Economic Growth and the Role of Taxation - Disaggregate Data

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ECONOMIC GROWTH AND THE ROLE OF TAXATION - DISAGGREGATE DATA

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ABSTRACT/RESUMÉ

Economic growth and the role of taxation - Disaggregate data

Economic growth is the basis of increased prosperity. This makes the attainment of growth a key objective for governments across the world. The rate of growth can be affected by policy choices through the effect that taxation has upon economic decisions and through productive public expenditures. This paper surveys the empirical analysis of disaggregate data on growth. The aim is to identify how economic policy can affect the choices that have been identified as influences upon the rate of growth.

JEL Classification: *O4; H2; H3; C01.*

Keywords: *Economic growth; taxation; public policy; disaggregate data.*

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La croissance économique et le rôle de la fiscalité - données désagrégées

La croissance économique est au fondement du progrès de la prospérité. Ceci fait de la croissance un objectif majeur pour les gouvernements du monde entier. Le taux de croissance peut être influencé par des choix de politique économique relatifs à la fiscalité, laquelle a un effet sur les décisions économiques des agents et est liée aux dépenses publiques productives. Cette étude résume les recherches qui ont porté sur l'analyse empirique des données désagrégées. Le but de cette étude est d'identifier comment la politiqueéconomique peut influencer les choix qui ont eux-mêmes un impact sur le taux de croissance.

Classification JEL : O4 ; H2 ; H3 ; C01.

Mots-clef : *Croissance économique ; fiscalité ; politique publique ; données désagrégées.*

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ECONOMIC GROWTH AND THE ROLE OF TAXATION: DISAGGREGATE DATA[1]

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This discussion paper is the third in a series of three that review the economic literature on the links between taxation and economic growth. These papers are extracted from the report *Economic Growth and the Role of Taxation* prepared for the OECD under contract CTPA/CFA/WP2(2006)31. The first and second papers discuss theoretical analysis and the analysis of aggregate data respectively.

1. Introduction

1.   Endogenous growth theory links the choices of individual economic agents to the growth rate of the aggregate economy. There are many such choices that are relevant. Increased schooling adds to the stock of human capital and the productivity of individuals. Increased research and development expenditure leads to technological advances by firms that raise output. Government expenditure on infrastructure complements the inputs of firms. The key point is that these choices may be influenced by economic policy. If they are, governments are then able to influence the rate of growth and the design of policy must take this effect into account. This paper surveys the empirical literature that addresses the extent to which these choices are affected by policy.

2.   The econometric analysis of individual decisions has made major advances in recent years. The availability of detailed data sets and developments in methodology, not least the exploitation of natural experiments, has allowed for much refined estimates of behavioural responses. Empirical estimates of the responsiveness of decisions to government policies, typically summarised in elasticities, can now be accepted with a degree of confidence. In all of the decisions relevant for growth - such as physical and human capital investment, and research and development - published studies are returning statistically significant estimates which are consistent in their values.

3.   A summary of the current position is that the elasticities of each of the individual components of growth are known with a degree of certainty. What is not clear is how these individual elasticities aggregate into an overall effect. Theoretical models predict that they should be significant but the effects

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[1]   Thanks are due to Christopher Heady for initiating and supporting the project, Nigar Hashimzade, Joel Slemrod, Stephen Bond, and participants at OECD presentations as well as Irene Sinha for excellent editorial support. Correspondance: Department of Economics, University of Exeter, Exeter, EX4 4PU, UK, gdmyles@ex.ac.uk

are not apparent in the aggregate data. To confirm the link between taxation and growth future research must integrate the individual effects into an overall picture. This appears to be a considerable challenge.

4.   Section 2 of the paper reviews the literature relating to a range of individual decisions. Section 3 considers corporate decisions. The conclusions of country studies are reviewed in Section 4. Conclusions are provided in Section 5. The appendix gives a brief introduction to natural experiments.

2. Personal Choices

5.   Endogenous growth models describe a number of separate channels through which growth can occur. The essential nature of endogenous growth is that these channels are the consequence of decisions taken by economic agents. As examples, the level of human capital results from the educational choices of individuals and the number of technical innovations is a consequence of expenditure by firms on research and development. Taxation will impact upon the rate of growth if it affects any of the economic choices involved with these growth channels.

6.   The second paper in this series focussed on empirical work conducted with aggregate data. The intention of from this point is to review the evidence on the individual decisions that endogenous growth theory has identified as relevant. It should be noted that this is a diverse and varied literature that was not necessarily written to answer the questions being asked of it here. In particular, the effects estimated do not always relate directly to taxation. Therefore the results have to be extracted through careful consideration.

2.1 Human Capital

7.   The economic theory of growth has assumed that it is a measure of quality-adjusted labour that enters the production function, rather than just the quantity of labour. The quality-adjusted labour supply is typically expressed as the product of some measure of education and labour supply. This specification is implicit in the empirical applications of growth regressions and growth accounting.

8.   This observation suggests that two points must be considered. First, how the decision on human capital accumulation is affected by the policy variables of the government. Second, what the correct measure of labour supply quality is in empirical growth theory. The latter question can itself carry implications for policy. These questions remain equally valid if human capital enters the production function in an alternative way.

2.1.1 Taxation and Educational Choice

9.   To obtain an insight into how educational choices are determined, and how policy can affect choice, a simple model of the education decision is now analysed.

10.   Consider a single consumer with a two-period lifespan. In the first period they can choose to work or to be educated. Working provides a wage of w_n and education has a cost e. A subsidy σ is received to pay for the costs of education. The consumer's initial wealth is W. Income is divided between consumption, x_1, and saving, s. Borrowing is represented as negative saving. The capital market is initially assumed to be perfect so both saving and borrowing can be undertaken at gross interest rate r.

11.   In the second period of life the consumer earns wage w_n if they did not choose education. If they chose education the wage received is $w_e > w_n$. An income tax at rate t is levied on income from employment and interest income from saving.

12.   If education is not chosen then the budget constraint in the first period of life is

$$W + (1-t)w_n = x_1 + s,$$ (1)

and in the second period of life

$$(1-t)w_n + (1 + r(1-t))s = x_2.$$ (2)

These combine to give the lifecycle budget constraint

$$W + (1-t)w_n + \frac{(1-t)w_n}{1 + r(1-t)} = x_1 + \frac{x_2}{1 + r(1-t)}).$$ (3)

If education is chosen the period budget constraints become

$$W = x_1 + s + e - \sigma,$$ (4)

and

$$(1-t)w_e + (1 + r(1-t))s = x_2.$$ (5)

These give the lifecycle budget constraint

$$W + \frac{(1-t)w_e}{1 + r(1-t)} - e + \sigma = x_1 + \frac{x_2}{1 + r(1-t)}.$$ (6)

13.   The assumption of a perfect capital market implies there are no limitations upon borrowing or saving. The lifecycle budget constraint is therefore linear so the consumer's decision can be based entirely upon the discounted value of lifetime wealth. If education makes the discounted value greater, then education will be chosen. Applying this reasoning the consumer described above will choose education if

$$\frac{(1-t)w_e}{1 + r(1-t)} - e + \sigma > (1-t)w_n + \frac{(1-t)w_n}{1 + r(1-t)},$$ (7)

or

$$\frac{w_e - w_n}{1 + r(1-t)} > w_n + \frac{e - \sigma}{(1-t)}.$$ (8)

14.   This reflects the requirement that the increase in wage due to education is sufficiently large to offset the cost. It can be seen from this expression that an increase in the subsidy always has the effect of making it more likely that this inequality is satisfied. The effect of an increase in the tax rate has an ambiguous effect. It raises the left-hand side and raises the second term on the right-hand side. It will make education less likely if the cost of education is greater than the interest earned in the net of tax wage.

15.   The result above implicitly assumes that interest received and interest paid are treated symmetrically by the tax system. Now assume that interest received is taxed but there is no relief on

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interest payments. Assume also that the consumer has to borrow to fund education but saves if education is not chosen. This modifies the lifetime budget constraint to

$$W + \frac{(1-t)w_e}{1+r} - e + \sigma = x_1 + \frac{x_2}{1+r} . \qquad (9)$$

This has the effect of changing the discount factor between the education and no education situations. The solution to the choice problem is now dependent upon the consumer's preferences.

16.　　　It is well known that there are difficulties in borrowing to finance education. This implies that it is more appropriate to model the capital market as imperfect with a higher rate for borrowing than lending. The effect of this is to create a kink in the budget constraint at the point of no borrowing or saving. It is then not enough to just consider the present value of income (since it is not clear what interest rate has to be used to do so) and the choice becomes dependent upon preferences. Moreover, the choice becomes dependent on initial wealth W.

17.　　　In fact, higher-income consumers will choose education when the lower-income ones will not because the former can self-finance rather than borrow at the higher rate. The increase in subsidy will be effective in this setting for assisting those who are close to the margin. Note that if preferences are very similar then all of those who benefit and move into education because of an increase in σ will be at a similar income level. The existence of imperfections in the capital market adds further ambiguity into the tax effect.

2.1.2 Empirical Results

18.　　　The first question to address is the sensitivity of educational choices to policy parameters. The available literature has paid little attention to the effect of taxation, possibly because of the basic ambiguity in its effect. Taxation also affects costs and benefits in the long-run, and evidence from behavioural economics suggests consumers may be more concerned with the short-run. The literature has focused upon determining the response of the educational decision to changes in the design of tuition subsidy programmes. These programmes affect the cost of education in the short term and can have significant and immediate effects. The results of this branch of the literature are now reviewed.

19.　　　In terms of the model described above the literature has estimated the consequence of an increase (or decrease) in the subsidy payment, σ. With an imperfect capital market the simple model shows that a change in the subsidy will affect only a narrow group of individuals - those on the margin between choosing education and no education. If preferences are similar this group will display homogeneity in income. Moreover, the effect will also tend to be focused on the group most affected by the imperfections in the capital market. Hence, it can be expected that the affected group will display homogeneity in credit market characteristics.

20.　　　The early literature from the 1970s and 1980s is surveyed by Leslie and Brinkman (1989). From the reported results they conclude that a $1 000 change in the cost of education (evaluated in year 2001 dollars) was associated with a four percentage point difference in college enrolment rates.

21.　　　An early contribution to the recent literature was Kane (1994) who analyzed the effect of the 1980s cut back in the Pell grant scheme for means-tested higher education support in the United States. The paper employed data on enrolments in higher education to assess the role of grants and returns, with particular emphasis on black youths. What the paper found was that the direct costs of education were very important in explaining enrolment. The reduction of the subsidy raised the direct cost which caused a fall in the proportion of black youths entering higher education in the United States. Evaluated at the mean

characteristics of the sample, an increase of $1 000 in the net direct cost of education generated a five percentage point reduction in black enrolment.

22.   The decline in white enrolment was smaller than this figure. Conversely, the returns to education did not seem as important. This latter result was tested by including the income differential between high school and college. For blacks this did not seem to have much effect but it did matter for whites. The paper observes that costs seem more important than returns, and justifies this by appealing to an argument based on the discounting of returns. An alternative interpretation could be the role of credit market imperfections.

23.   The analysis of educational choice is developed further in Kane (1995) which again looks at the effect of subsidies on enrolment. The paper concludes that the effect is large, particularly for students from low-income families and for those students attending two-year college. It also observes that college enrolment falls when the minimum wage is increased. The paper also concludes that the response to the targeted aid in the Pell Grant programme seems to be low with no disproportionate increase in enrolment of students from low-income families. This implies that means-testing did not have the effect predicted by the model of educational choice: targeting support to marginal students should cause the most significant increase in enrolment. Two arguments that might explain this are limitations on places in colleges and lack of information of marginal students on the Pell Grant scheme perhaps through general lack of prior involvement in college education.

24.   Seftor and Turner (2002) also analyze the Pell Grant scheme. The key feature of their work is that the sample population is older students who are in their twenties and thirties. The reason for interest in this group of students is that they typically have experience of work and are in a better position to evaluate the income they will earn in the no-education alternative. In addition, older students are likely to have developed a credit history and be able to borrow more easily on the credit market. These facts suggest that their behaviour should conform closely to the predictions of the economic model. The methodology applied to the data is that of a natural experiment with difference-in-differences estimation. The paper finds that the cost elasticity of participation is high for the older students, and certainly higher than that of the younger students studied in previous papers.

25.   Dynarski (2000) studies the HOPE programme introduced by the state of Georgia. This programme allows tax rebates on spending for educational purposes, thus reducing the net cost. This obviously helped the middle- and upper-income classes more since they could take full advantage of the scheme. The data is analyzed as a natural experiment using difference-in-difference estimators with nearby states without the programme being used as controls. The results show that programme seemed to have raised enrolment in Georgia by about 7.5 percentage points, with the enrolment probability increasing by 25%. This means that each $1 000 in aid increased the college enrolment probability by around four percentage points.

26.   The paper also reports evidence that the programme had a differential effect on whites compared to blacks for reasons of income distribution. The overall conclusion is that the elasticity of attendance is higher than previously suspected, so that schemes can have a significant effect. However, the paper also identifies the fact that for every student who chooses education because of the scheme there are four who would have gone to college anyway but now just benefit from the subsidy. So, from this perspective, the scheme is inefficient in its allocation of funding. It should also be noted that the paper develops a very simple human capital model with benefits and costs of education that shows how the scheme may affect choice. But the prediction of the theoretical analysis reduces to an unsigned second cross-derivative, so the outcome is ambiguous.

27.   Dynarski (2003) is interested in calculating the elasticity of higher education choice with respects to the level of student aid. To investigate this issue the paper studies the effect of the withdrawal of a

programme in which the children of deceased, disabled, and retired Social Security beneficiaries received a monthly lump-sum to finance study. Between 1965 and 1982 these benefits were extended to beneficiaries' children up to the age of 22, provided the child remained in full-time education. The payments were made without reference to the actual costs of education. The average value of the grant was $6700 which would almost pay for average private college in 1980. The programme was abruptly terminated and from May 1982 those not already enrolled were ineligible for future subsidies.

28.   The paper used difference-in-differences estimation of the equation

$$y = \alpha + \beta(\text{Father deceased} * \text{Before}) + \delta \text{Father deceased} + \theta \text{Before} + \upsilon, \qquad (10)$$

where y is a measure of college attendance. Before measures whether the individual graduated from high school before the benefits were eliminated. Father deceased measures eligibility for the benefits. The variable β captures the effect on the education decision of the eligibility for aid. The data used was the National Longitudinal Survey of Youth. The cohorts in their senior high school years in 1982 and 1983 are the After group who are ineligible. The cohorts in their senior year in 1979, 1980, and 1981 are the Before group who are potentially eligible for treatment.

29.   The empirical analysis produces an estimated value of $\beta = 0.219$ with a standard error of 0.102. The R^2 for the regression is 0.339 after the inclusion of a number of covariates. The introduction of the scheme is estimated to have increased take-up of college by 22%, so it has a large and significant effect.

30.   Dynarski notes that the student aid policy may have attracted into college students who had low ex ante expected returns to college. This represents inefficient use of expenditure. Also, the significance of the policy effect could come from either relaxing the liquidity constraint due to an imperfect capital market or from the direct subsidy effect reducing the net cost of education.

31.   The focus of Dynarski (2005) is primarily upon whether subsidy programmes affect the completion rate of education. The relevance of completion is that the United States has a very high entry rate into college education but the completion rate is much lower. The paper argues that any further major increases in entry are hard to achieve so completion is possibly the easier route to a significant increase in the stock of human capital. The effect of the scholarship programmes in Arkansas and Georgia are studied for their effects upon entry and completion. The method is again to treat these programmes as natural experiments and to use difference-in-differences estimation.

32.   The results show that the programmes increase the share of population completing college by 3 percentage points. The effect is strongest among women, with the share of non-white women completing college increasing by 7 percentage points. The size of these increases can be judged against the fact that the 27% of the cohort prior to the introduction of the programmes completed a college degree. It is concluded that subsidy programmes have a large and significant effect upon completion of college degrees but the proportion dropping out of college remains high even when education is free, so the cost of education is not the only factor preventing completion.

33.   The studies of educational choice described up to this point have concentrated upon the effect of grants or subsidies that are paid at the time the educational costs are incurred. In contrast, Long (2003) analyzes the effect of a tax credit which accrues the year after the educational costs are met. There is potential for these tax credits to have a very different effect to the subsidies because of the difference in timing.

34.   The US Tax Relief Act of 1997 introduced federal tax credits for higher education expenses. These credits were designed as targeted tax relief to the middle classes. The middle class target was

justified using the argument that this group constituted a large proportion of those attending college but were excluded from other federal grant programmes. Tax expenditures are also favoured by federal budget rules since they do not appear as expenditures. The tax credit accrues on a family basis. The credit for tuition expenses in one year do not accrue until the following year.

35.   Tax credits have several properties worth noting. First, if it is liquidity constraints that are holding down attendance at college then a tax credit will have little effect. This is because the timing does not assist with the relaxation of the credit constraint. Second, the use of credits limits the number of students who will choose college when it is not beneficial. This observation is based on the expectation that there will be an increased income against which to offset the tax credit. Third, there is no limit on how expensive the tax expenditure may be. For instance, the existence of tax credits may cause the choice of more expensive colleges which raises the tax expenditure.

36.   The paper notes that the use of the tax credits has been well below predicted levels. This is important for interpreting the analysis of the effects. In fact, only 36% of those who were eligible actually claimed the tax credit. Survey evidence is reported which shows that the majority of parents were not aware of the credits. The credits can affect the number going to college or can lead to the choice of a more costly college. The data indicates no significant enrolment response to the credits. This result is obtained by treating the credit as a natural experiment with results estimated using the difference-in-differences method.

37.   The lack of an enrolment response may be explained by the basic fact that students are not sensitive to inducements that are not received until some time in the future. The economics of hyperbolic discounting can explain this form of short-sightedness. Alternatively, the explanation could be the fact that tax credits do not relax a liquidity constraint. Or it may be that the lack of awareness means those who might change their behaviour – potential students on the margin of attendance - just do not know about the tax credits. (It is interesting to observe that this paper may be also informative about the effect of publication bias in surveying the published literature. The paper concludes that the policy has no interesting effects and has not yet been published despite being in circulation for some time and receiving several citations. In contrast, all the published work tends to report significant effects.)

38.   The role of costs in the choice of college is studied in Long (2004).The analysis exploits data on match-specific information between individuals and colleges. Using the conditional logistic choice model and a range of control variables, Long estimates that an individual is 41% less likely to attend a college that costs $1 000 more (valued in 2001 dollars). The sample used is from the US National Education Longitudinal Survey. For the average individual the responsiveness is enough to move the first choice college to fifth place if it charges $1 000 more. The paper also conducted a simulation that cut the price difference between public and private colleges in half. This resulted in up to 29% fewer students entering public four-year colleges. These results again reveal college choice to be cost sensitive.

39.   The analysis of scholarships programmes and educational participation provides results that confirm theoretical predictions. When the immediate cost of education is reduced participation increases. Furthermore, the reported percentage point increases from the natural experiments are relatively large and indicate that attendance is sensitive to cost. If college attendance adds to the stock of human capital and raises growth then the experience of the scholarship programmes reveals an effective policy tool. The analysis of tax credits provides a different picture. The take-up of tax credits has been low and the attendance effect negligible. The difference in outcome between tax credit and scholarship programme is most likely due to the timing. Two very different arguments can provide an explanation. If imperfect capital markets limit borrowing for college attendance then the tax credit will be less effective. Alternatively, if consumers exhibit the impatience described in behavioural economics (and represented by

hyperbolic discounting) then they will prefer the immediate benefit of a scholarship to the deferred benefit of a tax credit. Whatever the explanation, it is clear that the timing of the receipt of support is crucial.

2.1.3 What Should Go in a Regression?

40.   The level of human capital is one of the most important variables in endogenous growth theory. In most models it interacts with the level of physical capital to achieve the constant returns to scale that ensure the continuance of growth. The issue for the estimation of growth regressions is the measured variable that can be used to represent the theoretical construct. Furthermore, even if this issue is resolved there remains the direction of causality between growth and education. For example, Bils and Klenow (2000) demonstrate how growth can imply schooling just as much as schooling can imply growth.

41.   The research of Romer (1990b), Barro (1991) and Mankiw *et al.* (1992) used data on enrolment in education programmes. The drawback with this measure is that it is a flow variable whereas the theoretical variable is a stock. Barro and Lee (1993) constructed an educational measure that has been used in many later studies. This measures the stock of human capital through country survey and census data on the proportions of population with various levels of schooling. This variable goes part of the way to providing a measure of human capital but still has a number of shortcomings. One problem is the issue of comparability of the different levels of quality of schooling in international comparisons. Completion of a given level of education may imply different intellectual achievement across a heterogeneous set of countries. A second problem is that measures of primary and secondary education are silent on higher education and on the training provided by firms. The accumulation of general and firm-specific human capital while in employment can reasonably be argued to be closer to the theoretical concept of human capital than schooling. There is also the additional problem that the number of years of schooling cannot indefinitely increase to raise human capital and ensure growth.

42.   These difficulties are recognised by Hanushek and Kimko (2000) who construct an alternative measure of labour-force quality by employing performance on international tests of ability. The tests they employ have a focus upon mathematical and science skill. These are argued to be the most relevant abilities in a practical interpretation of the human capital variable that appears in theoretical models. Results at the individual level also show the importance of mathematics in determining individual incomes (Bishop, 1992). The results of the individual tests are averaged to provide a single indicator for each country. One process of aggregation assumes the mean score is constant over time (QL1) whereas the other measures scores relative to the US mean (QL2). The two averages are highly correlated and perform similarly in regression analysis.

43.   The first claim of Hanushek and Kimko (2000) is that the constructed measures perform better than years of schooling in growth regressions. This is illustrated by the estimated coefficients reported in Table 1 (with standard errors in parentheses). The constructed quality measures (QL1 and QL2) are significant in the regressions when included alongside the standard quantity of schooling variable. In contrast, the quantity of schooling variable loses significance. The inclusion of the quality variables also causes a significant increase in the explanatory power of the regression equation. These results are claimed to give strong support to the labour quality measure.

Table 1: Growth and labour-force quality

Constant	4.092 0.974	−1.756 (1.346)	−0.151 (1.142)
GDP 1960	−0.609 (0.186)	−0.481 (0.093)	−0.517 (0.112)
Annual population growth	−0.745 (0.181)	−0.038 (0.215)	−0.250 (0.211)
Quantity of schooling	0.519 (0.195)	0.106 (0.119)	0.116 (0.139)
Labour force quality (QL1)		0.133 (0.024)	
Labour force quality (QL2)			0.098 (0.015)
R^2	0.41	0.73	0.69

44.   Hanushek and Kimko then extend the analysis to include countries for which international test scores are not available. This is achieved by predicting the quality measured using observed information. The regression used to undertake this includes school enrolment rates, pupil-teacher ratios, education expenditures, and regional dummies. The growth regression is then repeated using the constructed quality variables. Very similar results are obtained to those reported in Table 1. The paper also reports that the measures are robust in the sense of Levine and Renelt (1992) and are most informative for the countries at the top and the bottom of the growth range.

45.   The work of Jones and Schneider (2006) further develops the argument that the concept of human capital in growth models should relate to something more basic than schooling. They claim that human capital should refer to the underlying ability to adapt to change and to problem-solve. From this perspective they argue that the level of IQ is closer to what the growth models envisage. Clearly, there is much scope for this assumption to be disputed.

        Jones and Schneider (2006) use the database of Lynn and Vanhanen (2002) which has data on IQ tests for 81 countries. These tests span the 20th century. The national average IQ from this data set is included in growth regressions along with all the standard variables. It is found that the effect of IQ is positive and significant even when all the standard regressors are present. In brief, they use all three-variable combinations of the 21 growth variables that passed Sala-i-Martin's (1997a,b) robustness test. This gives 1 330 regressions. IQ was statistically significant at the 5% level in 99.8% of these regressions. The IQ measure was also included in regressions with the standard measures of human capital. The IQ variable remained significant. The variable still works when OECD countries are removed from the sample (this checks that there is not cultural bias in attainment on IQ tests in favour of OECD countries).

46.   The key results from the paper are in Table 2. The coefficient value gives the average across a set of regressions and measures the effect of a one-point increase in a nation's average IQ on average annual

economic growth in percent. The controls represent the pool from which the other variables in the regression were drawn Top 21 is the set of most significant variables from Sala-i-Martin (1997a, b). Education controls are a wide range of different measures of total education in a county.

Table 2: Coefficient and significance of IQ, 1960 - 1992

Standard errors in parentheses

	Coefficient	% significant	% positive	No. of regressions
All countries Controls = Top 21	0.123 (0.025)	99.8	100	1330
All countries Controls = Education	0.150 (0.023)	100	100	56
Non-OECD Controls = Top 21	0.103 (0.048)	99.9	99.9	1330
Non-OECD Controls = Education	0.131 (0.043)	100	100	56

47.   These results raise questions about what the human capital variable is representing in the endogenous growth framework. Previous studies have used school enrolments and years of schooling as the measure of human capital on the basis that human capital is modelled as something that can be invested in. The finding that underlying abilities are significant suggests that it is not schooling that delivers growth but just basic IQ. Therefore, the investment in education is not justified by the model. If this is correct, the role of education has to be explained by its function as a signalling device. However, there is a possibility that IQ could be endogenous in that high growth and expenditure on education can raise IQ. Closer scrutiny is required to reveal whether this is the case.

2.2 Saving

48.   The level of saving plays a key role in the determination of the steady state in the Solow growth model. Saving is less prominent in endogenous growth models but it is still important. If there is no saving then there are no funds for investment and hence no growth. Saving is also an issue of considerable practical importance. It is frequently claimed that private saving in the United Kingdom and United States (amongst others) is inadequate to fund retirement. Increases in the dependency ratio are also putting pressure on state pensions systems. The combination of these factors has led to the "pensions crisis" that threatens many developed countries. The role of tax incentives in boosting saving is important both for reasons of economic growth and for tackling the pensions crisis.

2.2.1 Taxation and Saving

49.   The standard representation of saving behaviour is generated from the lifecycle model of consumer choice. The essence of the lifecycle model is that a rational consumer chooses a lifetime plan for consumption and labour supply taking into account the lifetime budget constraint. The model also captures optimal saving behaviour since the level of saving is the difference between income and the value of consumption in each period. The predictions of the model depend upon the detailed assumptions imposed but most specifications imply some degree of consumption smoothing across the lifecycle. The classic

survey of the economics of saving is King (1985) which discusses in detail non-stochastic and stochastic versions of the lifecycle model.

50.   Consider an individual with a lifetime of T periods. A choice for the consumer consists of levels of consumption, c_t, and labour supply, ℓ_t, in every period $t = 1, \ldots, T$, and the value of bequest, B. These choices are made to maximise the utility function

$$U = U(c_1, \ldots, c_T, \ell_1, \ldots, \ell_T, B), \tag{11}$$

subject to the lifetime budget constraint

$$\sum_{t=1}^{T} \frac{p_t c_t}{d_t} + \sum_{t=1}^{T} \frac{w_t(1 - \ell_t)}{d_t} + B = \sum_{t=1}^{T} \frac{w_t}{d_t} + I, \tag{12}$$

where I is the present value of non-labour income and d_t is the discount factor in period t. The necessary conditions for optimal consumption and labour supply are

$$U_{c_t} - \lambda \frac{p_t}{d_t} = 0, \ t = 1, \ldots, T, \tag{13}$$

and

$$U_{\ell_t} - \lambda \frac{w_t}{d_t} = 0, \ t = 1, \ldots, T. \tag{14}$$

51.   The necessary conditions can be combined with the budget constraint and solved to give the consumption demand and labour supply functions

$$c_t = c_t(p_1, \ldots, p_T, w_1, \ldots, w_T, d_1, \ldots, d_T), \tag{15}$$

and

$$\ell_t = \ell_t(p_1, \ldots, p_T, w_1, \ldots, w_T, d_1, \ldots, d_T). \tag{16}$$

52.   Econometric analysis of such demand functions requires complete knowledge of the lifetime prices, wages, and discount factors. The effect of taxation on saving can be found by noting that

$$d_t = \prod_{i=1}^{t} (1 + r_i(1 - \tau_i)), \tag{17}$$

where τ_i is the tax rate on interest income at time i. The solution shows that the effect of a change in the tax rate in any period is reflected in a change in consumption and labour supply in every period. In interpreting this, it should be stressed that this is a non-stochastic model where it is assumed all variables are known at $t = 1$ when the lifetime plan is chosen. If an unexpected change occurs at $\hat{t}$ then the plan can, of course, only be revised from $\hat{t}$ onwards.

53.   If the utility function is time separable an alternative solution method may be employed. Assume a time separable utility function of the form

$$U = \sum_{t=1}^{T} \beta^t U(c_t, \ell_t). \tag{18}$$

The necessary conditions are

$$\beta^t U_{c_t}(c_t, \ell_t) - \lambda \frac{p_t}{d_t} = 0, \ t = 1, \ldots, T, \tag{19}$$

and

$$\beta^t U_{\ell_t}(c_t, \ell_t) - \lambda \frac{w_t}{d_t} = 0, \ t = 1, \ldots, T. \tag{20}$$

54.   The important observation is that the only variable that links periods is the Lagrange multiplier, λ, and this has a constant value independent of time. The implied demand and supply functions are

$$c_t = c\left(\lambda \frac{p_t}{d_t}, \lambda \frac{w_t}{d_t}, \beta^t \right), \tag{21}$$

and

$$\ell_t = \ell\left(\lambda \frac{p_t}{d_t}, \lambda \frac{w_t}{d_t}, \beta^t \right). \tag{22}$$

55.   The implication of these demand functions is that consumption and labour supply can be seen to be directly related to within-period prices and wage rates. The time paths of labour supply and consumption (and, by implication, of saving) reflect the time paths of prices and wages. Hence, in time periods where the wage rate is high it should be expected that labour supply is high. Such claims can be made precise if additional structure is placed on the model.

56.   More specific results can be found by specialising the model. Consider a consumer who lives for two periods. They work in the first period of life and are retired in the second period. Part of first period income is saved to finance consumption in retirement. Assume that there is an income tax at rate τ_w. The lifecycle budget constraint in the first period of life is

$$x^1 + s = w\ell(1 - \tau_w), \tag{23}$$

where τ_w is the tax on labour income, and the budget constraint in the second period of life is

$$x^2 = s(1 + r(1 - \tau_r)), \tag{24}$$

where τ_r is the tax on interest income. In most tax codes these are identical. The choice of saving $\{s\}$ is made to maximise the additive utility function

$$U = U(x^1) + \delta U(x^2), \tag{25}$$

where δ is the discount rate.

The necessary condition can be written

$$-U'\left(x^1\right)+\delta U'\left(x^2\right)\left(1+r\left(1-\tau_r\right)\right)=0.\qquad(26)$$

This necessary condition shows that the income tax does not distort the allocation of consumption across the two periods. It does affect the level of consumption through an income effect. The tax on interest income does distort the choice. From the necessary condition the effect of the interest tax on saving is

$$\frac{ds}{d\tau_r}=\frac{\delta r\left[U'\left(x^2\right)+U''\left(x^2\right)\left(1+r\left(1-\tau_r\right)\right)s\right]}{S}$$

$$=\frac{\delta r U'\left(x^2\right)\left[1-R_R\right]}{S},\qquad(27)$$

where $S<0$ is the second-order condition for choice of s and R_R is the coefficient of relative risk aversion. It can be seen directly from this result that the effect of the interest tax is ambiguous since it has both an income and a substitution effect.

57.   This analysis reveals that the theory is unable to predict how taxation will affect saving. It provides a model that can be estimated but the value of the elasticity of savings with respect to the tax rate is ultimately an empirical question.

2.2.2 Empirical Results

58.   The level of saving determines the capital that is available for investment. It follows from this that the rate of growth can be increased by a policy that raises the level of saving. Such a policy will only be successful if the level of saving is responsive to changes in the net interest rate. This reasoning provided the motivation for numerous studies of the interest elasticity of saving.

59.   The first major contribution to this literature was Boskin (1978) who estimated an aggregate consumption function on US data for the period 1929-1969. The estimated range of the elasticity was between 0.3 and 0.6, with the preferred estimate being 0.4. This value was much larger than the consensus of opinion from earlier estimates. The key feature of Boskin's work was the construction of an expected interest rate using an autoregressive process. Furthermore, the aggregate consumption function estimated was not founded on micro principles. The approach of Boskin was modified by Howry and Hyman (1978) by replacing the expected interest rate with the actual real interest rate and adding lagged unemployment as an explanatory variable. This generated the conclusion that the interest rate had virtually no effect on consumption. The estimated value of the elasticity was then increased by the work of Summers (1982) who found the size of the elasticity to a value possibly in excess of 1. The data were then reconsidered again by Hall (1988) and the elasticity estimated to be close to 0 but not above 0.2. More discussion of this debate can be found in Batina and Ihori (2000).

60.   A recent analysis of the effect of taxation upon aggregate is provided by Tanzi and Zee (1998). The paper uses data from 21 OECD countries over the time period 1970-1994. This data includes the saving rate, plus the revenue for a number of taxes as a proportion of GDP. The econometric results are obtained by regressing the saving rate on various combinations of the tax variables. Results are presented for levels, logs, and first differences. In every case the coefficients on the tax variables are negative and, in almost all cases, are significant. This is claimed to be evidence that taxes impact upon saving. Taxes may

impact on saving, but the methods of this paper cannot prove the fact. At best, the regressions establish a strong correlation. However, the cause of this correlation is not identified. For example, some countries could have high taxes in order to finance generous state pensions. The provision of generous pensions would reduce the need to save for retirement, hence causing a negative correlation between tax rates and saving. The econometric analysis is also weak. The results are generated using OLS without exploiting any of the benefits of having a panel. Nor are any of the time series properties of the data tested. Finally, no additional covariates are included in the regressions.

61.   The nature of the analysis of taxation and saving has now changed. This reflected a move from the estimation of aggregate consumption functions on long time series to the study of the consequences of policy changes. In other literatures policy changes have been addressed using the natural experiments format, but for savings this has not been done directly. Instead, there has been more traditional structural modelling applied to the observed data.

62.   The United States has witnessed two major schemes designed to increase the level of saving. Individual Retirement Accounts (IRAs) were introduced in 1974 to allow saving in a tax-privileged form for employees without pension plans. Eligibility for IRAs was expanded by the Economic Recovery Tax Act of 1981 to permit almost all working taxpayers to contribute, and the IRA limits were increased. This led to a major increase in saving in IRAs. The Tax Reform Act of 1986 changed the position by excluding higher-income taxpayers with employer-provided pensions. Contributions to IRAs then fell considerably. 401(k) plans were made available in 1978 but did not become significant until clarification of their rules in 1981. The difference from an IRA is that a 401(k) is only available to employees of companies that choose to sponsor the plans. Contributions to a 401(k) are made through payroll deductions whereas IRA contributions are at the discretion of the employee. Further description of the programmes and the revisions are given in Poterba *et al.* (1996). The analytical importance of these schemes is that they have provided data for testing the responsiveness of savings.

63.   Venti and Wise (1990) model the consumer as having a choice between consumption, an IRA, and taxable, but liquid, savings. If the IRA and other savings are imperfect substitutes it follows that part of any increase in saving in the IRA must come from a reduction in current consumption. The data they employ comes from the Consumer Expenditure Survey. The first piece of evidence presented is the percent of families that have an IRA. This data is summarised in Table 3 and very clearly shows the increase in number over time. The observation is made that very few US families have any assets other than housing and that investment in other assets showed no comparable increase over the same period. These figures are interpreted as providing the first evidence that IRAs have increased saving.

Table 3: Percent of families with an IRA

1980	3.2
1981	3.1
1982	9.6
1983	15.7
1984	17.4
1985	20.0

64.   The model of saving used by Venti and Wise is a very simple one that is justified by a Cobb-Douglas utility function. The optimisation incorporates the rationing aspect of the limit on IRA contributions. The values predicted by the estimated model are quite close to the actual values, an observation that is presented as an informal demonstration of goodness-of-fit. They estimate that about 45 to 66% of the increase in IRA deposits following from the 1986 Tax Reform Act comes from current consumption, 30% from tax subsidies, and 3 to 20% is redirected from standard savings. The conclusion is that the vast majority of IRA saving is new and not diverted.

65.   At the opposite extreme of observations are Gale and Scholz (1994). They study the effect of IRAs by comparing the choices of savers at the IRA limit with those who are not at the limit. It is concluded that IRAs have a negative or a zero effect upon savings. The contributions to IRAs come entirely from saving that would have been undertaken in any case. But Poterba *et al.* (1996) observed that this conclusion was based on excluding households who reported having savings of over $100 000. When the exclusion was reduced to $90 000 or raised to $110 000 a new estimation revealed that the conclusion was entirely reversed and implied that funds placed in IRAs were entirely new saving.

66.   Can the effect on saving be large? It has been observed that 3/4 of contributors are the saving limit in each year. For these contributors the incentive does not affect marginal saving. So, the new effect must be small. This is the argument used by Burman *et al.* (1990) and Gravelle (1991). But it is the lifetime limit on saving that matters. Gale and Scholz (1994) demonstrate that only 30% contribute to the limit for three consecutive years. Hence 70% face a marginal incentive in at least one of the three years. Also, Feldstein and Feenberg (1983) argue that if saving moves from other sources to IRAs it would not take long for most households to exhaust their existing savings.

67.   The arguments of Feldstein (1995b) are important for assessing whether the tax cost of IRAs (and other saving incentives) are greater or smaller than the benefits. The paper does not address the size of the benefits directly but instead focuses on the observation that previous research has miscalculated the cost. It observes that previous papers looked at the direct effect of IRAs on saving (with the typical conclusion that some deposits are diversion and some an increase) and the direct revenue loss. It has then been concluded that aggregate saving falls since the increase in saving is smaller than the revenue loss, implying the incentive is unsuccessful. The new point that Feldstein makes is that the increase in private saving raises the corporate capital stock (through the investment = saving equilibrium condition) and therefore leads to an increase in tax revenue from the corporate sector. This offsets the loss of tax revenue from offering the IRA. Compounding this effect over time then shows that the IRA can lead to increased revenue. This argument becomes important when a cost-benefit calculation is undertaken of the provision of saving incentives. If increased saving raises above the level prior to the incentive then the cost is negative. The subsidy is immediately justified without the need for any further analysis.

68.   Hubbard and Skinner (1996) evaluate this evidence and a range of other studies. They offer the conclusion that none of the work provides a compelling answer. Instead, they suggest that the true effect lies somewhere between the two limits. The effects of 401 (k) plans are considered in the same light. Criticisms of existing work are given, and it is concluded that some 401(k) contributions represent new saving.

69.   In addition to this, Hubbard and Skinner (1996) also simulate the effect IRAs have on capital accumulation. This is done for a range of values for the proportion of IRA deposits that represent new saving. This simulation is reported in Table 4. The first line provides the baseline case and the second line incorporates the effect noted by Feldstein (1985): more saving means more investment by corporations and hence more corporate tax revenues. This effect offsets the revenue cost of the saving incentive. The conclusion to be drawn from the table is that the IRA schemes are worthwhile even when only a fraction of investment is new saving. The table also shows that the effect noted by Feldstein can be quite large.

Table 4: Change in net capital accumulation per dollar increase in government revenue lost on IRAs

	New private saving per dollar of revenue loss			
	0 Cents	10 Cents	19 Cents	26 Cents
Baseline	$0.22	$0.81	$1.51	$2.21
Including corporate tax revenue	$0.22	$0.97	$2.33	$4.84

70.   These arguments should be set against those made by Engen *et al.* (1996). They review the same literature and reach the conclusion that the increase in saving has been negligible. Faults are described in each of the empirical studies, such as biases in selection of the population, that are claimed to invalidate the results. In summary, it is concluded that decisions on the timing of economic transactions are responsive to taxation. Financial and accounting decisions - here interpreted as the choice of saving vehicle - are the next most responsive. Real decisions - the level of saving – are the least responsive choices. The tax incentives offered by IRAs and 401(k) plans therefore cause a reallocation of saving between types of asset but have little effect on the level of saving.

71.   Poterba *et al.* (1996) review their research into the effect of IRAs and 401(k)s on other savings. In Poterba *et al.* (1994, 1995) households are divided into groups according to their participation in savings programme. The data demonstrate that within each group there was no reduction in other asset holdings as saving in IRAs and 401(k)s increased. In contrast, the asset holding of households that did not participate in the programmes generally decreased over the same period. Poterba *et al.* also consider the difference in asset holdings of those eligible for 401(k)s and those not eligible. Before the introduction of the programmes the asset holding of the two groups are equal. After the introduction the asset holdings of the eligible group rise significantly relative to those of non-eligibles, with almost no change in non-401(k) assets. This again suggests a significant effect of the incentives. The results are summarised in Table 5. On the basis of the evidence Poterba *et al.* (1996) conclude that, although the methods may be imperfect, the incentives provided by IRAs and 401(k)s have clearly led to an increase in saving rather than simply the diversion of saving from other assets.

Table 5: Mean total financial asset balances

Income interval	Eligible	Non-eligible
< 10	2,033	1,378
10 – 20	4,045	1,997
20 – 30	5,499	2,558
30 – 40	8,693	3,256
40 – 50	14,470	6,206
50 – 75	26,093	10,080
> 75	51,080	29,842

72.   Auerbach (2002) studies the effect upon national saving of the tax cuts in the Economic Growth and Tax Relief Reconciliation Act of 2001. This act has a number of unusual features including the back-loading of the tax cuts and the "sunset" after 2010. These features particularly affect saving because of the long time horizon. The paper considers the effect on saving of the provisions for reducing marginal income tax rates, the reform of the Earned Income Tax Credit, and the increase in child tax credit. It does not analyze the phased repeal of the estate tax. This omission seems important since the treatment of estates is relevant for saving if there is a bequest motive.

73.   The paper conducts the analysis by using the Auerbach-Kotlikoff overlapping generations economy. This is simulated over the period 2001-2020, and 2150 is employed as representative of the steady state. The simulations vary in the length of time the tax cuts remain in place and in the tax instrument that is adjusted after repeal to reclaim revenue. The pattern of results is that savings initially fall, then rise, but fall again. In every simulation savings are lower in the long-run that at the initial point. They are also lower in the steady state. The point is made in the paper that the steady-state effect is larger than at first apparent. This is because capital accumulation is lower on the path to the steady state. Output is therefore also lower and, since savings are reduced as a proportion of output, the value of saving is much reduced over what it would have been without the Act.

74.   The work of Cunningham and Engelhardt (2002) uses data from the Health and Retirement Study to study the responsiveness of 401(k) saving to taxation and employer matching. The advantage of the data set is that it contains detailed information on each individual. In particular the data permit the calculation of individual contribution to 401(k) saving.

75.   Taxation is introduced into the analysis by assuming that the marginal dollar of saving is placed either in a 401(k) or in an IRA. The two forms of saving are viewed as imperfect substitutes so there is not complete switching from one to the other. Viewed from the present (time 0) a dollar invested in a 401(k) if there are T years to retirement is

$$V^{401} = (1 - \tau_T)(1 + m\xi_T)(1 + r)^T , \qquad (28)$$

where r is the interest rate, m is the employer matching rate, ξ_T is the fraction of the employer match that is vested in T periods, and τ_T is the tax rate at the time of withdrawal. For an IRA the value of a marginal dollar is

$$V^{IRA} = (1-\tau_T)(1-\gamma)(1+r)^T + (1-\tau_T)\gamma(1-\tau_0)(1+r)^T$$

$$+ \tau_T \gamma(1-\tau_0), \qquad (29)$$

where γ is the fraction of a pre-tax dollar contributed to an IRA that is not tax deductible. The relative tax benefit of a 401(k) compared to an IRA is then defined by

$$\frac{V^{401}}{V^{IRA}}. \qquad (30)$$

This variable is calculated for all the individuals in the data set and employed as one of the regressors. This construction shows that no simple tax effect can be calculated from the regression results. The tax rates entering the calculation of (30) are different between individuals according to their location in the income distribution. All that the econometrics predicts is the average effect of a change in the relative tax benefit.

76.   The econometric analysis finds that (30) has a positive coefficient but is not statistically significant in most of the regressions. For the preferred regression the parameter estimate implies that the limit on tax deductibility for IRA introduced in the Tax Reform Act of 1986 raised 401(k) saving by 6%.

77.   It should be noted how the techniques used to analyze these savings programmes differ from the econometric analysis of consumption. The standard tool used to understand consumption is the lifecycle model and its representation through the Euler equation (see Attanasio, 1999). This structural approach has not been applied in the savings debate reported. Instead, the papers have attempted to use tests that are independent of an underlying theory. This could be one of the explanations for the lack of a consensus on the size of the tax effect. Further discussion of this point can be found in Attanasio and Banks (2001).

78.   There is one further important point to be raised. The recent interest in behavioural economics has focused attention on the assumptions that are embedded in standard models of the savings decision. Experimental and empirical evidence has generated a range of "anomalies" where choices do not fit with the models predictions (see Thaler (1990)). Two of the most prominent areas for anomalies are choice under uncertainty and intertemporal choice. Both of these issues are central in the savings decisions.

79.   The standard model employs expected utility maximisation. There are numerous alternative theories of choice under uncertainty including those of Epstein and Zin (1989) and Kahneman and Tversky (1979, 1986). These theories suggest modified probabilities for weighting states, or alternative preference representations. The other key aspect of the standard model is exponential discounting. Numerous experiments provide evidence that individuals are more impatient in the short-run than suggested by exponential discounting, but are more patient in the long-run. This has led to the construction of alternative discounting schemes with hyperbolic discounting being the most prominent. The implications of hyperbolic discounting for choice have recently been explored (Laibson and Harris, 2000) but no compelling empirical implementation has been published yet. The impatience implied by hyperbolic discounting can be interpreted as a lack of self-control which pushes an individual into choosing immediate consumption and a postponement of saving. Such lack of self-control has been advanced as an explanation for the use of savings plans that involve a degree of commitment. A 401(k) plan ensures that savings are

tied until retirement and therefore involves commitment. The behavioural conclusion is that the commitment aspect, and not the tax effect, explains the popularity of the plans.

80.   Behavioural economics has opened many issues and it will be some time before a balanced assessment can be made. Research into anomalies may either prove to be a dead-end or it could lead to a new understanding of the reality of choices.

2.3 Labour Supply

81.   Labour supply is an important component in the production process. In models of economic growth it combines with human capital to determine the quantity of effective labour, and hence the level of output. Despite this, the analysis of labour supply in terms of the number of hours worked is of secondary importance for a discussion of growth. This is a consequence of the number of working hours and participation being bounded variables. Both have natural limits so cannot continue to rise to support sustained growth. For effective labour to continue to increase it is the human capital component that is critical.

82.   An impression of the value of the labour supply elasticity can be obtained by reviewing the results on Blundell *et al.* (1998). This paper uses data from the UK Family Expenditure Survey to estimate labour supply responses to the tax changes in the 1980s. The changes involved a steady reduction in the basic rate of tax (from 33% in 1978 to 25% in 1992), a reduction in the top rate of tax (from 83% in 1978 to 40% in 1992), an increase in the rate of contribution to National Insurance (from 6.5% in 1978 to 9% in 1992). The focus in on the labour supply of women since there is much more variation in female labour supply than in male labour supply. For reasons of social norms adult males are invariably in full-time employment with a labour supply elasticity approximately 0. In contrast, female labour supply can be more elastic with part-time employment possibilities and participation effects.

83.   The estimated elasticities are reported in Table 6. The wage elasticities (both non-compensated and compensated) are all positive. The elasticity is highest for women with young children. This group have the lowest average hours and it is here that participation effects and part-time working are most significant. These results confirm that labour supply of some groups of the population is sensitive to taxation.

<p align="center">Table 6: Female labour supply elasticities</p>

	Wage elasticity	Compensated wage elasticity	Other income elasticity	Mean hours
No children	0.140	0.140	0.000	32
Youngest child 0 – 2	0.205	0.301	-0.185	20
Youngest child 3 – 4	0.371	0.439	-0.173	18
Youngest child 5 – 10	0.132	0.173	-0.102	21
Youngest child 11+	0.130	0.160	-0.063	25

2.4 Entrepreneurial Activity

84.   Ever since the work of Schumpeter (1934) the role of entrepreneurial activity has been emphasised as one of the determinants of growth. New entrants to a market may use innovative techniques of production, introduce original products, or adopt different forms of organisation. If any of these changes are successful there will be spillovers to existing firms. These observations reveal the importance of the rate of entry of new entrepreneurs for growth through innovation.

85.   The role of tax policy can be understood by considering the choice of a potential entrepreneur. Assume two alternative choices are available: remaining in employment or founding a new business as an entrepreneur. The characteristic of employment is that the level of income can be treated as certain. Income as an entrepreneur is more likely to be risky, with an income level above that for employment if successful but an income less than that for employment if unsuccessful. Entrepreneurship is chosen if the expected utility of the risky income stream exceeds the utility of the sure income.

86.   Taxation of income affects this choice process in two ways. Firstly, a progressive income tax reduces the post-tax income for successful entrepreneurship relative to post-tax income for unsuccessful. This provides less incentive for a risk-averse individual to choose the entrepreneurship option. Secondly, if losses from entrepreneurship can be set against other income then the government takes a share in the risky project and the variance of income is reduced. This raises the incentive for a risk-averse individual to choose entrepreneurship. In addition, there is also the possibility that ownership of a small business may provide opportunities for under-reporting of income. This effect raises its attractiveness.

87.   These ideas can be easily formalised. Let employment provide income Y. Self-employment results in income $Y_s > Y$ if successful, and income $Y_f < Y$ if unsuccessful. Assume success occurs with probability p. The income tax system provides a lump-sum grant, g, and has a constant marginal rate, t. Self-employment is chosen if

$$pU\big(g + (1-t)Y_s\big) + (1-p)U\big(g + (1-t)Y_f\big) > U(Y). \qquad (31)$$

The two effects of taxation on this decision can be observed by noting that the expected level of post-tax income in self-employment is

$$E(Y) = g + (1-t)\big(pY_s + (1-p)Y_f\big), \qquad (32)$$

and the variance of post-tax income is

$$\mathrm{var}(Y) = p(1-p)(1-t)^2\big(Y_s - Y_f\big)^2. \qquad (33)$$

An increase in the tax rate reduces expected income but also reduces the variance of income. The effect on the choice between employment and self-employment then depends on the trade-off between risk and return in preferences. These ideas are developed further in Kanbur (1981) and Peck (1989).

88.   The empirical research of Gentry and Hubbard (2000) focuses on the role of progressive taxes in discouraging the risk-taking inherent in choosing entrepreneurship. Data from the Panel Study on Income Dynamics is used covering the period 1979-93. The investment of entrepreneurial capital is not recorded in the data set so self-employment is used as the indicator of status. A probit regression is used to model the probability of entry into self-employment. The key variable is a measure of tax progressivity. This variable is defined as the difference between the marginal rate of tax faced when successful as an entrepreneur with the tax rate faced when unsuccessful. Two cases are considered. The "less convex" case has successful

increasing income by 50% from the level in employment and unsuccessful reducing it by 25%. For the "more convex" case the changes are replaced by 100% and 50%, respectively. Given these income levels the marginal tax rates are predicted by the TAXSIM model (Feenberg and Coutts, 1993).

89.   The estimated probit model is reported in Table 7. Many of the variables have the expected sign. The important exception to this rule is the tax rate on employment. Theoretically, a higher tax rate in employment should make self-employment a more attractive option. However, the negative coefficient is not significant. The focus of the paper is the convexity variable. This has the expected negative sign and is very significant. This result shows that an increase in progressivity reduces the probability of choosing self-employment.

90.   The interpretation of the empirical results is that the choice of self-employment is sensitive to the progressivity of the tax system. The estimated coefficient shows that a 5 percentage point increase in the convexity measure reduces the probability of entry by 0.61 percentage points - which is a decline of approximately 20% in the number of self-employed given the average entry probability of 3.1%.

91.   An alternative approach to the same questions is pursued by Cullen and Gordon (2002). The data employed is a series of cross-section samples of income tax returns for 21 of the years between 1964 and 1993. The tax returns do not provide any method of distinguishing entrepreneurial income so an indirect method has to be used to identify the set of entrepreneurs. The method chosen is to focus on reported non-corporate losses and identify entrepreneurs by those with losses greater than 10% of wage and salary income. The regression analysis then estimates a model that explains the proportion of the sample that is identified as entrepreneurs.

92.   The results of the regression again show that the entrepreneurship choice is sensitive to taxation. A decrease in the personal income tax reduces the proportion choosing to become entrepreneurs because it lessens the effect of sharing losses with the government. The size of this effect is that a 5 percentage point reduction in the personal income tax reduces the proportion choosing entrepreneurship by 30%. The choice of entrepreneurship is also sensitive to the corporate tax rate. A 5 percentage point reduction in this, from 15% to 10%, is estimated to double entry into entrepreneurship.

93.   In a series of paper Carroll *et al.* (1998, 2000a, 2000b) have also investigated the tax returns of entrepreneurs to investigate the effect of the tax changes introduced by the 1986 Tax Reform Act. The tax returns considered are for individuals between the ages of 25 and 55 who reported being sole proprietors in 1985 (before the tax reform) and in 1988 (after the tax reform). The first paper (1998) analyses the investment decision. This is modelled using the basic equation

$$\text{Prob}(I_{88} > 0) = \alpha_0 + \alpha_1(\%\Delta c) + \alpha_2(\%\Delta c \times I_{85}) + \alpha_3 I_{85} + X\beta, \qquad (34)$$

Table 7: Self-employment and progressivity of taxation

Standard errors in parentheses

Variable	Less convex	More convex
Tax rate on employment	-0.000166 (0.000109)	-0.0000313 (0.000106)
Convexity in tax rate	-0.00121 (0.000129)	-0.00133 (0.0000931)
Head's labor earning	-3.01 (1.07)	-2.98 (0.998)
Head's labor earning squared	0.832 (0.363)	0.788 (0.333)
Dividend and interest income	0.914 (0.223)	0.668 (0.214)
Age	0.000962 (0.000618)	0.000712 (0.000606)
Age squared	-11.9 (7.88)	-8.98 (7.73)
Minority	-0.0137 (0.00172)	-0.0134 (0.00168)
Female head	-0.0188 (0.00172)	-0.0164 (0.00168)
Single (single = 1)	0.00779 (0.00244)	0.00906 (0.00242)
Number of kids	0.00199 (0.00073)	0.00309 (0.000720)
Homeowner	-0.00503 (0.00190)	-0.00596 (0.00187)
Rural	0.00106 (0.00167)	0.00101 (0.00163)
Less than high school	0.00507 (0.00254)	0.00546 (0.00252)
Some college	0.00975 (0.00255)	0.00913 (0.00248)
College	0.0124 (0.00315)	0.011 (0.003037)
Some post-college education	0.0166 (0.00497)	0.0142 (0.00467)
Pseudo-R^2	0.031	0.041

so that the probability of making a positive investment in 1988 is a function of the change in user cost of capital ($\%\Delta c = \ln(c_{88}) - \ln(c_{85})$), a dummy for positive investment in 1985, the interaction of the change in user cost and the dummy, plus a vector, X, of other personal and economic characteristics. The error is assumed to be normal to that the model becomes a probit. The results from conducting this estimation are reported in Table 8. The user cost variable, which incorporates the tax rate, has a negative and statistically significant coefficient both without and with the additional regressors. The size of the effect implied by these estimated values is that a 5 percentage point increase in the marginal tax rate of all the proprietors in the sample reduces the mean probability of investment falls from 0.335 to 0.300.

Table 8: Probability of investing

Intercept	-0.795 (0.0304)	-1.38 (0.607)
$\%\Delta c$	-1.26 (0.400)	-1.33 (0.419)
$\%\Delta c \times I_{85}$	-1.47 (0.584)	-1.41 (0.586)
I_{85}	0.822 (0.0472)	0.814 (0.0474)
Age		3.13 (3.07)
Age^2		-4.58 (3.76)
Capinc		0.0605 (0.163)
Married		0.0739 (0.0887)
Dependents		-0.354 (0.2032)
MFG		0.0754 (0.155)
Wholesale		0.159 (0.171)
Retail		-0.0641 (0.0979)
Finance		0.0245 (0.0956)
Service		0.137 (0.0650)

94.   The second paper (2000a) applies very similar methods to estimate the relationship between the personal income tax rate of the sole proprietors and the probability that they employ labour. A brief model is presented that assumes that monitoring must be undertaken when employees are taken on, and that proprietors differ in the cost monitoring places upon them. Assuming that the monitoring cost is normally distributed ensures the probability of employing at least one worker can be modelled as a probit. The estimation results show that the probability of offering employment in sensitive to taxation. A 10% increase in the entrepreneur's tax price (defined as one minus their marginal tax price) raises the mean probability of hiring by 10%.

95.   The subject of the third paper (2000b) is the growth rate of gross business receipts for the same set of sole proprietors. Once more the tax returns in 1985 and 1988 are used and the change in receipts measured between these two years. The (log) of the change in receipts is regressed up the (log) of tax price and the set of explanatory variables. The tax price variable has a positive and significant coefficient, showing that a lower marginal tax rate is correlated with increased business growth.

96.   The conclusion of this literature is that entry into self-employment - interpreted as engaging in entrepreneurial activity - is sensitive to taxation. The papers reviewed agree on the sensitivity but provide mixed evidence on how choices will change. This is not surprising since the tax system interacts with the self-employment choice in several different ways. In particular, progressivity reduces the relative benefit of successful outcomes whereas higher tax rates provide increased risk-sharing with the government.

2.5 Inequality

97.   There are several reasons why the rate of growth may be linked to the degree on inequality. Inequality can increase growth because the rich have a higher propensity to save. Redistributing to the rich therefore raises capital accumulation. Inequality may reduce growth because fiscal policy responds by introducing distortionary taxes to redistribute which retards growth. Capital market imperfections can prevent the poor from borrowing to invest in human capital or to engage in entrepreneurial activity. Inequality can lead to social insecurity and instability, providing an uncertain environment for investment. Inequality can also increase fertility which can reduce growth.

98.   A very extensive survey on the theory and empirical evidence relating economic growth to inequality is provided by Benabou (1996). His argument develops initially from the examples of South Korea and the Philippines. These countries were similar in many dimensions in the 1960s except that there was less inequality in South Korea. Since 1960 South Korea has grown much more rapidly than the Philippines and per capita output is now significantly higher. This example is taken as evidence of the general hypothesis that inequality reduces growth.

99.   The empirical evidence seems more concerned with whether there is convergence in income distributions between countries and whether spending on education is reducing inequality. It is concluded that the evidence on this point is mixed. The survey on the effect of inequality on growth is summarised in Table 9. This reports the sign and significance of the inequality variable in growth regressions.

Table 9: Summary of growth regressions using inequality as an explanatory variable

Author	Sign and Significance
Alesina and Rodrik, 1994	- ***
Benhabib and Spiegel, 1996	- *
Bourguignon, 1994	- ***
Brandolini and Rossie, 1995	0
Clarke, 1992	- ***
Deininger and Squire, 1995	- **
Keefer and Knack, 1995	- ***
Perottie, 1992	-***
Perottii, 1994	-***
Perotti, 1996	-***
Persson and Tabellini, 1992	-***
Persson and Tabellini, 1994	-***
Venieris and Gupta, 1986	-***

*** Consistent sign and generally significant[0pt]

** Consistent sign and sometimes significant[0pt]

* Consistent sign but generally not significant

100.   Further evidence on the link between inequality and growth is provided by Barro (2000). The technique in this paper is to take a standard growth regression and then include a Gini coefficient to capture the effect of inequality on growth rates. There is found to be little overall relation between growth and the Gini coefficient. In the basic regression equation coefficient on the Gini measure of inequality is estimated to be 0. But when the sample is split into poor countries and rich countries there is weak evidence the inequality reduces growth in the poor countries but raises it in the rich. The coefficient on the Gini for low-GDP countries is negative (-0.033) but insignificant. The coefficient on the Gini for high-GDP countries is positive (0.054) and significant. It is proposed that this is evidence on a nonlinear relation between inequality and growth.

101.   Odedokun and Round (2004) investigate the effect of inequality on growth for 35 African countries. Unfortunately, there is a lack of significance and very poor fit in the regression equations. But what is concluded is that there is some evidence that inequality hindered economic growth. Given the regression equations reported in the Table 10 this evidence can only be classed as weak. The explanatory power of the regressions is very low.

Table 10: Estimated effect of Income Inequality on Economic Growth

t statistics in parentheses

Constant	0.091 (1.4)	0.056 (0.9)
Log Per Capita Income	-0.003 (−0.5)	-0.003 (−0.4)
Population Growth	-10.711 (−2.0)	-10.708 (−2.0)
Govt. Consumption/GDP Ratio	-0.0001 (−0.1)	-0.0001 (−0.1)
Gini Coefficient	-0.042 (−0.9)	
Income Share of the Poorest 40%		0.108 (1.2)
Adjusted R^2	0.049	0.062

102.   The paper then proceeds to investigate the effect on inequality on various explanatory variables in growth regressions. It claims that there is strong evidence for credit market imperfections as a channel through which inequality can reduce growth because of the way that this limits human capital accumulation. This is achieved by regressing school enrolment rates on a range of variables including an inequality measure. Increased inequality is shown to reduce enrolment. The effect is significant at secondary and tertiary schooling levels and the regression equations have more explanatory power. There is also strong evidence for inequality increasing social instability. Finally some evidence for inequality increasing fertility. There is no evidence supporting the endogenous fiscal policy channel.

2.6 Summary

103.   This section has summarised the empirical literature on the sensitivity of individual choices to taxation. The educational choice is sensitive to cost but does not appear to be significantly affected by changes in return. The evidence on the relation between savings and tax incentives is contentious. The net effect may well be small. It is noteworthy that both the educational and the saving decisions involve intertemporal choices with uncertainty. The standard models are therefore open to all the criticisms that have been raised by behavioural economics. If the anomalies discovered in that literature properly characterise behaviour the explanation for the results are clear. This is an issue that is under considerable current investigation. The choice to become an entrepreneur is sensitive to taxation, as are the choices made when an entrepreneur. Whether it is the level of taxation or the progressiveness of taxation that matters most is still to be resolved.

3. Corporate Decisions

104.   The corporate sector (or the production sector more generally) controls many of the economic variables that determine the rate of growth. One key variable in both exogenous and endogenous growth models is the level of investment in physical capital and there has been a substantial literature analyzing the theory and empirics of investment. Innovation through the entry of new entrepreneurs has already been addressed in the second paper in the series. Another source of innovation is purposeful expenditure on research and development. There has been much recent empirical addressing the response of R&D to tax incentives. From a global perspective R&D expenditure is concentrated in a small number of large industrialised economies. This does not mean that smaller and developed economies do not benefit from R&D since there can be spillovers either through knowledge or through trade in products that embody R&D. The benefits of R&D can also be transferred across economies by foreign direct investment. This section reviews the empirical evidence on all of these activities.

105.   The structure of the corporate sector and the general business environment can also affect decisions that are relevant for growth. The role of entrepreneurship has already been identified. An extension of the same argument identifies the importance of small and medium enterprises in the economy. These firms are often viewed as being relatively more engaged in innovation. All firms need financial backing to support the development of ideas into products. The state of development of the financial sector determines whether funds are available at terms reflecting the true degree of risk. Finally, capital must be combined with labour for production to occur. The organisation of labour markets - meaning flexibility and competitiveness - are relevant in this respect.

3.1 Physical Capital

106.   The basis of investment theory is the simple observation that a firm will purchase new capital when the marginal benefit exceeds the marginal cost. Turning this observation into a convincing theory of investment has proved a difficult task. There are several reasons for the difficulties. First, investment involves durable goods so the benefits accrue over time. Both the benefits of the investment and the cost are uncertain at the point of investment. Second, investment involves an adjustment cost and a degree of irreversibility. These may not be observed by the analyst or known fully to the firm. Third, there is also uncertainty about future tax policy and the tax treatment of depreciation. Fourth, investment is dependent on the interaction of the corporation with financial markets. Finally, there are very general issues surrounding the objectives of the firm. An economic model may be built on the basis of profit maximisation or maximisation of market value. The managers of a firm may be pursuing different objectives. Nonetheless, models of investment do have some predictive power though they are by no means perfect.

3.1.1 Investment Theory

107.   This section will provide a very brief introduction to investment theory to illustrate how the investment decision can be affected by taxation. A full model of the investment decision requires much more detail since it must combine the interaction of the firm, its managers, and the firm's shareholders. A comprehensive theory also has to address the interaction of the corporate and personal tax systems.

108.   The most commonly used theory of investment is based on the concept of Tobin's q. Tobin (1969) argued that the investment decision should be based on the market value of investment relative to the replacement cost. If the market value exceeds the replacement cost then it would be rational for the firm to purchase additional capital. Conversely, if the market value were less than the replacement cost then the firm should reduce capital.

109.   Denoting market value by V and replacement cost by K the q theory of investment states that investment, I, satisfies

$$I = I(q)K, \qquad (35)$$

where $q = V / pK$, $I'(1) = 0$, $I'(q) > 0$ if $q > 1$ and $I'(q) < 0$ if $q < 1$. Here pK is the nominal value of the capital stock. The fact that the capital stock adjusts gradually can be explained by the existence of adjustment costs that are convex in the amount of investment. If there were no adjustment costs then instantaneous investment (or disinvestment) would ensure that q was continually equal to 1.

110.   The inclusion of taxation affects the decision of the firm. This can be motivated following the approach of Hayashi (1992) and Summers (1981). Let a fraction b of new investment be financed by debt. In the absence of tax the firm would invest if

$$\frac{V}{pK} + b - 1 > 0. \qquad (36)$$

Now add a tax credit for new investment (*ITC*) and tax savings for future tax-deductible depreciation allowances that have present value Z. Let B be the present value of tax savings on the existing capital stock. The firm will now invest if

$$\frac{V - B}{pK} + b - 1 + ITC + Z > 0. \qquad (37)$$

Let τ_d be the marginal tax rate on dividends and τ_c be the effective tax on capital gains. The firm has a choice between retaining earnings and investing or paying a dividend. Earning will be retained up to the point at which the last investment raises market value by $(1 - \tau_d)/(1 - \tau_c)$. Investment then occurs if

$$\frac{(V - B)(1 - \tau_c)}{pK(1 - \tau_d)} + b - 1 + ITC + Z > 0. \qquad (38)$$

Finally, the costs of investment are deducted from taxable earnings. Let the corporate tax rate be τ. The q theory including taxation is then described by the investment function

$$\frac{I}{K} = h(Q), \qquad (39)$$

$$h(0) = 0, \qquad (40)$$

$$h' > 0, \qquad (41)$$

where

$$Q = \frac{\dfrac{(V - B)(1 - \tau_c)}{pK(1 - \tau_d)} + b - 1 + ITC + Z}{1 - \tau}. \qquad (42)$$

111.   This model predicts that investment will not be caused by changes in τ. An increase in τ raises the rate of investment (or disinvestment) but does not affect the sign. All the other taxes and credits can affect the sign of investment. For example if $V > B$ then an increase in the tax on capital gains may turn investment into disinvestment. An increase in the tax on dividends has the opposite effect. Investment tax credits have the expected effecting of encouraging investment.

3.1.2 Empirical Results

112.   One of the earliest serious pieces of empirical research on investment was undertaken by Hall and Jorgenson (1967). The paper estimated the effect of three revisions in the tax treatment of investment in the United States. The paper concluded that the effects are "dramatic" with investment being highly sensitive to taxation. The major limitation of the model was that it assumes an arbitrary distributed lag formulation for investment. This assumption was motivated by a partial adjustment story for investment but otherwise has no explicit justification in the model. Later papers have questioned the conclusion of this paper on the basis of much more sophisticated (and internally consistent) modeling strategies.

113.   Summers (1981) estimates the investment equation implied by the q theory described above. The data used are for non-financial corporate investment in the United States over the period 1931 - 1978. Regressions are run for the simplest q model and for a model with a tax-adjusted q. The paper finds that the tax-adjusted q formulation has more explanatory power. This suggests that the tax effects are important.

114.   The results show that an increase of 5 percentage points in the investment tax credit would raise total investment by about 3%. Simulations of the model are then conducted for a parameterised version. A reduction in the corporate tax rate from 46% to 40% raised the steady-state level of investment by 9%. Eliminating the capital gains tax raised steady-state investment by 18%. Two significant comments have been made about this analysis. First, the value of q is potentially endogenous in the regressions. Second, the firm is irrational in its financial structure given the treatment of personal and corporate taxes. This irrationality was a standard criticism of investment models and is difficult to reconcile with the optimisation of investment. Since the publication of this research the behaviour of firms in financial decisions has changed (notably the importance of share buy-backs - see Brealey *et al.* 2005).

115.   Chirinko (1993) observes that the performance of q theory has generally been unsatisfactory in empirical research. By unsatisfactory is meant a very low R^2 and serially-correlated residuals. The structure of the residuals has been explained by ad hoc dynamic adjustment arguments but such adjustment does not fit with the optimising framework from which the q theory is derived. In addition, a variable representing cash flow is significant in many regressions. The importance of cash flow suggests liquidity constraints in financing investment but these are not incorporated with the model. A further important criticism is that the adjustment costs implied by the estimated coefficients are unreasonably large.

116.   It is noted that the use q theory requires two steps to be undertaken to determine the effect of a tax change. The first step is to find the effect of the tax change on q. Next, the effect of q on investment is found by using the estimated investment equation. It is claimed that the first step is difficult to perform satisfactorily since it requires determination of how tax parameters feed back into asset prices and the value of q. This argument is used to claim that the significant reaction of investment to taxation in the Summers' analysis is due to the specification of the tax code and the generation of large tax increases. In fact, a dollar of tax loss will in the model of Summers (1981) led to a cumulative change of the capital stock over five years of $0.18 to $0.37 for a relatively low value of the adjustment cost - which is a relatively small response. Other models of investment (besides the q theory) are also noted to provide limited tax responses.

117.   The Tax Reform Act of 1986 has provided the basis of many studies of tax responses. Auerbach and Hassett (1991) looked at the effect of the removal of a 10% investment tax credit to investment in machinery. This change should have reduced machinery investment relative to investment in structures, but in fact machinery investment increased after reform. This observation is contrasted to that of their earlier work (Auerbach and Hassett, 1990) which concluded there was no tax effect. The 1991 paper instead reports that the growth in machinery investment was a long-term trend starting before the tax reform. In fact, the tax reform seems to have resulted in less growth than there would otherwise have been. This conclusion is obtained from using a cross-section study which has some additional variation in how the tax changes were implemented across industries (36 categories of equipment and structures for 7 industry groupings).

118.   The estimation procedure is based on a two-stage process. First, the data for 1953-85 are used to estimate a reduced form model for investment demand that does not include any variables measuring the impact of taxes. At the second-stage the out-of-sample post-tax-reform residuals are related to residuals in the tax rate variables in the post-tax-reform period 1987-89. The structural model over-predicted investment in both equipment and structures for the post-reform period. The second stage involves the calculation of a tax wedge variable which is then used as a regressor to explain the out-of-sample forecast error. Results for this second-stage regression for investment in equipment are reported in Table 11. The coefficient on the user cost (which captures the surprise tax change caused by the reform) is negative and significant. When average tax paid is also included (on the basis that the average tax payment affects cash flow and potentially investment) the coefficient is insignificant and does not have the theoretically predicted sign. The paper concludes that investment is sensitive to taxation.

Table 11: Investment after reform

Period	1987	1987
Constant	-0.00 (-0.02)	-0.01 (-0.46)
User cost	-0.99 (-5.62)	-0.85 (-4.27)
Taxes paid		5.17 (1.27)
$\overline{R}^2$	0.59	0.61

119.   The consequences of the Tax Reform Act of 1986 are also studied by Cummins and Hassett (1992). The paper first notes that earlier literature had not found a large effect of taxation. A number of reasons are provided for why this conclusion has been reached. These reasons focus on the consequences of using aggregate data to estimate investment equations. Aggregate data hides any change in the composition of investment and the use of instruments for tax changes leads to weak estimation. These observations are used to motivate use of the natural experiment approach.

120.   Auerbach and Hassett (1991) use industry and asset level data. In contrast, Cummins and Hassett use more disaggregated firm-level data. The estimation model is based on the usual q theory of investment. The results generate an elasticity of investment with respect to Q of about -1.1 for equipment and about -1.2 for structures. Also, a lower estimate than many previous papers is obtained for the size of adjustment

costs which are about 25% of the cost of new equipment. The paper also finds that the cash-flow variable is significant but has a lower coefficient than in previous work.

121.   Cummins *et al.* (1994) apply the natural experiment methods to tax reforms in the United States from 1962 to 1988. The paper used firm-level panel data to exploit cross-sectional variation and to ensure that tax reforms are exogenous (taxation of investment may not be exogenous at the aggregate level). There were 13 reforms during 1962-88. There were changes (both up and down) in the average rate of taxation and changes in taxation on different types of asset. A tax component that is one minus the present value of tax savings from depreciation allowances and other investment incentives is constructed for 22 classes of equipment and 14 types of structure as classified by the Bureau of Economic Analysis. The plot of these for types/years revealed the variation to be large.

122.   The initial model is given by

$$\frac{I_{i,t}}{K_{i,t-1}} = E_{i,t-1}\big(S_{i,t}\gamma\big) + \varepsilon_{i,t}\,, \tag{43}$$

where $S_{i,t}$ is an underlying structural variable and γ is a coefficient related to convex adjustment costs. It is assumed major changes in S are infrequent and hard to predict. This motivated the use of the experimental approach to find the effect of changes in S. The estimation technique is based on the assumption that S is known immediately following a tax reform. This allows that expectation to be dropped so

$$\frac{I_{i,t}}{K_{i,t-1}} = S_{i,t}\gamma + \varepsilon_{i,t}\,. \tag{44}$$

Given this the deviation of the observed $I_{i,t}/K_{i,t-1}$ from the value that is predictable at $t-1$, $P_{i,t-1}\big(I_{i,t}/K_{i,t-1}\big)$, depends on the surprise change in S

$$\frac{I_{i,t-1}}{K_{i,t-1}} - P_{i,t-1}\!\left(\frac{I_{i,t}}{K_{i,t-1}}\right) = \big(S_{i,t} - P_{i,t-1}\big(S_{i,t}\big)\big)\gamma + \varepsilon_{i,t}\,. \tag{45}$$

The estimation procedure is to construct estimates of $I_{i,t-1}/K_{i,t-1} - P_{i,t-1}\big(I_{i,t-1}/K_{i,t-1}\big)$ and $S_{i,t} - P_{i,t-1}\big(S_{i,t}\big)$ then to pool a cross-section of these to estimate γ.

123.   The estimated effect of neoclassical fundamentals on investment were more statistically significant and economically significant than found in earlier work. The estimates implied reasonable adjustment costs. For each major tax reform in United States since 1962 the cross-section pattern of investment changed significantly. A selection of the results is given in Table 12. Years marked with an *f* follow a major tax reform. Years marked with an *o* are other tax reform years. The nature of the estimation method implies that the coefficient on *Q* should be most precisely estimated when there was a reform. This is confirmed to be the case by the t statistics reported in the table. Further results showed that a cash flow variable was also significant but its inclusion did not have a major impact on the coefficient of tax-adjusted *q*. The coefficient on *Q* is larger than in previous work and translates into a much higher sensitivity of investment to tax incentive.

Table 12: Investment equations

Year	Number of firms	$\overline{R}^2$	Intercept	Q
1963*f*	251	0.056	− 0.028 (2.74)	0.874 (3.86)
1964	362	0.000	0.044 (3.13)	0.011 (0.063)
1965*o*	457	0.033	− 0.020 (1.27)	0.742 (3.95)
1966	606	0.001	0.031 (3.38)	0.109 (0.73)
1967	636	0.000	0.030 (2.83)	0.002 (0.023)
1968*o*	666	0.018	0.026 (1.11)	0.554 (3.46)
1969*o*	682	0.028	0.028 (1.12)	0.607 (4.44)
1970*o*	722	0.049	− 0.030 (4.14)	0.533 (6.10)
1971*o*	707	0.046	− 0.085 (9.09)	0.494 (5.81)
1972*o*	735	0.037	− 0.056 (8.84)	0.446 (5.29)
1973*f*	828	0.029	− 0.046 (6.64)	0.470 (4.97)
1974	874	0.000	− 0.025 (3.46)	0.054 (0.50)
1975	959	0.002	− 0.068 (10.87)	− 0.119 (1.28)
1976*o*	1007	0.037	− 0.003 (0.61)	0.515 (6.23)
1977	1046	0.001	0.055 (9.96)	0.074 (0.79)
1978	1063	0.001	0.065 (10.22)	0.080 (0.812)
1979	1077	0.002	0.026 (3.37)	0.138 (1.41)
1980*o*	1081	0.024	− 0.003 (0.51)	0.491 (5.15)

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1981	1103	0.001	-0.022 (3.77)	0.088 (0.83)
1982*f*	1114	0.030	-0.026 (5.07)	0.599 (5.84)
1983*o*	1130	0.023	-0.004 (0.74)	0.609 (5.85)
1984	1136	0.000	0.028 (3.43)	-0.020 (0.20)
1985	1160	0.001	0.032 (4.15)	0.085 (0.83)
1986	1188	0.001	0.021 (2.50)	0.105 (1.14)
1987*f*	1250	0.034	-0.026 (3.18)	0.613 (6.66)
1988	1294	0.001	-0.030 (1.15)	0.127 (1.32)

124.   Cummins *et al.* (1996) build upon the work of Cummins *et al.* (1994) to analyze investment demand for countries in addition to the United States. The paper finds that fundamentals are important and are relatively similar across countries. More importantly, the results show that investment does respond to tax changes. The data employed related to tax reforms in 14 countries and the investment decisions of over 3 000 firms. Firm-level data was used rather than aggregate time- series data. Aggregate time-series data are seen as having three problems. First, policy is not exogenous (incentives are introduced when investment is low). Second, frequent changes in corporate taxation make it difficult to judge a firm's expected tax treatment. Third, noisy stock market value makes it hard to isolate the effects of tax changes.

125.   The paper first presents estimates of the *q* theory by using standard techniques. The model estimated is based on the equation

$$\frac{I}{K} = \mu + \gamma Q + \varepsilon ,$$ (46)

which is a standard linearisation of the *q* theory. This equation is estimated for Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States. These estimates provide reasonable values for the coefficient on *Q* that are similar across countries but the adjustment costs are about 70% of a unit of investment expenditure.

126.   The natural experiment method is applied by choosing one reform for each country that seems to represent the best experiment. The model is estimated only for that year. By best is meant a large change in the tax code and the avoidance of years in which it was known tax reviews were taking place. The estimated coefficients on Q are higher than standard estimate (see Table 13) and imply an adjustment cost of 5-10% of investment expenditure. The cash flow variable is included in the regression reported. This should not matter according to neoclassical theory but previous work has found that it does. Here it is significant for some of the countries. Note how the explanatory power of the regression equation is still fairly low.

Table 13: Natural experiment estimates of *q* theory

Standard errors in parentheses

	Intercept	Q	$\dfrac{CF}{K}$	$\overline{R}^2$
Australia	-0.130	0.647 (0.238)	0.083 (0.109)	0.063
Belgium	0.054	1.613 (0.593)	0.006 (0.109)	0.194
Canada	-0.044	0.803 (0.210)	0.230 (0.064)	0.123
Denmark	-0.210	0.865 (0.469)	0.003 (0.127)	0.026
France	-0.010	0.650 (0.292)	0.104 (0.068)	0.073
Germany	0.006	0.879 (0.249)	0.078 (0.077)	0.082
Italy	0.104	0.644 (0.241)	0.061 (0.116)	0.057
Japan	-0.026	0.819 (0.198)	0.354 (0.042)	0.222
Netherlands	0.049	0.296 (0.344)	0.299 (0.187)	0.043
Norway	-0.812	1.376 (0.487)	0.706 (0.289)	0.284
Spain	-0.014	0.888 (1.397)	0.461 (0.273)	0.059
Sweden	-0.226	0.644 (0.243)	-0.050 (0.163)	0.078
United Kingdom	-0.126	0.490 (0.186)	0.278 (0.035)	0.145
United States	-0.022	0.528 (0.085)	0.108 (0.014)	0.063

127.   Hubbard (1998) addresses the reason for the significance of the cash flow variable. Many papers on investment, including those reviewed above, have found that cash flow is an important explanatory variable in the regressions. If the neoclassical theory is correct then cash flow should not appear. The main point of this paper is to explain how credit market imperfections can lead to limits on borrowing and therefore make retained earnings the first source of investment funding. This effect causes cash flow to be relevant for the investment decision. Taxation can interact with this effect through the different consequences that alternative tax schemes have for the flow of retained earnings. This means that the

response to tax policy may be different between firms that are constrained by capital market imperfections and those that are not constrained.

128.   The observed data used in empirical estimation is the value of investment undertaken. The value is the product of the quantity and the price. Goolsbee (1998) looks more closely at the composition of the increases in investment generated by tax incentives. If a tax incentive raises investment it will cause price of investment to rise unless the supply curve is horizontal. The paper runs regressions for tractors, and then for a set of industries. The tractor regression shows that a 10% investment tax credit raises the prices of investment goods by more than 6.5%. Therefore, much of the increase in investment is absorbed in an increase in price rather than an increase in quantity. The general regression shows that 13 out of 22 sectors have a positive and significant coefficient on the ITC term, showing that an increase in the credit raises the price of investment goods. The major increases are in fabricated metals, heavy machinery, and large transportation equipment. The four where the effect goes in the wrong direction are computers, communications equipment, cars, and instruments - industries with significant technological advance where computation of meaningful price indices may be difficult.

3.2 Research and Development

129.   Innovation is one of the major components of economic growth. The modelling of innovation assumes that educated personnel are combined with capital equipment to undertake research effort. The outcome of the research is random, with successful innovations arising with a probability that is an increasing function of personnel and equipment. An innovation raises *TFP* either by adding a new product or by replacing an existing product with one of higher quality.

130.   This brief description reveals two aspects. First, there is the level of expenditure upon R&D inputs. This is the statistic that is measured in the data. It has been extensively analysed to determine its sensitivity to tax incentives. Second, there is the R&D output of new innovations. In the modelling of innovation there is a causal relation from expenditure to innovation output, but the two are not the same. The effect upon growth of R&D depends primarily on the output. The effect of tax policy on the output of R&D has not been investigated.

131.   The Economic Recovery Tax Act of 1981 included a tax credit for R&D expenditures. The Act provided a stimulus to R&D through a 25% credit that was obtained on R&D expenditure above that in a base year. The introduction of this credit has provided good data for testing the sensitivity of R&D to incentives.

132.   Berger (1993) analyzed two effects of the 1981 Act: how much expenditure increased, and how much of the increase was absorbed by an increased prices for R&D input (called an implicit tax). The study is based on data for 263 firms from Compustat that were clustered in manufacturing. A fixed effects estimator with a different intercept for each firm was used. Each firm's original data point was replaced with the deviation from the firm's times-series sample mean. Then OLS was applied to the data on deviations from mean for a pooled regression on a number of variables. The paper concludes that $1.74 of additional spending took place for every dollar of tax credit, indicating significant sensitivity of R&D to incentives. The implicit tax (the increase in the price of inputs) is estimated to be no more that 27.2%, so there is a significant increase in the quantity of R&D.

133.   The argument that part of any increase in R&D is absorbed into increased prices of R&D inputs is developed further in Goolsbee (1998). It is observed that federal spending in the United States on R&D is significant. Total expenditure on R&D is about 2 to 3% of GDP, and the federal share of this expenditure is between one third and two thirds. The paper observes that empirical research on R&D tends to focus on these values and discusses how federal programmes may raise or lower spending without looking more

closely at the breakdown of expenditures. The simple point is made that the supply of scientists is inelastic (training takes considerable time so adjustment is slow). An increase in R&D expenditure will increase the demand for scientists and therefore push up wages. As a consequence, any increase in R&D spending is partly absorbed into wages. This implies research that analyzes only the total level of spending on R&D will overstate the incentive effect. An empirical analysis is undertaken to show that this effect is significant. The 11% increase in R&D spending following the 1981 Act is claimed to have raised wages by 3.3%, so giving a net increase in R&D of just 7.6%. This result is given as evidence that measuring only expenditure overstates the effects of incentives.

134.   Hall and Van Reenen (2000) summarise the results of several empirical studies. The first set of results in Table 14 provides estimates of the effect of the Research and Experimentation (R&E) credit introduced in the Tax Reform Act of 1981. The table reveals that early studies found a low elasticity (around 0.6) but later studies found an elasticity of around 1. The difference in the results is explained by a process of learning by firms and the development of credibility for the incentive. This could also reflect set-up costs for R&D which makes it less responsive over the short-term.

Table 14: Estimated R&D elasticity for US firms

Author	Eisner *et al*. (1983)	Berger (1993)	Hall (1993)	Hines (1993)
Period of credit	1981 - 1982	1981 - 1988	1981 - 1991	1985 - 1989
Control period	1980	1974 - 1980	1980	Not relevant
Data	600 firms	263 firms	800 firms	116 firms
Estimated elasticity	Insignificant	1.0 – 1.5	1.0 – 1.5	1.2 – 1.6

135.   The responsive of R&D to incentives has also been analyzed for countries other than the US. The results of some of these studies are provided in Table 15 for a range of countries. Hall and van Reenen claim that the Australian study employs the most convincing methodology, and that this also finds an elasticity of approximately 1.

Table 15: Estimated R&D elasticity in non-US studies

Country	Canada	Sweden	Australia	France
Author	McFetridge and Warda (1983)	Mansfield (1986)	Australian Bureau of Industry (1993)	Asmussen and Berriot (1993)
Period of credit	1962 - 1982	1981 - 1983	1984 - 1994	1985 - 1989
Data	Aggregate	40 firms	> 1000 firms	339 firms
Estimated elasticity	0.6	Small	1.0	0.26

136.   The conclusions offered by Hall and van Reenen are that there is substantial evidence tax incentives have a significant effect on level of R&D performed and that the most compelling evidence is obtained from employing the natural experiment approach. It is concluded that the evidence reveals an elasticity of approximately 1, but there may be considerable worldwide variation around this value.

137.   The work of Hall *et al.* (2002) extends the analysis of how fiscal incentives affect R&D expenditures. They study data for nine OECD countries over a 17 year period. The paper treats changes of policy within countries, and differences of policy between countries, as natural experiments. The estimation method controls for a range of influences and country characteristics. The final conclusion is that a 10% fall in R&D cost leads to a 1% rise in R&D in the short run and a 10% rise in the long run. This implies a long-run elasticity of approximately 1. The consequences of the US tax credit are also considered by Billings *et al.* (2001). Their regression results support the finding of Hall *et al.* that there is a reasonably significant effect of the credit, with an elasticity between 1 and 2 for spending.

138.   Bloom, Griffith and van Reenen (2002) examine the effect of fiscal incentives on R&D using a dataset for nine OECD countries over the time period 1979-1997. The paper confirms the standard result that the long-run effect is large but the short-run effect is small. In particular, a 10% fall in the cost of R&D is estimated to cause a 1% rise in R&D spending in the short run but a much larger 10% rise in the long run. These are the same values as identified by Hall *et al.*

139.   The study of the nine countries is motivated by claiming it is harder to disentangle the effect of the tax incentive from other macroeconomics changes if a single country (typically, the United States) is studied. A cross-section of countries provides more variation that can be used to provide a stronger estimate of the incentive effect. Changes in the rules concerning R&D and taxation are used to identify the tax-price changes in a natural experiments framework. A simple model is constructed that produces a user cost for R&D capital. This user cost is calculated by using details of the tax systems for each of the countries and is then employed in the regressions. The estimated equation is

$$r_t = \lambda r_{t-1} + \beta y_t - \gamma p_t + \varepsilon , \qquad (47)$$

where r = log of industry funded research, y = log of output and ρ = their estimated user cost of capital. In the preferred specification of the regression equation the estimated coefficients are as summarised in Table 16. The value of γ is the short-run elasticity. The value of $\gamma/(1-\lambda)$ is the long-run elasticity. It can

be seen that the short-run and long-run elasticities are different, with the long-run elasticity being much larger in value. This is consistent with the findings of previous studies.

Table 16: Estimation of R&D equation

λ	β	γ	$\dfrac{\gamma}{1-\lambda}$
0.868 (0.043)	0.1439 (0.163)	-0.144 (0.054)	-1.088

140.   The theory of endogenous growth places great emphasis on the role of research and development. It is therefore reassuring that the empirical work has produced estimates of the sensitivity of R&D to tax incentives that is consistent across studies and across countries. In the short run R&D has a fairly low elasticity but in the long run the elasticity is approximately 1. Hence, in the long run, a change in tax incentive is matched by approximately the same change in R&D. But it remains important to recall the earlier comments that these papers refer to the value of R&D spending. This is not the same as success in R&D (nor, if the cost of inputs increases, is it the same as the real increase in R&D effort). If firms are rational in their choice of R&D projects then those with the highest expected return will be undertaken first. The introduction of a tax incentive will see only marginal projects undertaken. Hence, the additional projects will have a lower expected return than average, and a change in expenditure will overstate the success effect. For these reasons, the estimated elasticity most likely over-estimates the true effect of the incentives upon *TFP*.

141.   The theoretical models represent R& D in the very favourable context of a race with the probability of winning raised by the amount of expenditure. The winner, by definition, then has an innovation of a higher quality than anyone else's innovation. In an international context this gives all countries a chance of succeeding with R&D. In practice R&D a small number of countries are responsible for the vast majority of R&D expenditures. If there are returns to scale in R&D, or if the new increment of innovation is dependent upon the base from which a country begins, then the benefits from incentives to R&D will only be significant in those countries already domination R&D.

142.   What these observations suggest is that further work is required to clarify the link between R&D expenditure and R&D success. Success may be measured by the number of patents granted, or even the link between patents and financial results. What would be interesting is investigate the explanatory factors in a regression of patents on R&D. Is there a scale effect, or an effect feeding in through previous position? This form of knowledge would provide a more suitable targeting of tax incentives.

3.3 Imported R&D

143.   In an integrated world economy every country can benefit from R&D wherever it is undertaken. The benefits can arise directly through learning about new techniques and methods. They can also be obtained indirectly from the importation of imported producer goods that embody new technologies. Increases in international trade assist the diffusion of innovation around the world by the indirect method. A small literature exists that has quantified these effects.

144.   Coe and Helpman (1995) consider the relationship between *TFP* and R&D stocks for 21 OECD countries plus Israel over the period 1971-90. The estimation process is built upon the basic regression equation

$$\ln TFP = \alpha_0 + \alpha_1 \ln S^d + \alpha_2 m \ln S^f , \qquad\qquad (48)$$

where S^d is the domestic stock of R&D and S^f is the foreign stock. The variable m is the share of imports in GDP. This is included in the regression to reflect the argument that innovation can be imported in manufactured producer goods. The R&D stocks were constructed from expenditure data using the perpetual inventory model.

145.   Three variants of this regression equation are estimated. In the first column of Table 17 m is set equal to one for all countries so no account is taken of import shares. In the second column S^d is interacted with a dummy for G7 membership to allow a different effect for the seven largest countries. In the third column the interaction term is retained and m is permitted to vary across countries. For all three specifications the elasticity of *TFP* with respect to foreign R&D is positive and large (the paper reports no standard errors for the individual parameters so significance cannot be assessed).

Table 17: *TFP* and foreign R&D

$\ln S^d$	0.097	0.089	0.078
$G7 * \ln S^d$		0.134	0.156
$\ln S^f$	0.092	0.060	
$m \ln S^f$			0.294
R^2	0.534	0.600	0.630

146.   The values reported in the third column are then applied to the individual countries to construct country-specific elasticities. These elasticities are reported in Table 18. The elasticity of *TFP* with respect to R&D is restricted to be identical across the G7 countries, and identical across the other 15 countries. The general picture is that of an increase over time of the elasticity of foreign R&D. This is consistent with the view of increased international integration and the process of globalisation. The variation in the elasticities can also provide an explanation for differences among countries of *TFP* growth.

Table 18: Country-specific elasticities

	World R&D	Foreign R&D			Domestic R&D
	1990	**1971**	**1980**	**1990**	**1971-90**
United States	0.267	0.016	0.030	0.033	
Japan	0.261	0.028	0.037	0.027	
West Germany	0.311	0.056	0.072	0.077	
France	0.301	0.045	0.061	0.067	0.234
Italy	0.292	0.046	0.067	0.058	
United Kingdom	0.315	0.063	0.081	0.081	
Canada	0.309	0.059	0.078	0.075	
Australia	0.132	0.043	0.049	0.055	
Austria	0.192	0.091	0.106	0.114	
Belgium	0.337	0.129	0.181	0.260	
Denmark	0.169	0.091	0.094	0.092	
Finland	0.152	0.079	0.088	0.075	
Greece	0.172	0.050	0.063	0.094	
Ireland	0.243	0.124	0.180	0.165	
Israel	0.231	0.147	0.154	0.153	0.078
Netherlands	0.236	0.133	0.146	0.158	
New Zealand	0.144	0.075	0.086	0.066	
Norway	0.188	0.133	0.124	0.111	
Portugal	0.210	0.099	0.117	0.132	
Spain	0.141	0.043	0.043	0.063	
Sweden	0.171	0.067	0.087	0.093	
Switzerland	0.190	0.115	0.106	0.113	

147.   This analysis is extended by Coe *et al.* (1997) into a detailed analysis of the extent to which the R&D of 22 industrialised countries spills over into 77 developing countries. The paper observes that the industrialised countries accounted for 96% of world R&D in 1990, and 92% of R&D within the OECD was accounted for by the seven largest economies. Three changes are made to the earlier specification to model spillovers into developing economies: a human capital variable is included (secondary school enrolment), the import measure is restricted to machinery and equipment, and only foreign R&D is included. The preferred specification estimates an elasticity of *TFP* with respect to foreign capital stock of 0.058 and an elasticity with respect to imports of 0.279. These values are taken as evidence of significant spillovers.

148.   These estimates of international R&D spillovers are employed in a simulation analysis by Bayoumi *et al.* (1999). The purpose of the simulation is to determine the size and implication of the spillovers. The model used is a version of MULTIMOD (see Masson *et al.*, 1990) that includes 12 countries representing the G7, smaller industrialised countries, and developing countries. Following the comments of Lichtenberg and van Pottelsberghe de la Potterie (1998) the regression equations are augmented by the inclusion of the import share of GDP as a separate variable. The coefficient on this variable is negative (so a higher import ratio lowers *TFP*) but its inclusion raises the estimated elasticity for foreign R&D stock.

149.   With this modification the equation linking *TFP* to R&D for the G7 is

$$\ln TFP = \alpha_1 + 0.24 \ln S^d + 0.26 m \ln S^f - 3.18 m, \tag{49}$$

where α_1 is a country-specific constant. The smaller industrialised countries are modelled as having a lower elasticity with respect to own R&D

$$\ln TFP = \alpha_2 + 0.08 \ln S^d + 0.26 m \ln S^f - 3.18 m. \tag{50}$$

The developing countries are modelled as undertaking no R&D so *TFP* in these countries only advances through the foreign component%

$$\ln TFP = \alpha_3 + 0.43 m \ln S^f - 5.09 m. \tag{51}$$

150.   The results of three policy experiments can be briefly described as follows. First, if the United States increased its R&D investment by 0.5% of GDP and then maintained the new ratio of R&D to GDP its output would rise by over 9% after 80 years, the output of other industrialised countries would rise by almost 3%, and the output of the developing countries by 3.5% (note that these are level effects, not growth effects). Second, if all industrialised countries made an R&D increase of 0.5% of GDP then their output would rise by 17% (after 80 years) and that of the developing countries by over 10%. Third, if the developing countries became more open and expanded trade by 5% of GDP their output would rise by 6.5% after 80 years. These results reveal the size of the effects to be significant but, being based on simulation, are only indicative of the possibilities.

3.4 Foreign Direct Investment

151.   Foreign direct investment (FDI) includes acquisition of foreign firms and investment in new plants overseas. It is clear how the latter can transfer technological innovation between countries: if the new plant is more productive than existing plants, *TFP* must rise. The route by which acquisitions can raise *TFP* is more indirect. *TFP* can rise if the new ownership introduces improved methods of working and

innovations in management systems. The recent experience of China provides clear evidence of how foreign direct investment can raise the productivity of the host country and stimulate the growth process.

152.   The question that has been addressed in the empirical literature on FDI is what factors determine the location decisions of firms. Particular emphasis has been given to the role of taxation. Economic theory suggests taxation should be important since the location decision should involve the comparison of post-tax profits between alternative locations. Taxation is also important from a policy perspective since tax incentives are one of the main strategic variables through which countries compete to attract FDI.

153.   A simple introduction to international taxation from the perspective of the United States, and a description of how the system of foreign tax credits works, is provided by Hines (1999). The paper also surveys the empirical evidence of the extent to which taxation affects foreign direct investment. The paper also raises the issue of international tax avoidance and how this can be successful in an international context. The conclusions essentially argue that tax competition (in the sense of setting a tax policy from a strategic point of view) is a successful way for countries to behave.

154.   The main point of the paper is to argue that for FDI into the United States, and for US FDI abroad, the evidence suggests there is a significant negative elasticity of -0.6. If correct, this value of the elasticity demonstrates that taxation reduces FDI (or reductions in taxation can raise FDI). The first evidence reviewed is the aggregate time series studies of Hartman (1984), Boskin and Gale (1987), and Young (1988) where the q theory of investment motivates the use of after-tax rates of return as the key variable. It is further noted that when the level of FDI is separated into that financed by retained earnings of foreign affiliates and that financed by transfers of funds from parent companies, the former is more elastic with respect to taxation. It is observed that these aggregate studies suffer from a number of potential problems of interpretation concerning the reason for the observed correlation (for instance, if affiliates re-invest all earning these count as FDI, so FDI appears correlated with the after-tax rate of return).

155.   Slemrod (1990) uses time-series data and exploits cross-sectional differences to improve the estimates. The cross-section aspect is obtained by distinguishing FDI into the United States by the country from which it originated. This gives two types of country. Japan and the United Kingdom operate a system of international taxation that gives tax credits for foreign tax paid. In contrast, companies from Australia, Canada, France, Germany, and the Netherlands are essentially free from home country taxation on profits earned in the United States. Consequently, the second group have a stronger incentive to invest in low tax years than do firms from the United Kingdom and Japan. Using data over the period 1962-1987 Slemrod found no clear empirical evidence that there is any significant difference between the two groups. This is counter to what is expected and raises questions about the sensitivity of FDI to taxation.

156.   The tax treatment of companies in the United States treats differs across industries because of the assets in which they invest. This motivated Swenson (1994) to consider tax effects at the industry level for the period 1979-1991. Swenson found that industries in which the after-tax cost of capital increased most following the 1986 Tax Reform Act were those in which foreign investors concentrated their investment. This is consistent with investment from countries that receive tax credits since the US treatment does not then matter for the overall level of profitability. Auerbach and Hassett (1993) proved counter-evidence to this claim by providing evidence that there was no significant difference in behaviour between investors from countries granting foreign tax credits to those from countries not granting credits.

157.   The studies that are described next are cross-section. These studies exploit the variation in tax rates across countries to obtain estimates of the tax effect.

Grubert and Mutti (1991) analyze American owned Property, Plant, and Equipment (PPE) in manufacturing affiliates in 33 countries in 1982. The marginal effective tax rates are not available for all

the countries so instead an average effective tax rate on equity is used. This is calculated from the tax returns of US affiliates operating in the countries. A sample of the results is presented in Table 19. The variable τ is the tariff levied and t_e is the constructed average tax rate. The investment policy dummy is designed to capture countries where an active investment policy placed limitations on the holdings of foreign companies. The result shows an elasticity of at least -1.5 with respect to the local tax rate, and a much higher value when the inverse of the tax rate is the explanatory variable.

Table 19: Majority owned foreign affiliates

Constant	-22.5 (−4.96)	-26.6 (−5.68)	-21.1 (−4.80)	-25.0 (−5.68)
GDP	0.92 (5.71)	0.92 (6.36)	0.98 (6.21)	1.01 (7.20)
GDP per capita	1.42 (3.72)	1.72 (4.77)	1.13 (2.87)	1.36 (3.69)
$1+\tau$	2.58 (1.66)	3.92 (2.64)	2.20 (1.46)	3.32 (1.88)
$1-t_e$	1.96 (1.74)		1.50 (1.36)	
$1/t_e$		0.11 (2.50)		0.11 (2.59)
Distance	0.82 (1.14)	0.71 (1.03)	1.28 (1.75)	1.23 (1.82)
Investment policy			-1.14 (−1.87)	-1.27 (−2.30)
R^2	0.63	0.66	0.66	0.71

158.   Hines and Rice (1994) extend the study of the distribution of PPE to US affiliates in 73 countries. They report an estimated elasticity with respect to taxation of -1. Altshuler, Grubert, and Newton (1998) compare the sensitivity in 1984 to that in 1992. Using data on PPE in 58 countries they estimate that the elasticity of PPE with respect to taxation has risen from -1.5 in 1984 to -2.8 in 1992.

159.   The effect of sub-national taxes in the United States has also been considered. There is considerable sub-national variation in the United States since state taxes on foreign corporations varied (in 1998) from 0% to 15%. Ondrich and Wasylenko (1993) studied new plant establishments over 1978-1987. They modelled the probability of location in each state and their analysis led to an implied elasticity of -0.6.

160.   Hines (1996) also examined the effect of state tax rates on the distribution of foreign direct investment within the US. The paper compares the location decisions of companies from countries with tax credit systems (so they have no real need to avoid US taxes if lower than taxes in their own country) to

companies from countries without tax credit systems (who have a direct incentive to search for lower taxes).

161.   The estimated model is based on the reduced form equation

$$I_{ij} = \alpha_i \gamma_j + \beta_j s_i \gamma_j (\tau_i - \bar{\tau}) + \gamma_j u_{ij}, \tag{52}$$

where I_{ij} is investment in state i from investors in country j. α_i (unobservable) and s_i (observable) reflect the size of business activity in state i. τ_i is the tax rate in state i and $\bar{\tau}$ is the average state tax rate (formed using shares s_i). The estimated tax effect is large. Those not receiving tax credits are estimated to reduce investment by 9-11% for every 1 percentage point rise in taxation. This effect is found to be strongest when tax rates were low. But caution is suggested about taking these large figures too literally.

162.   Devereaux and Griffith (1998) propose a model in which firms make choices about whether to supply a market, and if they choose to supply whether it is done by production at home or in that market. This gives rise to an estimation of the probabilities of each choice being made. The dataset looks at US firms and their choice of location in Europe. The only countries considered in Europe are France, Germany, and United Kingdom. The average effective tax rate matters for the choice of location, conditional on the firm having chosen to locate in Europe. The central estimate is that a 1 percentage point increase in the effective average tax rate in the United Kingdom would lead to a reduction in the probability of a US firm choosing to produce there by 1.3 percentage points. The equivalent value for France is 0.5, and for Germany around 1. Tax is significant. However, the average effective tax rate does not have an effect on the choice between producing in Europe, supplying Europe from the United States, or not supplying Europe at all.

163.   The location decisions of US firms are also analysed by Grubert and Mutti (2000). The paper uses data aggregated from the tax returns of over 500 US multinationals for the year 1992. It looks at the role of host country tax rates in determining the location decision of capital investment. The empirical work shows that the average effective tax rate has a significant effect on the choice. The tax responsiveness is lower if the host country has a restrictive trade regime. They use OLS to estimate the equation

$$\ln K_i = f + g \ln(1 - t_i) + d \ln X_i, \tag{53}$$

where K_i is the amount of capital located in country i, t_i is the tax rate in i, and X_i is a vector of all other variables describing location i. As in any study of this kind there is debate about the appropriate tax rate. This paper uses the average effective tax rate. This can be computed since they have the tax return data. The role of tax credits and residual tax in the United States can also matter.

164.   The estimation results are summarised in Table 20. Trade Regime is measured by the four point scale given in the World Bank Development Report, with 0 the most open. The tax rate is calculated using total income taxes paid in the host country divided by the sum of earnings and profit. This is done to avoid issues about the definition of taxable income which may be dependent on investment incentives and depreciation provisions. The finding here is of a large elasticity of 3.23, which falls in value as the trade regime becomes more restrictive. The conclusion of the paper is that the choice of location is sensitive to taxation.

Table 20: Sensitivity of FDI to taxation

t values in parentheses

Variable	Coefficient
$\log(1-t_i)$	3.23 (3.02)
Trade Regime $*\log(1-t_i)$	-1.51 (2.44)
$\log(GDP)$	0.805 (4.58)
$\log(GDP$ per capita$)$	0.418 (2.92)
Trade Regime	-0.607 (2.59)
North America	2.40 (3.95)
Latin America	1.55 (4.82)
EEC	0.788 (2.37)
Asia	0.640 (2.03)

165.   The results of this empirical literature are placed into a common framework by De Mooij and Ederveen (2003). They compute that the median value (taken as the median from all of the results published in the surveyed papers) of the tax elasticity is - 3.3. This implies a 1 percentage point increase in the tax rate reduces FDI by 3.3%. The contribution of the paper is to use a common definition of elasticity. This definition is the semi-elasticity (the percentage change relative to the level change). The distribution of the values of this semi elasticity from the studies is given. This shows that most estimates are negative but the range is very large. Then the paper performed a meta analysis of the results. This involved regressing the calculated semi elasticity on the characteristics of each study. This was repeated for various subsets of the studies. The value of -3.3 is the simple mean of the sample with outliers removed. Various refinements of this result are also given.

166.   Table 21 reports the semi elasticities extracted from the papers. Each of the surveyed papers ran a number of different formulations of regression equation which gives rise to the number of elasticities reported. The estimated elasticity is then turned into a semi-elasticity and the mean is calculated. The paper uses this data to make the claims noted above, but the results are displayed here since they provide easily interpretable evidence of the size of the elasticity.

Table 21: Summary of elasticity estimates

Study	Number of elasticities	Mean semi-elasticity
Hartman, 1984	6	-2.6
Bartik, 1985	3	-6.9
Boskin and Gale, 1987	12	-5.8
Newlon, 1987	2	-0.4
Young, 1988	12	-1.1
Murthy, 1989	4	-0.6
Slemrod, 1990	58	-5.5
Grubert and Mutti, 1991	6	-1.7
Papke, 1991	2	-4.9
Hines and Rice, 1994	4	-10.7
Jun, 1994	10	-0.5
Swenson, 1994	10	1.3
Devereaux and Freeman, 1995	4	-1.6
Hines, 1996	46	-10.9
Pain and Young, 1996	6	-1.5
Cassou, 1997	17	-7.5
Shang-Jin, 1997	5	-5.2
Devereaux and Griffith, 1998	10	-0.8
Billington, 1999	2	-0.1
Broekman and van Vliet, 2000		-3.3
Gorter and Parikh, 2000	15	-4.5
Grubert and Mutti, 2000	15	-4.0
Altshuler, Grubert and Newton, 2001	20	-2.7
Benassy-Quere, Fontagne and Lahreche-Revil, 2001	4	-5.0
Swenson, 2001	95	-3.9

167.   An alternative perspective on the effect of taxation is provided by Kessing *et al.* (2006). Their research looks at CBA (mergers and acquisitions in overseas countries). It is shown that fiscal decentralisation has a negative effect on CBA activity. When taxes are included in the regressions the statutory tax rate also has a negative effect though it does not affect the decentralisation coefficients. It should be noted that there is a problem with the use of a statutory tax rate given the numerous incentive schemes.

3.5 Small and Medium Enterprises

168.   Beck *et al.* (2005) provide a range of arguments for why the relative size of the Small and Medium Enterprise (SME) sector may matter for growth. Among these arguments are the links between the size of this sector and increased competition, entrepreneurship, and innovation. SMEs may also be more productive than larger firms but are limited by borrowing constraints caused by imperfect capital markets. A large SME sector can also raise employment if the firms are labour intensive. If there is any truth in these arguments then government support of SMEs will increase the growth rate.

169.   The paper provides cross-country evidence on the link between SMEs and growth. The measure of the SME sector is the share of the manufacturing labour force in firms with 250 or fewer employees. This is taken from the database created by Ayyagari *et al.* (2003). The growth regression finds a statistically significant relation between the relative size of SME sector and growth. However, this relationship is reported not to be robust to using instruments to test for endogeneity. That is, it is not clear which way the causal relation runs. The test of causality is to use instruments to extract the endogenous part of the SME variable leaving the exogenous part to be regressed on growth. The exogenous part does not explain very well, so there is a lack of causality. It is claimed that "even if SMEs increase growth, government subsidisation of SMEs will not necessarily have this effect".

3.6 Labour Market Institutions

170.   The functioning of an economy is related to the structure and operation of its markets. Daveri and Tabellini (2000) make a very simple argument about how the labour market institutions in Europe have contributed to lower growth. The labour market in Europe is characterised by strong trade unions. High labour taxes are then fed into wages through union bargaining and this creates unemployment. Thus, high taxes led to a higher natural rate of unemployment and a lower growth rate.

171.   Data to motivate this argument are presented in Table 22. This presents unemployment rates and growth rates for Europe and the United States for four decades from 1960. These can be seen to be inversely related: as unemployment in the EU has grown relative to the United States, the EU growth rate has fallen.

Table 22: Unemployment and growth

	1960-70	1971-80	1981-90	1991-98
Unemployment				
EU	2.5	3.7	8.2	9.9
US	4.8	6.4	7.1	5.8
Growth				
EU	4.4	2.4	2.3	1.7
US	2.6	1.8	1.7	1.8

172.   The data for the EU are claimed to support this perspective. An increase in unemployment comes about because of the substitution of capital for labour as wage rates rise. The regression results show that unemployment has a negative and significant coefficient. These are reported in Table 23 for one regression in levels and one regression in first differences (standard errors in parentheses). If the conclusion on the effect of unemployment is correct then it is not taxes alone but their interaction with institutions that determines the growth rate. However, the regression in first differences has very little explanatory power and in the level regression only two variables have significant coefficients. This is very weak evidence for the argument.

Table 23: Growth regressions with unemployment

	Levels	**First differences**
Capital taxes	-0.006 (0.013)	0.036 (0.025)
Unemployment	-0.098 (0.039)	-0.227 (0.081)
Initial GDP	-3.30 (0.643)	0.013 (0.095)
Initial schooling	0.013 (0.010)	0.019 (0.017)
Adjusted R^2	0.44	0.09

3.7 Financial Development

173.   Schumpeter (1934) argued that the role of financial intermediaries may be important for economic growth because they choose which firms to support. The allocation of efficient allocation of finance to the correct projects is essential for entrepreneurial activity to flourish. Financial intermediaries can also support the growth process through the encouragement of saving and investment.

174.   An analysis of the Schmumpeterian viewpoint using the method of growth regressions is undertaken by King and Levine (1993). The paper used data on 80 countries over the period 1960-1989. Four different measures of financial development were introduced. First, LLY was financial depth which is the overall size of the formal financial intermediary sector (ratio of liquid liabilities to GDP). Second, BANK was deposit banks domestic credit divided by deposit money bank plus central bank domestic credit. Third, where the financial system distributes its assets was reflected by using (a) PRIVATE the ratio of claims on non-financial private sector to domestic credit and (b) PRIVY the ratio of claims on the non-financial private sector to GDP.

175.   They run a standard form of growth regressions to see the effect of the inclusion of the four financial development variables. The results are summarised in Table 24. Each of these regressions also includes log of initial income, log of initial secondary school enrolment rate, ratio of government expenditures to GDP, inflation rate, ratio of exports, plus imports to GDP.

Table 24: Growth regressions for contemporaneous development

Financial indicator	Coefficient	Standard effor	R^2
LLY	0.024	0.009	0.50
BANK	0.032	0.010	0.50
PRIVATE	0.034	0.010	0.52
PRIVY	0.032	0.010	0.53

176.   The next step was designed to test whether financial development can act as a predictor of future growth. The method was to average growth over each decade and to use the value of the financial development variable at the start of the decade as a predictor. The results of this exercise are described in Table 25. (Each of these regressions included log of initial income, log of initial secondary school enrolment rate, ratio of government expenditures to GDP, inflation rate, ratio of exports, plus imports to GDP.) The results offer support for the hypothesis that financial development is a good predictor of economic growth.

Table 25: Growth and initial financial indicator

Financial indicator	Coefficient	Standard effor	R^2
LLY	0.034	0.009	0.42
BANK	0.028	0.011	0.40
PRIVATE	0.016	0.009	0.39
PRIVY	0.037	0.011	0.42

177.   A longer-term perspective on the growth implications of the development of financial intermediation was presented by Rousseau and Wachtel (1998). They used time-series methods to analyze data for the period 1870-1929. Five countries were analyzed: the United States, the United Kingdom, Canada, Norway, and Sweden. The results demonstrated that there was a long-term relationship between output per capita and financial intermediation (in the sense of cointegration). Financial intermediation was shown to Granger-cause growth, but not the converse. In interpreting this final statement it should be emphasised that Granger causality is a statistical concept and not directly related to economic causality.

178.   An alternative perspective on the link between growth and development is presented by Rousseau and Wachtel (1998). Their analysis considered the relative rates of growth of different industries across countries. The analysis was based on the hypothesis that industries needing a greater proportion of external finance will grow relatively faster in countries with more developed financial sectors. This idea was implement by determining the degree of external financing for each industrial sector in the US and assuming that the same degree of external finance was required in every country.

179.   The estimation procedure is based on the equation

$$\text{Growth} = \text{Constant} + \sum_{i=1}^{m} \beta_i \text{Country indicators} + \sum_{i=m+1}^{n} \beta_i \text{Country indicators}$$

$$+ \beta_{n+1} \left(\text{Industry } j\text{'s share of manufacturing in country } k \text{ in } 1980 \right)$$

$$+ \beta_{n+2} \begin{pmatrix} \text{External dependence of industry } j \\ \times \text{Financial development of country } k \end{pmatrix}. \tag{54}$$

The focus was on the coefficient β_{n+2} that captures the interaction between the need for external finance and the level of financial development. Average growth over the period 1980 - 1990 is then regressed on four different measures of financial development: total capitalisation, bank debt, accounting standards, and accounting standards in 1983. The results are reported in Table 26. In each case the interaction of the financial development variable and external dependence is positive and significant in explaining growth. The differential in real growth rate is defined as follows. The industries at the 25th percentile and at the 75th percentile of external dependence are identified. The growth rate of these industries in the 25th percentile country and 75th percentile country in terms of financial development are calculated. The differential is then defined as how much faster the 25th percentile industry grows relative to the 75th percentile industry in the 25th percentile country as compared to the 75th percentile country. This is interpreted as a measure of the importance of financial development. The results show that the value of this

differential is large, certainly when measured relative to typical growth rates of approximately 3.5% per year.

Table 26: Industry growth and financial development

Variable	Total capitalisation	Bank debt	Accounting standards	Accounting standards in 1983
Industry's share of total value added in manufacturing in 1980	-0.912 (0.246)	-0.899 (0.245)	-0.643 (0.2047)	-0.587 (0.223)
Interaction	0.069 (0.023)	0.118 (0.037)	0.155 (0.034)	0.099 (0.036)
R^2	0.290	0.290	0.346	0.239
Differential	1.3	1.1	0.9	0.4

180.   A very specific aspect of financial development is considered in Jayaratne and Strahan (1996). The United States has witnessed a process of intrastate bank reform that has seen 35 states relax laws on intrastate branching since 1970. The effect of this process on growth is estimated by making a comparison of the growth performance of the states that have reformed with the states that have not. The results show that reform has a positive and significant effect on state growth rates. The estimated equations predict a growth rate increase of between 0.51 and 1.19 percentage points in the years following banking reform.

181.   The channel through which financial intermediation can affect growth is investigated in Beck *et al.* (2000). The level of development of financial intermediation is measured by the value of credit provided by financial intermediaries to the private sector as a proportion of GDP ("Private credit"). This variable is included in growth regressions and in regressions that explore the level of capital accumulation and private saving. Table 27 reports the basic growth regression results. Cross-country data refers to an Instrumental Variables estimator with the data for 63 countries averaged over 1960-1995. Panel data refers to a dynamic Generalised-Method-of-Moments estimator with a panel constructed by averaging over seven periods of five years. The p-value is reported under each estimated coefficient. It can be seen the financial development has a positive and significant coefficient for both regressions.

Table 27: Financial intermediation and economic growth

	Cross-country data	**Panel data**
Constant	2.643 (0.527)	0.082 (0.875)
Initial income	−1.967 (0.001)	−0.496 (0.001)
Average years of schooling	1.548 (0.0787)	0.950 (0.001)
Openness	0.931 (0.042)	1.311 (0.001)
Inflation	4.270 (0.096)	0.181 (0.475)
Government size	−1.207 (0.132)	−1.445 (0.001)
Black market premium	−0.139 (0.914)	−1.192 (0.001)
Private credit	3.215 (0.012)	1.443 (0.001)

182.   Further empirical analysis in Beck *et al.* (2000) shows that the Private credit variable is also positive and is significant in explaining total factor productivity growth. However, it is not significant in explaining physical capital accumulation or private saving. Therefore the paper provides evidence that the development of financial intermediation raises growth through increasing total factor productivity.

3.8 Summary

183.   The choices are firms are central to models of endogenous growth. Firms are responsible for investing in physical capital and for undertaking the research and development that generates innovation. A key policy question is how taxation affects these choices. Some early attempts at modelling investment were based on ad hoc formulations. Others were based on an optimising framework but delivered poor empirical estimates. The application of the natural experiment method to tax reforms has produced much stronger estimates and confirmed that investment does respond to tax incentives.

184.   The same comments apply to research and development. The estimation procedures have improved and consistent estimates of the response of R&D to incentives have been reported. R&D is more responsive in the long run than in the short run, and R&D expenditure has a long-run elasticity of approximately 1 with respect to subsidies. Countries that do not undertake R&D have been shown to benefit significant international spillovers. These spillovers have increased over time with the development of globalisation. Foreign direct investment is route through which R&D can be transmitted between

countries. This, too, is sensitive to tax rates on corporate income. Finally, firms need funds to undertake investment and R&D. This explains why financial development indicators are positively related to growth.

4. Country Studies

185.   This section presents a review of several country-specific studies. These studies evaluate tax proposals or tax reforms from a growth perspective. The studies are interesting for the variety of methods used. These include evaluation of the changes in the individual components of the growth process and the estimation of an efficiency frontier for alternative tax structures.

4.1 United States

186.   The US Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA) was a significant piece of tax legislation. The Act modified several areas of the US Internal Revenue Code, including those relating to income tax rates, estate and gift tax exclusions, and qualified and retirement plan rules. The overall effect of the act was to lower tax rates and to simplify the rules for plans such as IRAs and 401 (k)s. An interesting feature of the Act was that many of the tax reductions were designed to be phased in over a period of up to 9 years and that its provisions are designed to "sunset" (revert to the provisions that were in effect before it was passed). The Act will sunset on January 1, 2011, unless new legislation is enacted that makes its changes permanent.

187.   Gale and Potter (2002) consider the details of the Act, its budget implications and distributional implications, and then move on to address the growth consequences. They summarise the tax changes as reducing income tax rates, repealing the estate tax, providing new subsidies for education and retirement saving, and indirectly reducing public saving. The net effect on growth of the economy is concluded to be negative.

188.   The process for reaching this conclusion is as follows. Assume that the tax changes do not affect technical progress or the coefficients on capital and labour in a Cobb-Douglas production function. This places the focus on how the reform will affect labour supply and the capital stock. The labour input is interpreted as the product of time and human capital, and the physical capital input as the sum of home and overseas invested capital. Reference was then made to data from the Congressional Budget Office that predicted that the Act would raise the after-tax return to labour by between 2.2 and 2.8%, and the return to capital by between 0.6 and 3.4%. The empirical literature is used to support a labour supply elasticity of 0.05 for males and 0.30 for females (observe that the value for female labour supply is slightly higher than that reported in Section 8.4 but it is not unreasonable). These labour supply elasticities were then used to predict the labour supply response using the predicted increase in return to find the increase in hours. This provides an estimate of a 0.48% increase. It was then argued that there was no empirical literature that provided a clear prediction of the human capital effect of the change in return. Appeal was therefore made to the work of Dynarski (1999, 2000) to argue that change in tuition deduction and employer exclusion will increase human capital by 0.21%. The total change in effective labour supply is 0.69%.

189.   The next step is to pick a similar path through the components of saving to arrive at a change in capital stock. The redistribution of after-tax income towards high-income households is predicted to raise saving by 0.36% of GDP. Next, estate tax repeal is assumed to raise private saving by 0.13% of GDP. The Act is predicted to reduce public saving by 1.58% of GDP, so the next effect is a decrease in saving of 1.09% of GDP. One-third of this decline is assumed to be offset by an increased inward flow of capital from outside the United States, leading to the final conclusion of a -0.73% of GDP reduction in saving. This figure is employed to arrive at a reduction in capital stock of 2.16% of GDP by 2011.

190.   The final step in the argument is to use a simple parameterisation of the Cobb-Douglas production function to calculate the implied change in output. The base case conclusion using the figures above is a predicted reduction of -0.31%. The explanation for this finding is the distinction between the private incentives of the tax reductions and the effect on public saving. The calculations predict the Act will raise labour supply, human capital, and private saving, but it causes an even greater reduction in public saving. It is this net reduction in saving that causes the predicted output decrease.

191.   It is worth stressing that the calculations lead to a conclusion about the level of output. There is no prediction on how the Act will affect the growth rate effect. This was a consequence of the initial assumption that technical progress was unaffected by the reform. This emphasises the difficulty in moving from knowledge of how the components of growth change to a prediction of the resulting change in *TFP*.

4.2 Non-US

192.   China has experienced very rapid economic growth. This has been accompanied by major revisions in the tax system. These changes are described by Gordon and Li (2002) in a brief review of the recent history of Chinese tax reform. (A more detailed description of the changes is given in Huang (2006)). The central observation of Gordon and Li is that the tax system was initially focused on collecting revenue from a few large firms. In addition, there were high tariffs on imports. The high rates were coupled with corruption and evasion so that collected revenues were low. These features combined to deter entry of new firms, distort government decision making, and ultimately stifle the rate of economic growth.

193.   The paper then notes the changes that have since taken place in a series of reforms to the tax system. In brief, accounting procedures have been modernised, a VAT system has been introduced, and corporate tax rates have been lowered. It is claimed that these changes have all contributed to growth.

194.   The main point of the paper is to observe that a major factor in increasing growth has been the process of decentralisation. From 1980 the central government allowed local governments to collect and retain taxes from the firms that located in their regions. This gave local governments an incentive to encourage firm entry and reduces the information problems in collecting taxes. The National Tax Bureau now has responsibility for collecting VAT, excise taxes, and income taxes from state-controlled enterprises. Local Tax Bureaus collect business taxes, individual income taxes, agricultural taxes, and property taxes. This is all supported by a legal system that provides harsh punishments for tax evasion.

195.   One element of the Chinese success has been the use of tax incentives to attract foreign direct investment. Many other countries, such as Thailand, have also benefited from the use of incentives. Fletcher (2002) reviews the theory behind the pros and cons of tax incentives and applies the analysis in a study of tax incentives in Cambodia, Lao PDR and Vietnam. The important point is made that for firms from countries operating a tax credit system, such as the United States and United Kingdom, a tax incentive abroad is a transfer to the US or UK government rather than a direct benefit to the investing firm. (This applies except where there is a tax sparing agreement, but these agreements are not mentioned in the paper.) The empirical evidence on the elasticity of investment with respect to tax incentives is then reviewed. The paper reports the Hines finding that a 1 percentage point reduction in the corporate income tax rate leads to a 2% increase in investment.

196.   The analysis of the data for three countries is then considered. It is concluded that simple schemes are just as good as complex schemes. The data also reveal a significant cost of offering the tax incentives. This is estimated to be $224 million for Vietnam in 2001. A simple plot of the quantity of FDI for the three countries shows that this peaked in the mid-1990s and then decreased until the end of the sample period (2000). Plots are presented to show that FDI is negatively related to an index of tax incentives and negatively related to the standard corporate tax rate for a cross-section of South East Asian

countries. But both of these relationships are a consequence of Hong Kong which is a clear outlier in the data (highest FDI, lowest incentives, and lowest tax rate). Without Hong Kong there appears to be very little relationship. The paper concludes by conjecturing that tax incentives are not the primary determinant of investment and that accelerated depreciation may be the best policy.

197.   Poirson (2006) describes the Indian tax system as currently having high marginal rates but low revenues because of the narrow base and low level of tax productivity (the effectiveness of collecting taxation). Appeal is made to elements of the empirical literature reviewed above that this tax structure is bad for growth. The argument begins from the hypothesis that a reform combining lower statutory rates with base-broadening would raise growth. A set of proposals are then described that involve lowering the rate of direct taxation, broadening the base, and introducing a VAT on goods and services. The report then proceeds to analyze the proposed reform from a growth perspective. It is claimed that this reform could partly be achieved through the removal of exemptions and improved tax administration. The proposals are broadly praised by the report, but it offers no quantification of the effect upon growth.

198.   An interesting alternative methodology for explaining the link between taxation and growth is provided by Branson and Lovell (2001). The analysis starts with a discussion of the reform process undertaken by New Zealand in the 1980s. This reform matched what is proposed for India: a reduction in progressivity of personal income taxes, a reduction in the rate of corporate taxes, a broadening of the income tax base, and the introduction of a goods and services tax. It is observed that this reform has not reduced the overall level of taxes and the ratio of direct to indirect taxation has remained high. The remainder of the paper is focused on relating the tax burden and the tax mix to economic growth and characterising the optimal structure.

199.   The analysis states the standard growth accounting expression

$$g_Y = \alpha_K g_K + \alpha_L g_L + SR,\qquad\qquad(55)$$

and asserts that the five variables (α_K, g_K, α_L, g_L, and SR) are determined by the tax burden, tax mix, and a vector Z of other variables. Denote the revenue from direct taxes by D and the revenue from indirect taxes by I. Then the tax burden is $B = (D+I)/Y$ and the tax mix is $M = I/D$. The tax mix and tax burden are related to the rate of growth by writing

$$g_Y = f\left(\frac{Y}{D}, \frac{Y}{I}, Z\right).\qquad\qquad(56)$$

The next step in the analysis is to "solve out" the vector Z. Assume that some realisations of Z are good for growth and others are bad for growth. Years where growth is high must then represent relatively favourable realisations of Z. These years are identified by solving a linear programming problem which finds the extent to which Y/D and Y/I could be reduced in each year while achieving the observed rate of growth. Let $0 \leq \theta^t \leq 1$ be the solution of this programming problem in year t. In the most efficient years no reduction in revenue would be possible without reducing growth, so $\theta^t = 1$. Inefficient years would have a value of $\theta^t < 1$. The value of θ^t summarises information on the vector Z in each year.

200.   The effect of the tax burden and tax mix are then computed by running the regression

$$
\ln(g_Y) = \beta_0 + \beta_1 \ln\left(\frac{B}{\theta}\right) + \beta_2 \ln(M) + \frac{1}{2}\beta_3 \left[\ln\left(\frac{B}{\theta}\right)\right]^2
$$

$$
+ \frac{1}{2}\beta_4 [\ln(M)]^2 + \beta_5 \ln\left(\frac{B}{\theta}\right)(M)). \qquad (57)
$$

Given the estimated coefficients it is possible to choose the optimal burden for a given mix by maximising over *B*, or to find the optimal mix for a given burden by maximising over *M*.

201.   The application to data for New Zealand over the period 1945–1995 concludes that the observed tax burden exceeded the optimal tax burden (given the mix) for every year with the exception of 1951. The observed tax mix is less than the optimal mix in most years, and especially so in the years around 1980 when the New Zealand economy was performing poorly in terms of growth. The mean growth maximising tax mix comprises 65% direct taxes and 35% indirect taxes. In summary, it is concluded that the tax burden in New Zealand did more to reduce growth than did the tax mix.

4.3 Comments

202.   These country studies demonstrate a variety of methods of evaluating tax reforms. However, none makes a truly comprehensive assessment of the growth consequences of a reform. Gale and Potter provide detailed calculations for the effects of the reform on each component of growth, but assume away any consideration of total factor productivity. The methodology of Branson and Lovell is an interesting alternative to the established techniques and may prove worthy of development.

5. Overall Summary and Implications

203.   This section presents a brief summary of the major observations made in this paper. It then offers some views on the implications for policy of the literature that has been reviewed in the series of three papers. The section concludes with a discussion of areas in which further research is required.

204.   The empirical evidence on the effect of taxation on saving is contentious. This is true for the aggregate elasticity of saving and for the response of saving to favourable tax treatment. The evidence on the effect of IRA and 401 (k) plans is disputed but there is probably a small response of saving to the tax incentive. Subsidies that reduce the cost of education raise enrolment rates. The effect can be significant for groups that are constrained by capital market imperfections. The empirical counterpart of the theoretical human capital construct has been contested. Measures of underlying ability perform better in growth regressions than measures of formal education. The decision to become an entrepreneur is sensitive to taxation. It is not clear if it is the level of taxation or the progressivity of taxation that matters most. Behavioural economics challenges many of the assumptions of traditional economic analysis. These challenges are especially relevant in the context of intertemporal decision making.

205.   Models of investment have traditionally performed poorly in explaining the empirical data. The investment model provides stronger predictions when set within the natural experiments framework. The frequent changes in tax rules for investment allowances and depreciation allow estimation of the response. Investment is increased by tax incentives. The effect of subsidies on research and development expenditure has been estimated very cleanly and consistently. Research and development expenditure is sensitive to subsidy in the long term. Research and development expenditure is concentrated in small

number of countries but international spillovers are significant. Foreign direct investment has been extensively studied. It is responsive to tax incentives. Taxation affects the choices of entrepreneurs. An increase in taxation reduces their probability of employing labour and of investing, and reduces the rate of growth of small firms.

206.   The empirical results have been used to calculate the output effect of policy reforms. The results have not been used to calculate the effect upon total factor productivity growth of a tax reform. Lower rate, base broadening, and an increase in consumption taxes relative to income taxes, are the package of reforms generally accepted to be growth enhancing. Frontier analysis can determine efficient tax structures and guide tax reform.

         What policy conclusions can the drawn from this literature? There is no empirical evidence in the aggregate data that the rate of economic growth is related to the level of taxation. The level of government consumption expenditure was a significant variable in some growth regressions but this correlation was not robust. Many specifications of tax rate variables have been employed in tax regressions but none has provided a convincing result when other covariates have been included. It is important to note that this is not making the claim that the structure of taxation does not affect the rate of growth.

207.   There is evidence that growth is higher when the corporate income tax is lower. When the aggregate level of taxation is separated into components for the different taxes the level of corporate income tax becomes significant. The policy implications of this observation have to be carefully considered within an international setting. The corporate income tax affects investment at home, and foreign direct investment. If the increase in growth is driven by foreign direct investment (through the process of internationally-mobile capital seeking the maximum post-tax return) a multilateral reduction in corporate income taxes will not be beneficial.

208.   Increases in the personal income tax reduce growth only by affecting the decision to choose entrepreneurship. The personal income tax might affect growth through it effect on labour supply, human capital accumulation, and saving behaviour. Labour supply is connected with a level effect, not a growth effect so even if labour supply is sensitive to taxation this is not important for growth. The effect of the income tax on human capital and saving are theoretically ambiguous. These are discussed further below. There is clear evidence that the personal income tax does affect the choice to enter entrepreneurship and the decisions of entrepreneurs. An increase in personal income tax reduces growth by discouraging entrepreneurship.

209.   A change in the tax mix that increases the importance of consumption taxes relative to income taxes will raise growth. The theoretical mechanism through which this argument works is very clear. Income taxes distort the choice between consumption and saving by reducing the return on saving. This raises the effective price of consumption tomorrow relative to consumption today. An increase in saving raises the rate of increase of the capital stock. The effect is apparent in the aggregate tax regressions and is implicit in the disaggregated empirical results.

210.   The empirical evidence on saving is mixed but on balance suggests some sensitivity to tax incentives. The aggregate elasticity of saving with respect to taxation was an issue of contention in the 1970s. The debate has now moved to the sensitivity of saving to tax incentives. However, the results remain equally contentious. Behavioural economics provides an alternative model of saving behaviour which could explain the empirical evidence. Educational choices at the college level are sensitive to incentives but there is no evidence on how they are affected by tax instruments. The effect on college attendance of scholarship programmes is cleanly estimated and can be large for some groups of the population. But these incentives relate to choices in the near-term. How the income tax, which operates on the long-term return to education, affects education decisions is not known. This is another dimension of choice to which behavioural economics might contribute.

211.   The decision to become an entrepreneur is affected by the level of taxation and the progressivity of taxation. Theoretical analysis predicts that taxation alters the risk and return characteristics of the income stream faced by a potential entrepreneur. The empirical results show that the net effect is a reduction in the probability of entrepreneurship being chosen. This can reduce innovation in the economy and have an adverse effect upon the growth rate. The choices of entrepreneurs are also sensitive to tax incentives. The empirical analysis has identified sole-proprietors with entrepreneurial activity. The research has shown that the business decisions of sole-proprietors are affected by the personal tax system. An increase in taxation reduces the probability that they will employ workers, reduces the probability that they will invest, and reduces the rate of growth of their business.

212.   Investment expenditure is sensitive to tax incentives. The empirical analysis of tax reforms has established stronger estimates of the tax response. The estimates show that investment will increase when the tax-adjusted user cost falls. Expenditure on Research and Development is sensitive to tax incentives. The sensitivity of R&D expenditure to tax incentives is one of the most clearly estimated coefficients in the entire literature reviewed. The use of natural experiments coupled with significant changes in policy has given a good measure of the value. The elasticity is smaller in the short run than in the long run, and is consistent across countries. The level of Foreign Direct Investment is sensitive to tax incentives. Foreign direct investment arises from mobile capital seeking the highest net return. It is therefore no surprise that it is responsive to taxation. This is true between different states within the US, and between countries. There have been many studies of foreign direct investment with good consistency in recent estimates of the tax elasticity.

213.   A number of comments have been made in this paper on unanswered questions and on limitations of the methodology. This section expands upon some of those comments. It has been noted at many points that there are convincing estimates of economic responses to changes in policy. These estimates have invariably been obtained by the use of microeconometrics. Microeconometrics is a set of tools that has developed in the past two decades into set of very powerful techniques for examining micro-level decisions. In contrast, it has also noted the limited success of the aggregate econometric analysis. There appear very few significant relationships in the aggregate data on economic growth. This has brought the analysis to a position where many of the relevant micro responses are known. If they are not known, a methodology exists for discovering them wherever suitable data is available. In principle, it should be possible to aggregate these micro-level reactions to find the overall effect of a policy reform upon growth. The work of Gale and Potter (2002) provides a template for how this can be partially achieved - partially is justified here because Gale and Potter consider only the level effect of the policy reform and do not attempt a calculation of the change in total factor productivity.

214.   There is a good reason why Gale and Potter do not try to calculate the change in *TFP*. This reason is the lack of any existing empirical evidence that can guide such a calculation. This point can be understood from another perspective. The application of growth accounting determines a separation of growth into three components (or four if human capital is treated separately). Two of these components - the growth in the capital stock and in labour supply - are observed. The third, the growth of *TFP*, is calculated as the residual. This provides a measure of *TFP* growth but no understanding of what has caused that growth. This issue was discussed at length in Prescott (1998) who raised important questions about the limitations for current understanding. Those questions currently remain unanswered.

215.   In brief, what is missing from the body of knowledge is the link from changes in the variables identified as important by endogenous growth models to changes in the value of *TFP* calculated by growth accounting. The work of Bernanke and Gurkaynak (2001) investigated the determinants of *TFP* by using a regression analysis. That work provided evidence of the endogeneity of *TFP* growth and could form the basis of interesting extensions.

216. The aggregate regressions analysis has met with limited success. It is natural to question whether it is possible to improve these regressions. Certainly, using variables that represent the separate components of the tax system (direct taxes, indirect taxes, *etc*.) has led to some improvement but there are limits on how far this can be taken. As Slemrod noted, if there was a significant effect of taxation on economic growth hidden in the data why has it proved so hard to find? The answer lies either in the fact that there is no major effect or that the correct specification of the models has still not been found. The comments made in this report have all tended to support the former conclusion, at least for the range of values of the tax variables currently observed.

217. An important point is made by Slemrod (1992) that relates to all analysis of tax responses. The empirical work focuses on the question of how a change in taxation affects behaviour in a narrow range of the choice space. A change in the chosen level of an economic variable is not the only possible response to taxation ad there is an important class of more general responses. It is possible to alter the timing of an action, or engage in financial or accounting practices that alter the taxable position of the action. The extreme version of this form of response is to move from the observed to the hidden economy. These changes are not immediately apparent in the aggregate data and require a more extensive form of analysis. Generally, an increase in taxation can be met by behavioural changes that attempt to mitigate the effect by making choices that are outside the data used in the analysis. The analysis of the hidden economy (Schneider and Enste, 2000).has made it clear that there is a significant body of economic activity outside the normal process of measurement. These issues have not been fully resolved in the analysis of the aggregate data.

218. There is a considerable variety of theoretical work exploring models of endogenous growth. One important limitation of this literature is the lack of a compelling model of economic growth that captures the international transmission of technical innovation. Bayoumi *et al.* (1999) provide an empirical that identifies the size of the effects but does not explore the underlying processes. A model should reflect the concentration of research and development amongst a few major economies and explore the diffusion process for the resulting innovations. Models that are available (for example, Howitt, 2000) have a very simple structure and place countries in a position of symmetry.

219. Important questions have also been raised about what the human capital variable entering the theoretical model represents in the empirical data. The standard interpretation is that it relates to schooling (which is why schooling was included from the outset in growth regressions). This provides a convenient fit with a model of choice in the amount of investment that can be undertaken. This leads to a process of human capital accumulation, so endogenising the rate of growth. The empirical evidence suggests that this might not be the correct interpretation. The success of mathematical ability and IQ measures in growth regressions casts doubt on years of education being the correct measure of human capital. Clearly, the resolution of this debate has implication for some very important areas of public policy. The link between economic growth and education needs to be more closely tested in order to justify this emphasis.

220. Finally, two brief issues that have not featured in the empirical analysis of growth. First, behavioural economics is becoming increasingly established as a mainstream approach. The key point is that changes to the method of discounting or to the formulation of preferences imply very different responses of choices to taxation. An assessment from the perspective of behavioural economics could provide a very different policy interpretation of the empirical findings. Second, no mention has been made of government non-price intervention. This might have been proxied by measures of government size in aggregate regressions. Given the increasing relevance of economic regulation it justifies a separate analysis.

APPENDIX ON NATURAL EXPERIMENTS

221.   The problem with much econometrics is that the problem of correlation between the right hand variables in a regression. This makes it difficult to disentangle their separate effects. What is needed is some independent variation of the variables so that the individual effect can be obtained.

222.   A natural experiment occurs when an exogenous change allows the derivation of the effect of a change in a single variable. An example of how this can occur is if one state changes a policy (such as introducing a subsidy to college tuition) while other neighbouring states do not. In the absence of other changes that do not affect the states asymmetrically this allows the identification of the effect of the variable that has changed. This is called a natural experiment because it is not under the control of the investigator but has the same form of changing one variable of interest as one would in a controlled experiment.

223.   The value to the investigator is that it is typically conducted on large populations with all reactions natural and no selection bias. The standard terminology is to call the subjects exposed to the policy change the *treatment group* and those not exposed the *control group*. Natural experiments also have the benefit that if the change in policy is truly exogenous then there should be no selection bias in the allocation of subjects to the treatment or control groups.

224.   In most applications of natural experiments the situation involves before and after design with an untreated comparison group. This is the case if one state or country alters a single policy but are otherwise exposed to the same influences. The method of estimation this case is that of *difference in differences*.

225.   Assume observations on a population of $i = 1, \ldots, N$ subjects in two time periods $t = 0, 1$. The value of the observed action is y_{it}^j, where $j = 0$ for the control group and $j = 1$ for the treatment group. The model is then specified by

$$y_{it}^j = \alpha + a_1 d_t + \alpha^1 d^j + \beta d_t^j + \varepsilon_{it}^j, \tag{8.35}$$

where $d_t = 1$ if $t = 1$ and 0 otherwise, $d^j = 1$ if $j = 1$ and 0 otherwise, and $d_t^j = 1$ if $t = 1$ and $j = 1$ and 0 otherwise. The value of a_1 captures how the groups are affected by time, and α^1 captures the time invariant differences between the groups. The variable d_t^j is a dummy for membership of the control group after it receives the treatment and β is the true effect of the treatment for the outcome of this group.

226.   The identifying assumption is that β would be zero in the absence of treatment. If this is the case then the unbiased estimate of β can be obtained by differences in differences

$$\hat{\beta}_{dd} = \left(\bar{y}_1^1 - \bar{y}_0^1 \right) - \left(\bar{y}_1^0 - \bar{y}_0^0 \right), \tag{8.36}$$

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where the bar denotes the mean value over i, the subscript denotes the time period and the superscript denotes the group. The value of $\hat{\beta}_{dd}$ provides a measure of the effect of the treatment.

227.   Further discussion of estimation for natural experiments can be found in Meyer (1995).

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