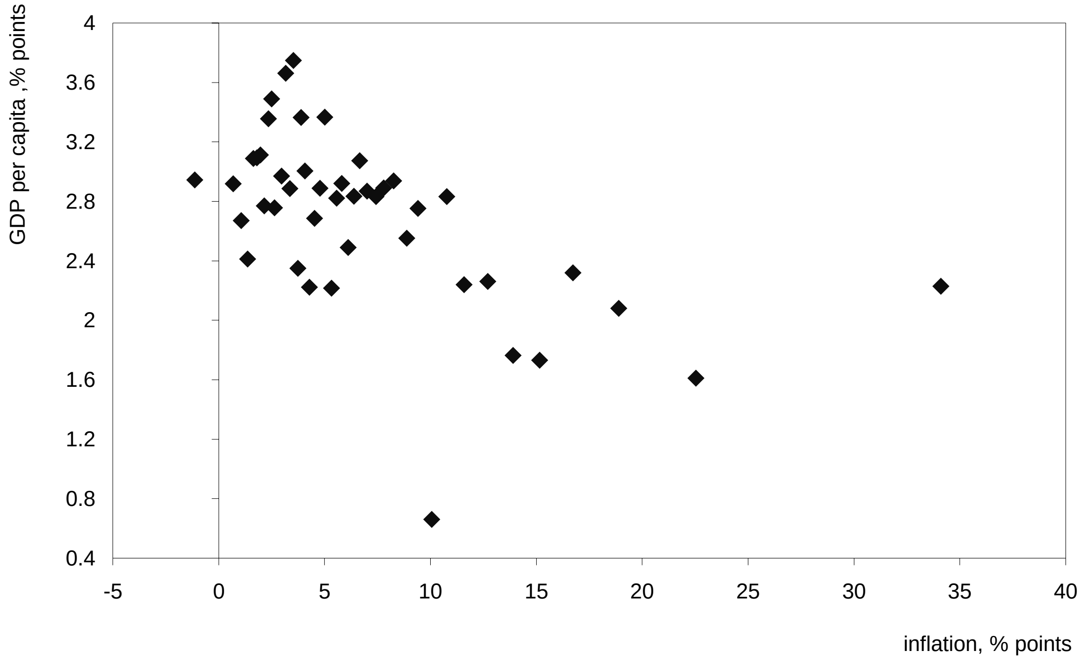
Government activities clearly play a major role in setting the economic framework in which economic growth takes place. Some of these activities are geared towards redistributive and wider social policy objectives that, at least in the short-run, are not primarily intended to lead to higher economic growth. In addition, demand for some government services (health, education, defence, etc.) could depend on the level of output per capita, so that the associated government spending would rise with living standards.[18] Bearing these considerations in mind, fiscal policy settings can affect output and growth in the medium term as well as over the business cycle. In particular, where government deficits finance consumption or transfers, a traditional argument for prudent policy is to reduce the crowding out effects on the private sector. Also, if fiscal policy is seen as being at odds with monetary policy, the credibility of the latter could be undermined leading to risk premia in interest rates and pressures on exchange rates.

Fischer (1991) has also pointed out that inflation is often taken as an indicator of the ability of governments to manage the economy.

17. Amongst the several studies that suggest a negative association between uncertainty on the one hand, and investment and growth, on the other see Dixit and Pindyck, 1994 and Bertola and Caballero, 1994. Amongst the studies that have put into question the negative association between uncertainty and investment are Abel (1983) and Hartman (1972). They suggest that in an economy with no frictions, an increase in uncertainty could even lead to higher investment rates.

18. For example, long-run data often show that government expenditure as a share of GDP tends to rise with standards of living (Wagner's law), reflecting income-elastic demand for key government services (health, education and law and order). Kolluri *et al.* (2000) find strong support for Wagner's law operating in OECD countries based on regressions linking total government expenditure with GDP.

Figure 4. **Average growth and median inflation in equal-sized samples of annual data for OECD countries**



Correlation co-0.69
T-statistic -6.26

Note :
Individual observations across countries and time are first ranked by the level of inflation. These ranked observations, coupled with corresponding figures for growth in GDP per capita, were then divided into successive groups of 20 observations. The points shown in the figure represent the median inflation of each group and the corresponding average growth in GDP per capita
Note that two points with median inflation above 30 per cent and one point with average growth above 5 per cent are not shown in the figure.
Source : OECD.

Supply side theories have also hypothesised that the taxes necessary to support government spending could distort incentives, reduce the efficient allocation of resources and hence reduce the level or growth of output. In the neo-classical framework, these distortions imply an efficiency loss with a negative level effect on output.[19] In contrast, endogenous growth model emphasise the potentially long-lasting effect of tax distortion and certain kinds of public consumption on growth (see amongst others, Barro, 1990; Barro and Sala-i-Martin, 1995; and Mendoza *et al.*, 1997). These studies often classify elements of the government budget into different categories: distortionary and not distortionary taxation;[20] and productive and non-productive expenditures. Broadly speaking, distortionary taxes (e.g. taxation on income and profit, taxation on payroll and manpower etc.) could affect the investment decision of economic agents (with respect to the level and composition of physical capital, and human capital), by creating tax wedges and hence distorting the steady-state level (and growth) of output. Non-distortionary taxes (e.g. taxation on

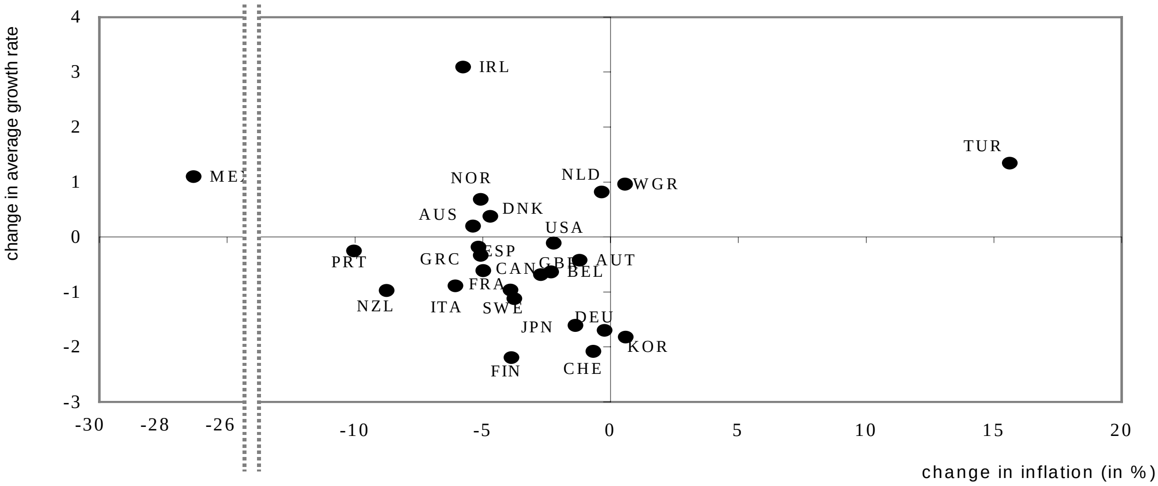
19. Jorgenson and Yun (1986, 1990) report simulations of the neo-classical model which imply that a shift from direct to indirect taxation could lead to significant gains in economic welfare in the United States.

20. See Leibfritz *et al.* (1997) for a comprehensive survey on the link between taxation and economic performance.

domestic goods and services) do not affect the preference function of economic agents and thus are neutral with respect to output growth. In a similar vein, government expenditures are sometimes differentiated according to whether they are included as arguments of the production function or not. In the first case they are classified as "productive", and thus have a direct effect on growth; otherwise they are classified as non-productive. In the first group are policy interventions that try to overcome market failures and directly add to productive capital (e.g. infrastructure investment).[21]

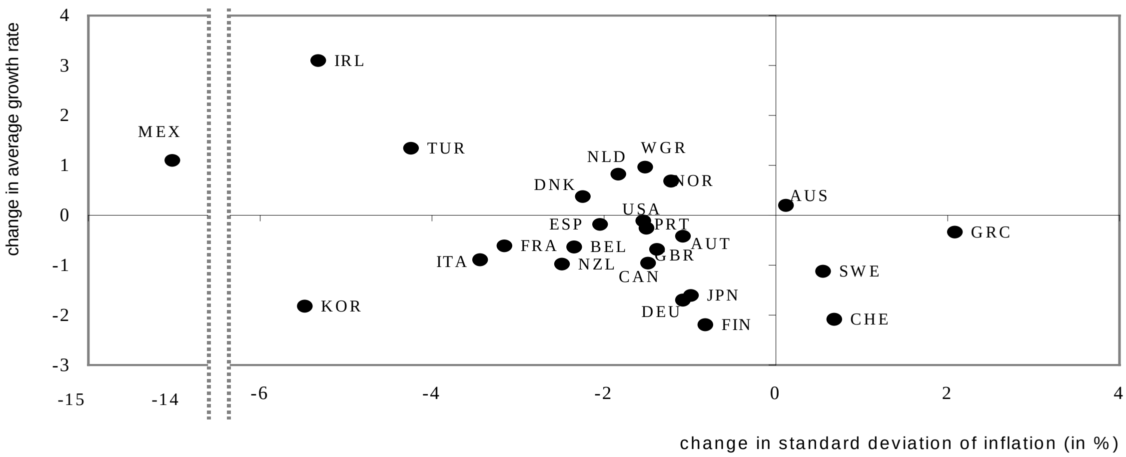
Figure 5. **Inflation and growth, 1980s and 1990s**

Panel A. **Changes in average growth and inflation between the 1980s and 1990s**



Correlation coeff: -0.01
T statistic: -0.05

Panel B. **Changes in the average growth and the standard deviation of inflation between the 1980s and 1990s**



Correlation coeff: -0.42
T statistic: -2.23
Source: OECD.

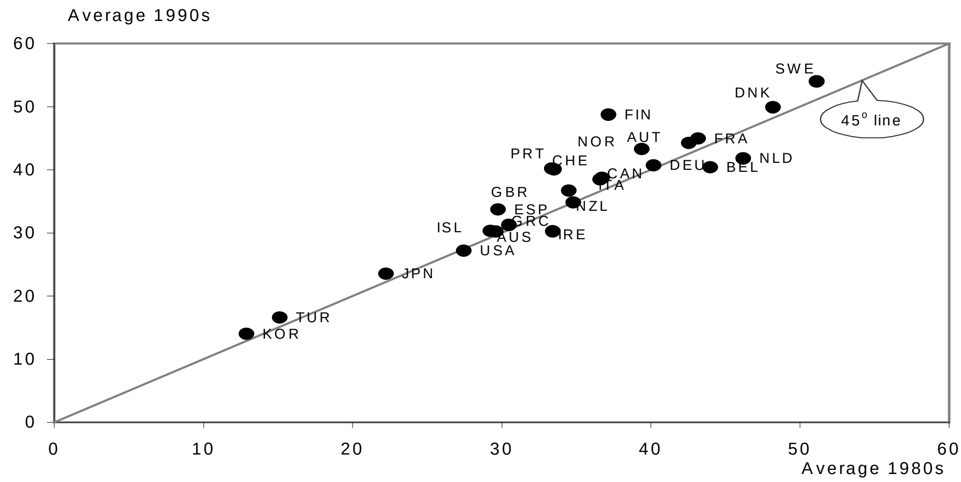
21. Classical examples include: publicly financed investment in education, if social returns to education exceed private returns (Lucas, 1988); public stimulus to innovation and technical development as well as regulations protecting intellectual property rights, if imperfect competition and scale effects are present in research and development activities (Romer, 1990); finally, public infrastructure can be considered as productive investment with a direct bearing on output growth (Barro, 1990).

The main conclusion from the literature is that there may be both a "size" effect of government intervention as well as specific effects stemming from the financing and composition of public expenditure. At a low level, the productive effects of public expenditure are likely to exceed the social costs of raising funds. However, government expenditure and the required taxes may reach levels where the negative effects on efficiency and hence growth start dominating. This may reflect an extension of government activities into areas that might be more efficiently carried out in the private sector; or perhaps misguided or inefficient systems of transfers and subsidies. These negative effects may be more evident where the financing relies more on so-called "distortionary" taxes and where public expenditure focuses on so-called "unproductive" activities.

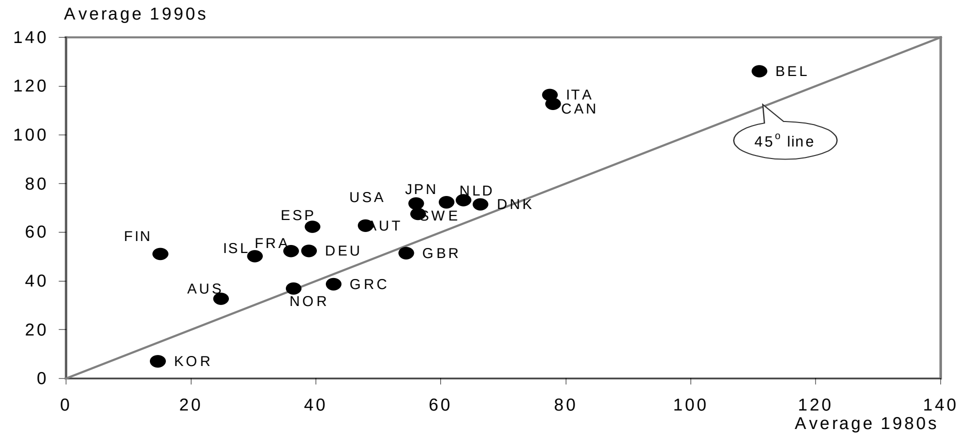
Between the 1980s and 1990s the "size" of the public sector tended to increase in most OECD countries as did government gross liabilities (see Figure 6). More recently, public-sector finances have improved significantly. Notwithstanding these important developments, the share of total government expenditure in GDP was still in the range of 40-50 per cent in a number of OECD countries in 1999 (Table 3). Moreover, less than 20 per cent of public expenditure in OECD countries consists of expenditure that could be classified as "productive" (*e.g.* schooling, infrastructure and R&D). And in a number of countries, the share of "productive" expenditure declined over the past decade.

Figure 6. **General government expenditures and liabilities, 1980s and 1990s**

Panel A. **Total government expenditure on goods, services and transfers as a percentage of GDP**



Panel B. **General government gross financial liabilities as a percentage of GDP**



Source: OECD.

Table 3. **Total government outlays and "productive" government spending as a share of total spending in OECD countries, 1985, 1995 and 1999**

Percentage

	A Education		B Transport and communication		C R&D		A+B+C		Share of total government outlays in GDP		
	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	1999
Australia	14.6	13.2	10.1	8.3	2.1	2.2	26.8	23.6	37.3	35.5	32.3
Austria	9.6	9.5	3.3	2.1	1.2	1.4	14.1	13.0	50.1	52.6	50.7
Belgium	12.7	..	8.7	..	0.9	..	22.3	..	57.3	50.1	47.9
Canada	13.0	..	5.4	..	1.5	..	19.8	..	46.0	46.3	40.2
Denmark	11.3	11.7	4.0	3.0	1.2	1.2	16.4	15.9	56.6	59.0	54.3
France[1]	10.5	10.7	2.9	1.9	2.3	1.8	15.7	14.4	51.8	53.5	52.2
Germany	9.5	7.6	4.3	3.4	2.2	1.8	16.0	12.9	45.6	46.3	45.6
Iceland	13.0	12.3	9.0	7.6	1.6	2.5	23.6	22.4	32.5	36.0	33.4
Ireland[1]	10.6	12.2	4.5	5.0	0.8	0.8	15.9	18.0	46.6	36.4	31.5
Italy	10.0	8.9	7.7	4.6	1.2	1.0	18.8	14.5	50.6	52.3	48.3
Japan	12.8	10.8[4]	..	..	1.8	1.9	..	..	31.6	35.6	38.1
Korea	17.8	18.1	7.1	9.6	..	2.7	..	30.4	17.6	19.1	25.5
Netherlands	9.9	..	..	..	1.8	..	..	..	51.9	47.7	43.2
New Zealand	..	13.3[4]	..	..	..	1.3[1]	..	..	52.6	38.8	40.8
Norway	12.0[3]	13.7	6.6[3]	5.9	1.6	1.6	20.2	21.3	41.5	47.6	46.1
Portugal[2]	8.7	13.3	3.6	4.8	0.5[5]	0.9	12.9	19.0	40.2	44.5	44.7
Spain	8.8	10.3	6.3	6.0	0.7	0.9	15.8	17.1	37.7	42.5	38.6
Sweden	..	..	..	..	1.7	1.7	..	..	60.3	62.4	55.9
Switzerland	19.7	..	11.4	..	..	..	..	..	..	..	..
United Kingdom	10.2	12.1	3.2	3.6	2.0	1.5	15.5	17.2	43.0	44.4	39.9
Unites States	..	..	..	..	4.1	2.8	..	..	33.8	32.9	30.1

Notes:

1. 1993 instead of 1995.
2. 1992.
3. 1988.
4. 1994.
5. 1984.
6. 1986.
7. 1987

The concept of "productive" government spending is based on a taxonomy used by Barro (1991).

Source: OECD.

In the empirical analysis in section 2, the supply-side hypotheses relating government size to growth are tested by looking at both taxation and government spending. The potential role of the structure of financing and expenditure was considered by looking separately at direct and indirect taxes and different elements of government expenditure. In this context, the human capital variable discussed above may be taken to represent past and present governments' efforts in financing education.[22] Likewise, public spending on research and development are clearly identified in the extended models that include R&D (see below). Finally, public investment has been included as distinct from consumption to test if that distinction is pertinent.

I.5 International trade and growth

Aside from the benefits of exploiting comparative advantages, theories have suggested additional gains from trade arising through economies of scale, exposure to competition and the diffusion of knowledge. The significant progress OECD countries have made in reducing tariff barriers and dismantling

22. In most OECD countries, government finances the bulk of expenditure on educational institutions. See OECD (2000*b*) for more details.

non-tariff barriers would therefore suggest positive gains from trade.[23] However, trade may also be endogenous to the process of growth. The relatively open stance towards trade in OECD countries would suggest that the amount of trade conducted is more a reflection of patterns of growth (and to some extent geography, size and transport costs) rather than something that reflects constraints in the form of tariff and non-tariff barriers.[24]

Given the rather more ambiguous link between trade and growth in OECD countries, this study treats the intensity of trade as an indicator of trade exposure, capturing features such as market size and competitive pressures, rather than one with direct policy implications. However, small countries are by default more exposed to foreign trade, regardless of their trade policy or competitiveness, while competitive pressure in large countries also arises from competition across states or regions. To better reflect overall competitive pressures, the indicator of trade exposure was adjusted for country size by regressing the crude trade exposure variable on population size and taking the estimated residuals from this exercise as the (adjusted) trade variable in the analysis.

II. Cross-country time-series growth regressions

II.1 The estimated equation

The growth equations can be derived from a growth model built around a constant-returns-to-scale technology. Output is a function of inputs of capital, and employment, the efficiency with which they act together, and the level of technology. Given straightforward assumptions on how the factors of production evolve over time, the steady-state level of output per capita can be expressed as a function of the propensity to accumulate physical capital, the population growth rate, the level and growth rates of technological and economic efficiency, and the (constant) rate of depreciation of capital. Moreover, if the concept of capital is widened to include human capital, then the propensity to accumulate the latter is also a factor shaping the steady-state path of output per capita. If countries were at their steady state - or if deviations from the steady state were random - growth equations could be simply based on the relationship linking steady-state output to its determinants. However, actual data may well include out-of-steady-state dynamics due, among other things, to a slow convergence to the steady state (see, amongst others, Mankiw *et al*., 1992, for a discussion).[25] Hence, observed changes in output per capita at any point in time are likely to include, in addition to technological progress, both a convergence component and a level component, due to shifts in the steady-state output per capita arising from other factors than technology.[26]

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23. For example, Coe and Helpman (1995) find significant interaction between import propensities and the ability to benefit from foreign R&D: *i.e*. for a given level of R&D performed abroad, countries with higher import propensity have higher productivity growth. Moreover, small countries benefit more from R&D performed abroad than from domestic R&D. Sachs and Warner (1995) claim trade openness as being an important constraint to convergence for many of the world's economies. Moreover, using aggregate data on trade between (mainly) OECD countries, Ben-David and Kimhi (2000) find evidence to support the idea that increasing trade between pairs of countries is associated with an increased rate of convergence.

24. See *e.g.* Frankel and Romer (1999) and Baldwin (2000).

25. Estimates of the speed of convergence to steady-state output varies greatly in the literature, from about 2-3 per cent per year (Mankiw, *et al*., 1992; Barro and Sala-i -Martin, 1995) - which implies that an economy spends about 20-30 years to cover half of the distance between its initial conditions and its steady state - to 10 per cent and more - which imply less than 9 years to cover half of the distance.

26. Moreover, the speed of convergence to the steady state can be expressed as a function of the rate of technological progress, the rate of growth of population, the depreciation rate of physical and human

The empirical approach adopted in this paper starts with a parsimonious specification of the growth equation and then analyses extended models. The initial specification is consistent with the standard neoclassical growth model and includes only a convergence factor and the basic determinants of the steady state, namely the accumulation of physical capital and population growth. The first extension involves the introduction of human capital while further extensions consider R&D and a set of policy and institutional factors potentially affecting economic efficiency.

The OECD sample permits the use of annual data instead of averages over time, as often done in the cross-country empirical literature.[27] However, year-to-year variations in output include cyclical components. These have been controlled for by including short-run regressors in the estimated equations. Thus, in its more general form, the growth equation can be written as follows:

$$\begin{aligned}\Delta \ln y_{i,t} = {} & a_{0,i} - \phi_i \ln y_{i,t-1} + a_{1,i} \ln s^K_{i,t} + a_{2,i} \ln h_{i,t} - a_{3,i} n_{i,t} + \sum_{j=4}^{m} a_{j,i} \ln V^j_{i,t} + a_{m+1,i} t \\ & + b_{1,i} \Delta \ln s^K_{i,t} + b_{2,i} \Delta \ln h_{i,t} + b_{3,i} \Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i} \Delta \ln V^j_{i,t} + \varepsilon_{i,t}\end{aligned} \qquad \textbf{(1)}$$

where s^K is the propensity to accumulate physical capital; *h* is human capital; *n* is population growth; the V^j is a vector of variables affecting economic efficiency, *t* is a time trend; the *b-regressors* capture short-term dynamics and ε is the usual error term.

Equation [1] can be estimated in different ways. At one extreme is a pure time-series approach, where all coefficients are treated as completely unrelated across countries. At the other extreme is dynamic-fixed-effects estimations, where all a_s *and* b_s coefficients are assumed equal across countries, with the exception of the constant term. The first case does not allow to exploit the cross country variability in the data to learn about the growth process, while the second imposes severe restrictions on the parameters, which are likely to be rejected by the data. This paper uses a novel approach that lies in between these two cases: the Pooled Mean Group (PMG) procedure. This approach allows intercepts, the convergence parameter (ϕ),[28] short-run coefficients (b_s) and error variances to differ freely across countries, but imposes restrictions on the other parameters leading to more efficient estimates. Conditional on the existence of a convergence to a steady state, these restrictions permit the direct identification of the parameters of factors affecting steady state path of output per capita ($a_{s,i} / \phi_i = \theta_s$, see below).[29] In other words, with the PMG

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capital as well as on output elasticities to human and physical capital. See *e.g.* Bassanini and Scarpetta (2001).

27. Where data for a large number of countries was available, growth regressions have typically taken averages over long time periods (*e.g.* 20 years). Other studies have taken averages over 5-year periods (see *e.g.* Islam, 1995; Caselli *et al.*, 1996). This, however, implies a loss of information. Moreover, the lack of synchronicity in country business cycles (especially in the recent past) does not purge five-year averages from cyclical influences.

28. In a theoretical growth model, ϕ is a function of population growth ($n_{I,t,}$) and technological progress ($g_{i,t}$) and thus could vary across countries and over time. For the purpose of the econometric analysis, time homogeneity had to be imposed, but the parameters are allowed to vary across countries.

29. There are good reasons to believe in common long-run coefficients for the OECD countries, given that they have access to common technologies, and have intensive intra-trade and foreign direct investment, all factors contributing to lead to similar long-run production function parameters. However, there is no reason to assume that the speed of convergence to the steady states would be the same across countries (as in dynamic fixed effects), not least because, formally, it also depends upon the rate of growth of population.

procedure, the following restricted version of equation [1] is estimated on pooled cross-country time-series data:

$$\Delta \ln y_{i,t} = -\phi_i \left(\ln y_{i,t-1} - \theta_1 \ln s^K_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 n_{i,t} - \sum_{j=4}^{m} \theta_j \ln V^j_{i,t} - a_{m+1} t_i - \theta_{0,i} \right)$$
$$+ b_{1,i} \Delta \ln s^K_{i,t} + b_{2,i} \Delta \ln h_{i,t} + b_{3,i} \Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i} \Delta \ln V^j_{i,t} + \varepsilon_{i,t} \qquad \textbf{(2)}$$

The hypothesis of homogeneity of the long-run policy parameters cannot be assumed *a priori* and is tested empirically in all specifications.

It should be stressed that equation [1] is a fairly general specification, and different growth models can lead to growth equations that are nested in it. The empirical results allow some discrimination across models, but there remains some uncertainty. For example, although a statistically significant convergence coefficient allows the rejection of endogenous growth models *à la* Romer (1986),[30] this is not sufficient evidence to rule out other endogenous models (*e.g. à la* Lucas, 1988).[31] In this second class of models, the a_s coefficients in equation [1] (or the corresponding $\theta_s \cdot \phi_i$ in equation 2) would not necessarily represent transitory growth effects - resulting from the shift in steady state levels - but may indicate more permanent effects. Indeed, a number of empirical papers using specifications similar to [1] above have interpreted the a_s coefficients as output *growth* effects (see, amongst others, Durlauf and Quah, 1999 for a survey; Barro, 1991). Bearing this caveat in mind, the analysis below takes a conservative view and interprets the estimated coefficients as indication of the potential shift effect on the steady-state path of output per capita.

A detailed description of the theoretical model behind the different growth equations and the econometric procedure is provided in Bassanini and Scarpetta (2001) and in Appendix 1 to this paper.

II.2 Regression results and interpretation

The growth equations were estimated for 21 OECD countries over the period 1971-1998.[32] The countries were chosen because they have continuous annual series for most of the variables used in the growth equations over the bulk of the 1971-98 period. Details on the variables used in the regression are in Box 1. This section presents the core results of the econometric analysis; details on the model selection process for the different specifications and the sensitivity analysis are presented in Appendix 2.[33]

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30. This is the case in AK models with only one type of capital (see *e.g.* Romer, 1986; Rebelo, 1991).

31. This is the case in AK models that explicitly consider different types of capital goods (*e.g.* physical and human), each characterised by its own accumulation process (*e.g.* investment and education). See Uzawa (1965); Lucas (1988) Barro and Sala-i-Martin (1995).

32. The country sample include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany (western), Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

33. An important aspect of the regression analysis is the sensitivity of results to the choice of the estimation method and the inclusion/exclusion of certain observations that significantly increase the standard error of the regression and/or affect the estimated coefficients. Eight outliers have been identified on the basis of the so-called leverage-residual plot (Belsey *et al*., 1980; Fiebig, 1987) using dynamic fixed effect estimators: the 1972-73 observations for New Zealand; 1995-97 for Ireland; 1972 for Finland and 1972-73

Box 1. **Description of the variables used in the empirical analysis**

The baseline variables used in the regression includes the following explanatory variables:

- *Dependent variable ($\Delta logY$)*. Growth in real GDP per head of population aged 15-64 years expressed in (1993) Purchasing Power Parities (PPP).
- *Convergence variable ($logY_{-1}$)*. Lagged real GDP per head of population aged 15-64 years, in PPP.
- *Physical capital accumulation ($logS_K$)*. The propensity to accumulate physical capital is proxied by the ratio of real private non-residential fixed capital formation to real private GDP.[34]
- *Stock of human capital (logH)* is proxied by the average number of years of schooling of the population from 25 to 64 years of age.[35]
- *Population growth ($\Delta logP$)*. Growth in population aged 15-64 years.

The auxiliary policy-related variables included in the augmented growth regressions were as follows:

- *Measures of inflation*: *i)* the rate of growth of the private final consumption deflator (*Infl*); and *ii)* the standard deviation of the rate of growth in private final consumption deflator (*SDInfl*) - estimated over a three-year period.
- *Indicators of government size and financing*: *i)* the ratio of general government current nominal tax and non-tax receipts in nominal GDP (*logTax*); *ii)* the ratio of direct to indirect tax receipts (*log(Tax distr)*; *iii)* the ratio of government nominal final consumption expenditure to nominal GDP (*log(Gov cons)*); and *iv)* the ratio of government real fixed capital formation to real GDP ($logS_K^{gov}$).
- *Measures of R&D intensity: i)* gross domestic expenditure on R&D as a percentage of GDP ($logR\&D^{tot}$); *ii)* business sector expenditure on R&D as a percentage of GDP (*logBERD*); and *iii)* the difference between gross domestic expenditure on R&D and business sector expenditure on R&D as a percentage of GDP ($logR\&D^{pub}$).
- *Indicators measuring financial development*: *i)* private credit of deposit money banks provided to the private sector as a percentage of GDP (*log(Priv Credit)*); and *ii)* stock market capitalisation as a percentage of GDP (*log(Stock Cap)*).[36]
- *Indicators of the exposure of countries to foreign trade*: a weighted average of export intensity and import penetration.[37] In the empirical analysis this measure was adjusted for country size ($log(Trade\ exp)^{adj}$).

All the auxiliary policy-related variables, with the exception of those related to R&D, have been introduced with a lag to better identify their impact on output. See Appendix 2 for the discussion of this issue.

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for Portugal. The results from different estimation methods are similar and broadly confirm the expected sign and significance of the coefficients on the explanatory variables included in the baseline specification. However the PMG estimates appear on balance to be more robust to changes in the specification. Although the outliers appear to be important mainly in the context of dynamic-fixed-effects estimates, these were nevertheless controlled for in all regressions presented in the paper. The sensitivity analysis also tested for the robustness of coefficients through exclusion of one country in turn from the sample and to the shortening of the sample period to 1981-98.

34. In extended models, government fixed capital formation is also considered, but its impact on growth is allowed to differ from that of private fixed capital formation.

35. See Bassanini and Scarpetta (2001) for details on the indicator of human capital used in this paper.

36. These indicators are from the World Bank's financial development database (see Beck *et al.*, 1999). For more details on the pros and cons of these two indicators and for the motivation of their inclusion, see Leahy *et al.* (2000).

37. The index of trade exposure is calculated as follows: $Trade\ Exp = Xi + (1 - Xi)*Mp$, where X_i is the ratio of exports to GDP and M_p is the ratio of imports to apparent consumption (domestic production minus exports plus imports).

II.2.1 The role of convergence and capital accumulation in the growth process

Table 4 reports the estimated coefficients and implied parameters for the basic factors driving the growth process, physical capital, human capital and convergence. All specifications suggest a (conditional) process of convergence, supporting the specification adopted in equation [2]. Moreover, in all specifications, the coefficients on both physical and human capital appear with the expected sign and are highly significant. There is, however, some variability in the estimated coefficients that implicitly underlines the importance of model specification.[38] The three specifications in Table 4 indicate coefficients for physical capital that are broadly consistent with the empirical literature: a 1 percentage point increase in the investment share on average brings about an increase in steady state GDP per capita of about 1.3 - 1.5 per cent. The coefficients on human capital still suggest relatively high returns to education: one extra year of average education (corresponding to a rise in human capital by about 10 per cent) would lead to an average increase in steady-state output per capita by about 4-7 per cent. [39] These values contrast with (many) growth studies that have found no or very limited effects of human capital on growth (see for example, Benhabib and Spiegel, 1994; Barro and Sala-i-Martin, 1995),[40] although the lowest of the present estimates are broadly consistent with estimated returns to schooling in the microeconomic literature (see Psacharopoulos, 1994).[41] Overall, the estimated output elasticity to broad capital (*i.e*. physical and human) and the speed of convergence seem to be out of line with the predictions of the standard neo-classical growth model (see Bassanini and Scarpetta, 2001).

The results on human capital might imply significant positive spillovers and a gap between private and social returns to education, or that the human capital indicator is acting as a proxy for other variables (over and above those included as framework conditions) an issue also raised in some microeconomic studies.[42] The first interpretation of the results potentially has important policy implications. Insofar as policy affects the accumulation of human capital (most prominently through education policy), and the spill-over effects are sufficiently large to imply overall non-declining returns over some range, its effect on growth may not be limited to a shift in the steady-state output level but possibly lead to more persistent (although not necessarily irreversible) effects.

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38. One potential issue in the human-capital augmented regressions is the possible correlation between human capital variable and a time trend: for many OECD countries the average number of years of schooling has increased steadily over the sample period. The sensitivity analysis in Bassanini and Scarpetta (2001) suggests that a time trend is only statistically significant when human capital is omitted and is not statistically significant at standard confidence levels when human capital is included. Consequently, in the retained specification, human capital was included while the time trend was dropped.

39. It should be stressed that these conclusions do not depend on a particular specification of the growth equation: they are indeed confirmed by a sensitivity analysis (inclusion of a linear time trend, introduction of country-specific time dummies; check of the robustness of coefficients to sample variations across countries and over time). See Bassanini and Scarpetta (2001) for details.

40. This is likely to be due to the better quality of the proxy for human capital used in this paper with respect to those used in the past. Indeed, using a similar proxy, de la Fuente and Doménech (2000) also found a strongly significant coefficient for human capital in level and growth equations.

41. However, it should also be stressed that the evidence on the returns to education reflects average rates of return based on historical data, whereas future marginal returns may not be as high.

42. Evidence from natural experiments such as changes in school-start years and from studies using data on twins tend to support the hypothesis that there is genuine effect of schooling on earnings. At the same time, there is evidence that the recent tightness in the US labour market may have benefited those with weak educational credentials, which is consistent with at least some degree of credentialism in conditions of labour market slack.

Table 4. **The role of convergence and capital accumulation for growth: summary of regression results**
(Pooled Mean Group Estimates)

Estimated coefficients	Standard equation[1]	Human-capital augmented	Trade-and-policy-augmented equations A[2]	B[3]	C[4]
logSk	0.39 ***	0.18 ***	0.25 ***	0.23 ***	0.24 ***
	(0.11)	(0.04)	(0.04)	(0.04)	(0.04)
logH	…	1.00 ***	0.41 ***	0.70 ***	0.71 ***
		(0.10)	(0.13)	(0.16)	(0.13)
$\log Y_{-1}$	-0.05 ***	-0.12 ***	-0.17 ***	-0.15 ***	-0.15 ***
	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
half way to convergence[5]	13.9 years	5.3 years	3.9 years	4.3 years	4.3 years

All equations include a constant country-specific term and control for outliers.
Standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.
1. The standard equation includes investment share in physical capital, population growth and lagged output per capita.
2. The equation also includes trade exposure, inflation and standard deviation of inflation.
3. The equation also includes trade exposure, standard deviation of inflation and tax and non-tax receipts.
4. The equation also includes trade exposure, standard deviation of inflation and government consumption.
5. Time to cover half way to convergence as implied by the estimated average coefficient of $\log Y_{-1}$.
Source: OECD.

II.2.2 The role of policy and institutions on growth

The results discussed in this section focus on the role of variables reflecting macro policy, trade exposure and financial development (see Tables 5 and 6).[43] Where appropriate, a version of the regression allowing the long-run coefficient of the additional variable of interest to vary across countries is reported alongside results where the homogeneity of long-run coefficients is imposed. It should be recalled that all the augmented regressions include investment (in physical capital) as an explanatory variable. Hence, the results can be interpreted as showing the effect on output over and above that that may be operating indirectly via investment.

II.2.2.1 Macro policy variables

Overall, the results suggest a significant impact of macro policy settings on output per capita across countries and over time. The regression results suggest that the variability of inflation has an important influence on output per capita: its estimated coefficient is always negative and more than two standard errors from zero (Table 5). This result supports the hypothesis that high variability of inflation adds noise to capital and other markets, with the repercussion likely including an inefficient choice of potential investment projects, with lower average returns of the set of projects actually undertaken. As discussed in Appendix 2, the effect of the level of inflation is less clear-cut:[44] in the trade-augmented

43. Each policy-augmented specification was estimated with and without the trade exposure variable to test for the sensitivity of coefficients. As discussed in Appendix 2, the coefficient on trade exposure is always significant and the equations reported here include this variable. This result is consistent with, amongst others, Miller and Russek, 1997 who focused on OECD countries in their empirical analyses.

44. The cross-country homogeneity restriction is rejected at the 5 per cent level in the model that does not include the trade exposure variable and, once allowed to vary across countries, it becomes statistically insignificant.

specifications presented in Table 5, the level of inflation seems to have a negative and significant impact on the steady state level of GDP per capita, but this is not always so when the trade variable is excluded.[45]

Table 5. **Macro policy influences on growth [1]**
(Pooled Mean Group Estimators)

Dependent variable: ∆logY	with control for inflation variables	with control for taxes and government expenditures		with control for both inflation and government intervention		
Long-Run Coefficients						
logSk	**0.25** ***	**0.14** ***	**0.36** ***	**0.29** ***	**0.23** ***	**0.24** ***
	(0.04)	*(0.04)*	*(0.04)*	*(0.05)*	*(0.04)*	*(0.04)*
logH	**0.41** ***	**0.92** ***	**1.26** ***	**0.88** ***	**0.70** ***	**0.71** ***
	(0.13)	*(0.13)*	*(0.22)*	*(0.19)*	*(0.16)*	*(0.13)*
∆logP	**-5.69** ***	**-15.70** [2] ***	**-3.86** [2]	**-11.01** ***	**-9.76** ***	**-7.87** ***
	(1.02)	*(3.96)*	*(3.82)*	*(1.57)*	*(1.31)*	*(1.21)*
SDinfl$_{-1}$	**-0.02** ***			**-0.02** ***	**-0.03** ***	**-0.03** ***
	(0.00)			*(0.01)*	*(0.00)*	*(0.00)*
Infl$_{-1}$	**-0.01** ***					
	(0.00)					
logSk$^{gov}_{-1}$		**0.09** ***	**0.07** ***	**-0.02**		
		(0.02)	*(0.03)*	*(0.02)*		
log(Gov cons)$_{-1}$		**-0.15** **	**0.19** ***	**0.04**		**-0.10** **
		(0.06)	*(0.04)*	*(0.07)*		*(0.05)*
logTax$_{-1}$			**-0.44** ***	**-0.18** **	**-0.12** **	
			(0.10)	*(0.07)*	*(0.05)*	
logTaxDistr			**-0.08** **			
			(0.04)			
log(Trade exp^{adj})$_{-1}$	**0.20** ***	**0.10** *	**0.20** ***	**0.14** **	**0.20** ***	**0.22** ***
	(0.05)	*(0.05)*	*(0.05)*	*(0.06)*	*(0.06)*	*(0.06)*
Convergence coefficient						
logY$_{-1}$	**-0.17** ***	**-0.21** ***	**-0.17** ***	**-0.13** ***	**-0.15** ***	**-0.15** ***
	(0.02)	*(0.05)*	*(0.04)*	*(0.03)*	*(0.03)*	*(0.03)*
No. of countries	21	21	17	17	18	21
No. of observations	523	522	427	427	444	523
Log likelihood	1553	1541	1362	1595	1349	1556

1. All equations include short-run dynamics and country-specific terms (see Appendix 2 for details). Moreover, they control for outliers Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
2. The Hausman test rejected the hypothesis of common long-run coefficient and thus the coefficient was estimated without cross-country restrictions (see Appendix 2 for details).
Source: OECD.

The hypothesis that the size of government has an impact on growth receives some qualified support (Table 5). The overall measure of tax and non-tax revenue can be used only for a sub-sample of 18 OECD countries, due to data availability. The overall tax burden is estimated to have a negative impact on output per capita[46] and, controlling for the overall tax burden, there is an additional negative effect

45. This result is consistent with Alexander (1997) who also used an OECD sample. However, several papers have focussed only on the level of inflation and indicated strong links with growth, even in the OECD samples. See, for example, Andres and Hernando (1997), Englander and Gurney (1994) and De Gregorio (1996). See also Table 1 for details.

46. The latter result is consistent with that of Folster and Hemrekson, 1998, 2000, who focus on the link between the 'size' of government and growth OECD countries. However the conclusions reached by Folster and Henrekson have been questioned by some researchers, notably Agell *et al*. (1997).

coming from a tax structure focusing on direct taxes. With control for the financing of total government expenditure, both government consumption and investment seem to have a positive impact on output per capita; this could be taken to imply that the omitted factor on the expenditure side, *i.e.* public transfers, are driving the negative effects on total financing.[47] The second specification on fiscal policy considers only the expenditure side of the government budget, and allows extending the sample to 21 countries. The results are qualitatively similar for all but the coefficient on government consumption, which becomes negative (and statistically significant). This confirms the point that focusing on one side of the budget and ignoring the other leads to systematic biases associated with the "implicit financing" assumption.[48] In particular, given the high within-country correlation between the tax variable and government consumption,[49] the coefficient on consumption when the tax variable is not included may indicate the effect on growth of the "size" of government, rather than the true effect on growth of one specific element of total expenditure.

Given the likelihood of interaction between the monetary and fiscal indicators, the equations on the last three columns of Table 5 include both the variability of inflation and the different fiscal policy variables. The key result is the stability of the coefficient for the variability of inflation across all specifications and on the negative impact of government size, whether proxied by total tax burden or by government consumption in the last column of the table. By contrast, government investment becomes insignificant as soon as the model is extended and is dropped in the final specification on the right-hand side of the table.

II.2.2.2 Indicators of financial market development

Some indication of the link between financial development and growth is presented in regressions including indicators of private credit from the banking sector and stock market capitalisation (see also Leahy *et al.*, 2000). Table 6 gives general support to the notion that the level of financial development influences growth, even after controlling for the propensity to invest. This perhaps points to a greater capacity of more developed financial systems to channel resources towards projects with higher returns. The results point to a robust link between stock market capitalisation and growth, while that between private credit provided to the private sector and growth has the wrong sign. However, the banking credit indicator is not independent from other monetary variables, being strongly related to money supply and demand conditions. Indeed, an extended model that also includes an inflation variable points to a positive relationship between private credit and growth.

II.2.3 Policy and institutional influences on capital accumulation

To explore whether a given policy influences growth indirectly *via* its impact on the accumulation of physical capital, investment-share regressions are shown in Table 7. The estimation approach is similar to that of the growth regression. Following experimentation with three control variables - lagged output per capita, human capital and lagged trade exposure - the preferred specification includes only a control for trade exposure (see Appendix 2).

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47. Public transfers are not included in the regression in order to identify the other components of the government budget.

48. See Helms (1985); Mofidi and Stone (1989); Kneller *et al*. (1998).

49. The cross-country correlation between the government consumption variable and the tax and non-tax receipts variable is greater than 0.5 in each year of the sample and always greater than 0.6 after 1976. In time-series the correlation is greater than 0.9 in 9 out of 18 countries and greater than 0.7 in all but 3 countries (Belgium, the Netherlands, and the United States).

Table 6. **Regressions including indicators of financial development**[1]
(Pooled Mean Group Estimators)

Dependent variable: ∆logY	with private credit		… and control for inflation		with stock market capitalisation	
Long-Run Coefficients						
logSk	**0.07**		**0.30**	***	**0.14**	***
	(0.06)		*(0.06)*		*(0.02)*	
logH	**1.04**	***	**0.99**	***	**0.93**	***
	(0.12)		*(0.14)*		*(0.15)*	
∆logP	**-14.48**	***	**-11.54**	***	**-4.80**	***
	(2.34)		*(1.77)*		*(0.89)*	
log(Priv credit)$_{-1}$	**-0.14**	***	**0.04**	**		
	(0.04)		*(0.02)*			
log(Stock cap)$_{-1}$					**0.09**	***
					(0.01)	
SDinfl$_{-1}$			**-0.02**	***		
			(0.00)			
Convergence coefficient						
logY$_{-1}$	**-0.10**	***	**-0.13**	***	**-0.22**	***
	(0.02)		*(0.02)*		*(0.05)*	
No. of countries	21		21		18	
No. of observations	523		523		338	
Log likelihood	1449		1498		1058	

Note:

1. All equations include short-run dynamics and country-specific terms (see Annex 2 for details), and control for outliers.
   Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.

Source: OECD.

Table 7. **Investment regressions** [1]
(Pooled Mean Group Estimators)

Dependent variable: ∆logSk								
Long-Run Coefficients								
SDinfl$_{-1}$	**-0.02**	*	**-0.01**	*				
	(0.01)		*(0.01)*					
Infl$_{-1}$	**-0.02**	***	**-0.03**	***	**-0.02**	***	**-0.03**	***
	(0.01)		*(0.00)*		*(0.00)*		*(0.01)*	
logSk$^{gov}_{-1}$	**-0.21**	***	**-0.11**	**	**0.02**		**-0.05**	
	(0.06)		*(0.04)*		*(0.03)*		*(0.03)*	
log(Gov cons)$_{-1}$	**-0.26**	*			**-0.71**	***		
	(0.15)				*(0.14)*			
logTax$_{-1}$			**-0.77**	***			**-0.36**	**
			(0.12)				*(0.14)*	
log(Stock cap)$_{-1}$					**0.14**	***	**0.17**	***
					(0.01)		*(0.02)*	
log(Priv credit)$_{-1}$	**0.09**	**	**0.06**					
	(0.03)		*(0.04)*					
log(Trade exp^{adj})$_{-1}$	**-0.32**	***	**-0.05**		**0.05**		**-0.31**	***
	(0.12)		*(0.08)*		*(0.10)*		*(0.09)*	
Convergence coefficient								
logSk$_{-1}$	**-0.15**	***	**-0.22**	***	**-0.27**	***	**-0.26**	***
	(0.03)		*(0.05)*		*(0.07)*		*(0.05)*	
No. of countries	21		18		18		16	
No. of observations	531		443		338		301	
Log likelihood	936		776		693		601	

Note:

1. All equations include short-run dynamics and country-specific terms (see Annex 2 for details), and control for outliers.
   Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.

Source: OECD.

The variability of inflation has a negative coefficient but it is only marginally significant at the standard levels. Interestingly, the coefficient of the level of inflation is strongly significant and negative in the investment equation, in contrast with the weaker result in the growth regressions. These results are consistent with the view that uncertainty about price developments mainly influence growth via distortion in the allocation of resources (as discussed above), rather than via discouraging the accumulation of physical capital, while high levels of inflation indeed discourage savings and investment. There is also evidence that the "size" of government may be negatively associated with the rate of accumulation of private capital. This can be seen by looking at the coefficients on either taxes or government consumption (estimation with the latter allows the use of a larger sample). Possible interactions between private and government investment were also tested, but the results do not yield robust results of either a negative or positive link.

The coefficients on financial variables in the investment regressions in Table 7 have the expected signs and significance. As in the growth regressions, the indicator of credit provided by the banking sector appears to be only weakly associated with investment, while the stock market capitalisation has a stronger bearing on investment. However, data limitations constrained the number of variables that could be included alongside the indicator of stock market capitalisation.

II.2.4 Research and development

The analysis of the determinants of growth can be further extended to include R&D activities, even though the sample is smaller and inference more tentative. In particular the analysis is restricted to 14-17 countries depending on the specification, and to the period 1981-98 (and for some countries the period is shorter). The shorter time-series significantly restrict the number of variables that could be considered in the regressions. These include, in addition to the R&D variables, the basic controls and trade exposure, whenever possible.[50] The indicators of R&D activity used here are expenditures on R&D as collected in national accounts expressed as a percentage of GDP and are thus indicators of the 'intensity' of R&D within each country. The results (Table 8) support previous evidence suggesting a significant effect of R&D activity on the growth process.[51] Furthermore, regressions including separate variables for business-performed R&D and the R&D performed by other institutions (mainly public research institutes) suggest that it is the former that drives the positive association between total R&D intensity and output growth.[52] The results also indicate that the coefficient on business-sector R&D is somewhat lower in the regression with the indicator of trade exposure (see Appendix 2). This suggests possible interactions between R&D and international trade; for example, domestic R&D may have a smaller impact on growth in countries widely exposed to foreign R&D. Nevertheless, the R&D coefficients largely remain significant in this augmented regression.

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50. The growth regression maintains its basic properties when estimated over the smaller sample used in the R&D regressions. The coefficients on both physical and human capital maintain their sign and statistical significance, although the convergence is higher than in the regression estimated over the larger sample. This latter result is not driven by the small country sample but rather by the shorter time period over which the model is estimated (see Appendix 2).

51. In terms of previous evidence, Fagerberg (1994), for example, found a patent-based index significant in growth regressions; and Englander and Gurney highlighted R&D expenditure as a robust variable in their growth regressions (See Table 1).

52. Park (1995) also found private-sector R&D more important than public R&D in OECD-based growth regressions (See Table 1).

Table 8. **Regressions including R&D intensity**[1]
(Pooled Mean Group Estimators)

Dependent variable: ΔlogY	with total R&D		with distinction between business and non-business R&D		with business R&D only	
Long-Run Coefficients						
logSk	**0.31**	***	**0.28**	***	**0.34**	***
	(0.03)		*(0.02)*		*(0.02)*	
logH	**1.13**	***	**1.76**	***	**0.82**	***
	(0.16)		*(0.05)*		*(0.18)*	
ΔlogP	**-12.15**	***	**-33.19** [2]	**	**-16.43**	***
	(1.64)		*(13.94)*		*(2.02)*	
$logR\&D^{tot}$	**0.14**	***				
	(0.03)					
logBERD			**0.26**	***	**0.13**	***
			(0.01)		*(0.02)*	
$logR\&D^{pub}$			**-0.37**	***		
			(0.04)			
$logBERD^{ind}$						
$logBERD^{pub}$						
$log(Trade\ exp^{adj})_{-1}$	**0.33**	***			**0.32**	***
	(0.05)				*(0.05)*	
Convergence coefficient						
$logY_{-1}$	**-0.22**	***	**-0.23**	**	**-0.18**	***
	(0.05)		*(0.11)*		*(0.04)*	
No. of countries	16		15		16	
No. of observations	252		236		251	
Log likelihood	860		831		849	

Notes:

1. All equations include short-run dynamics and country-specific terms (see Appendix 2 for details). Moreover, they control for outliers. Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
2. The Hausman test rejected the hypothesis of common long-run coefficient and thus the coefficient was estimated without cross-country restrictions (see Appendix 2 for details).

Source: OECD.

The negative results for public R&D needs some qualification. Taken at face value this result suggests publicly performed R&D crowds out resources that could be alternatively used by the private sector, including private R&D. There is some evidence of this effect in studies that have looked in details at the role of different forms of R&D and their interaction between them (Guellec and Van Pottelsberghe, 2000). In particular, it is found that defence research performed by the public does indeed crowd out private R&D, partly by raising the cost of research, while civilian public research is neutral with respect to business-performed R&D. However, there are avenues for more complex effects that regression analysis cannot identify. For example, while business-performed R&D is likely to be more directly targeted towards innovation and implementation of new innovative processes in production (leading to improvement in productivity), other forms of R&D (*e.g.* defence, energy, health and university research) may not raise technology levels significantly in the short run, but they may generate basic knowledge with possible "technology spillovers". The latter are difficult to identify, not least because of the long lags involved and the possible interactions with human capital and associated institutions.[53]

Bearing these caveats in mind, the coefficient on business-performed R&D intensity, if interpreted structurally, suggests that a persistent 0.1 percentage point increase in R&D intensity (about 10 per cent increase with respect to average R&D intensity) could boost output per capita growth by some 0.3 - 0.4 per cent. This could imply a long-run effect of about 1.2 per cent higher output per capita under the "conservative" view that changes in R&D do not permanently affect output growth.[54]

II.3 Some quantitative implications of the regression results

The estimated coefficients of the different growth regressions can be used to shed light on the role of policy and institutional settings on the growth experience of different countries over the past three decades. Two important caveats need to be borne in mind in this exercise. As discussed above, it is assumed that the policy and institutional variables affect only the *level* of economic efficiency and not the steady-state growth rate. Moreover, the calculations should only be taken as broad indications, given the variability of coefficients across the specifications, and interaction effects that may be important but cannot be taken into account. The estimated coefficients are used to perform three calculations: *i*) the effect of a given change in a policy or institutional variable on steady-state output per capita; *ii)* the decomposition of observed differences in average growth rate across countries over a 20-year period; and *iii)* the decomposition of observed changes in growth rate within each country into its determinants. In the first calculation, the direct effect of a policy change and the indirect effect (via investment) are considered, while in the other two calculations only the direct effect is estimated and investment in physical capital is considered as a one of the components of the decomposition.

II.3.1 The long-run effect of policy and institutional changes

Bearing the above-mentioned caveats in mind, the *direct effects* - derived from the growth equations that control for the level of investment and *indirect effects* - derived by combining the effect on investment with that of the latter on output per capita - of policy variables are discussed below:

- The point estimate for the variability of inflation suggests that a reduction by 1 percentage point in the standard deviation in inflation - *e.g.* about one and a half times the reduction recorded on average in the OECD countries from the 1980s to the 1990s - could lead to an increase in long-run output per capita by 2 per cent, *ceteris paribus*.

- The effect of the level of inflation mainly works through investment: a reduction of one percentage point - *e.g.* one-fourth of what recorded in the OECD between 1980s and 1990s - could lead to an increase in output per capita of about 0.4 per cent, over and above what could also emerge from any accompanying reduction in the variability of inflation.

- Taxes and government expenditures seem to affect growth both directly and indirectly through investment. An increase of about one percentage point in the tax pressure (or, equivalently one half of a percentage point in government consumption, taken as a proxy for government size) - *e.g.* two-thirds of what was observed over the past two decades in the

53. Given the short time period that can be used in this sample, lagging the R&D variable would have induced an excessive loss of degrees of freedom.

54. These estimated effects are large, pointing to significant externalities in R&D activities.

OECD sample - could be associated with a direct reduction of about 0.3 per cent in output per capita. If the investment effect is taken into account, the overall reduction would be about 0.6-0.7 per cent.

– Finally, an increase in trade exposure of 10 percentage points - about the change observed over the past two decades in the OECD sample - could lead to an increase in steady-state output per capita of 4 per cent.

II.3.2 Explaining cross-country differences in average growth rates

The empirical results discussed above can be used to shed light on the role of different policy and institutional settings in explaining differences in average growth rates across OECD countries and over the past decades. Table 9 shows how cross-country differences (relative to the OECD average) in the main factors influencing the steady-state level of output per capita contributed to cross-country differences in growth rates (again relative to the OECD average).[55] To maximise the country coverage, the regression to the right-hand-side of Table 5 is considered: it was run on 21 countries and uses government consumption as a proxy for the potential effect of government "size" on growth. The results suggest that the model fits the data rather well: there are only three countries where the unexplained differential growth rate is large in absolute terms.[56] In two of these three countries (Greece and Portugal) the model would have predicted a higher growth rate than that actually recorded. By contrast, the model under-predicts the average growth rate in the United States. In these three countries, additional factors not accounted for in the present analysis played a significant role in shaping the growth process. The other results in Table 9 confirms some priors about the driving forces of output growth in the OECD countries. In the English-speaking countries, a relatively low saving/investment rate had a negative impact on growth, *ceteris paribus*. A relatively low level of human capital on average over the period negatively influenced growth in a number of European countries, but especially in Portugal and Spain. In addition, some countries, including Australia, Canada, Ireland and New Zealand, had a somewhat lower per capita growth as a result of a rapidly growing population. Average macro policy conditions also had a bearing in shaping cross-country differences in growth. Thus, the higher than average variability of inflation had a negative impact in Greece and, to some extent in Portugal, while the large "size" of government seems to have negatively influenced growth in Denmark and Sweden. Finally, the relatively low exposure to foreign trade (after controlling for the size of each country) seems to have had a negative impact on growth in Australia and New Zealand, possibly reflecting geographical realities, while the reverse occurred in Belgium and Netherlands - though the trade exposure for these two countries reflects the large cross-border transactions amongst themselves - as well as in the United Kingdom.

II.3.3 The role of policy and institutions in shaping the growth process over the past two decades

Policy and institutional settings have changed significantly over the past three decades and it is also important to shed light on the possible impact of these changes on the growth path of each country

55. If all policy and institutional factors were the same across the board, countries would converge to the same steady-state level of output per capita, and the growth rate in each of them would depend only on the initial conditions: the lower the income per capita at the beginning of the period the higher the predicted growth rate. However, as discussed above, the policy and institutional factors vary significantly across countries and Table 9 shows the effects of these differences in terms of average growth rate with respect to the OECD average. The decomposition is discussed in detail in Appendix 2.

56. A positive country-specific effect implies that actual growth was higher than predicted by the model, and vice versa.

(Figure 7). The improvement in human capital has been one of the key factors behind the growth process of the past decades in all OECD countries, but especially so in Germany, Italy, Greece, Netherlands (mainly in the 1980s) and Spain, where the increase in human capital accounted for more than half a percentage point acceleration in growth (in both the 1980s and 1990s) with respect to the previous decade. The contribution stemming from changes in the investment rate is more mixed. Some countries are estimated to have benefited from an increase in the investment rate in the past two decades with respect to the 1970s (*e.g.* Japan, Canada, Austria, Belgium, New Zealand), while other could have had a negative impact from lower investment rates (*e.g.* Italy and Ireland in the 1980s, Finland in the 1990s).

There have also been important changes in policy and institutional settings in each country that have contributed to growth, over and above the changes in factor inputs. Most countries have benefited, especially in the 1990s, from reduced uncertainty due to a lower variability of inflation. The most noticeable examples include the United Kingdom and Japan (in the 1980s) and Portugal and New Zealand (in the 1990s) where about half a percentage point higher annual output per capita growth rate is estimated to be due to the lower variability of inflation, *ceteris paribus*. By contrast, in spite of the greater fiscal discipline especially in the last decade, the rise in the size of government contributed to slow down growth in most countries. Notable exceptions include the United States, Ireland and the Netherlands where a reduction in taxes and expenditures as a share of GDP somewhat boosted output per capita growth in the 1990s. Finally, but not least, the generalised process of trade liberalisation in which all OECD countries have been involved is estimated to have increased growth by up to two-thirds of a percentage point annually over the past decade.

Growth regressions clearly have limits in the extent to which they can confirm and quantify links between policy and institutional settings and economic growth. An obvious, and inherent difficulty is that relatively recent growth issues - in particular the current debate about the possible shift to a 'new economy' due to the development and diffusion of ICT in production and consumption - are difficult to examine using the regression approach. The most fruitful analyses on the effects of ICT to-date have been based on growth accounting or case studies which attempt to isolate the impact on aggregate productivity of the ICT-producing sector, and the identification of wider effects on productivity in other sectors (*e.g.* Gordon, 2000; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Whelan, 2000). These studies point out that rapid technological change in the ICT-producing sectors and falling relative prices of ICT equipment induced rapid growth of investment (in efficiency terms) in the United States, thereby boosting growth in ICT-using sectors.

Table 9. **Decomposition of country deviations from OECD average output per capita growth rates, 1970s-1990s** [1]

(annual percentage point growth rates)

Country	**Annual average growth rate**	**Growth differential**	**Initial conditions (real GDP/pop)**	**Investment share (Sk)**	**Human capital (H)**	**Population growth (∆logp)**	**Variability of inflation (SDinfl)**	**Government consumption (Gov cons)**	**Trade exposure (Trade exp^{adj})**	**Residual country specific effect**
Australia	1.68	**0.13**	-0.37	0.20	0.52	-0.25	0.03	0.01	-0.41	0.40
Austria	1.57	**0.02**	-0.41	0.07	0.26	0.01	0.05	0.00	0.03	0.01
Belgium	1.66	**0.11**	-0.53	0.02	-0.15	0.20	0.03	-0.05	0.53	0.06
Canada	1.32	**-0.23**	-0.90	-0.21	0.62	-0.18	0.04	-0.07	0.14	0.32
Denmark	1.69	**0.14**	-0.57	0.28	0.21	0.12	0.02	-0.14	-0.05	0.27
Finland	1.82	**0.27**	0.51	0.05	0.02	0.15	0.00	-0.06	-0.26	-0.14
France	1.35	**-0.20**	-0.59	-0.09	-0.10	0.07	0.07	-0.08	0.05	0.48
Greece	1.15	**-0.40**	2.00	0.19	-0.56	-0.07	-0.16	0.17	-0.51	-1.48
Ireland	3.02	**1.47**	1.54	-0.18	-0.32	-0.18	0.01	0.09	0.17	0.34
Italy	1.73	**0.18**	0.22	-0.13	-0.69	0.13	0.02	0.01	0.14	0.48
Netherlands	1.26	**-0.29**	-0.47	-0.03	0.25	0.01	0.06	-0.13	0.52	-0.50
New Zealand	0.53	**-1.02**	0.34	-0.17	0.31	-0.29	-0.07	0.10	-0.36	-0.87
Norway	1.72	**0.17**	-0.12	-0.05	0.35	0.07	0.03	-0.06	-0.04	-0.01
Portugal	2.15	**0.60**	2.56	0.58	-1.20	0.07	-0.10	0.10	0.11	-1.52
Spain	1.28	**-0.27**	0.73	0.04	-1.12	0.00	0.03	0.07	-0.14	0.11
Sweden	1.20	**-0.35**	-0.60	-0.10	0.21	0.11	-0.10	-0.17	0.01	0.30
Switzerland	0.81	**-0.74**	-1.75	0.08	0.59	-0.04	0.00	0.15	0.02	0.21
United Kingdom	1.63	**0.08**	0.05	-0.21	0.17	0.15	-0.03	-0.02	0.31	-0.34
United States	1.93	**0.38**	-1.62	-0.34	0.63	-0.09	0.07	0.09	-0.25	1.89

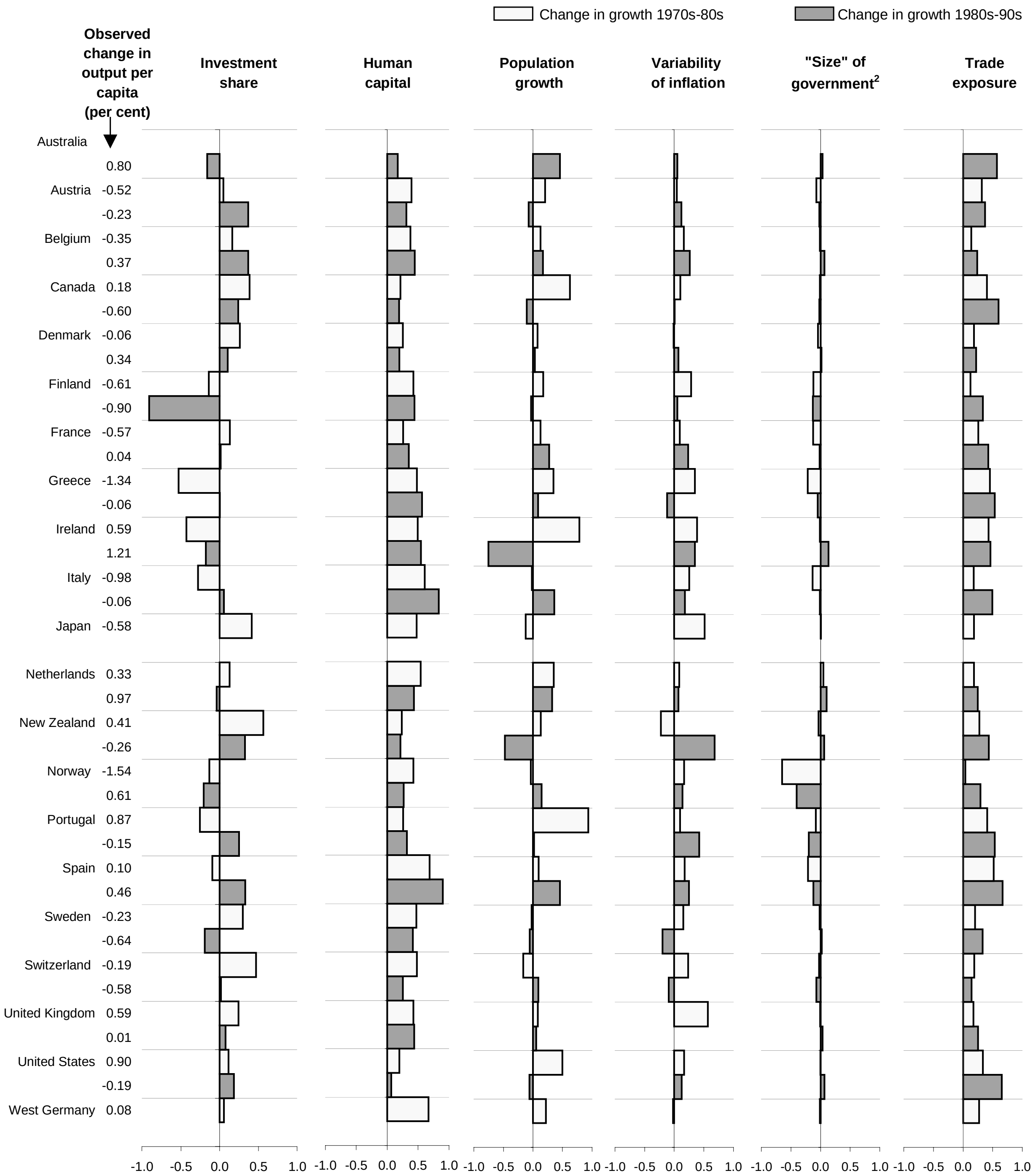
Note:

1. Decomposition of cross-country differences in annualised growth rate (in %) from the average output per capita of 1974-77 to the average output per capita of 1994-97. The decomposition is based on the following formula: $\Delta_t y = \left[(1-\phi)^t - 1\right] y_{-t} + \sum_i \sum_{h=1}^{t} (1-\phi)^{h-1} \phi \cdot a_i V_{i,1-h}$

where *-t* indicates initial conditions, and *-h* indicates that the variable is lagged h periods; ϕ is the estimated coefficient on lagged log output per capita y; V is a vector of other explanatory variables; and a_i are their respective coefficients. Output per capita refers to GDP per working-age person. See Annex 2 for details. The contribution of ir conditions is based on the estimated average convergence coefficient.

Source: OECD.

Figure 7. **The estimated effect of changes in explanatory variables to changes in output per capita growth rates**[1]



Notes:
The calculations are from decompositions of differences in growth rates based on the results of multivariate regressions. The estimated impact of initial levels of GDP per capita and the component unexplained by the regressions are not shown.
1. The changes in growth are based on differences in average growth in GDP per person of working age over each decade.
2. Government consumption as a percentage of GDP is used as a proxy for the size of government due to data availability. This variable is highly correlated in most countries with the tax and non-tax receipts (as a share of GDP) for which, however country coverage is more limited.
Source: OECD.

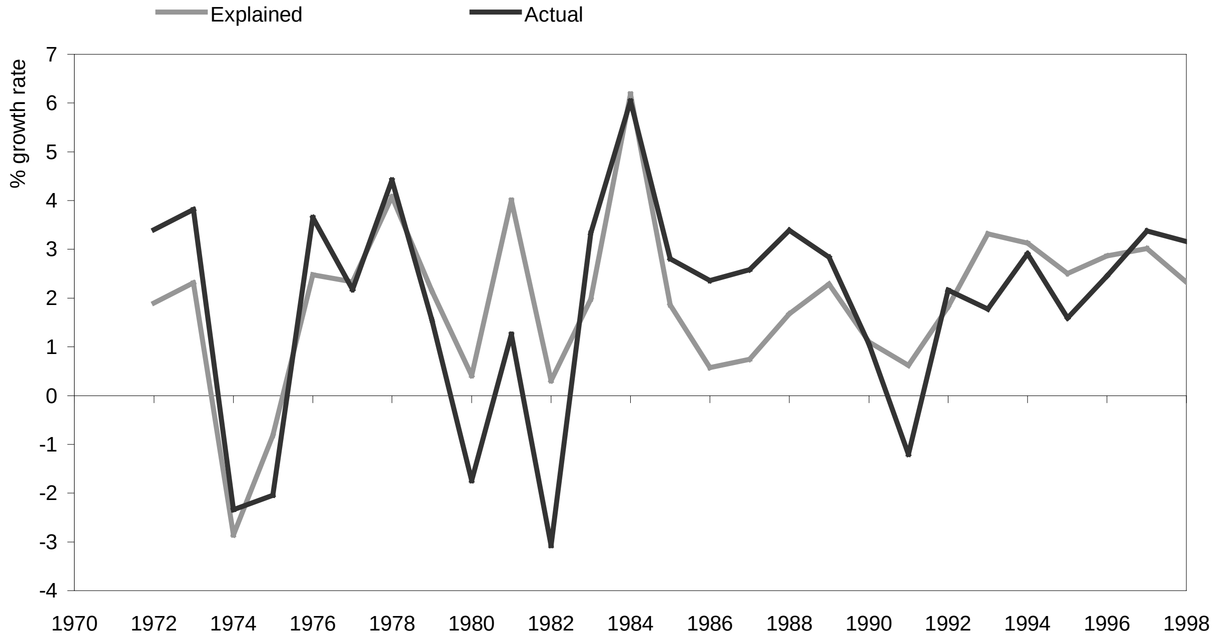
However, a crude and indirect contribution from the regression analysis to the current debate can be made by comparing the growth rates predicted by the models presented and the values actually observed in a country where there is some evidence of a “new economy”, the United States. Panel A of Figure 8 plots predicted annual growth rate of output per capita in the United States against the actual values. The estimated model seems to fit the US data rather well and thus allows some inference on recent growth paths. In particular, there is very little evidence of a significant departure of actual growth rates from predicted values, that is to say, factors included in the model explain most of the observed growth paths, and there is little need to call for additional explanatory factors. Amongst the factors included in the growth regressions, the key driving force of the high growth rates estimated for the United States in the second half of the 1990s is the significant rise in the investment share. Panel B of Figure 8 plots the change in the contribution of the investment rate on the steady state output per capita level that emerges from the last equation of Table 5. The figure shows that this contribution soared in the United States in the 1993-1998 period - accounting for a rise in the steady state output per capita of more that 10 percentage points - while it had remained roughly constant in the previous decades. No such a boost to output could be detected in the OECD as a whole over the same period. If the rise in the investment share in the United States is a more permanent phenomenon, its economy is projected to converge over time to this higher steady-state level of output per capita. This may not seem implausible given that a significant part of the rise in investment in the United States has been due to a major fall in the relative prices of ICT equipment (see Scarpetta *et al*., 2000, and Bassanini *et al*., 2000), that is to say, the rise in investment did not require a similar change in the saving rate.

II.4 Additional policy influences on growth

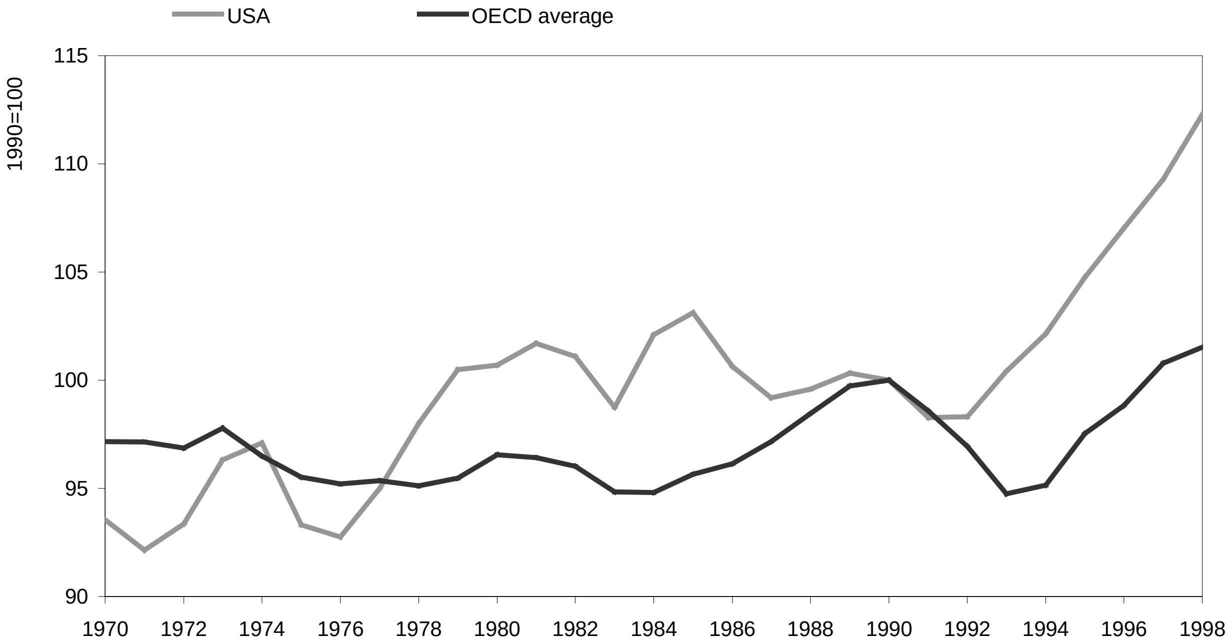
A number of micro economic policy and institutional factors are also likely to have an impact on growth by influencing the efficiency with which product and labour markets operate. For example, earlier work (see Scarpetta *et al*., 2000) showed that trends in labour utilisation account for an important component of growth in a simple accounting exercise. While there has been a significant process of convergence in labour productivity levels over the past decades, countries still differ widely in terms of GDP per capita levels, precisely because of the very different degrees with which the population of working age is actually employed. And previous work has clearly identified a strong role for policy and institutions in determining the level of labour utilisation in each country (see, amongst others, the *OECD Jobs Strategy* series).

Figure 8. **US growth performance and the role of investment in steady-state output per capita**

Panel A. **Observed and fitted annual growth rates in the United States, 1972-98**



Panel B. **Contribution of investment to the steady-state level of output per capita in the United State 1990=100**



Note:

1. The fitted series is obtained using the common long-run coefficients and country-specific coefficients for convergence, short-run dynamics and fixed effects from the right-hand side equation in the Table 5.

Source: OECD.

In the current period, characterised by a process of adaptation to information and communication technologies, a number of other policy and institutional factors are also likely to play a key role in growth, by influencing the ability of markets to adapt to the new technologies. The latter requires reallocating resources to new activities, re-shaping existing firms and discovering new business opportunities. Re-allocating resources means primarily allocating financial capital to new firms and activities at the cost of that allocated to declining activities. Hence financial institutions play an important role in this context and their challenges are discussed in other OECD studies (see OECD, 2000*a*; OECD, 2000*c*). Regulations affecting entrepreneurship are also important. For example, excessive regulation in the registration of new businesses (as well as opacity in the procedures) adds further costs that can discourage entry.[57] Furthermore, administrative procedures might require many steps and a multitude of different agencies.[58]

In this study, the dynamic-panel approach used in the regressions prevents testing the impact of product market regulations on growth because available indicators are not available on a time-series basis. However, bivariate correlations between some OECD indicators of regulation and growth seem to provide some supporting evidence that the negative impact of stringent regulations on the efficiency of product markets also results in a negative influence in overall economic growth. Table 10 presents correlations between the acceleration of multifactor productivity (MFP) over the past decade and different indicators of the stringency of regulation in the product markets.[59] Figure 9 gives a visual impression of the correlation between the acceleration in MFP and administrative regulations. Estimates of multifactor productivity growth are derived from a growth accounting exercise (see Scarpetta *et al.*, 2000). The estimated changes in MFP growth rates include changes in technological progress[60] as well as changes in efficiency with which factors of production are used.

57. See Bassanini *et al.* (2000) where it is also suggested that certain labour market regulations, namely excessive employment protection legislation, could significantly affect the process of reallocation of resources and output growth over and above factor inputs.

58. A number of approaches have been used to show the effects of various aspect of regulation on growth (see Gonenc *et al*., 2000, for a survey). For example, some studies have used simulation exercises to gauge the impact of regulatory environments on growth. There have also been a few regression-based investigations that generally point to a negative correlation between regulation and growth. Koedijk and Kremers (1996) and Gwartney and Lawson (1997) both find a negative correlation between measures of the strictness of national regulations and the average growth rates of GDP per capita in a cross-section of countries. Koedijk and Kremers (1996) cover eleven European countries and use an indicator that includes six dimensions of product market regulation (business establishment, competition policy, public ownership, industry-specific support, shop-opening hours and the implementation of the Single Market programme). Gwartney and Lawson (1997) build a broader indicator of "economic freedom" (including the policy environment in public finance, financial markets, product markets and foreign trade and investment) for 115 countries. Goff (1996) uses an index of regulatory intensity (constructed by means of factor analysis techniques) in a time-series investigation of the long-run relationship between regulation and GDP growth in the United States. He finds that, on average, regulation has decreased growth by almost 1 per cent over the 1950-1992 period. Dutz and Hayri (1998) relate their index of pro-competitive policy environment (resulting from a survey of managers of multinationals) to growth in a cross-section of countries. They find a positive effect of their indicator on the growth rate of GDP per capita.

59. The latter are from a recent study based on a wide range of specific aspects of regulatory regimes in each country (see Nicoletti *et al*., 2000).

60. This does not include embodied technological progress that is recorded as increases in the capital stock because deflators are constructed on the basis of hedonic regressions.

Table 10. **Correlation between changes in MFP growth between 1980s and 1990s and OECD product-market regulatory indicators**

	All countries (total 19)			Norway excluded		
	Correlation	t-statistic		Correlation	t-statistic	
Overall product market regulation	-0.30	-1.29		-0.48	-2.19	**
_Inward orientated policies	-0.41	-1.85	*	-0.48	-2.18	**
__State control	-0.25	-1.05		-0.37	-1.57	
___Public ownership	-0.04	-0.14		-0.18	-0.72	
___Involvement in business operations	-0.43	-1.98	*	-0.48	-2.18	**
__Barriers to entrepreneurship	-0.52	-2.50	**	-0.50	-2.32	**
___Administrative burdens	-0.63	-3.34	***	-0.65	-3.40	***
___Barriers to competition	0.14	0.57		0.18	0.74	

Notes:

* significant at 10% level; ** at 5% level; *** at 1% level.

The countries covered are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and United States.

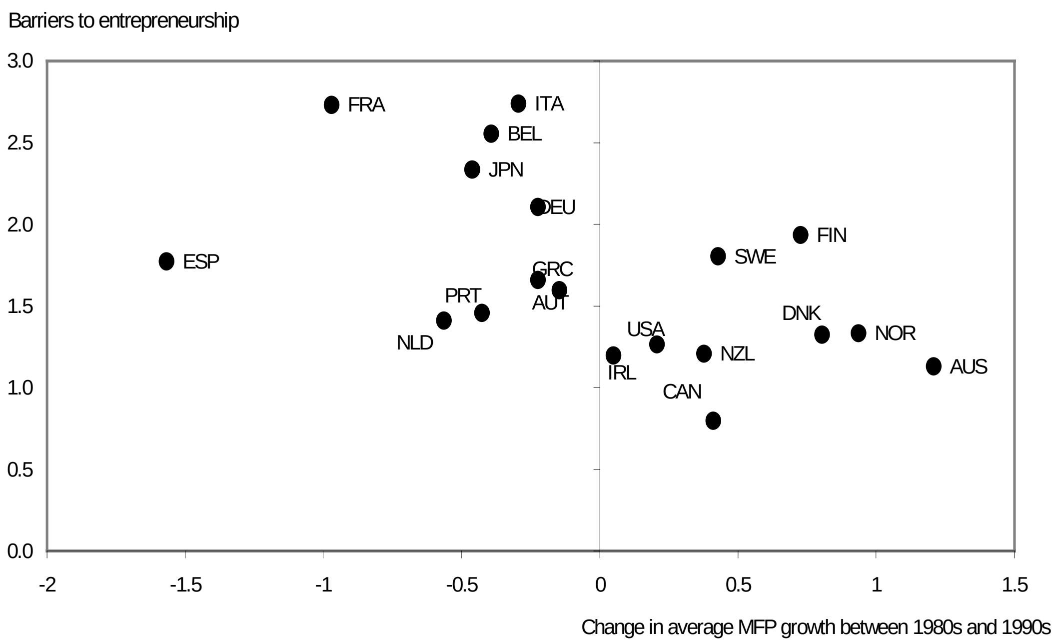
Available data do not allow to estimate MFP growth changes for Switzerland and United Kingdom.

The MFP growth data are trended figures from Scarpetta et al. (2000). MFP growth in Germany for 1991 is excluded from the calculations. The indicators of regulation are based on factor analysis of a range of variables.

Note that "outward-orientated" indicators could not be used for correlations because EU countries were given the same value in most of the underlying variables. See Nicoletti *et al.* (2000) for more details.

Source: OECD.

Figure 9. **Changes in MFP growth and barriers to entrepreneurship, 1980s-1990s**



Correlation coeff: -0.52
T statistic: -2.50

Source: the MFP estimates are from Scarpetta *et. Al.* (2000). The indicator of the stringency of barriers to entrepreneurship are from Nicoletti *et. Al.* (2000).

Various aspects of product market regulation seem to negatively affect productivity growth.[61] This general idea is supported by the correlation between the overall indicator of product market regulation and the acceleration in MFP. Likewise, a number of indicators concerned with aspects of “inward” oriented regulations (*e.g*. different forms of state control and barriers to entrepreneurship) are negatively correlated with the acceleration in MFP growth.[62] In particular, an indicator of the stringency of regulations affecting entrepreneurship appears to correlate strongly with MFP measures.[63] Of the components used to construct this indicator it appears that the degree of administrative burden on start-ups (*e.g.* licence and permits, communication rules, administrative burden on corporate and sole proprietor firms, legal barriers to entry) is particularly important. In addition, the sub-indicator reflecting government involvement in business operations (*e.g.* price controls, use of command and control regulations) appears to relate negatively to MFP growth. All in all, these results point to the potential negative implications for productivity growth of stringent regulations in the product market and suggest an area where, despite recent reforms, more remains to be done.

III. Concluding remarks

This paper offers a broad analysis of the empirical links between accumulation of physical and human capital as well as policy conditions and economic growth. In broad terms, the estimated growth regressions explain much of the observed growth paths across countries and over time. In addition to the ‘primary’ influences of capital accumulation and skills and experience embodied in the human capital, the results confirm the importance for growth of R&D activity, the macroeconomic environment, trade openness and well developed financial markets. They also confirm that many of the policy influences operate not only ‘directly’ on growth but also indirectly *via* the mobilisation of resources for fixed investment.

More specifically, the results raise a number of policy-relevant issues:

- In contrast with some previous studies that also focused on OECD countries, the results strongly support the idea that the accumulation of physical and, especially, human capital is important for growth. The estimated partial elasticity of output to physical capital is not inconsistent with the values implied in National Accounts data, even though it is on the low side of the range. By contrast, the estimated elasticity of output to human capital points to potential externalities in investment in education, i.e. social returns seem higher than private returns. The role of the accumulation of human capital on growth is discussed in more detail in Bassanini and Scarpetta (2001).

- The evidence suggests that high inflation is negatively associated with the accumulation of physical capital in the private sector and, through this channel, has a negative bearing on output.

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61. The indicator is derived from factor analysis of detailed indicators on *a)* economy-wide administrative burdens on start-ups of corporate and sole-proprietor firms; *b)* industry-specific administrative burdens on start-ups of retail distribution and road freight companies; *c)* the features of the licensing and permit system; and *d)* the communication and simplicity of rules and procedures (for more details, see Nicoletti *et al*., 2000).

62. Note that the “outward” orientated regulatory indicators developed by the Secretariat, which are aimed at covering areas such as barriers to trade and international investment could not be investigated using this technique because all EU countries were given the same value, thus resulting in too few observations for making reasonable correlations.

63. Norway is often an outlier in these bivariate relations because of the strong influences of the oil industry.

Moreover, a high variability of inflation affects growth, possibly because it leads to a shift in the composition of investment towards lower return projects.

- In addition, the empirical evidence lends some support to the notion that the overall involvement of government in the economy may reach levels that impede growth. Although expenditure on health, education and research clearly sustains living standards in the long term, and social transfers help to meet social goals, all have to be financed. It should be stressed, however, that as in the case of education, the reverse causality argument can be raised for the "size" of government, to the extent that certain government services have an income-elastic demand. Bearing this caveat in mind, the results suggest that for a given level of taxation, higher direct taxes lead to lower output per capita, while on the expenditure side transfers as opposed to government consumption, and especially as opposed to government investment, could lead to lower output per capita. Government investment does not seem to influence the rate of private accumulation of capital significantly but it may affect growth by improving the framework conditions (e.g. better infrastructure) in which private agents operate.

- Research and development (R&D) activities undertaken by the business sector seem to have high social returns, while no clear-cut relationship could be established between non-business-oriented R&D activities and growth. There are, however, possible interactions and international spillovers that the regression analysis cannot identify. Moreover, non-business oriented R&D (e.g. defence, energy, health and university research) may generate basic knowledge with possible "technology spillovers" in the long run.

- The empirical evidence also confirms the importance of financial markets for growth, both by helping to channel resources towards the most rewarding activities and in encouraging investment. In particular, the degree of stock market capitalisation is found to be strongly related with both output per capita (while controlling for investment) and with the investment rate.

Aggregate growth regressions have inherent limits in the extent to which they can identify and quantify links between policy and institutional settings and economic growth, especially as regards very recent developments. To shed some tentative light on the sources of the recent acceleration in the US growth rate, the model-predicted growth rates were compared with observed growth rates. The closeness of the two series, even in the most recent years, implicitly suggests that most of the observed acceleration in growth could be ascribed to shifts in factors included in the growth model, especially the ICT-driven rise in investment.

There are a number of microeconomic policy influences on growth that cannot be directly analysed in this paper. As an illustration, however, the paper reports some bivariate correlations between OECD indicators of product and labour market regulations and growth. They provide some supporting evidence that the negative impact of stringent regulations and administrative burden on the efficiency of product markets also results in a negative impact on overall economic growth. The corollary would be that recent policy efforts to relax regulations should have a positive influence on future growth.

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APPENDIX 1

1. The policy-and-institutions augmented growth model

Following a standard approach (see *e.g*. Mankiw, 1993, and Barro and Sala-i-Martin, 1995), the standard neoclassical growth model is derived from a constant returns to scale production function with two inputs (capital and labour) that are paid at their marginal products. Production at time t is given by:

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

where Y, K, H and L are respectively output, physical capital, human capital and labour, α is the partial elasticity of output with respect to physical capital, β is the partial elasticity of output with respect to human capital and $A(t)$ is the level of technological and economic efficiency. It can be assumed that the level of economic and technological efficiency $A(t)$ has two components: economic efficiency $I(t)$ dependent on institutions and economic policy and the level of technological progress $\Omega(t)$ (see amongst others, Cellini *et al.*, 1997 for a similar formulation). In turn, $I(t)$ can be written as, *e.g.* a log-linear function of institutional and policy variables, while $\Omega(t)$ is assumed to grow at the rate $g(t)$.

The time paths of the right-hand side variables are described by the following equations (hereafter dotted variables represent derivatives with respect to time):

$$\begin{aligned}
\dot{k}(t) &= s_k(t)A(t)^{1-\alpha-\beta} k(t)^{\alpha} h(t)^{\beta} - (n(t)+d)k(t) \\
\dot{h}(t) &= s_h(t)A(t)^{1-\alpha-\beta} k(t)^{\alpha} h(t)^{\beta} - (n(t)+d)h(t) \\
A(t) &= I(t)\Omega(t) \\
\ln I(t) &= p_0 + \textstyle\sum_j p_j \ln V_j(t) \\
\dot{\Omega}(t) &= g(t)\Omega(t) \\
\dot{L}(t) &= n(t)L(t)
\end{aligned} \qquad [2]$$

where $k = K/L$, $h = H/L$, $y = Y/L$, stand for the capital labour ratio, average human capital and output per worker respectively; s_k and s_h stand for the investment rate in physical and human capital respectively; and d stands for the depreciation rate. Under the assumption that $\alpha + \beta < 1$ (*i.e.* decreasing returns to reproducible factors), this system of equations can be solved to obtain steady-state values of k^* and h^* defined by:

$$\begin{aligned}
\ln k^*(t) &= \ln A(t) + \frac{1-\beta}{1-\alpha-\beta}\ln s_k(t) + \frac{\beta}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln(g(t)+n(t)+d) \\
\ln h^*(t) &= \ln A(t) + \frac{\alpha}{1-\alpha-\beta}\ln s_k(t) + \frac{1-\alpha}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln(g(t)+n(t)+d)
\end{aligned} \qquad [3]$$

Substituting these two equations into the production function and taking logs yields the expression for the steady-state output in intensive form. The latter can be expressed either as a function of s_h (investment in human capital) and the other variables or as a function of h^* (the steady-state stock of human capital) and the other variables. Since in this paper human capital is proxied by the average years of education of the working age population, a formulation in terms of the stock of human capital was retained. The steady-state path of output in intensive form can be written as:[64]

$$\ln y^*(t) = \ln \Omega(t) + p_0 + \sum_j p_j \ln V_j(t) + \frac{\alpha}{1-\alpha} \ln s_k(t) + \frac{\beta}{1-\alpha} \ln h^*(t) - \frac{\alpha}{1-\alpha} \ln(g(t)+n(t)+d) \qquad [4]$$

However, the steady-state stock of human capital is not observed. As shown by Bassanini and Scarpetta (2001), the expression for h^* as a function of actual human capital is:

$$\ln h^*(t) = \ln h(t) + \frac{1-\psi}{\psi} \Delta \ln(h(t)/A(t)) \qquad [5]$$

where ψ is a function of (α,β) and $n+g+d$.

Equation [4] would be a valid specification in the empirical cross-country analysis only if countries are in their steady states or if deviations from the steady state are independent and identically distributed. If observed growth rates include out-of-steady-state dynamics, then the transitional dynamics have to be modelled explicitly. A linear approximation of the transitional dynamics can be expressed as follows (Mankiw *et al.*, 1992):

$$\Delta \ln y(t) = -\phi(\lambda) \ln(y(t-1)) + \phi(\lambda) \frac{\alpha}{1-\alpha} \ln s_k(t) + \phi(\lambda) \frac{\beta}{1-\alpha} \ln h(t) + \sum_j p_j \phi(\lambda) \ln V_j(t) + \frac{1-\psi}{\psi} \frac{\beta}{1-\alpha} \Delta \ln h(t) - \phi(\lambda) \frac{\alpha}{1-\alpha} \ln(g(t)+n(t)+d) + \left(1 - \frac{\phi(\lambda)}{\psi}\right) g(t) + \phi(\lambda)(p_0 + \ln \Omega(0)) + \phi(\lambda) g(t) t \qquad [6]$$

where $\lambda = (1-\alpha-\beta)(g(t)+n(t)+d)$. Adding short-term dynamics to equation [6] yields:

$$\Delta \ln y(t) = a_0 - \phi \ln y(t-1) + a_1 \ln s_k(t) + a_2 \ln h(t) - a_3 n(t) + a_4 t + \sum_j a_{j+4} \ln V_j + b_1 \Delta \ln s_k(t) + b_2 \Delta \ln h(t) + b_3 \Delta \ln n(t) + \sum_j b_{j+4} \Delta \ln V_j + \varepsilon(t) \qquad [7]$$

Equation [7] represents the generic functional form that has been empirically estimated in this paper. Estimates of steady state coefficients as well as of the parameters of the production function can be retrieved on the basis of the estimated coefficients of this equation by comparing it with equation [6]. For instance, an estimate of the elasticity of steady state output to the investment rate (that is the long-run effect of the investment rate on output) is given by $\hat{a}_1 / \hat{\phi}$, where ^ identifies estimated coefficients.

64. Strictly speaking, equation [4] is written under the simplifying assumption that policy and institutional variables do not change persistently in the long-run. If this is not the case, ln(*g*+*n*+*d*) must be augmented by a term reflecting the rate of change of policy and institutional variables. As the estimable equation is linearised and contains short-run dynamics anyway, this term will be omitted hereafter for simplicity.

Conversely, an estimate of the share of physical capital in output (the parameter α of the production function) can be obtained as $\hat{a}_1 / (\hat{\phi} + \hat{a}_1)$.

2. Specification of the growth equation and the data

Growth regressions have been estimated in the literature using either GDP per person employed or, more frequently, GDP per capita (generally referring to working age population to avoid problems related to differences in demographic structure). Under the assumption of full employment and stable participation rates, these two specifications yield the same results and the choice depends on the availability and quality of data on population and employment. However, as discussed in previous Secretariat work (*e.g.* Scarpetta *et al*., 2000) employment rates (employment over population of working age) have changed significantly over time in most Member countries and in particular in Continental Europe where significant declines were recorded in the 1980s and 1990s. The resulting path of GDP per worker is strongly affected by short- and long-run fluctuations in the employment rate. Under these conditions, a specification in GDP per person employed is likely to yield different results from that in GDP per capita and to be less informative of both (conditional) convergence and the role of investment in physical and human capital on growth.

The data

The data used in this paper are from the following sources:

- Data on GDP, working age population, gross fixed capital formation, general government current nominal tax and non-tax receipts, direct and indirect taxes, government nominal final consumption and imports and exports are from the OECD *Analytical Data Base* (ADB). Purchasing Power Parity benchmarks for 1993 are from the OECD Statistics Department. In the case of Norway, data refer to the mainland economy. In the case of Greece and Portugal the ratio between total gross fixed capital formation and total real GDP was used as a proxy for the investment rate (*i.e.* the ratio of private non-residential fixed capital formation to business sector real GDP), due to data availability.

- Data on Research and Development (R&D) are from the OECD *Main Science and Technology Indicators* (MSTI) database. A few missing observations were obtained by interpolation.

- Data on human capital are calculated on the basis of raw data on education attainment from De la Fuente and Doménech (2000)[65] and from the OECD *Education at a Glance* (various issues). In particular: three educational groups were considered: below upper secondary education (ISCED 0 to ISCED 2); upper secondary education (ISCED 3); and tertiary education (ISCED 5 to ISCED 7). Data on education attainment up to the early 1980s are interpolated from five-year observations from De la Fuente and Doménech (2000), while later observations are from matched OECD sources. The cumulative years of schooling by educational level - required to estimate the average number of years of total schooling used in the empirical analysis - are from the OECD Education at a Glance - 1997 (OECD, 1998).

- The indicators measuring financial market developments are discussed in Leahy *et al.* (2000).

65. De la Fuente and Doménech (2000) revised the original series from Barro and Lee (1996) to eliminate anomalies in connection with attainment rates.

The definition of each variable is provided in Box 1 of the main text. The exact country coverage of the variables is presented in Table A1.1, while the basic statistics are in Table A1.2.

Table A1.1. **Details on data availability**

Variable	Start date	End date	Exceptions
Real GDP per person of working age (***Y***)	1971	1998	1971-1997 for Portugal and Spain; 1971-1996 for Greece; 1971-1994 for Western Germany.
Physical capital accumulation (***Sk***)	1971	1998	1971-1997 for Austria, Belgium, Ireland, Italy, New Zealand, Portugal, Spain and Sweden; 1971-1996 for the United Kingdom; 1971-1995 for Switzerland; 1971-1990 for Western Germany; 1975-1998 for Australia.
Human capital (*H*)	1971	1998	1971-1990 for Western Germany and Japan
Growth of working age population($\Delta \mathbf{logP}$)	1971	1998	1971-1997 for Spain; 1971-1996 for Greece; 1971-1994 for Western Germany.
Standard deviation of inflation ($\mathbf{SDinfl}_{-1}$)	1971	1998	
Inflation ($\mathbf{Infl}_{-1}$)	1971	1998	
Government consumption ($\mathbf{Gov\ cons}_{-1}$)	1971	1998	
Government capital accumulation ($\mathbf{Sk}^{gov}_{-1}$)	1971	1998	1971-1997 for Switzerland; 1971-1996 for Portugal; 1971-1995 for Western Germany.
Tax and non-tax receipts ($\mathbf{Tax}_{-1}$)	1971	1998	1971-1997 for Portugal; 1971-1995 for Western Germany; 1978-1998 for Ireland; 1987-1998 for New Zealand; 1988-1998 for the United Kingdom; no data for Switzerland.
Ratio of direct/indirect taxes ($\mathbf{Tax\ distr}_{-1}$)	1971	1998	1971-1998 for Switzerland; 1971-1996 for Portugal; 1971-1995 for Western Germany; 1978-1998 for Ireland; 1987-1998 for New Zealand; 1988-1998 for the United Kingdom.
Total R&D ($\mathbf{R\&D}^{tot}$)	1981	1998	1981-1997 for Greece, Ireland, the Netherlands, Sweden and the United Kingdom; 1981-1996 for Australia and Switzerland; 1982-1997 for Portugal; 1983-1995 for Belgium; 1989-1997 for New Zealand; no data for mainland Norway.
Business-performed R&D (***BERD***)	1981	1998	1981-1997 for Australia, Greece, Ireland, the Netherlands, Sweden and the United Kingdom; 1981-1996 for Switzerland; 1981-1995 for Belgium; 1981-1993 for Austria; 1982-1997 for Portugal; 1989-1997 for New Zealand; no data for mainland Norway.
Non-business performed R&D ($\mathbf{R\&D}^{pub}$)	1981	1998	1981-1997 for Greece, Ireland, the Netherlands, Sweden and the United Kingdom; 1981-1996 for Australia and Switzerland; 1981-1993 for Austria; 1982-1997 for Portugal; 1983-1995 for Belgium; 1989-1997 for New Zealand; no data for mainland Norway.
Private credit ($\mathbf{Priv\ credit}_{-1}$)	1971	1998	1971-1997 for Ireland and Portugal; 1971-1992 for Western Germany.
Stock market capital. ($\mathbf{Stock\ cap}_{-1}$)	1977	1998	1977-1997 for Belgium and Switzerland; 1977-1991 for Western Germany; 1979-1995 for Portugal; 1982-1998 for Norway; 1984-1998 for Finland; 1986-1998 for New Zealand; 1996-1998 for Ireland.
Trade exposure ($\mathbf{Trade\ exp}_{-1}$)	1971	1998	

Table A1.2. **Basic statistics**

Variables (in per cent)	Sample mean	Standard Deviation
Y^{1}	23951	5783
Sk	17.11	4.46
H^{2}	10.15	1.69
ΔlogP	0.79	0.62
$SDinfl_{-1}$	1.51	1.27
$Infl_{-1}$	6.87	4.89
Gov $cons_{-1}$	18.46	5.11
Sk^{gov}_{-1}	3.70	2.06
Tax_{-1}	39.62	9.19
Tax $distr_{-1}$	112.44	43.44
$R\&D^{tot}$	1.72	0.80
BERD	1.05	0.64
$R\&D^{pub}$	0.66	0.21
Priv $credit_{-1}$	56.98	29.50
Stock cap_{-1}	33.79	28.86
Trade exp_{-1}	43.25	18.18

1. In 1995 US$ (expressed in 1993 EKS PPPs).
2. Average years of education.

3. The econometric approach

Based on annual data and considering pooled cross-country time series (*i*, denotes countries, *t* time) the growth equation, in its more general form, can be written as follows:

$$\Delta \ln y_{i,t} = a_{0,i} - \phi_i \ln y_{i,t-1} + a_{1,i} \ln s^K_{i,t} + a_{2,i} \ln h_{i,t} - a_{3,i} n_{i,t} + \sum_{j=4}^{m} a_{j,i} \ln V^j_{i,t} + a_{m+1,i} t$$
$$+ b_{1,i} \Delta \ln s^K_{i,t} + b_{2,i} \Delta \ln h_{i,t} + b_{3,i} \Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i} \Delta \ln V^j_{i,t} + \varepsilon_{i,t} \qquad [8]$$

where most acronyms are defined above, ***V*** is a vector of policy and institutional variables, *t* is the time trend; the *b-regressors* capture short-term dynamics and ε is the usual error term.

The main advantage of pooled cross-country time-series data for the analysis of growth equations is that the country-specific effects can be controlled for, for example by using a dynamic fixed-effect estimator (DFE). However, this estimator generally imposes homogeneity of all slope coefficients, allowing only the intercepts to vary across countries. The validity of this approach depends critically on the assumption of a common technology growth rate and a common convergence parameter. While the first assumption is difficult to reconcile with evidence of multifactor productivity patterns across countries (see *e.g.* Scarpetta *et al.*, 2000), the latter is not consistent with the underlying growth model, where the speed of convergence depends, amongst other factors, upon the rate of population growth. Pesaran and Smith (1995) suggest that, under slope heterogeneity, estimates of convergence are affected by an upward heterogeneity bias. The alternative approach is to use the mean-group approach (MG) that consists of estimating separate regressions for each country and calculating averages of the country-specific coefficients (*e.g.* Evans, 1997; Lee *et al.*, 1997). While consistent, this estimator is likely to be inefficient in small country samples, where any country outlier could severely influence the averages of the country coefficients.

An intermediate choice between imposing homogeneity on all slope coefficients (DFE) and imposing no restrictions (MG) is the pooled mean group estimator (PMG) that allows short-run coefficients, the speed of adjustment and error variances to differ across countries, but imposes homogeneity on long-run coefficients. There are good reasons to believe in common long-run coefficients for the OECD countries, given that they have access to common technologies, and have intensive intra-trade and foreign direct investment, all factors contributing to lead to similar long-run production function parameters. Under the long-run slope homogeneity the PMG estimator increases the efficiency of the estimates with respect to mean group estimators (Pesaran, Shin and Smith, 1999). Formally, conditional on the existence of a convergence to a steady state path, the long-run homogeneity hypothesis permits the direct identification of the parameters of factors affecting steady state path of output per capita ($a_{s,i}/\phi_i = \theta_s$, see below). In other words, with the PMG procedure, the following restricted version of equation [8] is estimated on pooled cross-country time-series data:

$$\begin{aligned}\Delta \ln y_{i,t} = &-\phi_i\left(\ln y_{i,t-1} - \theta_1 \ln s^K_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 n_{i,t} - \sum_{j=4}^{m}\theta_j \ln V^j_{i,t} - a_{m+1}t_i - \theta_{0,i}\right)\\ &+ b_{1,i}\Delta \ln s^K_{i,t} + b_{2,i}\Delta \ln h_{i,t} + b_{3,i}\Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i}\Delta \ln V^j_{i,t} + \varepsilon_{i,t}\end{aligned} \qquad [9]$$

The hypothesis of homogeneity of the long-run policy parameters cannot be assumed *a priori* and is tested empirically in all specifications. In particular, the Hausman test (Hausman, 1978) is used for this purpose: under the null hypothesis, the difference in the estimated coefficients from the MG and the PMG are not significantly different and PMG is more efficient.

Given the limited degrees of freedom in the country-specific policy-augmented growth regressions (MG), the time trend was not included. Indeed a sensitivity analysis suggested that a time trend was only statistically significant when human capital is omitted and was not statistically significant at standard confidence levels when human capital is included (see Bassanini and Scarpetta, 2001).[66] It should be stressed, however, that some of the policy variables included in the growth equations are likely to account for some of the time variability in the dependent variable.

66. Bassanini and Scarpetta (2001) also included specifications with five-year time dummies instead of a time trend. The hypothesis of common time dummies across countries (*i.e.* the one commonly made using de-meaned data or time dummies in dynamic fixed effect regressions) or country-specific dummies was also tested empirically. The results suggest that the hypothesis of homogeneity of time dummies across countries is strongly rejected by the data. Moreover, the inclusion of country-specific time dummies does not change the statistical significance and magnitude of the coefficients for the other explanatory variables.

Control for outliers

An important aspect of the regression analysis based on pooled cross-section time series data is the sensitivity of results to the inclusion/exclusion of certain observations that significantly increase the standard error of the regression and/or affect the estimated coefficients. This is particularly important in cases of relatively small samples across the country and/or the time dimension. Moreover, the rejection of the homogeneity of (one or more) long-run coefficient(s) may be influenced by outlier observations that significantly affect one (or more) country equations.[67] The identification of outliers is based on the analysis of *studentised residuals* and *leverage values* (see Belsley *et al.*, 1980; Fiebig, 1987) obtained from dynamic fixed effects estimates.[68]

67. Recent work by Temple (2000) and Sturm and de Haan (2000) shows that, when rigorous control of outliers is allowed for, growth regressions tend to be more robust, although they might lead to different results from regressions without outlier control.

68. The *studentised residuals* are obtained by considering a mean-shift outlier model in which the basic equation is augmented by a dummy variable that has the *i-th* element equal to one and all other elements zero. The studentised residual is the t-statistics of the dummy variable. The *leverage point* is identified by the diagonal elements of the least-squared projection matrix, also called the *hat* matrix. It proxies the distance between the *ith* observation and the centre of the data. Belsley *et al*. (1980) suggest a size-adjusted cut-off value at $2k/NT$. The outliers that have been removed from the sample are those with a studentised residual greater than 2.5 and a leverage point above the cut-off value. See Scarpetta (1996) for more details on this procedure. The dynamic fixed effect estimator used for the identification of the outliers allows for country-specific short term adjustment.

APPENDIX 2 MODEL SELECTION OF POLICY-AUGMENTED EQUATIONS

This appendix presents the model selection used to identify the most suitable specifications of the different policy-augmented growth equations, under the constraints imposed by data availability and problems related to the limited degrees of freedom available in the MG estimates that are used to test long-run homogeneity restrictions. The economic interpretation of the preferred specifications is presented in the main text.

Trade exposure and macroeconomic conditions

Table A2.1 presents a set growth regressions that include different inflation variables. In the first specification (A), both the level and the variability of inflation are considered. The Hausman test on the long-run coefficient of the level of inflation rejects the homogeneity assumption at the 5 per cent level and, thus, the coefficient is left free in specification B. The third specification (C) extends the model to include the indicator of trade exposure: this is the specification reported in Table 5 of the main text.

Table A2.1. **Regressions including inflation variables**
(Pooled Mean Group Estimators)

Dependent variable: ΔlogY	A		B		C	
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*
logSk	**0.06** *	1.29	**0.19** ***	0.40	**0.25** ***	0.46
	(0.03)		*(0.03)*		*(0.04)*	
logH	**0.81** ***	0.01	**0.97** ***	0.18	**0.41** ***	1.51
	(0.13)		*(0.09)*		*(0.13)*	
ΔlogP	**-9.04** ***	0.98	**-9.08** ***	0.96	**-5.69** ***	1.16
	(1.33)		*(1.20)*		*(1.02)*	
$SDinfl_{-1}$	**-0.02** ***	2.53	**-0.02** ***	2.24	**-0.02** ***	0.94
	(0.01)		*(0.00)*		*(0.00)*	
$Infl_{-1}$	**-0.01** ***	4.90 **	**-0.01**	*free*	**-0.01** ***	1.44
	(0.00)		*(0.00)*		*(0.00)*	
$\log(\text{Trade exp}^{adj})_{-1}$					**0.20** ***	0.11
					(0.05)	
Convergence coefficient						
$\log Y_{-1}$	**-0.15** ***		**-0.18** ***		**-0.17** ***	
	(0.02)		*(0.02)*		*(0.02)*	
Short-Run Coefficients						
ΔlogSk	**0.12** ***		**0.11** ***		**0.12** ***	
	(0.02)		*(0.02)*		*(0.02)*	
ΔlogH	**-1.48** ***		**-0.95** **		**-1.18** **	
	(0.52)		*(0.48)*		*(0.54)*	
$\Delta^2 \log P$	**0.91** *		**0.79**		**0.81**	
	(0.48)		*(0.64)*		*(0.55)*	
$\Delta Infl_{-1}$	**0.00**		**0.00**		**0.00**	
	(0.00)		*(0.00)*		*(0.00)*	
$\Delta SDinfl_{-1}$	**0.00**		**0.00**		**0.00**	
	(0.00)		*(0.00)*		*(0.00)*	
$\Delta\log(\text{Trade exp}^{adj})_{-1}$					**-0.01**	
					(0.05)	
No. of countries	21		21		21	
No. of observations	523		523		523	
Log likelihood	1522		1547		1553	

All equations include a constant country-specific term and control for outliers (see Table A2.4). Standard errors are in brackets.
*: significant at 10 % level; ** at 5% level; *** at 1 % level.

Table A2.2 focuses on fiscal variables. The first equation (A) extends the basic model by including tax and non-tax receipts and the composition of taxes (*e.g*. the share of direct over total taxes) as well as government consumption and government fixed capital accumulation. Government transfers are omitted in order to identify the other elements of the government budget. This specification has serious problems with the long-run homogeneity assumption, as indicated by the fact that PMG does not pass the Hausman tests for any of the exogenous variables. On the basis of experimentation with different specifications, it turned out that the homogeneity assumption on the long-run coefficient for population growth has a strong bearing on this result and, thus, the assumption is relaxed in the following specification (B). The third specification extends the model to include trade exposure. As in the previous case, there is a severe problem with the Hausman tests and the equation was re-estimated letting free the coefficient on population growth (D). The Hausman tests for the tax variable and the tax composition reject the null hypothesis of homogeneity at the 5 per cent level, but not at 1 per cent. Further experimentation did not improve the fit of the regression further. Equations (E) to (G) omit the tax variables, enabling the country coverage to be extended to 21 countries. The first equation (E) does not include trade exposure, while the other two do so. In equation (F) the homogeneity assumption on the coefficient on population growth is rejected at the 5 per cent level and the equation was re-estimated (G) removing this restriction. It should be noted that while the coefficient on government investment remains positively signed and statistically significant, that on government consumption becomes negative if the implicit financing is not taken into account. As discussed in the main text, this coefficient captures the overall size of government effect rather than the effect of one specific component of government expenditure.

Table A2.3 combines inflation and fiscal policy variables. Given the limited degrees of freedom, only the standard deviation of inflation is considered. The latter appeared to be a more robust determinant of growth in the equations presented in Table A2.1. The first two equations (A and B) in Table A2.3 include policy variables without and with trade exposure, respectively. In the specification with trade exposure, the Hausman test rejects the homogeneity of the long-run coefficient on population growth and, thus the hypothesis is relaxed in equation (C). In the latter, the estimated coefficients on government consumption is positively signed and statistically significant, but that on government investment ,while positive, is not statistically significant. For sensitivity analysis, equation (D) excludes both government consumption and investment and simply focuses on the standard deviation of inflation and total taxes. However, the use of the tax variable limits the sample to 18 countries and the final equation (E) replaces it with government consumption to extend the sample to 21 countries. In this case, as stressed in the main text, government consumption should be interpreted as a proxy for government "size", rather than the impact of this specific expenditure component.[69]

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69. Regressions that include one side of the government budget but not the other suffers from a systematic bias to the parameter estimates associated with the implicit financing assumptions. This point has been demonstrated by, amongst others, Helms (1985); Mofidi and Stone (1989) and Miller and Russek (1993).

Table A2.2. **Regressions including fiscal policy variables**
(Pooled Mean Group Estimators)

Dependent variable: ΔlogY	with government expenditure and tax and non-tax receipts								with government expenditure only					
	A		B		C		D		E		F		G	
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*
logSk	**0.57** ***	n.a.	**0.37** ***	0.98	**0.63** ***	n.a.	**0.36** ***	0.00	**0.26** ***	0.00	**0.30** ***	1.82	**0.14** ***	0.63
	(0.12)		*(0.03)*		*(0.22)*		*(0.04)*		*(0.04)*		*(0.05)*		*(0.04)*	
logH	**2.09** ***	n.a.	**1.46** ***	2.06	**3.39** ***	n.a.	**1.26** ***	0.04	**1.58** ***	1.37	**0.25**	0.03	**0.92** ***	1.09
	(0.34)		*(0.15)*		*(0.85)*		*(0.22)*		*(0.07)*		*(0.18)*		*(0.13)*	
ΔlogP	**-18.73** ***	n.a.	**-2.15**	*free*	**-21.49** ***	n.a.	**-3.86**	*free*	**-6.36** ***	1.04	**-6.31** ***	6.14 **	**-15.70** ***	*free*
	(3.80)		*(16.08)*		*(6.85)*		*(3.82)*		*(1.13)*		*(0.98)*		*(3.96)*	
$logTax_{-1}$	**-0.18**	n.a.	**-0.36** ***	5.31 **	**-0.45**	n.a.	**-0.44** ***	4.77 **						
	(0.17)		*(0.09)*		*(0.32)*		*(0.10)*							
logTaxDistr	**-0.66** ***	n.a.	**-0.02**	2.42	**-0.90** ***	n.a.	**-0.08** **	5.87 **						
	(0.14)		*(0.03)*		*(0.30)*		*(0.04)*							
$logSk^{gov}_{-1}$	**0.26** ***	n.a.	**0.08** ***	0.03	**0.30** ***	n.a.	**0.07** ***	0.09	**0.03** **	0.64	**0.03**	2.42	**0.09** ***	0.31
	(0.06)		*(0.02)*		*(0.11)*		*(0.03)*		*(0.01)*		*(0.02)*		*(0.02)*	
$log(Gov\ cons)_{-1}$	**-0.05**	n.a.	**0.18** ***	0.21	**-0.21**	n.a.	**0.19** ***	0.61	**-0.16** ***	0.06	**-0.19** **	0.55	**-0.15** **	0.31
	(0.21)		*(0.03)*		*(0.29)*		*(0.04)*		*(0.05)*		*(0.08)*		*(0.06)*	
$log(Trade\ exp^{adj})_{-1}$					**-0.13**	n.a.	**0.20** ***	0.25			**0.50** ***	0.07	**0.10** *	4.79 **
					(0.18)		*(0.05)*				*(0.06)*		*(0.05)*	
Convergence coefficient														
$logY_{-1}$	**-0.06** ***		**-0.17** ***		**-0.04** **		**-0.17** ***		**-0.17** ***		**-0.15** ***		**-0.21** ***	
	(0.02)		*(0.04)*		*(0.02)*		*(0.04)*		*(0.05)*		*(0.04)*		*(0.05)*	
Short-Run Coefficients														
ΔlogSk	**0.17** ***		**0.14** ***		**0.18** ***		**0.13** ***		**0.14** ***		**0.13** ***		**0.12** ***	
	(0.02)		*(0.03)*		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*	
ΔlogH	**-0.15**		**-1.46**		**0.05**		**-1.25**		**-0.60**		**0.00**		**-0.33**	
	(0.68)		*(1.15)*		*(0.81)*		*(1.19)*		*(0.60)*		*(0.00)*		*(0.50)*	
Δ^2 logP	**-0.04**		**0.32**		**-0.40**		**-0.02**		**0.55**		**0.28**		**0.42**	
	(0.49)		*(0.60)*		*(0.55)*		*(0.56)*		*(0.50)*		*(0.44)*		*(0.45)*	
$\Delta logTax_{-1}$	**-0.01**		**0.01**		**-0.02**		**-0.02**							
	(0.10)		*(0.11)*		*(0.11)*		*(0.11)*							
ΔlogTaxDistr	**0.01**		**-0.01**		**0.01**		**0.00**							
	(0.04)		*(0.04)*		*(0.04)*		*(0.03)*							
$\Delta logSk^{gov}_{-1}$	**0.00**		**0.01**		**0.01**		**0.01**		**0.01**		**0.02**		**0.01**	
	(0.02)		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*	
$\Delta log(Gov\ cons)_{-1}$	**0.06**		**0.02**		**0.10**		**0.07**		**-0.01**		**0.02**		**0.02**	
	(0.12)		*(0.05)*		*(0.07)*		*(0.06)*		*(0.05)*		*(0.05)*		*(0.06)*	
$\Delta log(Trade\ exp^{adj})_{-1}$					**0.03**		**0.02**				**-0.04**		**0.14** ***	
					(0.06)		*(0.06)*				*(0.05)*		*(0.04)*	
No. of countries	17		17		17		17		21		21		21	
No. of observations	427		427		427		427		522		522		522	
Log likelihood	1315		1328		1348		1362		1485		1517		1541	

All equations include a constant country-specific term and control for outliers (see Table A2.4). Standard errors are in brackets.
*: significant at 10 % level; ** at 5% level; *** at 1 % level.

Table A2.3. **Regressions including both inflation and fiscal policy variables**
(Pooled Mean Group Estimators)

Dependent variable: ΔlogY

	A		B		C		D		E	
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*
logSk	**0.34** ***	1.18	**0.29** ***	0.15	**0.27** ***	0.23	**0.23** ***	1.70	**0.24** ***	1.36
	(0.05)		*(0.05)*		*(0.04)*		*(0.04)*		*(0.04)*	
logH	**1.04** ***	0.79	**0.88** ***	0.86	**0.82** ***	0.80	**0.70** ***	1.75	**0.71** ***	0.75
	(0.15)		*(0.19)*		*(0.18)*		*(0.16)*		*(0.13)*	
ΔlogP	**-12.84** ***	0.99	**-11.01** ***	5.91 **	**-5.51**	free	**-9.76** ***	1.24	**-7.87** ***	0.24
	(1.85)		*(1.57)*		*(5.11)*		*(1.31)*		*(1.21)*	
$logSk^{gov}_{-1}$	**0.02**	0.80	**-0.02**	1.88	**0.03**	0.75				
	(0.02)		*(0.02)*		*(0.02)*					
$log(Gov\ cons)_{-1}$	**0.03**	1.22	**0.04**	0.86	**0.15** ***	1.50			**-0.10** **	1.48
	(0.08)		*(0.07)*		*(0.04)*				*(0.05)*	
$SDinfl_{-1}$	**-0.03** ***	0.10	**-0.02** ***	0.02	**-0.02** ***	0.19	**-0.03** ***	0.75	**-0.03** ***	3.03 *
	(0.01)		*(0.01)*		*(0.00)*		*(0.00)*		*(0.00)*	
$logTax_{-1}$	**-0.16** **	0.78	**-0.18** **	1.45	**-0.33** ***	1.89	**-0.12** **	0.05		
	(0.08)		*(0.07)*		*(0.07)*		*(0.05)*			
$log(Trade\ exp^{adj})_{-1}$			**0.14** **	1.31	**0.21** ***	0.96	**0.20** ***	1.55	**0.22** ***	1.19
			(0.06)		*(0.06)*		*(0.06)*		*(0.06)*	
Convergence coefficient										
$logY_{-1}$	**-0.12** ***		**-0.13** ***		**-0.19** ***		**-0.15** ***		**-0.15** ***	
	(0.02)		*(0.03)*		*(0.03)*		*(0.03)*		*(0.03)*	
Short-Run Coefficients										
ΔlogSk	**0.15** ***		**0.15** ***		**0.14** ***		**0.15** ***		**0.14** ***	
	(0.02)		*(0.02)*		*(0.02)*		*(0.02)*		*(0.02)*	
ΔlogH	**-0.73**		**-0.63**		**-0.80**		**-0.95**		**-0.72**	
	(0.62)		*(0.74)*		*(0.93)*		*(0.76)*		*(0.47)*	
Δ^2 logP	**0.63**		**0.44**		**0.36**		**0.51**		**0.69**	
	(0.54)		*(0.52)*		*(0.43)*		*(0.50)*		*(0.63)*	
$\Delta logSk^{gov}_{-1}$	**0.01**		**0.01**		**0.02**					
	(0.02)		*(0.02)*		*(0.02)*					
$\Delta log(Gov\ cons)_{-1}$	**0.03**		**0.06**		**0.04**				**0.01**	
	(0.04)		*(0.05)*		*(0.05)*				*(0.05)*	
$\Delta SDinfl_{-1}$	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**	
	(0.00)		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*	
$\Delta logTax_{-1}$	**-0.07**		**-0.07**		**-0.05**		**-0.06**			
	(0.06)		*(0.06)*		*(0.07)*		*(0.06)*			
$\Delta log(Trade\ exp^{adj})_{-1}$			**-0.02**				**-0.04**		**-0.02**	
			(0.05)				*(0.05)*		*(0.05)*	
No. of countries	17		17		17		18		21	
No. of observations	427		427		427		444		523	
Log likelihood	1310		1595		1359		1349		1556	

All equations include a constant country-specific term and control for outliers (see Table A2.4). Standard errors are in brackets.
*: significant at 10 % level; ** at 5% level; *** at 1 % level.

Table A2.4 focuses on financial market indicators. It replicates the equations presented in Table 6 of the main text, with additional information on short-term dynamics and Hausman tests. In particular, the first two equations (A and B) focus on the private credit indicator of financial market developments. The second controls for monetary conditions as proxied by the variability of inflation. The third specification focuses on stock market capitalisation.

Table A2.4. **Regressions including indicators of financial development**
(Pooled Mean Group Estimators)

Dependent variable: ∆logY	A		B		C	
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*
logSk	**0.07**	1.44	**0.30** ***	8.14 ***	**0.14** ***	0.01
	(0.06)		*(0.06)*		*(0.02)*	
logH	**1.04** ***	7.61 ***	**0.99** ***	5.27 **	**0.93** ***	4.04 **
	(0.12)		*(0.14)*		*(0.15)*	
∆logP	**-14.48** ***	2.46	**-11.54** ***	1.57	**-4.80** ***	0.34
	(2.34)		*(1.77)*		*(0.89)*	
log(Priv credit)$_{-1}$	**-0.14** ***	0.05	**0.04** **	0.01		
	(0.04)		*(0.02)*			
log(Stock cap)$_{-1}$					**0.09** ***	0.48
					(0.01)	
SDinfl$_{-1}$			**-0.02** ***	0.25		
			(0.00)			
Error Correction Coefficient						
logY$_{-1}$	**-0.10** ***		**-0.13** ***		**-0.22** ***	
	(0.02)		*(0.02)*		*(0.05)*	
Short-Run Coefficients						
∆logSk	**0.15** ***		**0.12** ***		**0.13** ***	
	(0.02)		*(0.02)*		*(0.02)*	
∆logH	**-1.89** **		**-1.16** **		**-0.84**	
	(0.78)		*(0.58)*		*(1.07)*	
Δ^2 logP	**0.71** *		**0.59**		**0.62**	
	(0.36)		*(0.41)*		*(0.62)*	
∆log(Priv credit)$_{-1}$	**0.06** **		**0.03**			
	(0.03)		*(0.03)*			
∆log(Stock cap)$_{-1}$					**0.02** *	
					(0.01)	
∆SDinfl$_{-1}$			**0.00** ***			
			(0.00)			
No. of countries	21		21		18	
No. of observations	523		523		338	
Log likelihood	1449		1498		1058	

All equations include a constant country-specific term and control for outliers (see Table A2.4). Standard errors are in brackets.
*: significant at 10 %level; ** at 5% level; *** at 1 % level.

Research and development

Table A2.5 present growth regressions including different indicators of R&D activity. As noted in Table A1.1, the sample size is shorter on both the time dimension (1981-98 in most cases) and the country coverage (Belgium and New Zealand are excluded because of too short samples for R&D; Japan and Germany because of lack of other data for the 1990s). The first two equations (A and B) focus on total

R&D intensity (*i.e.* R&D expenditure as a share of GDP), without and with control for trade exposure, respectively. Given the limited degrees of freedom, further decomposition of the R&D variable implies that the trade variable should be removed. Bearing this in mind, equations (C) and (D) distinguish between business-performed R&D and non-business-performed R&D: given the Hausman test on the coefficient on population growth in equation (C), the latter was re-estimated without the long-run homogeneity assumption on this coefficient (equation D). The next two equations (E and F) focus on business-performed R&D, insofar as it is the variable with the positive (and statistically significant) coefficient in the previous two equations. As can be seen, the inclusion of the trade exposure variable (equation F) has an impact on the size of the coefficients on business R&D, but not on their statistical significance. The Hausman tests on three long-term coefficients, however, reject the homogeneity assumption at the 5 per cent level (but not at 1 per cent). Nevertheless, further experimentation estimating freely each coefficient still rejected the homogeneity assumption).

The investment equation

As discussed in the main text, factors affecting economic growth can work through the accumulation of physical capital (*i.e.* the investment-income ratio) and through the rate of return on capital, given the investment-income ratio. The results presented above have shed light on this second channel. Table A2.6 looks at the effects of policy and institutions on the accumulation of physical capital expressed as the ratio of real private non-residential fixed capital formation to real private GDP. The first equation (A) in the table uses the same explanatory variables as in the growth equations, but also include income and human capital as potential additional factors. This specification includes government consumption and government investment but do not consider the tax and non-tax receipt variable, to maximise the sample size across the time and country dimensions. As can be seen, the coefficients of both the income variable and the human capital variable are not statistically significant and are removed in the following equations. Equation (B) replicates (A) with the exclusion of these two variables, while the next two equations (C and D) consider taxes instead of government expenditure. Within the constraints of the limited degrees of freedom, equation (E) tackles the potential problem related to the *implicit financing* biases by combining the tax variable with the government investment variable (government consumption is excluded because of its limited statistical significance in equation B). The following four equations replicate the model selection from (B) to (E) replacing the private credit variable with the stock market capitalisation variable. The latter variable is generally more robust in all specification but its use instead of the private credit variable alters somewhat the significance of the other regressors. In particular, once both government investment and consumption are considered (equation F), the latter is statistically significant, while the former is not, in contrast with the equations with private credit as the financial market indicator.

Growth decomposition

Section II.3 in the main text presents a decomposition of observed average growth patterns into a set of explanatory variables (see Table 9 and Figure 7 in the main text as well as Table A2.7 below). The decomposition is based on the following formula:

$$\Delta_t y = \left[(1-\phi)^t - 1\right] y_{-t} + \sum_j \sum_{h=1}^{t} (1-\phi)^{h-1} \phi \cdot \theta_j X_{j,1-h} \qquad [10]$$

where $\mathbf{X}$ = {lns_k , ln$h$, n , $\mathbf{V}$} is the vector of independent variables, Θ is the vector of their long-run coefficients, ϕ is the convergence coefficient; -t indicates initial conditions and -h indicates that the variable is lagged h periods.

Table A2.5. **Regressions including R&D intensity**
(Pooled Mean Group Estimators)

Dependent variable: ΔlogY	total R&D				with distinction between BERD and non-BERD				with BERD only			
	A		B		C		D		E		F	
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*
logSk	**0.37** ***	0.63	**0.31** ***	0.01	**0.10** **	0.03	**0.28** ***	0.45	**0.34** ***	0.85	**0.34** ***	0.04
	(0.01)		*(0.03)*		*(0.05)*		*(0.02)*		*(0.03)*		*(0.02)*	
logH	**1.48** ***	0.83	**1.13** ***	3.49 *	**1.63** ***	0.21	**1.76** ***	0.16	**1.72** ***	0.16	**0.82** ***	5.99 **
	(0.09)		*(0.16)*		*(0.26)*		*(0.05)*		*(0.18)*		*(0.18)*	
ΔlogP	**-13.63** ***	1.30	**-12.15** ***	3.78 *	**-18.37** ***	31.23 ***	**-33.19** **	*free*	**-26.79** ***	0.01	**-16.43** ***	6.17 **
	(1.79)		*(1.64)*		*(3.66)*		*(13.94)*		*(2.53)*		*(2.02)*	
$logR\&D^{tot}$	**0.25** ***	0.66	**0.14** ***	0.97								
	(0.01)		*(0.03)*									
logBERD					**0.18** ***	3.20 *	**0.26** ***	4.72 **	**0.22** ***	0.73	**0.13** ***	5.78 **
					(0.04)		*(0.01)*		*(0.02)*		*(0.02)*	
$logR\&D^{pub}$					**-0.29** ***	1.20	**-0.37** ***	1.65				
					(0.08)		*(0.04)*					
$logBERD^{ind}$												
$logBERD^{pub}$												
$log(Trade\ exp^{adj})_{-1}$			**0.33** ***	0.13							**0.32** ***	2.27
			(0.05)								*(0.05)*	
Convergence coefficient												
$logY_{-1}$	**-0.17** ***		**-0.22** ***		**-0.15** ***		**-0.23** **		**-0.13** ***		**-0.18** ***	
	(0.04)		*(0.05)*		*(0.03)*		*(0.11)*		*(0.04)*		*(0.04)*	
Short-Run Coefficients												
ΔlogSk	**0.13** ***		**0.09** ***		**0.13** ***		**0.11** ***		**0.12** ***		**0.11** ***	
	(0.03)		*(0.03)*		*(0.03)*		*(0.04)*		*(0.03)*		*(0.03)*	
ΔlogH	**0.46**		**1.34**		**0.65**		**0.12**		**0.80**		**1.08**	
	(1.00)		*(1.49)*		*(1.22)*		*(0.92)*		*(0.99)*		*(1.22)*	
Δ^2 logP	**0.42**		**1.00**		**1.32** *		**0.81**		**0.99** **		**1.05** *	
	(0.47)		*(0.78)*		*(0.68)*		*(0.71)*		*(0.45)*		*(0.60)*	
$\Delta logR\&D^{tot}$	**-0.08**		**-0.11** *									
	(0.05)		*(0.06)*									
ΔlogBERD					**-0.06**		**-0.09** *		**-0.04**		**-0.02**	
					(0.04)		*(0.06)*		*(0.05)*		*(0.03)*	
$\Delta logR\&D^{pub}$					**-0.07** *		**-0.05**					
					(0.04)		*(0.05)*					
$\Delta logBERD^{ind}$												
$\Delta logBERD^{pub}$												
$\Delta log(Trade\ exp^{adj})_{-1}$			**0.09** *								**0.09**	
			(0.05)								*(0.06)*	
No. of countries	17		16		15		15		17		16	
No. of observations	264		252		236		236		263		251	
Log likelihood	872		860		795		831		868		849	

All equations include a constant country-specific term and control for outliers. Standard errors are in brackets.
*: significant at 10 % level; ** at 5% level; *** at 1 % level.

Table A2.6. **Investment regressions**
(Pooled Mean Group Estimators)

Dependent variable: ΔlogS	A		B		C		D		E		F		G		
Long-Run Coefficients		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*		*Hausman test*	
$logY_{-1}$	**0.11**	0.49													
	(0.20)														
logH	**-0.60**	1.21													
	(0.42)														
$SDinfl_{-1}$	**-0.00**	2.91 *	**-0.02** *	3.57 *	**-0.01**	0.33			**-0.01** *	1.03					
	(0.01)		*(0.01)*		*(0.01)*				*(0.01)*						
$Infl_{-1}$	**-0.03** ***	0.03	**-0.02** ***	0.77	**-0.04** ***	6.44 **	**-0.04** ***	1.91	**-0.03** ***	0.23	**-0.02** ***	0.29	**-0.02** ***	0.08	**-0.03**
	(0.01)		*(0.01)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.01)*
$log(Gov\ cons)_{-1}$	**-0.07**	0.56	**-0.26** *	1.53							**-0.71** ***	1.16	**-0.74** ***	0.51	
	(0.18)		*(0.15)*								*(0.14)*		*(0.12)*		
$logSk^{gov}_{-1}$	**-0.37** ***	1.94	**-0.21** ***	0.40					**-0.11** **	0.89	**0.02**	0.06			**-0.05**
	(0.06)		*(0.06)*						*(0.04)*		*(0.03)*				*(0.03)*
$logTax_{-1}$					**-0.82** ***	0.47	**-0.73** ***	0.01	**-0.77** ***	0.99					**-0.36**
					(0.15)		*(0.14)*		*(0.12)*						*(0.14)*
$log(Stock\ cap)_{-1}$											**0.14** ***	2.10	**0.15** ***	0.86	**0.17**
											(0.01)		*(0.01)*		*(0.02)*
$log(Priv\ credit)_{-1}$	**-0.02**	2.90 *	**0.09** **	1.84	**0.13** ***	4.62 **	**0.15** ***	7.67 ***	**0.06**	0.66					
	(0.04)		*(0.03)*		*(0.05)*		*(0.04)*		*(0.04)*						
$log(Trade\ exp^{adj})_{-1}$	**-0.33** **	0.08	**-0.32** ***	4.59 **	**0.08**	5.09 **	**0.05**	8.08 ***	**-0.05**	0.35	**0.05**	0.90	**0.02**	0.27	**-0.31**
	(0.15)		*(0.12)*		*(0.10)*		*(0.10)*		*(0.08)*		*(0.10)*		*(0.08)*		*(0.09)*
Convergence coefficient															
$logY_{-1}$	**-0.20** ***		**-0.15** ***		**-0.20** ***		**-0.20** ***		**-0.22** ***		**-0.27** ***		**-0.28** ***		**-0.26**
	(0.04)		*(0.03)*		*(0.04)*		*(0.04)*		*(0.05)*		*(0.07)*		*(0.07)*		*(0.05)*
Short-Run Coefficients															
$\Delta logY_{-1}$	**0.26**														
	(0.23)														
ΔlogH	**2.66**														
	(3.16)														
$\Delta SDinfl_{-1}$	**0.00**		**0.00**		**0.00**				**0.00**						
	(0.00)		*(0.00)*		*(0.00)*				*(0.00)*						
$\Delta Infl_{-1}$	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**
	(0.00)		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*		*(0.00)*
$\Delta log(Gov\ cons)_{-1}$	**-0.54** ***		**-0.61** ***								**-0.51** ***		**-0.50** ***		
	(0.13)		*(0.14)*								*(0.16)*		*(0.16)*		
$\Delta logSk^{gov}_{-1}$	**0.06** *		**0.00**						**-0.06**		**-0.03**				**-0.11**
	(0.03)		*(0.04)*						*(0.06)*		*(0.06)*				*(0.07)*
$\Delta logTax_{-1}$					**-0.09**		**-0.10**		**-0.11**						**0.05**
					(0.13)		*(0.13)*		*(0.14)*						*(0.15)*
$\Delta log(Stock\ cap)_{-1}$											**0.09** ***		**0.09** ***		**0.13**
											(0.03)		*(0.03)*		*(0.04)*
$\Delta log(Priv\ credit)_{-1}$	**-0.09**		**-0.10**		**-0.13**		**-0.14**		**-0.07**						
	(0.07)		*(0.06)*		*(0.09)*		*(0.09)*		*(0.09)*						
$\Delta log(Trade\ exp^{adj})_{-}$	**0.09**		**-0.08**		**0.20**		**0.17**		**0.28** *		**0.10**		**0.00**		**0.27**
	(0.18)		*(0.18)*		*(0.15)*		*(0.15)*		*(0.16)*		*(0.20)*		*(0.21)*		*(0.22)*
No. of countries	21		21		18		18		18		18		18		16
No. of observations	531		531		449		449		443		338		338		301
Log likelihood	995		936		765		754		776		693		674		601

All equations include a constant country-specific term and control for outliers (see Table A2.4). Standard errors are in brackets.
*: significant at 10 % level; ** at 5% level; *** at 1 % level.

The formula is derived from equation [7] in Appendix 1 and omits short-run dynamics for the independent variables, that is:

$$y = (1-\phi)y_{-1} + \phi \sum_j \theta_j X_{j,0} \qquad [11]$$

Iterating one more period, this yields:

$$y = (1-\phi)^2 y_{-2} + \phi \sum_j (1-\phi)\theta_j X_{j,-1} + \phi \sum_j \theta_j X_{j,0} \qquad [12]$$

Similarly, iterating equation [11] *t*-1 times yields:

$$y = (1-\phi)^t y_{-t} + \phi \sum_{h=1}^{t} \sum_j (1-\phi)^{h-1} \theta_j X_{j,1-h} \qquad [13]$$

Then, equation [10] can be derived by rearranging equation [13].

To be comparable across countries and/or over time, growth decompositions undertaken according to equation [10] have to refer to the same time span *t*. In fact, taking for simplicity the case of a hypothetical independent variable *X* that is approximately constant over time, equation [10] suggests that the weight of this variable is greater (in absolute terms) the longer the time span over which the decomposition is performed.

Table A2.7. **Decomposition of changes in annual average growth rates of GDP per capita**[1]

		Change in growth	**due to changes in:**						
	Periods [2]		**Investment share**	**Human capital**	**Population growth**	**Variability of inflation**	**Government consumption**	**Trade exposure**	**Unexplained residual**
United States	1970s-80s	**0.90**	0.11	0.19	0.50	0.17	0.00	0.33	0.51
	1980s-90s	**-0.19**	0.19	0.07	-0.06	0.13	0.07	0.65	-0.70
Japan	1970s-80s	**-0.58**	0.42	0.48	-0.12	0.51	0.01	0.18	0.31
	1980s-90s								
West Germany	1970s-80s	**0.08**	0.05	0.67	0.22	-0.02	-0.01	0.27	0.09
	1980s-90s								
France	1970s-80s	**-0.57**	0.13	0.26	0.12	0.10	-0.13	0.26	0.03
	1980s-90s	**0.04**	0.01	0.35	0.27	0.23	-0.02	0.42	-0.30
Italy	1970s-80s	**-0.98**	-0.28	0.61	-0.02	0.25	-0.14	0.18	0.22
	1980s-90s	**-0.06**	0.05	0.84	0.36	0.18	-0.01	0.49	-0.87
United Kingdom	1970s-80s	**0.59**	0.25	0.42	0.08	0.57	-0.01	0.18	0.09
	1980s-90s[2]	**0.01**	0.08	0.44	0.05	0.00	0.03	0.25	0.37
Canada	1970s-80s	**0.18**	0.39	0.21	0.63	0.10	-0.01	0.40	-0.50
	1980s-90s	**-0.60**	0.24	0.19	-0.10	0.01	-0.02	0.60	-0.34

Table A2.7. **Decomposition of changes in annual average growth rates of GDP per capita**[1] (continued)

	Periods [2]	Change in growth	due to changes in: Investment share	Human capital	Population growth	Variability of inflation	Government consumption	Trade exposure	Unexplained residual
Australia	1970s-80s								
	1980s-90s	**0.80**	-0.16	0.17	0.46	0.05	0.03	0.57	0.63
Austria	1970s-80s	**-0.52**	0.05	0.40	0.21	0.04	-0.07	0.32	0.15
	1980s-90s	**-0.23**	0.37	0.31	-0.07	0.12	-0.02	0.37	-0.06
Belgium	1970s-80s	**-0.35**	0.16	0.38	0.13	0.16	-0.01	0.14	0.08
	1980s-90s	**0.37**	0.37	0.45	0.17	0.26	0.06	0.24	-0.06
Denmark	1970s-80s	**-0.06**	0.26	0.26	0.08	-0.01	-0.04	0.19	0.40
	1980s-90s	**0.34**	0.10	0.20	0.03	0.07	0.01	0.22	0.84
Finland	1970s-80s	**-0.61**	-0.14	0.43	0.17	0.29	-0.12	0.13	0.60
	1980s-90s	**-0.90**	-0.91	0.44	-0.03	0.05	-0.13	0.33	0.86
Greece	1970s-80s	**-1.34**	-0.53	0.48	0.35	0.35	-0.22	0.45	-0.56
	1980s-90s[3]	**-0.06**	0.00	0.57	0.09	-0.12	-0.05	0.54	-0.47
Ireland	1970s-80s	**0.59**	-0.43	0.49	0.78	0.38	-0.01	0.43	0.57
	1980s-90s	**1.21**	-0.17	0.54	-0.75	0.35	0.13	0.46	2.71
Netherlands	1970s-80s	**0.33**	0.13	0.54	0.35	0.08	0.05	0.18	-0.38
	1980s-90s	**0.97**	-0.04	0.43	0.32	0.07	0.10	0.25	0.69
New Zealand	1970s-80s	**0.41**	0.56	0.24	0.13	-0.23	-0.04	0.27	-0.35
	1980s-90s	**-0.26**	0.33	0.21	-0.47	0.68	0.06	0.44	-1.02
Norway	1970s-80s	**-1.54**	-0.13	0.43	-0.03	0.17	-0.65	0.04	0.61
	1980s-90s	**0.61**	-0.21	0.27	0.15	0.14	-0.41	0.30	1.23
Portugal	1970s-80s	**0.87**	-0.25	0.26	0.94	0.10	-0.08	0.41	0.58
	1980s-90s	**-0.15**	0.25	0.32	0.02	0.42	-0.20	0.53	0.21
Spain	1970s-80s	**0.10**	-0.10	0.69	0.10	0.18	-0.21	0.51	-0.06
	1980s-90s	**0.46**	0.33	0.90	0.46	0.25	-0.12	0.67	-0.94
Sweden	1970s-80s	**-0.23**	0.30	0.47	-0.03	0.15	-0.02	0.20	-0.07
	1980s-90s	**-0.64**	-0.19	0.42	-0.05	-0.20	0.02	0.33	0.12
Switzerland	1970s-80s	**-0.19**	0.47	0.48	-0.16	0.23	-0.03	0.19	-0.44
	1980s-90s[4]	**-0.58**	0.02	0.26	0.09	-0.09	-0.07	0.14	-0.30

Notes:
1. Output per capita refers to GDP per working-age person.
2. 1970s-80s: average growth change from 1973-81 to 1981-89.
 1980s-90s: average growth change from 1981-89 to 1989-97.
3. 1980s-90s: average growth change from 1981-89 to 1988-96.
4. 1980s-90s: average growth change from 1981-89 to 1987-95.
Source: OECD.

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