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The Impact of Fiscal Policy Variables on Output Growth

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Abstract

This paper surveys the theoretical and empirical literature on the relationship between taxation and public expenditure and economic growth. Particular attention is paid to the effect of taxation and government expenditure on the supply and productivity of labor and physical capital. Studies suggest that well-targeted government expenditures on health, education, and infrastructure should have a positive impact on growth. By contrast, the impact of taxation on the supplies of labor and capital, and on output growth, is more muted.

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SUMMARY

This paper surveys the theoretical and empirical literature on the effect of fiscal policy variables—government expenditure programs and taxes—on economic growth. Inspired in part by the recent literature on endogenous growth models, a number of studies have begun to examine empirically the impact of fiscal policy on output growth. However, most of these studies consider only aggregates, such as total expenditure or government revenues, as a percent of GDP. In addition, they often fail to identify the channels through which fiscal policy affects growth. Instead, this paper adopts a disaggregated approach, looking at the impact of fiscal policy variables on labor productivity, capital productivity, and the cost (and supply) of capital and labor.

On the expenditure side, many studies have found that high levels of educational and health *achievement* correlate positively with output growth. If the link between *spending* on education and health and output growth is weaker, this probably reflects poor targeting or allocation of expenditure. Many studies have also documented a link between government expenditure on infrastructure and growth, although here again the empirical link may be weakened by inefficient spending. On the other hand, evidence suggests that spending on defense and public order in many countries exceeds the minimum required for growth-enhancing political and social stability.

The empirical evidence suggests that tax policy may have its main impact on growth through the allocation of investment and labor across sectors of the economy, rather than through the aggregate supply of labor and capital. However, because individuals do not fully pierce the corporate veil, revenue-neutral shifts of the tax burden from corporations to individuals, and other policies that encourage firms to retain earnings rather than pay dividends, may increase saving, investment, and growth. In addition, countries open to trade generally grow faster than those that are not.

I. THE THEORETICAL FRAMEWORK AND APPROACH OF THE PAPER

A. Introduction and Overview

This paper reviews the literature on the relationship between the structure of taxation and public expenditure and economic growth. Apart from its macroeconomic effects, fiscal policy can affect the rate of growth of aggregate output through many channels. The impacts of public education expenditure on human capital formation, of the provision of public sector infrastructure on the productivity of private capital, and of capital income taxation on saving are but three of these. Given the need to examine the impact of the components of expenditure and tax policy on growth, the paper adopts a disaggregated approach. Its major concern is the way in which the components of expenditure and tax policy will affect the supply and productivity of labor and of capital and the efficiency of resource allocation.

The paper is organized as follows. Section II sets out a simple version of the basic neoclassical growth model, which is used as a way of organizing the subsequent discussion. Sections III, IV, and V then deal successively with the impact of fiscal policy on labor productivity; on capital productivity; and on the cost (and supply) of capital and labor. In each of these sections, the paper first considers what economic theory predicts would be the way in which expenditure policy and tax structure would affect the particular source of growth under discussion. It then reviews the substantial corpus of empirical work that attempts to quantify these effects. In Section VI, the paper discusses some aggregative studies on taxation and growth. Finally, Section VII presents a summing-up. An appendix illustrates mathematical solutions to some simple models of economic growth.[2]

B. The Theoretical Framework

In this section, a simple model is set out that provides an organizing framework for thinking about the ways in which the elements and components of fiscal policy affect growth. The production function below takes the standard neoclassical form with a minor modification:

$$Y(t) = F[A(t)K(t), B(t)L(t)] \tag{1}$$

where Y is output at time t, $K(t)$ and $L(t)$ are the stocks of physical capital and labor, respectively, at time t, $B(t)$ is an index of the quality (measured in terms of productivity) of the stock of labor, and $A(t)$ is a similar measure for physical capital. B will depend on the educational level of the workforce, as well as on its health or nutritional status, while A will reflect the level of technological development. This equation states merely that at any moment, the total output of the economy depends on the quantity and quality of physical

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[2]More detailed analyses of models of growth are provided in Barro and Sala-i-Martin (1995). Tanzi and Zee (1997) also review some of the theoretical and empirical literature related to fiscal policy and growth.

capital employed, the quantity of labor employed, and the average level of skills of the labor force. More generally, it is clear that output can only increase if K, L, A, or B also increases. Perpetual increases in output <u>per worker</u> can only occur if the stock of capital per worker or the average quality of labor or of capital also increases perpetually.

In a world with decreasing returns to physical capital, the economy will tend to a constant capital/labor ratio, where the return from additional investment just equals its cost.[3] Once the economy reaches this steady state, additional growth in the stock of capital per worker will take place only if the productivity of the capital stock is enhanced, for example, through technological innovation (an increase in A) or improvements in the quality of the labor force (increases in B).

In the original neoclassical model (Swan (1956) and Solow (1956)), the production function features decreasing marginal returns to both capital and labor, and A and B are exogenous (and equal, meaning that with constant returns to scale $Y = AF(K,L)$). Thus, the per worker stock of physical capital, k, will always eventually reach a steady-state value k^*, and long-run per capita output growth will be determined by the rate of exogenous technological change. A policy that leads to a permanent increase in the steady-state capital/labor ratio (e.g., one that raises the after-tax rate of return on investment) cannot, therefore, lead to long-run per capita growth, unless A is continually increasing. However, because it is costly to add to the capital stock, firms are likely to take some time to converge to the new steady-state capital/labor ratio and per capita output will not jump discontinuously to its new level (that which would prevail at $k=k^*$) but will instead increase gradually over time.

In contrast to the traditional neoclassical approach to growth, in recent years economists such as Romer (1986) and Lucas (1988) (building on the work of Arrow (1962) and Uzawa (1965)) have developed models in which perpetual, endogenously determined increases in A or B ensure that the marginal product of physical capital does not tend to zero when the amount of capital per worker increases, allowing for long-run increases in per capita output. To produce this result, the "endogenous growth" literature typically (although not invariably) relies on mechanisms such as learning by doing on the part of the labor force, or increasing social returns to scale in physical or human capital.[4] For example, if the very process of producing output leads to an increase in the skill level of the labor force, the

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[3]This point is illustrated mathematically in the attached appendix.

[4]Mathematical solutions of two endogenous growth models, one based on increasing social returns to physical capital and one based on accumulation of human capital, appear in the appendix.

marginal product of the existing capital stock will rise in each period, and it may always be worthwhile for firms to invest in additional physical capital.[5]

In endogenous growth models, policies that affect the incentives to invest in either physical or human capital can have permanent effects on the long-run rate of output growth. For example, if there are externalities from investment in physical or human capital (i.e., if there are benefits that accrue to society as a whole from the investment decisions of individual firms and workers, and the firms or workers are not compensated for those benefits), then government intervention to increase school enrollment or capital formation may boost growth and be welfare improving.

Despite the differences in their implications for the impact of increases in the rate of investment, there is one respect in which drawing a practical distinction between the exogenous and endogenous approaches is problematic. Although in the neoclassical model policy reforms do not produce a permanently higher rate of growth, the process of convergence to a new steady state may take many years to play itself out. In the interim, output would be observed to grow regardless of the underlying structure of the production function. Consequently, this paper will consider policies that the empirical literature suggests lead to higher output growth rates for a significant period of time, even when the neoclassical model might imply that their policies would affect only the level of output, not its long-run rate of growth.[6]

The paper will consider three types of fiscal policies that can affect growth:

- Those that can affect the average skill level of the labor force (B);

- Those that directly influence the productivity of the stock of physical capital (A); and

- Those that affect the quantity of physical capital or labor supplied to the economy (K or L).

Corresponding loosely to these three classes of policies are three basic maxims for fiscal policy:

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[5]Strictly speaking, this requires that the average skill level of the workforce be a function of cumulative output over time.

[6]The sort of growth considered thus far can be described as movement of the economy from an equilibrium located on one production-possibility frontier to one on a subsequent frontier. In practice, however, all economies will find themselves inside the frontier. To the extent that policy improvements lead simply to a more efficient reallocation of existing resources, they may generate no increase in the stock of capital (or lead to only once-and-for-all increases in the amount of labor supplied to the economy). The resulting increase in output may take a very short period of time to materialize, and growth will be short-lived.

- The government should undertake investment in human and physical capital only when it complements private sector economic activity, by compensating for externalities or market imperfections that make socially profitable investment unprofitable.

- The government should provide a basic social and economic infrastructure that facilitates private sector economic activity and planning.

- The government should finance its activities in ways that minimize distortions to the supply and demand for capital and labor.

Policies in the first category would include expenditure on education and health, and possibly expenditure on social assistance for the poor. Those in the second category would include provision by the government of goods and services that would raise the productivity of private capital but that the private sector could not easily provide by itself, for example, public order. Finally, the third category could include the reduction of distorting taxation. Of course, there are interactions among these policies, and the distinctions among them may not always be clear. For example, the reduction of the distortions of a tax-transfer system could increase employment in a sector with a large potential for learning by doing, in which case it would not only improve efficiency but could also have an important growth component.

It was noted that the three maxims corresponded **loosely** to the three classes of fiscal policies affecting growth. There is, however, a potentially important distinction between the class of fiscal policies that can affect growth and the class of fiscal policies that respect the above maxims, which is that while some fiscal policies can increase growth but not welfare, all policies respecting the maxims should increase both growth and welfare. One example of a fiscal policy that could increase growth but reduce welfare is a policy that increases saving but forces the current generation to endure significant privation in order to finance the capital to be used by the next.

That said, increases in public sector investment are unlikely to increase growth at a given rate of saving if they do not correct for an externality or market failure, since without externalities or market failures there is no reason to assume that additional public sector investments would be more productive than the private sector investments they would replace. The paper describes the conditions under which the elements of fiscal policy can increase—or at least not reduce—growth without reducing welfare. At the same time, it reviews the literature on what the **actual** effects of tax and expenditure policies on growth are thought to be. Although it cannot be concluded that policies that increase growth are necessarily good (welfare increasing), it is reasonable to conclude that a strong effect means that both growth and welfare are increased. Moreover, when there is a presumption that a certain kind of policy increases welfare and growth (e.g., investment in primary schooling in a country with low literacy levels), the empirical literature may tell us something about the size of the impact.

II. FISCAL POLICY AND LABOR PRODUCTIVITY

This section will examine the possible effects of government fiscal policy on the productivity of the labor force (i.e., on the B of equation (1)).[7] Government expenditures on education and on public health are two frequently cited examples of fiscal policies that can raise the long-run growth rate of an economy, based on the assumption that educated and healthy workers are not only more productive than uneducated and sickly ones, but are also better able to acquire job-specific human capital and to adjust rapidly to possible technological and other changes in the workplace. The role of the government in the financing or provision of these services is justified by various market failures. After a review of the theoretical literature, this section will examine the empirical studies of the link between government expenditure on health and education and the rate of growth of output.

Although it seems intuitively obvious that the educational decisions of individual workers and firms should have a significant impact on economic growth, in fact, economists have had some difficulty integrating education and training decisions made at a microeconomic level into a unified model of macroeconomic growth. Arrow (1962) and Uzawa (1965) modify the basic neoclassical growth model by adding a human capital component. However, Arrow (1962) and Uzawa (1965) conceive of human capital in distinctly different ways. In Arrow's model, human capital takes the form of a pool of knowledge that is disembodied from individual workers, like scientific or technical knowledge contained in books and available to everyone. In Arrow's model, this stock of knowledge increases as a result of firms increasing their stocks of physical capital ("learning by doing" or "by investing"). However, Arrow limits his analysis to the case where the combined effect of physical capital and knowledge is small, so that steady-state growth in output occurs only because of population growth. As in the neoclassical model, changes in the rate of savings or of taxation can have effects on the level of income but not on the long-run rate of growth. In the Uzawa model, by contrast, human capital is embodied in workers: the only way for the stock of human capital to be increased is for workers to take time away from producing output and devote it to increasing their skills, presumably through some form of self-study. In contrast to the Arrow model, per capita steady-state growth is possible in the Uzawa model, but only if there are constant returns to scale in the production function for human capital. That is, it must be the case that a constant (say) annual amount of self-study leads to a constant annual increase in a worker's productivity, an assumption that seems unlikely.

Over the last several years, economists have seized on the idea of constant (or increasing) social returns to human capital in order to create models capable of generating constant, positive per capita output growth rates despite decreasing individual returns to

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[7]Policies that could have an impact on labor supply—that is, on L—will be considered in the section on taxes.

investment in education and training.[8] In these models, individual firm or worker production functions for final output or for human capital, respectively, depend positively on the total amount of human capital available to the entire economy. The models effectively assume that it is easier to acquire an education in an economy where many other people are highly educated than in one where they are not, or that workers are more productive when they can associate with other educated individuals. The externality underlying the models could stem from scale effects in the production of educational materials such as textbooks and television programs, or networking effects from having more highly educated friends and neighbors from whom to learn. In these models, the stock of human capital in the economy can grow indefinitely. Increases in human capital make physical capital more productive, which means that firms will always want to invest in additional physical capital. Accordingly, in equilibrium, total output grows in each period.

Even if one accepts that increases in the educational attainment of the population can lead to long-run output growth, the role of fiscal policy in achieving this growth cannot always be deduced directly from the models presented above. Indeed, in the human capital based growth models of Arrow (1962), Uzawa (1965), and Lucas (1988) there is no government sector and hence no fiscal policy. Even when workers in these models do not learn simply in the course of doing their regular jobs, they are willing to take some time away from production of output in order to acquire skills because the higher wages they will earn afterward are sufficient to compensate them for the opportunity cost of reduced current incomes. For government spending on education to be growth enhancing, it thus must be the case that this spending does not simply substitute for private spending, but instead leads to an increase in the consumption of education services. There are a number of reasons why this may be the case.

First, because of a lack of appropriate collateral, it is extremely difficult for many individuals to borrow to finance their education, even if their higher future wages would be sufficient to justify the expense of schooling.[9] Government financing of education is one method of ensuring access to education in the presence of imperfect credit markets.[10] Second,

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[8]For example, Lucas (1988) or the models in the appendix to this paper.

[9]Barham et al. (1995) develop a model in which individuals are unable to finance their education through capital markets and instead must borrow from their parents to pay for schooling. In their model, a poverty trap can exist whereby the savings of uneducated parents are insufficient to finance their children's education, resulting in a level of education in the economy that is below the social optimum. In their model, a system of lump-sum taxes and transfers can make it possible for children from lower-income families to finance their education and—if the education sector is sufficiently productive—for the economy to achieve the socially optimal amount of education.

[10]For example, in the United States at the end of 1989, the stock of direct federal loans to

as in some of the endogenous growth models, there may be externalities in education such that the benefits of education increase, or the costs decrease, the larger the number of people enrolled in school or already educated. These sorts of economies of scale are almost certain to exist in the provision of high-technology skills, for example. On a more basic level, there are externalities to society if, for example, education makes people better able to care for themselves. If private returns to education are small relative to the cost of schooling, but social returns are large, students will tend to underinvest in education relative to the social optimum. Subsidized public provision of education financed by a tax could ensure that the optimal number of people go to school for the optimal amount of time. Finally, in the case of on-the-job apprentice training, firms may be unable to recoup the full cost of training workers because they cannot be sure that their employees will not join other firms offering higher wages after they complete their training. In these circumstances, government funding may be essential for apprentice programs to operate. However, while each of these examples illustrates a justification for government subsidization of education, none requires that the government necessarily provide education itself.

In addition to education, government spending on health and nutrition can also lead to increases in the productivity of the workforce. Not only can spending on health and nutrition reduce illness and absenteeism, leading to increases in L, but it can also increase the capacity of the workforce to absorb education and learn new skills. Indeed, if workers learn by doing, then reducing absenteeism is identical to increasing the capacity of workers to acquire new skills and increase their productivity. As with education, however, it may be important both to distinguish among the various levels of health care, and to ensure that government funding does not simply replace private expenditure but actually increases access to services. For example, the externalities associated with primary health care and especially public health are likely to be much greater than those of tertiary care. Perhaps, the clearest example of this is immunization programs where the immunization of one individual confers a positive externality onto others by reducing the possibility that he will pass the disease to them. In general, the higher benefit/cost ratios of primary and public health care suggest that spending at this level is more likely to be growth enhancing than is spending on tertiary care at specialized hospitals. Similarly, food subsidies that are intended to improve the nutritional status of the population may be growth enhancing if they are targeted at malnourished groups, but are less likely to be so if they are untargeted.

There is a large body of statistical work, some of it dating back more than 30 years, that has sought to document the impact of educational attainment on labor productivity. Much of this work is microeconomic, attempting to estimate the effect of education on the wages of

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[10](...continued)
college students stood at more than $12.6 billion while the stock of federally guaranteed college loans stood at $48.5 billion. Together, these represented some 8 percent of all direct and guaranteed federal loans. Excluding federally guaranteed mortgage loans, they represented some 13 percent of the total (see Fries (1992)).

individual workers.[11] However, a number of studies have examined the extent to which increases in aggregate output can be traced to increases in the aggregate amount of education of a country's workforce. By using a "growth accounting" exercise based on a model like the one developed in Section I, Denison (1962) calculated that between 1930 and 1950, approximately 23 percent of the rate of growth of output in the United States was due to increases in the level of education of the workforce. In a subsequent study (Denison (1967)) he found that for the period 1950 to 1962, the contribution of education to output growth in the United States was somewhat smaller (about 15 percent) and that it varied considerably among countries, from about 2 percent in Germany to about 25 percent in Canada.

Nadiri (1972) applied these techniques to a sample of developing countries and found the contribution of education to output growth ranging from 16 percent in Argentina to less than 3 percent in Brazil, Mexico, and Venezuela. Working with cross section data, Bowman and Anderson (1963), Kaser (1966), and others have also demonstrated a positive correlation between per capita income and educational development.

Although intuition suggests that government **spending** on health and education (as distinct from the average **level of educational attainment** of the workforce) should have a positive impact on economic growth, studies that have investigated this link have not always been able to document it. Easterly and Rebelo (1993) draw on panel data[12] covering the 1960s through the 1980s for a sample of 119 countries (although data from the 1960s are available for only 36 of the countries) and find that public investment in education has a significant impact on per capita output growth for some specifications but not for others. They also find that public investment in health care does not significantly affect output growth in any of the specifications tested.

By contrast, in an analysis of data from 55 countries, Otani and Villanueva (1990) find that spending on education and health has a significant, positive effect on the rate of growth of output. Diamond (1989) finds that capital expenditure on social areas, including education, has a positive and significant effect on growth, although current expenditure on education has an insignificant effect. Castles and Dowrick (1989) find expenditure on education and health is insignificant in its effect on per capita output growth, but Hansson and Henrekson (1994) find that among OECD countries, higher government expenditure on education did lead to higher average private sector productivity growth in a sample of 14 countries covering 1965-82.

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[11]Psacharopoulos (1994) provides the results of a variety of these studies based on data from many developed and developing countries.

[12]Econometric work generally relies on three broad classes of data sets: time series, which typically report information for one country or individual over a period of years; cross sections, which contain a single observation (usually a point in time or period average) for each of a number of countries or individuals; and panel data, which merges the two to report in a single data set a series of observations for a number of countries or individuals.

These empirical results suggest that despite the theoretical support for the contention that public expenditure on health and education would have some positive effect on output growth, there is as yet no consensus about whether this effect can be demonstrated statistically.

Of course, since each of these studies examines data on different countries at different times, it is not surprising to encounter some inconsistencies in their results. Another possible explanation for the absence of a strong empirical link between spending on education and output growth is that although these studies treat education as a single, undifferentiated good, the benefit/cost ratio of education expenditure is likely to be much lower for university education than for primary education. Thus, the total amount spent by a country's government on education may not correlate very well with improvements in the overall educational status of its population if a large share of the education budget is directed to universities. Psacharopoulos (1994) reviews a large number of studies that have measured the social and private return to education in countries throughout the world and provides some evidence that this may be the case.[13] In grouped data for Africa, Asia, Latin America, the Middle East and North Africa, and the high-income countries, average social returns to primary education always exceed those for secondary education, which in turn exceed those for university education. In Africa, the average social returns to primary education are more than double those to university education, while in Latin America returns to primary education are about 50 percent greater than those to university education. However, because higher education is relatively more heavily subsidized than primary or secondary education, the average private returns to university education exceed those to secondary education in each region except the OECD countries. By one measure (the ratio of average private returns to average social returns), higher education in Africa is 70 percent more heavily subsidized than secondary education, and nearly 50 percent more heavily subsidized than primary education. Only in Asia and the OECD countries is primary education more heavily subsidized than university education. Even in these groups, the subsidy to university education exceeds that to secondary.

A similar argument applies to health care expenditure, where studies have looked at health care as a single good, even though the returns on primary and public health care may be much greater than those on curative services. As was the case with education, the amount that a country's government spends on health care may not correlate very well with improvements in the health status of its citizens if the health care budget is disproportionately allocated to services with lower rates of return. Such suboptimal allocations are in fact common in many countries. Thus, for example, the World Development Report 1993 (World Bank (1993)) calculates that while the average developing country spent $1 on public health, $6 on essential primary health care, and $14 on secondary and tertiary care in 1990, an optimal allocation of the same $21 per capita would have been to spend $5 on public health, $10 on primary health care, and only $6 on secondary and tertiary care.

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[13]These studies typically assume that the benefits of additional education are reflected in the difference between the earnings of people with more education and those of persons with less.

In addition, increased spending on education and health may take a long time, perhaps well over a decade, to generate productivity gains, weakening the empirical link between the two. For example, in the case of education it would take many years for students benefiting from increased school funding to pass through the educational system and join the labor force. Similarly, the benefits from increased spending on prenatal care may not materialize until years after the children receiving the care are born. Overall, the message from the empirical literature may therefore be that since increases in the educational attainment of the population do appear to lead to output growth, government spending on education should be directed to sectors where it would have the greatest impact on national educational achievement (measured in terms of its effect on aggregate productivity), usually primary education, and away from those where it would have the least, such as untargeted subsidies to university students. The appropriate mix would, of course, depend on literacy rates and other factors impinging on the relative returns to expenditure at different levels.

III. Fiscal Policy and Capital Productivity

As noted above, a second channel through which fiscal policy can influence output growth is through its effect on the productivity of capital in general (A in the framework of the introduction). An increase in the productivity of capital will increase output both directly, by increasing the amount of output that the existing capital stock can produce, and indirectly, by encouraging additional investment that increases the stock of capital. This section will examine two classes of fiscal policy that have been theorized to affect the productivity of physical capital: policies that encourage or discourage international trade; and the direct provision of productive inputs (such as physical infrastructure or defense and public order) by the government.

A. Trade and Productivity

One of the first contributions of the classical economists was to demonstrate theoretically the link between international trade and national incomes. However, while David Ricardo and the other classical economists were able to illustrate why countries that engage in international trade should be wealthier than those that do not, their theory was static in nature and therefore could not analyze the impact of trade on growth. In the language of growth theorists, the beneficial effects stressed by the classical economists were level, not growth, effects. In recent years, however, economists have devoted a significant amount of attention to the impact of international trade on the growth of domestic output, especially in developing countries. Within this literature, a consensus seems to have developed that for the most part, economies that are open to international trade grow faster than those that are not.

There are a number of reasons why relatively open economies might grow more quickly than relatively closed ones. Bardhan and Lewis (1970), Chen (1979), and Khang (1987) develop models in which the importation of capital goods allows developing countries to take advantage of technological changes occurring elsewhere. If innovations are embedded in new capital goods, then countries that restrict international trade, especially with respect to imports of capital goods, will restrict their access to technological improvements.

Competition from imports can also lead to increases in the rate of domestic innovation, with local firms forced to raise their own productivity to remain competitive with foreign producers. In addition, in relatively small markets, indivisibilities or fixed costs may make it unprofitable to adopt more efficient production technologies (see, e.g., Murphy et al. (1989)). Producing for the export market may make the adoption of some of these technologies profitable, thus increasing growth rates. Finally, import competition may force firms to operate more efficiently, meaning that economies adopting more open trade regimes would narrow the gap between actual and potential output, leading to temporary increases in the rate of output growth.

An extensive empirical literature supports the view that countries with more open trade regimes tend to grow more quickly than those with more closed regimes. Balassa (1978), Krueger (1978), and Bhagwati and Srinivasan (1979) all find that higher exports correlate positively with higher growth. Otani and Villanueva (1990) draw on a sample of 55 developing countries over the period 1970 through 1985 and find that export performance correlates positively, and very significantly, with output growth. Breaking their sample down into high-, middle-, and low-income developing countries, they find that the link between exports and output growth is strong for high- and low-income developing countries, but less so for middle-income developing countries. Villanueva (1993) looks at data for 36 developing countries over the period 1975 through 1986 and finds that the share of trade in an economy (exports plus imports divided by GDP) is significant in predicting output growth.

Other studies have gone beyond examining the correlation between exports, or exports plus imports, and GDP growth, either to look at other variables related to the degree of openness of an economy, or to try to identify more precisely the nature of the link between openness and growth. Knight et al. (1993) use panel data from 1960 through 1985 for a sample of 98 countries to examine the impact of tariffs on economic growth. They find that the weighted (by import share) average of tariffs on intermediate and capital goods has a significant effect on economic growth, with lower tariff countries growing more rapidly than high tariff ones. When they restrict their sample to 76 developing countries, the same result holds. Borensztein et al. (1994) look at the effect of foreign direct investment on economic growth and, in a sample of 69 developing countries covering the period 1970-89, find that the larger the share of foreign direct investment in total investment, the faster a country grows. They also find that increases in foreign direct investment in a country tend to generate increases in domestic investment, so that foreign investment "crowds in" domestic investment.

In a study of 89 countries covering the period 1960-85, Lee (1994) finds that countries that have a relatively high ratio of imported to domestic capital goods grow faster than countries that do not.[14] He also finds that when the ratio of trade to GDP is added to his regression, it is not significant, perhaps suggesting that it is not trade per se but rather the composition of trade that is important for output growth. He obtains the same results when he

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[14]This may be a reflection of the phenomena of convergence, since industrializing economies typically do not have domestic capital goods industries.

restricts his sample to 68 nonOECD countries. Finally, based on a sample of 90 countries over the period 1960 through 1985, Romer (1989) finds that countries that are open have higher levels of investment and capital growth, but do not have lower marginal products of capital. Since the marginal product of capital might normally be expected to decline as investment, and the stock of capital, increase, one implication may be that countries that are relatively open experience more technological growth than countries that are more closed.

While the preponderance of evidence indicates that economic growth and openness are highly correlated, this need not necessarily indicate that openness leads to growth. Indeed, it is certainly possible that as economies grow they tend to become more open, so that growth causes openness. For example, as countries grow they may be able to adopt lower cost, more efficient production technologies that allow them to compete in international markets. In practice, it is extremely difficult to determine causality through econometric techniques, and those studies that have attempted to do so for growth and openness have not yielded definitive results.[15] However, at the very least, it is clear that there is a strong correlation between rapid growth and openness, and there is a solid theoretical basis to believe that at least part of the causality runs from openness to growth.

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[15]Lately, some economists have attempted to examine the nature of the relationship between output growth and openness by looking for evidence of "Granger Causality." In brief, one event is said to Granger cause another (in the sense defined by Granger (1969)) if information about prior values of the first variable is useful in predicting the current value of the second. Thus, for example, rain Granger causes flooding, because information about levels of rainfall in the last few days is useful in predicting the likelihood of flooding today. With any two variables A and B, A could Granger cause B without B Granger causing A; B could Granger cause A without A Granger causing B; each could Granger cause the other; or neither one could Granger cause the other. Jung and Marshall (1985) examine data from 37 developing countries between 1951 and 1981 and find that in only four do exports Granger cause growth without growth also Granger causing exports. In 22 of the countries, they found no evidence of Granger causality between exports and growth in either direction. In a study of eight newly industrialized countries, Chow (1987) found that in only one did Granger causality run only from exports to growth. In six of the countries Granger causality ran in both directions, and in the remaining country there was no Granger causality in either direction. Ghartey (1993) finds that based on data from 1960 through 1990, output growth Granger caused export growth in the United States (but not vice versa), while export growth Granger caused output growth in Taiwan (but not vice versa). Based on a sample from 1955 through 1991, he found that Granger causality ran in both directions in Japan. While these results suggest that the assumption that openness leads to output growth should be treated with some caution, they should not be taken too seriously, since the definition of Granger causality is statistical and does not wholly correspond to what one typically thinks of as causality. Indeed, it is worth remembering that the flashing lights at the edges of a Washington metro platform Granger cause the trains to arrive.

B. Government Expenditure and Productivity

Government capital spending

A second potential source of increasing the marginal productivity of capital involves goods and services provided directly by the government. In much the same way that government provision of education and public health could increase the productivity of labor, leading to an increase in the supply of effective labor without influencing the size of the labor force directly, government provision of, for example, research and development or infrastructure could lead to increases in the supply of effective capital, without influencing directly the size of the private capital stock.[16] In the spirit of this approach, Barro (1990) develops an endogenous growth model in which final output depends on a constant returns production function involving private and government nonlabor inputs.

As noted earlier, firms or individuals in the private sector will tend to invest in physical capital until the marginal return they expect to earn from each successive unit of investment just equals its cost. In that case, it might appear that investments by the public sector will tend to be either unproductive—in the sense that their benefits will not exceed their costs—or will simply duplicate profitable investments that the private sector would have made anyway. It is difficult to see how either of these types of public investment would increase the productivity of the capital stock. The answer lies in understanding why it is sometimes the case that investments that would be productive from the point of view of the economy as a whole, with benefits that exceed their costs, might nevertheless be unprofitable from the point of view of a firm considering undertaking the investment.

Economists typically draw a distinction between "public goods," like clean air, national defense, or flood control, whose benefits cannot be restricted to those people who are willing to pay for them but instead accrue to everyone who lives in a particular region, and "private goods," (which include most consumer products and services) that have benefits that can fairly easily be restricted. The problem for an individual considering an investment in a public good is that even if the benefit that individuals would receive collectively from the investment would exceed its cost, so that it would theoretically be profitable, in practice it would be very difficult to earn any return on the investment because other individuals would receive the benefits from the investment whether they paid for them or not. Unlike private investors, the government has the power to compel payment through taxes, even for the consumption of public goods. Accordingly, there are some investments that might be profitable for the government to undertake that might not be so for an individual entrepreneur. If the investment in question is for a public good that would permanently raise the productivity of the private

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[16]Government investment could indirectly increase the size of the private capital stock, however. When the marginal product of private physical capital increases, some investments that in the past were not profitable will now be so. As a result, the size of the private capital stock will increase until the risk-adjusted rate of return on physical capital declines to equal the interest rate once again.

capital stock, then government investment in physical capital could have a positive impact on the long-run growth rate of output.[17] [18]

A number of studies have looked at the effects of government capital expenditure on output growth. Overall, the results have been mixed. Landau (1986) draws on data covering 65 countries over the period 1960-80 and finds that government capital expenditure generally has no significant effect on output growth. Knight et al. (1993) find that the ratio of public investment to GDP is not a significant factor in determining the rate of output growth in their sample of 81 developed and developing countries covering the period 1960-85. However, when they restrict their sample to 65 developing countries, they find that the public investment/GDP ratio is significant.[19] On the other hand, Cashin (1994) finds some evidence that in a sample of 23 OECD countries covering the period 1971-88, the share of government investment in GDP has a significant positive effect on per capita output growth. Using data on 39 Sub-Saharan African countries between 1986 and 1992, Hadjimichael et al. (1995) find that government capital spending has a significant positive effect on both per capita output growth and private investment.

As with studies of the impact of health and education expenditure on growth, some dispersion of results is a natural outcome of differences in data sets and specifications. However, these mixed results may also be due in part to the fact that the studies cited above have not generally attempted to distinguish among the various possible categories of government capital expenditure. As noted earlier, government capital investment will only

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[17]As noted in the earlier discussion of government expenditure on education, however, these arguments support government provision of public goods but not necessarily government production of them. As with education, it may be possible for the government to provide subsidies to the private sector to ensure that an optimal supply of the public good is achieved without directly undertaking any investments itself.

[18]A second reason that theoretically profitable investments might not be made arises when the productive technology for a good or service involves a natural monopoly, one that arises because a technology involves decreasing average costs. If the monopolist is producing a good or service that increases the productivity of the stock of capital, the tendency of monopolists to produce too little, and at too high a price, relative to the social optimum may retard the rate of output growth. In that case, if government regulation of the monopoly is impracticable, government investment to provide the good or service directly could lead to increases in the rate of output growth. This begs the question of how a government that cannot regulate a service could nevertheless be capable of producing it.

[19]They speculate that this difference arises because the important variable for growth is the stock, not the flow of public capital. Because the stock of public capital is much lower in developing than in developed countries, the flow of public capital, they argue, is a much better proxy for the stock in developing than in developed countries. It may also be that the "public good" type of investment has already been fully exploited in the developed country group.

lead to increases in the rate of output growth if it is directed to projects that would increase the productivity of the capital stock but that the private sector could not profitably undertake itself. Thus, there is no reason to expect that aggregate government capital expenditure should have a positive impact on growth. To address this problem, Easterly and Rebelo (1993) draw on a sample of 119 countries covering the 1960s through the 1980s but differentiate among the various categories of government investment. They find that government investment in transport and communication is positively related to growth (with a very high coefficient), while investment in public enterprises has no effect on growth, and government investment in agriculture has a negative effect on growth. They also find that increasing public investment in transport and communications has no effect on the level of private investment, suggesting both that there is no crowding out of private investment in these areas, and that this type of investment increases the social returns to private investment but not private investment itself.

The significant effect of investment in transportation and communications on output growth is striking, and is consistent with theoretical predictions, since this type of investment meets many of the criteria that are conjectured to be necessary for government investment to be growth enhancing. The benefits of improved transportation and communications may be difficult to restrict to those who are willing to pay for them. Transportation and communications investments may also involve large fixed costs, which implies that they will have decreasing average costs and thus will often have the characteristics of natural monopolies. As an example, consider that once a bridge is built it costs little more for 1,000 cars per day to use it than for 10 to do so. Moreover, the tariff that a monopolist who had privately financed the bridge would charge would exceed the social optimum, since at a price equaling the marginal cost (of nearly zero) he could not earn any profit. Each of these investments, by increasing the mobility of labor and capital and enhancing the ability of firms to communicate with each other and with foreign suppliers and purchasers, could be expected to increase the productivity of capital. However, these and other public infrastructure investments might never be undertaken except by the government.[20]

A number of studies have attempted to investigate empirically the effect of government infrastructure investments on private sector productivity and growth. Using time-series data for the United States, Aschauer (1989), Munnell (1990a), and Holtz-Eakin (1988) report significant and positive values for the elasticity of public infrastructure investment and growth, on the order of 0.3 to 0.4. Ford and Poret (1991) estimate an elasticity of 0.45 from their cross-section data on nine OECD countries. Diamond (1989) studies 38 developing countries using data covering the period 1980-85 and finds that capital expenditure on infrastructure has a significant, positive impact on output growth. Berndt and Hansson (1992) find, in their analysis of Swedish data, that infrastructure investment has a significant productivity effect, leading to lower labor requirements for firms. However, Hulten and Schwab (1991a) and Tatom (1991) find no statistically significant relation between infrastructure capital and output growth in the United States. Using data from American states, Munnell (1990b), Costa et al. (1987), and Mera (1973) all report positive, but smaller,

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[20]Or, as noted above, without government financial support.

elasticities (on the order of 0.15 to 0.2), while Hulten and Schwab (1991b) and Holtz-Eakin and Schwartz (1994) find that infrastructure investment by states has little explanatory power regarding their growth experience.

Nadiri and Mamuneas (1994) adopt a more disaggregated approach, drawing on data from American states covering the period 1956-86, to look at the effect of public infrastructure investment not on aggregate productivity but rather on productivity in 12 different two-digit industries. In theory, this approach would allow for the possibility that public infrastructure investment is important for some industries but not others, which could explain the low aggregate elasticities found in the previous studies. They find that infrastructure investment has a positive effect on total factor productivity in each of the manufacturing industries they study, but that the elasticities tend to be small. Feltenstein and Ha (1995) use data on Mexican infrastructure investment between 1970 and 1990 and examine its impact on cost functions in 14 different sectors of the economy. They find that infrastructure investments in electricity and communications generally reduce costs in other sectors, but that investment in transportation infrastructure generally increases costs. Shah (1988), however, using data on 34 Mexican industries between 1970 and 1983, finds that public infrastructure spending has a significant, positive, but small effect on output.

Overall, the results give only weak support to the idea that government infrastructure expenditure has a significant effect on output growth. In some studies, the effect is significant and relatively large while in other studies it is neither. Part of this mixed message may be due to the fact that existing empirical studies have, by necessity, relied solely on quantitative rather than qualitative measures of government investment. Unfortunately, the quality of infrastructure investments is not uniform around the world, or even within individual countries and states, and quantitative data on infrastructure investment will not always give an accurate impression of increases in the value of public capital. For example, infrastructure investment to construct a second airport in a city when the first airport is operating well below capacity may have a negative impact on productivity growth, while a much less expensive investment to widen a highway suffering from congestion problems could dramatically increase productivity. Without controlling for the quality of public investment, studies of the impact of the quantity of investment may always be inconclusive. In addition, it is worth noting that even accepting the results of studies reporting relatively larger elasticities, the growth effects of plausible increases in infrastructure investment would still be fairly small: if the elasticity were 0.3, a permanent 10 percent increase in such spending would increase the rate of output growth only from, for example, 3.0 to 3.1 percent per year.

Transfers, defense, and public order

The previous subsection discussed studies of the impact on growth rates of government spending on physical infrastructure, but there is a second type of expenditure that governments typically provide that may also have an important growth-enhancing effect. This type of spending is sometimes described as maintaining the social fabric, and consists of transfers to disadvantaged individuals, spending on defense and public order, and the maintenance of a civil service that is sufficiently trained and staffed to carry out the basic

responsibilities of government. To date, the number of empirical studies that have investigated the effects of government spending on these areas is somewhat limited, in part because the appropriate level of expenditure on variables like defense and transfer payments is likely to depend heavily on the extent to which a country perceives an external threat, or the degree of political and social cohesion of the population, which vary greatly among countries and, therefore, make generalization hazardous. These variables are also difficult to quantify.

There are a number of reasons why spending to maintain the social and political order may increase the productivity of the capital stock. In an economy where there is a risk of loss of property either from expropriation or theft, transactions costs are likely to be extremely high, and a good deal of expenditure is likely to be directed to what are essentially unproductive activities (such as crime or security services). Such an environment discourages investment, because of the risk that the gains will be lost or stolen, and because it diverts resources from more productive but less secure to less productive but more secure investments. In particular, investment in physical plant and equipment would be discouraged by the risk of political or social upheaval. The investment that does occur will tend to be of a short-term nature, since it will be perceived to be less risky, and potentially productive long-term investment may be foregone.[21] Innovation might also suffer, since there is a greater risk that the benefits of an innovation would be stolen or expropriated before its costs had been recuperated. Torstensson (1994), Sala-i-Martin (1992), and others develop models based on these conjectures. For example, in Sala-i-Martin's model transfer payments from the wealthy to the poor discourage crime and thereby encourage investment.[22]

Several studies have attempted to examine the link between political or social stability and economic growth. Barro (1991) finds that measures of political unrest—the number of assassinations and the frequency of violent revolutions and coups—have significant, negative effects on growth. Alesina et al. (1992) find that in a sample of 113 countries covering the period 1950-82, countries that have high propensities for governmental collapse grow significantly more slowly than those that do not. They find that this result holds both for "regular" changeovers, involving only minor ideological shifts, and for those that are irregular and involve fundamental changes in ideology. They also present evidence that the causality runs from instability to slow growth rather than from slow growth to instability, in that while government changes have a significant, negative impact on growth in their simultaneous equations estimates, neither current nor lagged growth has a significant effect on the

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[21]However, the risk of social and political upheaval could actually increase the skill level of the labor force, with individuals choosing to invest in more easily transportable human capital rather than in physical capital.

[22]Cashin (1994) suggests another reason why government transfer payments might increase the rate of output growth. If the presence of a social safety net encourages less-able workers to drop out of the workforce, the average skill level of workers will increase. Thus, transfer payments would increase the productivity of labor, not that of capital.

probability of a government change.[23] Easterly and Rebelo (1993) examine data from 74 countries from 1970 through 1988 and, like Barro, find that the number of assassinations per million population has a significant, negative effect on per capita GDP growth.

Other studies have examined the relationship between other indicators of political stability and bureaucratic efficiency and growth. Brunetti and Weder (1994) use questionnaires to determine the attitudes of private entrepreneurs about the stability of political institutions in 28 developing countries during the 1980s, and find that this subjective measure of stability is significantly and positively correlated with output growth. Mauro (1996) examines subjective indices of corruption, bureaucratic "red tape", and other factors for a sample of 68 countries between 1980 and 1983 and finds that the level of corruption has a significant, negative effect on investment and output growth.[24]

Transfers

The above studies have suggested that there is a strong link between social and political stability and economic growth. A number of papers have examined the extent to which fiscal policies that might contribute to stability can also be linked to growth. Sala-i-Martin (1992) looks at data from 75 countries and finds that after controlling for the overall size of the government sector, public transfers have a positive effect on per capita income growth. Barro (1989) obtains a similar result, although he questions whether the causality runs from transfers to growth or in the opposite direction, with countries that grow faster simply being able to afford more generous social assistance schemes. Cashin's (1994) OECD study suggests that the level of government transfers has a significant and highly positive effect on per capita output growth, although he does not control for the total level of government expenditure. However, Diamond (1989) finds that current social spending (in which he includes not only welfare and social security expenditure but also current expenditure on health, education, and housing) has no significant effect on growth in a study of data from 38 countries covering the period 1980-85. In addition, Hansson and Henrekson (1994) look at industry data for 14 OECD countries from 1965-82 (using period averages) and find that the share of transfers in GDP has a significant negative effect on private sector total factor productivity, with a 10 percent increase in spending on transfers implying a decrease of about 0.8 percent in the annual growth rate. Their results may differ from those of Barro (1989) and Sala-i-Martin (1992) because they look only at wealthier countries. In addition, although one would expect that increases in private sector total factor productivity and in output growth rates would be related in the long run, this need not be the case in any given year.

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[23]However, when they restrict their attention to coups, they do find that current low growth increases the probability that a country will experience a coup.

[24]Mauro (1997) provides an interesting discussion of the economics of corruption, as well as the results of some empirical work on corruption and growth.

Alesina and Rodrik (1991) and Persson and Tabellini (1991) both found a negative relationship between the degree of income inequality in an economy and its rate of per capita output growth, a finding that points to a potential role for transfers in fostering growth. Apart from its impact on political stability, income inequality could also affect growth adversely by contributing to poor health (and thus low productivity) among the poor and by discouraging schooling.

Defense

A number of studies have examined empirically the impact of defense spending on output growth. As noted earlier, defense spending could have a positive impact on economic growth if it provided for increased political stability (either from external or, presumably, internal threats). In addition, defense spending could raise the productivity of capital and, hence, output growth, if there are significant "spin-off" effects. For example, military expenditure could lead to more rapid technological advancement, either through increased research and development or through the importation of capital goods that have technological change embodied in them. In addition, military expenditure could involve the creation of infrastructure that would also be available for the private sector, such as roads and airports. If productivity is higher in the military sector of the economy than in the nonmilitary, increased spending on defense would raise output growth by shifting resources into more productive areas. Finally, defense expenditure could also raise the productivity of labor by providing education and other forms of human capital to soldiers, many of whom would eventually enter the civilian labor force.[25]

Balanced against these are the risks that military expenditure could reduce the volume of savings available to finance private capital accumulation, could lower the volume of foreign exchange available to finance imports of nonmilitary capital goods, could restrict human capital development by cutting into spending on health and education, and could limit government spending on civilian infrastructure.[26] Thus, there is no a priori reason to predict that the effect of military spending on output growth would be either positive or negative, except perhaps that small amounts of military spending would enhance growth, with the effect diminishing or even becoming negative as defense expenditures grow.

The failure of theory to provide a straightforward prediction about the effect of military expenditure on output growth is to some extent echoed by the empirical literature that

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[25]Of course, even if these "spin-off" effects of defense expenditure exist, military spending may not be the most cost-effective method to achieve them. For example, apprentice programs may be more efficient than military training in providing teenagers with human capital that will be valuable to civilian employers.

[26]Strictly speaking, these factors do not relate to the effects of defense outlays per se but rather reflect the effects of reducing other expenditures to accommodate increased defense expenditure.

has investigated the matter, although most studies have found a negative or, at best, insignificant effect on growth. One exception is Benoit (1978), who examines data from 44 less-developed countries from 1950 through 1965 and finds that defense expenditure correlates positively with per capita output growth. However, using a sample of 54 countries covering a different time period (1965-73), Lim (1983) finds a negative relationship between military expenditure and growth. When he divides his sample by regions, he finds a negative relationship between military spending and output growth in Latin America and Africa, but no significant relationship between the two in Asia or the Middle East. Faini et al. (1984) examine data from 62 countries covering the period 1952 through 1970 and find that military expenditure has a negative impact on output growth, investment, and the share of agriculture in total output, as well as no significant effect on the share of manufacturing in total output.

Biswas and Ram (1986) find, using data from 55 countries over the period 1960-77, that military expenditure has no significant effect on output growth. They go on to examine some of the arguments regarding the possible beneficial impact of military expenditure on output growth, and find little empirical support for them. They reject the hypothesis that there are important spin-offs from military expenditure, finding that defense spending has no significant effect on productivity in the civilian sector. They also reject the hypothesis that military expenditure could shift investment from lower- to higher-productivity industries, finding no significant difference in productivity between the civilian and military sectors in their sample. Deger (1986) looks at data from 50 LDCs from 1965 through 1973 and finds that while military expenditure has a positive and significant direct effect on output growth (presumably through its spin-off effects), this is more than offset by its negative effect on domestic savings. Thus, the overall effect of military expenditure on output growth is negative.

More recently, Landau (1993) examines the possibility that the impact of defense spending on output growth is nonlinear, with relatively low levels of defense spending enhancing output growth, but relatively high levels of military expenditure inhibiting growth. Looking at data from 71 countries between 1969 and 1989, he finds that this is in fact the case, with a positive relationship between military expenditure and output growth holding until defense spending reaches about 4 percent of GDP and a negative relationship taking over at about 9 percent of GDP. This result, however, is heavily influenced by a relatively small number of countries in his sample.[27] He also rejects the hypothesis that military expenditure crowds out private investment or government expenditure on education, health, or infrastructure. In fact, for subsamples restricted to Latin America and to Africa, he finds a significant, positive relationship between military expenditure and the share of government education and health expenditure in GDP.[28]

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[27]The relationship between military expenditure and output growth becomes insignificant at any level of spending when the Eurasian and North African countries are dropped from his sample.

[28]This result might imply that countries that have large military expenditures also tend to have

(continued...)

Hewitt (1991) also rejects the notion that military expenditure crowds out social spending, finding in a study of panel data from 125 countries covering the period 1972-88 that autonomous increases in military expenditure lead to equivalent increases in total government expenditure, leaving spending on other categories unaffected. By contrast, a study reported in Bhatia (1988) that examines data from 69 developing countries between 1950 and 1960 finds that increases in military expenditure were associated with decreases in overall investment, agricultural production, government social expenditure, and economic growth. Knight et al. (1995) use panel data on 79 countries covering 1971-85 (using five-year period averages) and find that the ratio of military spending to GDP has a negative and significant effect on output growth and on the ratio of investment to GDP.

Overall, the empirical literature seems to suggest that the relationship between military expenditure and output growth is either negative or insignificant. However, there is a clear consensus that increased political instability reduces output growth. To the extent that some limited amount of defense spending is required to maintain this stability, a minimal volume of spending on defense, which will vary on a country-by-country basis, should contribute to output growth. The empirical evidence reviewed above suggests that defense spending in many countries may exceed that essential limit, although whether this has had negative (or simply no) implications for growth is unresolved.

Government sponsored research and development

There is a large volume of literature documenting the importance of research and development (R&D) investment for productivity growth at a firm and even at a national level (Griliches (1991) provides a summary of many of these papers). However, the set of papers that has examined the extent to which cross-country differences in R&D investment can explain differences in country growth performance is relatively small. Lichtenberg (1992) draws on a sample of 98 countries covering the period 1960-85 and develops a model where output is a function of human and physical capital, labor, and the stock of research and development. He finds that the coefficient on average R&D investment (as a percentage of GNP) is positive and significant in a regression where the dependent variable is the level of GNP in 1985. He obtains the same result when the dependent variable is the average rate of growth of GNP between 1960 and 1985. However, when he disaggregates the R&D data to separate privately sponsored R&D from government sponsored R&D in his regressions, he finds that the coefficient on government sponsored R&D is not significant in either regression.[29] Birdsall and Rhee (1993) examine data from 21 OECD countries and 19 developing countries, covering the period 1970-85. In addition to the ratio of R&D

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[28](...continued)
either higher tax burdens, higher deficits, and/or lower nonsocial expenditure than countries that spend less on the military.

[29]In fact, the coefficient on government sponsored R&D is even negative in some of the specifications Lichtenberg estimates.

investment to GDP, they also include in some of their regressions data on the number of scientists and engineers engaged in R&D, which they interpret as a proxy for the stock of R&D capital. In contrast to Lichtenberg, they find that spending on R&D as a share of GDP is not significant in explaining output growth per capita either for the full sample or when the sample is divided into OECD and developing countries. When they disaggregate R&D investment into publicly and privately funded, they find that neither is significant. The number of scientists and engineers engaged in R&D activities—whether expressed as a percentage of the population or directly—is significant for the sample of OECD countries, and for the aggregate data set, but not for the developing countries as a group. Working with a data set covering 73-80 countries (depending on the specification tested) between 1960 and 1988, Gittleman and Wolff (1995) obtain a similar result, with measures of R&D activity having a significant effect on average per capita GDP growth only in the subsample of industrial market economies and not among middle- or lower-income countries. When they divide their sample by decades, they find that the percentage of the population that is scientists or engineers engaging in R&D activities has a significant effect in each of the time periods for the industrial market economies, but that spending on R&D as share of GDP was significant in these economies only in the 1960s.

One interpretation of these results is that R&D activity has a significant effect on output growth only when a country has passed a threshold and achieved a sufficient level of development. Under this scenario, developing countries undergo technological change not by extending technical boundaries themselves but rather by copying and implementing innovations made in more developed countries. Some support for this interpretation comes from Coe and Helpman (1993) who look at data from 21 OECD countries plus Israel over the period 1970-90 and who include in their model not only domestic R&D but also R&D activity in other countries in the sample. For each country in the sample, they construct an "imported R&D" variable that equals the trade-weighted share of R&D activity among its trading partners. They find that both domestic and imported R&D have a significant effect on growth in total factor productivity. However, they also find that for the smaller OECD countries imported R&D has as important an effect on productivity growth as does domestic R&D. Only in the G7 countries does domestic R&D contribute more to productivity growth than does R&D activity among trading partners. One implication of this interpretation is that in middle-income and developing countries, a growth-enhancing fiscal policy would not involve government subsidies to research and development—either direct or implicit—but rather policies to foster domestic competition and encourage the importation of new technologies and capital goods. Even among industrial market economies, the evidence suggests that differences in the level of government sponsored R&D do not have significant effects on output growth.[30]

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[30]Indeed, in some studies the point estimate for the effect of government sponsored R&D is negative. One possible explanation could be that government sponsored R&D may be concentrated in areas like defense, that lead to innovations that may not be captured well by national accounts data. In fact, some types of government sponsored R&D, for example, in

IV. FISCAL POLICY AND THE COST OF CAPITAL AND LABOR

This section considers the effect of an economy's tax structure on output growth. Because the effects of taxes on economic activity are pervasive, its potential scope is extremely broad. Rather than attempt to provide a detailed analysis of the impact on economic growth of every possible form of taxation, this section will instead provide a very brief account of the theory of how taxes on labor income, capital income on particular inputs, and on expenditure might affect economic growth. It will then survey the empirical work that has examined these effects.

A. Theory

Increases in the level of output per worker can be decomposed into four factors: increases in the volume of capital per worker, increases in the average productivity of that capital, increases in the amount of labor supplied by each worker, and increases in the average productivity of the labor force. If taxes are to affect output per worker, therefore, they will do so by altering one of these factors. Specifically, taxation can have an impact on per capita output through the following channels:

- Taxation of labor income (primarily through the personal income tax) reduces the benefit of additional time on the job without typically altering its opportunity cost—the leisure foregone—which would tend to reduce labor supply. However, it also reduces real income which would tend to increase labor supply.

- Taxation of labor income reduces the return workers enjoy from the acquisition of additional skills, which may lead to a decline in the average quality of the labor force. Conversely, the introduction of tax exemptions for certain kinds of education and training expenses may increase the benefit of acquiring skills, tending to increase labor quality.

- Taxation of capital income (through personal income taxes, capital gains taxes, etc.,) may reduce the return to saving and may lead to increases in current consumption, tending to reduce the pool of savings available to finance new investment. By contrast, taxes on consumption may encourage saving and lead to increases in the stock of capital.

- The tax treatment of enterprise and corporate income can affect the investment decision through its impact on the cost of capital. Differential rates of taxation on different assets may also induce savers to reallocate their portfolios and enterprises to reorder their investment priorities and, thus, may affect growth by encouraging investment in some sectors and discouraging it in others.

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[30](...continued)
environmental matters, may improve welfare but reduce standard measures of output.

- Differential rates of taxation on the output of certain industries (e.g., through excise taxes and tariffs) will alter the allocation of factors of production among sectors of the economy, which could have a growth impact if some sectors of the economy experience more rapid technological change or are subject to increasing returns to scale. Moreover, differential rates of taxation on the output of industries, or on the use of inputs in different industries, can have effects on the rates of return on capital and labor that can encourage or discourage human or physical capital formation.

Virtually all taxes distort economic activity. Consequently, they are best viewed as necessary evils to finance government expenditure or as an indirect means of improving social welfare. It should also be noted that because the distortionary effects of a tax depend on the economic environment in which it is applied, there are strong interactions among taxes themselves, and it is therefore important to look at a tax code as a whole and not to focus too much on any single tax. In open economies, even the tax codes of trading partners and competitors need to be considered.

Taxation of labor income

Although conventional wisdom holds that increases in the taxes on labor income reduce the volume of labor supplied to the economy, in fact the theory suggests that in some cases increases in income tax rates could increase the supply of labor. If individuals are free to vary the amount of labor they supply,[31] they will normally continue to work until the marginal benefit of additional labor, the after-tax wage they receive, equals the marginal opportunity cost of working, the value to them of the extra leisure that they have just given up. If the tax on labor income increases, the marginal benefit of working an extra hour declines but the marginal cost (in terms of foregone leisure) does not, so that the increase in the tax will induce workers to substitute leisure for labor at the margin.

At the same time, the increase in the tax rate will lower the incomes of workers. If leisure is a "normal good" (i.e., if people tend to consume more of it as their incomes rise, and less as their incomes fall), then the decline in income will encourage workers to supply more labor. Therefore, an increase in income taxes will produce two effects on labor supply:

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[31]Often, primary workers are believed to be less able to vary their hours than are secondary workers (who include spouses reentering the workforce after childrearing). According to this argument, most primary workers are offered no option other than the standard 40-hour work week, and so cannot adjust their hours worked in respond to wage changes. However, this argument does not explain why firms are unwilling to offer their employees shorter shifts, since doing so would presumably enable them to attract labor at reduced wages. One possible explanation could be the presence of fixed costs in employing workers, for example, for bookkeeping, that make it impractical to hire a larger number of workers but employ them on shorter shifts. It is also possible that part-time workers would exhibit less loyalty to their employers, and so increase turnover and its associated costs.

a "substitution effect" that tends to reduce hours worked, and an "income effect" that tends to increase them.

Theory by itself cannot determine which of the two effects will dominate, and, therefore, whether increases in income tax rates increase or decrease the supply of labor. That said, it may be possible to determine the likely impact of various alternative tax structures on labor supply without having to know the exact magnitudes of the income and substitution effects prevailing in an economy. The substitution effect depends on the marginal tax rate, the amount of tax taken out of the last dollar earned, while the income effect depends on the average tax rate, the total amount of tax taken from a worker's income. Therefore, a tax system with high marginal rates but low average rates will discourage the supply of labor more than will a system with higher average rates but lower marginal rates. In fact, if one abstracts from issues of equity and considers only labor supply, a regressive tax system, with marginal tax rates that decline as incomes rise, would be preferable to a progressive one that raises the same total revenues.

A similar type of analysis can be applied to consider the effect of taxation on human capital development. Assume that individuals acquire education or training until the point where the marginal benefit of additional schooling—the extra wages a worker will command—precisely offsets its costs, viz., school tuition plus any earnings foregone while in school. In that case, an increase in the marginal tax rate will tend to reduce both the benefits of acquiring skills and their costs. However, as long as tuition costs are greater than zero, then the benefit of higher future wages must always exceed the cost of current foregone wages, and any permanent increase in the personal income tax rate that leaves school tuition unchanged will have a greater impact on the marginal benefits than on the costs of education. Thus, increases in the marginal income tax rate will tend to reduce the average level of human capital in an economy.

In an economy with a highly progressive tax structure, the marginal benefits of additional education will decline more quickly than in one with a more regressive tax structure, and the average level of human capital will tend to be lower.[32] By contrast, a change in the tax code that allows workers to deduct their educational expenses, if it is not accompanied by an increase in marginal tax rates or by an increase in educational charges due to supply constraints, will reduce the costs of acquiring education without an offsetting decline in its benefits, tending to increase the level of human capital in the economy. In models that depend on workers continually acquiring new human capital or on increasing social returns from the level of human capital in the workforce in order to generate perpetual

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[32]On the other hand, the redistributive effects of a progressive income tax could lead to increases in the stock of human capital. As noted in the section on transfers, income inequality could lead to poor health status and low educational achievement among the disadvantaged.

increases in per capita output, any tax that affects the average level of skills in the labor force will affect the long-run rate of per capita output growth.[33]

Taxation of capital and corporate income

Like taxes on labor income, taxes on capital income also distort the marginal conditions for equilibrium, this time possibly leading to a decline in the rate of saving (or investment) in an economy and in the equilibrium stock of capital. To save is to postpone current consumption. If taxes on income from savings are increased, the price of future consumption relative to current consumption is increased. Thus, current consumption is encouraged and savings will tend to decrease.

As in the analysis of the labor supply decision, however, an increase in the rate of tax leads to a decline in the real income of the representative individual. If current consumption is a normal good, it will tend to fall and the rate of savings will tend to rise. As with a tax on labor, the effect on savings of a tax on capital income is therefore ambiguous, depending on the relative magnitudes of offsetting income and substitution effects.

As noted in Section I of the paper, in the neoclassical model of economic growth, changes in the rate of savings have no effect on the long-run rate of per capita output growth, although countries with higher savings rates will have higher levels of per capita output. However, many endogenous growth models feature increasing social returns to scale in physical capital. In these models, a change in the rate of taxation of capital incomes that leads to changes in the per capita stock of capital would have a permanent effect on the per capita rate of economic growth.[34] In addition, as also noted in Section I, if convergence to the steady state is slow, taxes on capital income could affect observed growth rates for a very long time even in the neoclassical growth model.

The impact of the tax code on corporate income and profitability is a complex subject. Economists are chiefly concerned by the impact of the tax code on the marginal effective tax rate (METR), which is given by the gap or "wedge" between the after-tax real cost of capital and the before-tax cost of capital. The greater the wedge, the higher the before-tax rate of return has to be for the marginal investment project to pay for itself. Consequently, changes to the tax code that increase the wedge ought to discourage investment, at least until before-tax profitability has increased by enough to offset the impact of taxation on the cost of capital.

In addition to the statutory rate of tax on corporate profits, the METR of an investment will depend, inter alia, on the tax treatment of depreciation and other noncash

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[33]Preferential tax treatment of educational expenses would have effects similar to those of a subsidy for schooling which were discussed in the section on expenditure.

[34]The effect of capital taxation on output growth rates is illustrated mathematically in the attached appendix.

expenses, as well as the nature of any limits on the deductibility of interest expenditure. Under a classical profits tax, where interest is deductible but no deduction is allowed for the cost of equity capital, the METR will vary with firms' debt/equity ratios and with the rate of inflation. It should also be noted that evasion further affects the METR.

In no country are all forms of capital or corporate income taxed equivalently. For example, tax holiday provisions typically exempt from taxation income from relatively new capital investment but not income from older investments. Income from investment in certain sectors, for example, housing or environmental protection, may be given more favorable treatment than income from investment in other sectors with a corresponding difference in the METRs on investments in the two sectors. As for capital income, dividend payments may be treated differently than interest income. This discriminatory treatment of certain kinds of investment or saving has the potential to lower substantially the average rate of return to investment.

Production and consumption taxes

A proportional tax on consumption, such as a sales tax or value-added tax, does not alter the relative price of present versus future consumption and, as such, should not affect the incentives to invest in human or physical capital. On purely theoretical grounds, there is no particular argument for a uniform sales tax rate, although in practice the information needed to determine precisely how the tax rate should be differentiated will not be available, while the lack of uniformity can seriously complicate tax administration.

Of more direct relevance to the consideration of its impact on growth, however, a production or consumption tax that is not applied uniformly can lead to changes in the allocation of inputs among sectors of the economy. If these taxes tend to shift factors into sectors that are subject to more rapid technological growth or to increasing returns to scale and out of sectors that are not, this could have an impact on the long-run rate of economic growth. It could also lead to changes in the rewards paid to various factors of production, which might themselves have an effect on the long-run rate of output growth.

For example, suppose that a tax is levied on a good whose production is relatively capital intensive. If the tax leads consumers to substitute away from the good, relatively more capital than labor will be freed from production of the taxed good to find employment in other sectors of the economy. This will tend to reduce the relative price of capital in the economy, possibly leading to a fall in the savings rate. As noted above, in many endogenous growth models this would imply a decline in the long-run rate of per capita output growth.

Alternatively, suppose that a tax is applied only on the use of a particular input in a particular sector, for example, on physical capital in the manufacturing sector. The tax will tend to raise the price of manufactured goods, which will lead consumers to substitute away from them and toward the output of the other sectors of the economy. As noted above, if the manufacturing sector is relatively capital intensive, this will tend to decrease the relative price of capital in the economy, while if it is relatively labor intensive, it will tend to reduce the

relative price of labor. At the same time, within the manufacturing sector, firms will tend to adopt more labor-intensive production technologies, freeing up capital to be used in other sectors of the economy and decreasing its price. Thus, if the manufacturing sector is relatively capital intensive, the tax on capital employed in that sector unambiguously reduces the price of capital throughout the economy. However, if the manufacturing sector is relatively labor intensive, the effect of the tax is ambiguous and could actually make capital relatively better off and labor relatively worse off. More generally, a tax on any one factor in any one sector will tend to affect the returns to all factors in all sectors of the economy, with growth effects that may be ambiguous.

Open economy considerations

Thus far, we have implicitly been analyzing a closed economy. When we modify the analysis to look at the effects of different types of taxes in an open economy, however, many of our results continue to hold. Assume that the economy in question is small, and takes both the global real interest rate and the prices of traded goods as given. In a closed economy, we found that a tax on capital income could either increase or decrease the rate of saving in the economy, depending on the relative sizes of the income and substitution effects. In an open economy, the introduction of the tax will lower the domestic after-tax return on capital, making overseas investment more attractive than domestic. Thus, the tax will not lead to a decline in the savings rate, but rather will engender an outflow of domestic capital until the after-tax domestic marginal return on capital equals the global interest rate. If labor is not fully mobile, the decline in the domestic capital stock will unambiguously decrease labor incomes, which may actually lead to an increase in the domestic savings rate through the income effect. The fall in the domestic capital stock will reduce the rate of output growth transitionally in the neoclassical model and permanently in some endogenous growth models.

In open economy versions of each of the examples discussed above, tax policies that were assumed to lead to decreases in the rate of saving will instead lead to outflows of domestic capital and reductions in the incomes of labor, until the real after-tax domestic marginal return on capital equals the global real rate of interest.

Taxation and the underground economy

High rates of income taxation can lead to the development of "underground" economies and encourage evasion. In addition, Tanzi (1994) notes that tax systems with arbitrary exemptions and other distortive features are likely to increase the degree of corruption in an economy. By distorting the flow of human and physical resources between heavily taxed formal activities and relatively untaxed underground activities, high tax rates could reduce the level of output and the stock of physical capital. This effect is reinforced to the extent that individuals dedicate some portion of their productive resources to evasion rather than to more directly productive activities.

Corruption can also reduce the rate of growth by its distorting impact on resource allocation. It can do this by breaking the relationship between the social rate of return to an

investment and its financial return. The prospect of bureaucratic "rents" can also promote an excessive interest in public sector employment at the expense of more productive private sector employment.[35]

The basic message of this survey is that the effects of taxes on economic growth are numerous and ambiguous. Taxes on labor income may increase or decrease work effort. Taxes on capital income may increase or decrease domestic saving in relatively closed economies, but may conceivably increase the rate of saving while decreasing the domestic capital stock in open economies. Even in a closed economy, taxes on the use of capital in particular industries can make labor, not capital, worse off. Fortunately, there is a large volume of empirical literature that has investigated the effects of taxes on labor effort and saving which will help to resolve some of this ambiguity. There is also a smaller volume of cross-sectional studies that have examined more directly the links between the tax structure of an economy and its growth rate.

B. Empirical studies

Taxation and labor supply

Killingsworth (1983) reviews a large number of studies of the responsiveness of labor supply to changes in the net of tax wage rate. While the effect on labor supply of an increase in the marginal tax rate might not be identical to the effect of a decrease in the wage, it makes sense that the two would be related, since an increase in taxes on labor income reduces the effective wage the worker receives. There is considerable variation among the studies cited, but the consensus seems to be that while the labor supply of primary earners is not very responsive to changes in their wages (which is to say that the substitution and income effects are about equal, or that the uncompensated wage elasticity is near zero), the labor supply of secondary earners is much more so.

Due to data limitations, most studies of the wage elasticity of labor supply are confined to the developed countries, particularly the United States. Ashenfelter and Heckman (1973) use a sample of married, working, white American men with nonworking spouses and find that the uncompensated wage elasticity of labor[36] is -0.15, meaning that based on an average 40-hour work week, a 10 percent increase in the average worker's salary would lead to a decrease in workload of about 40 minutes per week. Boskin (1973) draws on a sample of

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[35]There is, however, a school of thought (see Gould and Amaro-Reyes (1983)) that holds that corruption may enhance allocative efficiency by increasing the probability that scarce resources, like government favors, flow to those who can make the most productive use of them and are therefore willing to pay the largest bribes.

[36]That is, the net combination of the substitution effect—which, because it considers what would happen if the agent suffered no loss of income, is the compensated elasticity—and the income effect.

men and women living in 12 large American metropolitan areas who are neither students nor disabled and finds that among men, the uncompensated wage elasticity is -0.29 for whites and -0.20 for blacks. Brown et al. (1981) use a sample of married, working British men and find that the uncompensated wage elasticity of labor supply ranges between -0.11 and -0.26, while Layard (1978), working with a sample of married British men between the ages of 25 and 55, finds an uncompensated wage elasticity of -0.13.

These studies are vulnerable to criticism for their choice of econometric technique,[37] but later studies that attempted to address such issues have not yielded markedly different results. For example, Hausman (1981b) finds an uncompensated wage elasticity of labor supply between 0 and 0.03 for his sample of married American men between the ages of 25 and 55, although he finds relatively large values for both the income effect and the compensated wage elasticity (with implications for the effects of taxation on labor supply that will be discussed below). Ruffel (1981) finds an elasticity of about -0.07 for his sample of married British men under age 65. Flood and MaCurdy (1992) work with a sample of data on 492 Swedish men between the ages of 25 and 65 and find an uncompensated wage elasticity of -0.2, while Triest (1990) uses a variety of techniques on a sample of 965 American men from 1983 to obtain uncompensated wage elasticities that vary from -0.2 to 0.1. Thus, although studies do not all agree on whether the uncompensated wage elasticity of men is positive or negative (i.e., on whether men increase or decrease their hours worked in response to an increase in their wages), the majority of studies agree that whatever the sign of the elasticity, its absolute value is small.

By contrast, the majority of studies of women find that their estimated wage elasticities are positive and much larger than those for men, presumably because women are more likely than men to be secondary workers and thus are freer to vary their hours. For example, Cogan (1981) uses a sample of married, white, American women aged 30 to 44 and estimates an uncompensated wage elasticity of 2.1. Zabalza (1983) draws on a sample of married, working British women under age 60 (with working husbands under the age of 65) and estimates the uncompensated wage elasticity at 1.6, while Franz and Kawasaki (1981) use a sample of married West German women and obtain an estimate of 1.1. While other studies reviewed in Killingsworth (1983) produce somewhat smaller elasticities of labor supply for women, almost all studies report elasticities that are greater than 0.6. Thus, while the value of estimated wage elasticities of labor supply for women covers a wide range, there is a clear

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[37]For example, the fact that individuals are not free to work fewer than zero hours means that researchers cannot observe the behavior of individuals who would theoretically prefer negative hours of work. (More intuitively, the behavior of individuals who are not only working zero hours but would, if it were possible, be willing to pay for additional leisure at the margin.) It also means that at low wages, only individuals with large positive error terms will be working, while at higher wages those with both positive and negative errors will be part of the sample. Thus, the error term will tend to correlate negatively with the wage in most samples.

consensus both that the elasticity is positive, and that the female labor supply is much more sensitive than is the male labor supply to changes in the wage rate.

Econometric studies of the effects of labor income taxation could reasonably be expected to produce results that correspond to the results of studies of the response of labor supply to changes in workers' wages. However, because of the progressive nature of many national income tax systems, many studies have found that the labor supply of primary wage earners is more sensitive to changes in marginal tax rates than to changes in wages, in the sense that small changes in the tax rate will induce a much larger labor supply response than would small changes in the wage rate.[38] In an influential paper, Hausman (1981a) examines data for prime age working men in the United States from 1975 and finds that if taxes on labor income were entirely eliminated (including taxes on social security income and state income taxes, where appropriate) desired labor supply would have increased by 8.6 percent, or by about 198 hours per worker per year. Moreover, Hausman finds that replacing the progressive American tax system in place in 1975 with a flat rate income tax at 14.6 percent with no exemptions (which would yield total revenue equivalent to that from the existing tax structure), would increase desired total labor supply by about 7.4 percent. If the flat rate tax involved a standard exemption of $4,000 but featured a higher tax rate of 20.7 percent (so that again the same amount of total revenue was raised), the desired labor supply would have increased by about 7.1 percent. Thus, a decrease in marginal tax rates does appear to have a significant effect on labor supplied by prime age men in the United States.

Ashworth and Ulph (1981) draw on a sample of prime age working British men to analyze the effect of changes in the tax structure. They consider the impact of increases and decreases of 7 and 15 percent in the then standard British marginal income tax rate of 30 percent (which applied to some 90 percent of the workforce). They find that a 15 percent tax cut would have increased total labor supply by about 1.8 percent, while a 15 percent tax

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[38]Under a progressive income tax, for a given hourly wage and level of nonlabor income, workers face a piecewise linear budget constraint with kinks located at the points where marginal tax rates change. It is possible to imagine an individual choosing the amount of labor to supply in a two-step process: first, decide which linear segment of the budget constraint on which to locate, then decide on a precise number of hours to work. Once an individual has chosen a section of the budget constraint, his problem is analogous to that of an individual who faces a flat tax rate equal to the marginal rate applying at that section of the budget constraint, but receiving a lump-sum transfer equal to the difference between the actual taxes he will pay and the taxes he would have paid had the marginal rate applied to all of his income. Triest (1990), Table 1, calculates that under the United States tax system of 1983 the implicit lump-sum transfer was $15,998 for married couples in the highest tax bracket filing joint returns and not itemizing. The higher the marginal tax rate, the greater the value of the transfer. Thus, rather than decreasing income, an increase in the marginal tax rate may therefore actually increase "virtual income," leading (if the income effect is negative and large in absolute value) to a substantial decline in labor supply, even if the uncompensated wage elasticities are close to zero.

increase would have decreased labor supply by 2.9 percent. A 7 percent tax increase would have reduced the desired labor supply by 1.2 percent, while a 7 percent tax cut would have increased desired labor supply by 0.8 percent. Blomquist (1983) conducted a similar exercise using data on prime age Swedish males in 1973 and found that eliminating all taxes on labor income would have increased desired labor supply by 13.1 percent. This figure is significantly larger than that obtained by Hausman, perhaps, in part due to the higher tax rates applying in Sweden than in the United States. Blomquist found that replacing Sweden's existing tax structure with one that featured proportional tax rates that increased with total wage income, so that each worker paid the same total tax as under the existing system but now faced constant rather than increasing marginal tax rates, would have led to an increase of about 7 percent in total desired labor supply. The effect would have been greatest for those with the highest wages, who face the highest marginal tax rates.

Although these papers suggest that the work disincentive effects on primary wage earners of progressive tax systems are significant, more recent work has called into question the appropriateness of the econometric techniques used by Hausman and others to examine the effects of nonlinear budget constraints. As MaCurdy et al. (1990) demonstrate, many of these studies incorrectly treat workers' wage rates and nonwage income as exogenous. Some also implicitly constrain the values of the compensated wage and income elasticities to unjustifiably narrow ranges. Using techniques to correct for some of these problems, Flood and MaCurdy (1992) find that the income elasticity is zero, and that the effect of taxes on labor supply in Sweden is very small. Moreover, Triest (1990) using estimating techniques similar to those of Hausman (1981a), but relying on a more recent version of the same data set he used (1983 versus 1975), finds a much smaller effect of taxes on male labor supply in the United States, with the elimination of all federal and state taxes on labor income leading to an increase of only 2.6 percent of annual hours worked, less than one third the figure obtained by Hausman (1981a). Summarizing the results of the last two decades of empirical studies, Heckman (1993) concludes that most analysts now agree that the effect of taxes on primary workers' labor supply is small, though not necessarily trivial.

In the studies reviewed above, there is a consensus that the wage elasticities of labor supply for secondary workers are substantially greater than those for primary workers. This alone would suggest that income taxes are likely to have a greater effect on the supply of labor of secondary workers than of primary workers. This effect is compounded by the fact that because most tax systems are based on total family incomes, the marginal tax rate applying to the first dollar earned by a secondary worker is equal to the marginal tax rate on the last dollar earned by the primary worker. Accordingly, it is not surprising that empirical studies have found that the presence of income taxation has a much greater impact on female than on male labor supply.

Hausman (1981a) finds that eliminating all income taxation would have increased the total desired labor supply of married women by more than 18 percent, more than twice the effect he found for men. He estimated that a 10 percent cut in tax rates would have led to a 4.1 percent increase in desired female labor supply, while a 30 percent tax cut would have led to a 9.4 percent increase in female labor supply. In each case, these effects are more than

double those he estimates for men. Feenberg and Rosen (1983) simulate the effect of taxing working wives as individuals rather than as members of a household unit (substantially reducing the marginal tax rate they face), and find that it would lead to an increase of 5.5 percent in total labor supplied. Triest (1990), using 1983 United States data, finds that eliminating all state and federal wage taxes would have increased married women's labor supply by at least 10 pecent and possibly as much as 30 percent, depending on the estimation technique employed.

Feldstein (1995) examines the impact of taxes not on labor supply but rather on taxable income. As he notes, there are a number of reasons why changes in marginal tax rates could affect taxable income, even if labor supply is unaltered. For example, lower marginal tax rates could encourage workers to take compensation in the form of taxable wages rather than tax-free benefits and could induce investors to shift their portfolios towards assets that produce more current income. Using a panel data set comprised of tax return information on more than 4,000 United States individuals from 1985 and 1988 to examine the impact of the 1986 tax reform in the United States, he finds that the elasticity of taxable income to changes in marginal tax rates is greater than one. The implication is that even if labor supply is inelastic with respect to changes in marginal tax rates, increases in tax rates may not generate increases in tax revenues.

Overall, the results of the studies of the effect of income taxation on labor supply confirm that secondary workers are much more sensitive to changes in tax rates than are primary workers. However, there is a consensus among the studies that cuts in income tax rates would increase the total volume of labor supplied by both primary and secondary workers, and that progressive income taxes discourage labor supply much more than do proportional taxes. Because secondary workers are, almost by definition, much less numerous than primary workers, the effect on total labor supply of relatively small increases or decreases in marginal tax rates is likely to be minimal. Thus, the growth effects of small changes in marginal tax rates may not be substantial.

Taxation, savings, and investment[39]

The link between domestic saving and domestic investment

In a study of the effects of fiscal policy variables on economic growth, the relevant dependent variable for econometric studies of the type considered here should be investment. However, most of the empirical work studied in this section uses domestic saving, rather than investment, as the dependent variable. In a closed economy, where savings and investment are

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[39]This section deals with the effects of government tax policies on saving and investment. Of course, government expenditure policies can also have an impact on saving. For example, there exists a significant body of literature—which this paper will not address—that examines the effect of social security expenditure on private saving. For a survey and analysis of this work, see Mackenzie et al. (1997).

always equal, this distinction would be unimportant. In an open economy, changes in domestic saving need not correlate with changes in domestic investment, and fiscal incentives that alter the rate of saving need have no impact on investment, with the difference between savings and investment being reflected in the current account balance. Policies designed to encourage saving, such as a tax on consumption, might have no impact on domestic investment, while taxes designed to encourage domestic investment, such as tax holidays, could alter the composition of the ownership of the domestic capital stock, with foreign capital increasing its share, but might have no effect on saving.

However, research by a number of economists indicates that even in highly open economies with ready access to international capital markets, domestic saving and domestic investment are closely linked. Feldstein and Harioka (1980), using data on OECD countries during the 1960s and 1970s, find that there is a strong, positive correlation between levels of saving and of investment in countries, with changes in saving leading almost dollar for dollar to changes in investment. Subsequent work by Smith (1989), Bayoumi (1990), and others has confirmed this result.[40] Feldstein (1994a) reports regressions of foreign direct investment and direct investment abroad on domestic saving rates among OECD countries and finds that neither is significantly affected by domestic saving. In addition, Mishkin (1984) and Cumby and Obstfeld (1984), among others, have demonstrated the existence of persistent differences in real rates of return on investments internationally which also implies that capital is not perfectly mobile. Finally, Adler and Dumas (1983) and French and Poterba (1991) have found that individual investors are much more likely to hold domestic than foreign securities, despite the benefits of international diversification. These results all suggest that the link between domestic savings and domestic investment is not so tenuous as the theory of international finance would suggest, and that the rate of domestic savings will, in many cases, be a useful, if imperfect, proxy for the rate of domestic investment.[41]

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[40]Smith suggests that it may have weakened somewhat in recent years, however. He finds that when domestic investment as a share of GDP is regressed on a constant term and on savings as a share of GDP (using period average data for the OECD countries), the coefficient on the savings share has dropped from 0.993 for the period 1960-74 to 0.865 for 1975-79 and 0.701 for 1980-85.

[41]Gordon and Bovenberg (1994) review a number of possible explanations for the apparent international immobility of capital: that capital is mobile internationally, but that productivity and other shocks affect both desired savings and desired investment in the same direction at the same time; that countries wish to restrict overseas investment by their citizens to reduce the risk of tax evasion; that transactions costs for overseas investments may be high; that overseas investors fear expropriation of their investments; that significant exchange rate risks exist; and that there are important information asymmetries that favor domestic over foreign investors.

Taxation and saving

Tax policies that encourage or discourage saving work primarily by altering the real rate of return on assets, so that for tax policy to have a meaningful impact on the level of saving, it must be the case that saving is sensitive to changes in the after-tax rate of return. There is as yet no consensus on the degree of that sensitivity, despite the many studies devoted to analyzing it.[42] In one of the earliest studies, Wright (1969) estimates an uncompensated[43] interest elasticity for saving of between 0.18 and 0.27 for the United States, implying that a permanent 10 percent increase in the real rate of return (e.g., from 3 percent to 3.3 percent) would lead to a permanent increase in the saving rate of about 2 percent. Blinder (1975) finds a much smaller interest rate elasticity for saving, about 0.03, but fails to take explicit account of the effects of taxation on the net rate of interest. Boskin (1978) corrects not only for the effect of taxes but also for that of inflation, and estimates that the elasticity is as high as 0.4. Gylfason (1981) and Makin (1986) estimate values between 0.3 and 0.4 for the uncompensated interest rate elasticity of savings. Bovenberg and Evans (1990) use quarterly United States data covering the period 1960-88 and obtain an interest rate elasticity of saving of 0.5. Summers (1981) agrees that most econometric studies have found that saving is relatively interest rate inelastic, but notes that in a life-cycle setting, changes in interest rates can have a significant effect on savings through their impact on the net present value of lifetime incomes. Because empirical studies of the effect of interest rate changes on saving often hold wealth constant, these studies are likely to understate the interest rate elasticity of saving.

Friend and Hasbrouck (1983) use data from the United States from 1952 through 1980 and find that the interest rate elasticity of saving is negative, with increases in the real rate of return leading to increases in current consumption (presumably through the income effect, the higher real income that encourages greater current consumption, dominating the substitution effect, the higher real returns that encourage greater saving). Hendershott and Peek (1985) find that the real after-tax rate of interest has no direct influence on the saving rate in the United States, while Montgomery (1986), Baum (1988), and Hall (1988) find that the interest rate elasticity of saving is small or insignificant in the United States. Makin (1986) also found a very small interest rate elasticity of saving (0.02) in Japan.

Clearly, the results of any study whose dependent variable is saving will depend critically on the definition of saving that is employed. Howrey and Hymans (1978) exclude consumer durables and owner-occupied housing from their definition of saving and find that the rate of cash saving in the United States is not sensitive to changes in the real rate of return on investment. Bernheim and Shoven (1988) find that the rise in real interest rates that occurred in the United States in the early 1980s led to a decline in employer contributions to

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[42]Boadway and Wildasia (1994) provide a survey of many of these studies.

[43]Again, the uncompensated elasticity represents the combined substitution and income effects.

defined benefit pension plans, with higher investment returns allowing firms to fund their unchanged expected future pension obligations with lower current contributions. Tanzi and Sheshinski (1984) show that these real interest rate increases shifted the intergenerational distribution of income toward the elderly, who are more likely to hold financial assets, and away from the young, who are less likely to do so. The result may have been a reduction in the aggregate level of savings.

Feldstein (1994b) argues that the ambiguity of the evidence on the responsiveness of savings to changes in the after-tax rate of return is inevitable, because—among other reasons—no universally acceptable definition of savings exists; because savings depends on the expected real rate of interest, which is not observable; because savers in fact face a variety of rates of return depending on the type of asset in which they choose to invest;[44] and because borrowers and lenders face different interest rates. Moreover, he points out that even if the rate of savings is entirely unaffected by the real rate of return, this does not imply that taxation of investment income is a low-cost source of government revenues. A tax on investment income that reduces the after-tax rate of return without altering the level of saving in the economy implies a decline in the future consumption of savers and therefore possibly substantial welfare losses.[45] However, Feldstein and Tsiang (1968) note that for individuals with virtually no financial saving the income effect largely disappears, implying that in many low-savings countries, saving rates should unambiguously rise with the real rate of return, with a magnitude determined by the size of the substitution effect.[46]

Data constraints have dictated that most studies of the interest rate elasticity of saving have been conducted on developed countries, mainly the United States. Theory can identify some reasons why the interest rate elasticity of saving in developing countries may be greater or smaller than that in developed countries, but can provide no firm conclusions. On the one hand, as noted by Feldstein and Tsiang (1968), the fact that the stock of savings in many developing countries is likely to be quite low implies that the wealth effects arising from an interest rate change will be negligible, and that the substitution effect should dominate. If this

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[44]To the extent that higher-income individuals are more likely to invest in assets offering relatively high rates of return (such as equities), individuals in the highest marginal tax brackets may nevertheless have the highest after-tax real rates of return on their savings.

[45]If the return on savings declines but present consumption is unaffected, then future consumption must fall. Thus, even though there is no change in current period behavior, there may be a significant decline in lifetime utility. Feldstein (1994a) illustrates this point with the example of an individual saving over a 25-year time horizon. If a 50 percent tax on savings income is introduced that reduces the after-tax rate of return from 12 percent to 6 percent, the value of future consumption that can be sustained from an unchanged level of savings is only about one quarter of its level without the tax.

[46]Feldstein (1992) quotes Federal Reserve Board survey data that reports the median value of household financial assets in the United States in 1984 as $2,600.

is the case, one would expect interest rate elasticities of saving to be positive, and potentially quite large, in developing economies.

On the other hand, Ogaki et al. (1995) note that if poorer households spend a larger fraction of their incomes on necessities whose consumption cannot easily be shifted from one period to another, their interest rate elasticities of saving would be relatively low. In addition, the presence of liquidity constraints owing mainly to highly imperfect capital markets in developing economies may limit the ability of households to alter their intertemporal consumption patterns in response to changes in interest rates. The effect of liquidity constraints is asymmetric, in that they restrict households that would choose to consume more than their incomes, but not those who would choose to consume less than their incomes. Thus, the elasticity of saving would vary positively with income levels.

The available econometric evidence suggests that, in fact, saving rates are likely to be less responsive to changes in real interest rates in developing countries than in developed ones. Fry (1980) uses national savings data from seven Asian countries covering the period 1962-72 and estimates an interest rate elasticity of saving of -0.2, implying that an increase in the rate of return on saving leads to a decrease in saving. Giovannini (1985) examines national consumption data from 18 developing countries and concludes that in only 5 were changes in the real rate of interest likely to induce changes in saving rates that are significantly different from zero. Rossi (1988) examines pooled cross section private per capita consumption data for six geographical regions (examining a total of 49 low- and middle-income countries) and estimates intertemporal rates of substitution that imply real interest rate elasticities of saving that are negative for each group, ranging in value from about -1.0 in the Middle East and North Africa to close to zero in South America and Sub-Saharan Africa. Schmidt-Hebbel et al. (1992) use a cross-section of annual household saving and disposable income data from a sample of ten developing countries covering the period 1970-85[47] and find that the domestic real interest rate has a negative but insignificant effect on the domestic household saving rate.

Both Rossi (1988) and Schmidt-Hebbel et al. (1992) find evidence that suggests that liquidity constraints may limit the ability of poor households to respond to changes in interest rates. Ogaki et al. (1995) look at a sample of 58 developing, middle-income, and high-income countries for the period 1985-93 and find that, in general, personal saving as a percentage of GDP increases with per capita income. They also find that the estimated intertemporal elasticity of substitution in consumption is higher for high-income countries than for low-income countries, meaning that individuals in higher-income countries are more willing to substitute future consumption for present consumption than are individuals in lower-income countries. As a result, in their simulation exercises, saving rates in high-income countries are much more sensitive to changes in the real interest rate than are saving rates in low-income countries: although the precise value of the interest rate elasticity of saving they obtain depends on the discount factor they employ, Ogaki et al. find that the average elasticity is

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[47]For no country was data available for more than 13 consecutive years. Data for each was available for at least seven consecutive years.

about 0.32 for their low-income group of countries and about 0.60 for the high-income group. Within income groups they also find a wide variance of estimated elasticities of saving: the estimated elasticity of saving is about ten times as great for Pakistan (about 0.46) as for Uganda (about 0.04).

Most studies of the effect of taxation on saving concentrate on personal saving, or on how changes in the rate of return on saving affect the consumption decisions of individuals. However, between 1950 and 1986, corporations typically accounted for 45 to 50 percent of gross private saving, and about 30 percent of net private saving, in the United States.[48] If individuals "pierce the corporate veil" and treat saving by the corporations in which they own shares as their own, then the distinction between personal and corporate saving is not important in the aggregate. Individuals would treat the full value of corporate assets as part of their wealth and would respond to increases in corporate saving with matching decreases in their personal saving. Individual consumption would then not be affected by the breakdown of corporate income between dividends and retained earnings unless the two were taxed differently.

On the other hand, if individuals pierce the corporate veil incompletely and fail to fully adjust their own saving decisions to account for corporate saving, then the distribution of corporate income between dividends and retained income will affect their saving decisions. This incomplete adjustment to changes in corporate saving could occur if, for example, individuals treat changes in dividend payments as being more permanent than increases or decreases in corporate share values driven by changes in the level of retained earnings. It could also occur if individuals are liquidity constrained. Although individuals could in theory divest some of their shareholdings to turn retained earnings into a dividend-like flow, indivisabilities and brokerage fees could make this impractical for many shareholders.[49] In addition, if the marginal propensity to consume among corporate shareholders differs from that of the population at large, an increase in corporate taxes that is offset by a decrease in personal taxes could lead to a change in aggregate private saving even if shareholders completely pierce the corporate veil. For example, if corporate shareholders have a lower marginal propensity to consume than does the population as a whole, the increase in corporate taxes will tend to reduce total private saving by shifting the tax burden away from low savers and toward high savers.

Empirical tests, most of which use United States data, of the effect of changes in corporate saving on personal saving suggest that individuals do not, in fact, fully pierce the corporate veil. Feldstein (1973) examines data for the United States and finds that an increase of one dollar in corporate retained earnings (at the expense of dividend payments) led on

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[48]See Poterba (1987) (Table 1) for annual National Income and Product Account data on personal and corporate gross and net savings in the United States from 1950 through 1986.

[49]It is also possible that individuals could have an irrational aversion to funding consumption with capital gains.

average to a decrease of only 75 cents in personal saving. Thus, a change in tax policy that induced an increase of one dollar in retained earnings at the expense of one dollar in the disposable income of a representative consumer would lead to a twenty-five cent increase in private (corporate plus personal) saving. Feldstein and Fane (1973) examine data from the United Kingdom and also find that increases in corporate retained earnings would generate increases in private savings. Von Furstenberg (1981) finds that a one dollar increase in corporate saving would lead to about a thirty cent increase in private saving. Poterba (1987) uses data for the United States for 1948-86 and finds that an increase in corporate saving of one dollar leads to a increase of private savings of about 25 cent. When he extends his sample period to 1931-86 (excluding the period 1941-45) he finds that changes in corporate saving have an even bigger impact on private saving, with each dollar of retained earnings leading to a 65 to 84 cent increase in private saving. These results suggest that changes in tax policy that induce increases in corporate saving—for example, decreases in corporate profit taxes with offsetting increases in personal income taxes, the adoption of preferential treatment for shareholder capital gains, or the removal of any preferential tax treatment for shareholders' dividend income—could have positive effects on saving, investment, and output growth.

Taxation and investment

To the extent that the availability of domestic saving constrains domestic investment—and there is some evidence it does—then the limited impact of tax policies on the level of saving implies that tax policy can do little to stimulate investment. That said, the cost of capital to an enterprise is not determined simply by the rate of tax on capital income, so that in principle, there should be some scope for changing the after-tax cost of capital to an enterprise without affecting the after-tax return to savers.

Numerous studies, involving a wide variety of functional forms, have attempted to measure the influence of the cost of capital on investment. While many of these studies find that investment is negatively related to the cost of capital, most find that the size of the effect is rather small. Hall and Jorgenson (1971), Bischoff (1971), and Coen (1971) estimate traditional neoclassical models of investment, in which the level of investment is a function of the current level of output and the cost of capital. Using data from the United States, they find that investment is much more sensitive to output levels than it is to costs. More recent work based on somewhat more sophisticated modeling techniques has largely confirmed these results. For example, Meese (1980) finds that the price of capital has an insignificant effect on investment, while Bernanke (1983) obtains an elasticity of current investment of only -0.20 with respect to changes in the real rate of interest. Pindyck and Rotemberg (1983) find that the elasticity of the stock of capital with respect to the cost of capital is -0.13, while Morrison (1986) finds long-run price elasticities of between -0.18 and -0.05 depending on how expectations about the future are modeled. Bernstein and Nadiri (1989) obtain relatively larger estimated long-run price elasticities (of about -0.45), while Shapiro (1986) estimates a long-run price elasticity of the stock of capital of -0.31. Reviewing these and other studies, Chirinko (1993) concludes that although "there is clearly no uniformity of results ... the response of investment to price variables tends to be small and unimportant relative to quantity variables" (page 1906).

As is often the case, because of data limitations most empirical studies of investment have concentrated on data from developed countries, especially the United States. However, a few studies have attempted to measure the determinants of private investment in developing countries. For example, Ebrill (1987) uses data on 31 developing countries to analyze the determinants of domestic investment and finds that the cost of capital has a negative and significant effect on investment. However, when Chile and Argentina are dropped from the sample, the cost of capital has no significant effect on domestic investment. Haque et al. (1990), in another study of 31 developing countries, and Greene and Villanueva (1990), using data from 23 developing countries over the period 1975-87, both find that the real interest rate has a significant, negative effect on private investment. These results contradict McKinnon's (1973) conjecture that because of credit rationing, higher real interest rates would stimulate investment by mobilizing additional private saving.

Studies of the impact of tax incentives on investment also shed some light on the impact of tax policy on the investment decision. Because of the wide variety of potential investment incentives that could be offered to firms, international comparisons of the effects of incentives can be difficult, and many studies have therefore focused on the effects of incentives within a single country or a very small group of countries. Boadway and Shah (1992) review a number of studies that have attempted to analyze the impact of tax incentives for investors in Brazil, Malaysia, Mexico, Korea, the ASEAN countries as a group, the Philippines, Sri Lanka, Colombia, and Thailand. They find that most of these studies conclude that the tax incentives in place in these countries do not stimulate new investment but instead provide windfalls for investments that would have occurred anyway. Trela and Whalley (1991) examine the impact of tax incentives (specifically, the rebate of direct and indirect taxes on exports, investment tax credits, and tax holidays) in Korea and find that tax policy accounted for less than one tenth of Korea's growth between 1962 and 1982. Shah ed. (1995) contains a number of studies of the impact of tax incentives in developing countries. In general, the studies find that nontargeted tax incentives typically result in more lost revenue than additional investment, and that the elimination of nontax disincentives to investment—for example, a lack of adequate infrastructure—would do more to stimulate investment than would tax incentives.

In addition, Hines (1993) examines the extent to which the pattern of foreign investment in American states is affected by their corporate income tax rates. He finds that the higher a state's corporate income tax rate, the higher is the share of investment that originates from firms located in countries that grant domestic tax credits for taxes paid to American states, suggesting that state taxes significantly affect the pattern of foreign direct investment. However, the bulk of the studies surveyed by Wasylenko (1991) find that state taxes have little impact on the location of investment in the United States. For example, Carlton (1979) finds that both the combined state corporate and personal business income tax rates, as well as local property tax rates, had no significant effect on the creation either of single establishments or of branches of existing firms in three manufacturing industries in the United States between 1967 and 1971 (or 1975 for some of the data). Plaut and Pluta (1983) examine the percentage change in aggregate manufacturing employment in the 48 contiguous American states from 1967 through 1977 and find that corporate and personal income taxes had no significant

effect. Bartik (1985) examines data on all new branch plants opened by Fortune 500 firms in the 48 contiguous American states from 1972 to 1978, and finds that high corporate tax rates had a negative effect on the probability that a branch would be opened in a given state, but Schmenner et al. (1987), using similar data, find that tax rates influenced the probability that a state would appear on firms' shortlists of possible investment locations but had an insignificant effect on the ultimate selection.

This evidence, which suggests that fiscal policies have limited influence on the location of investment among states in the United States, is particularly significant. The states share many of the other factors that would influence the location choice, like language of business, political system, and basic features of the legal system. Under these circumstances, the effects of fiscal policies on investment location might be expected to be magnified.

V. AGGREGATE STUDIES ON TAXATION AND GROWTH

The evidence reviewed so far suggests that since tax rates appear to have limited impact on the supply of labor or capital to an economy, they will not have a dramatic effect on growth rates.[50] Nevertheless, a number of economists have attempted to measure the effect of tax rates on growth directly, sometimes omitting the intermediate step of determining how taxes affect factor supplies. One econometric problem with these studies is that the importance of different taxes varies systematically with the level of economic development (Tanzi (1987)): wealthier countries tend to rely more on income and payroll taxes, and less on trade taxes, than do less wealthy countries. Because per capita growth rates are usually negatively correlated with initial GDP, a regression of per capita growth rates on income tax ratios will have difficulty separating the effects of the tax from the effects of different initial income levels.[51]

Marsden (1986) works with cross section data from a sample of 20 countries spanning a range of per capita national incomes. Regressing the average per capita growth rate of GDP

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[50]However, there is good reason to believe that they will have a negative effect on welfare due to their deadweight costs. They may also have an effect on the composition of output.

[51]This phenomenon arises, for example, in Koster and Kormendi (1989). In a study of the 63 countries that have tax revenue data available in the GFS for at least five consecutive years in the 1970s, they find that both the average aggregate tax rate (total taxes collected divided by GDP) and the "marginal" aggregate tax rate (equal to the coefficient calculated by regressing total taxes collected on a constant plus GDP in an individual time series for each country in the data set) are significantly, negatively correlated with average GDP growth from 1970 to 1979. However, when per capita income in 1970 is added as an explanatory variable the coefficients on both tax rates become insignificant. Thus, it appears to be the positive correlation between their calculated tax rates and initial income, and not any direct interaction between the tax rates and growth, that accounts for the significant coefficients on tax rates in their first regression.

from 1970 through 1979 on a constant term and the ratio of taxes to GDP over the same period, he finds that the tax ratio has a significant, negative impact on growth. However, when he includes the growth rates of gross domestic investment and the labor force among the independent variables, he finds that the coefficient on the tax ratio, while still negative, is significant only at the 10 percent level. He does not include initial per capita GDP as a control variable. However, when he divides his sample into ten higher-income and ten lower-income countries, he finds that the tax ratio has a significant, negative impact on growth rates in the low-income countries but not in the higher-income countries. For the sample as a whole, he also finds that the tax ratio has a significant, negative effect on the growth rate of investment, although among individual categories of taxes only domestic taxes on goods and services (and not corporate taxes, personal income taxes, or taxes on foreign trade) have a significant effect. He finds that only social security taxes have a significant (negative) effect on labor force growth, while only domestic taxes on goods and services and taxes on foreign trade have significant (again, negative) effects on labor productivity growth. The negative effect of social security taxes may be due to more generous pension benefits inducing earlier retirement.

Mañas-Anton (1986) looks in particular at the effect of income taxes on per capita output growth, using a sample of period average data for 39 developing countries over the period 1973-82. He finds that both the ratio of income taxes to GDP and the ratio of income taxes to total taxes collected have significant, negative effects on per capita GDP growth. However, when he includes each of the ratios of personal and corporate income taxes to total tax collections in his regression, he finds that while the coefficient on each remains negative, neither is significant. Thus, while his results provide some indication that reliance on income taxes tends to correlate with slower output growth, this relationship cannot be asserted with confidence.

Skinner (1988) uses a data set for Sub-Saharan African countries covering the period 1965-82[52] and finds that only the corporate and personal income taxes have significant (and negative) effects on output growth. Import, export, and especially sales taxes have little effect on output growth. However, import, export, and corporate taxes do have a significant, negative effect of the share of private investment in GDP. Engen and Skinner (1992) use data from 107 countries over the period 1970-85 and find that changes in the aggregate average tax rate do not have a significant effect on output growth. They do find, however, that increasing the aggregate average tax rate has a negative effect on the marginal productivity of investment in physical capital and, to a lesser extent, of labor.

Easterly and Rebelo (1993) use cross-section data based on period averages for 1970-88 and find that the "marginal" rate of income tax (calculated by regressing a time series of income tax revenues on a time series of GDP for each country) has a significant, negative effect on per capita GDP growth, but that no other tax measures do. They do find that income taxes, the ratio of domestic taxes to GDP, and the ratio of domestic taxes to consumption plus

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[52]The data set consists of 56 observations: period averages for 27 countries covering 1965-73 and for 29 countries covering 1974-82.

investment have significant, negative effects on the share of private investment in GDP, however.

Overall, the evidence from these cross-section studies of the effects of tax rates on per capita income growth appears to be contradictory. Marsden (1983) finds that only domestic taxes on goods and services have a significant effect on output growth, while Easterly and Rebelo (1993) find that domestic taxes on goods and services do not matter but income taxes do. Skinner (1987) agrees that personal and corporate income taxes matter, but Mañas-Anton (1986) finds that they are insignificant. Engen and Skinner (1992) do not consider the effects of individual taxes, but find that the aggregate tax bill is not a significant determinant of growth rates. These contradictory results may be due to a number of possible factors. All cross-section regressions implicitly assume that countries included in the sample differ only with respect to variables that can be controlled for in a regression. As is well known, this assumption may be difficult to justify for a cross-section study that includes, for example, Canada and Cambodia. In addition, data limitations typically ensure that cross-section studies rely on average tax rates, rather than on the marginal effective tax rates that the theory suggests are most important. As noted above, there may be substantial multicollinearity among variables in the data set, complicating inference. And in some papers, the empirical specifications tested do not grow out of a well-specified model of economic growth, making them more ad hoc than most empirical economic work.

Under these circumstances, even if the cross-section studies of the effects of taxes on growth yielded a consensus opinion, it would be wise to treat their results with some caution. In the absence of a consensus, it certainly pays to draw on the results of the substantial body of empirical work that indicates that labor supply decisions—at least of primary workers—savings, and investment are all relatively unresponsive to changes in wages and rates of return, and therefore that the growth effects of most taxes are likely to be relatively small.

VI. CONCLUSION

This paper has reviewed the theoretical and empirical literature regarding the effects of fiscal policy on output growth. The review has focused on three broad categories of policies: fiscal policies that would affect the marginal productivity of labor; those that would affect the marginal productivity of capital; and those that would affect the cost of, or the return to, labor and physical capital. Most of the policies in the first two categories involved government expenditure, while the last section dealt exclusively with tax policies. Although in some areas the evidence has been inconclusive, in others a consensus seems to have emerged. The most important lessons are as follows:

- *Educational attainment* and *public health status* have significant, positive effects on per capita output growth. However, the evidence on *education* and *health spending* is far less conclusive. Presumably, this reflects the fact that government spending on education and health correlates poorly with actual achievement, either because of gestational lags or because of inefficient allocation of resources. This result argues for

better targeting of social spending—in most cases, toward primary services and away from tertiary ones—as being an important component of a growth-enhancing fiscal policy.

- Economies that are *open to international trade* grow faster than those that are closed. Accordingly, fiscal policies that encourage openness should also encourage growth.

- Government expenditure on *physical infrastructure* typically increases private sector productivity and output growth. To the extent that the empirical link between infrastructure expenditure and output growth is weak, this may reflect the fact that not all infrastructure investments are equally valuable: building one sewer system in a city may increase growth, while building three such systems may decrease it.

- Spending on defense and social services to maintain the social fabric may increase output growth if it contributes to political stability. In many countries, present levels of spending on defense and public order may exceed the minimum necessary to maintain the social fabric, but there is no conclusive evidence that this has hurt their growth performance.

- The labor supply of primary workers appears to be relatively inelastic with respect to the real wages they receive, implying that increases in the marginal personal income tax rate should have a limited effect on labor supply and growth. The labor supply of secondary workers, however, is much more elastic with respect to real wages.

- Saving and investment also appear to be relatively insensitive to changes in the rate of return, especially in developing countries. This implies that increases in the personal and corporate income tax rates should have a limited effect on saving, investment, and growth. However, because individuals do not fully discount saving undertaken on their behalf by corporations, a revenue-neutral shift of the tax burden from corporations to individuals, or other policies that encourage firms to retain earnings rather than pay dividends, may increase saving, investment, and growth.

These conclusions appear to suggest that government expenditure policies have a more important effect on growth rates than do revenue policies, or that, to a point, balanced budget increases in spending on health, infrastructure, and the social fabric, if well-targeted, should be growth enhancing. However, as noted in the introduction to this paper, the large, cross-country analyses of economic growth that could validate these conclusions have not yet been able to do so, in part because the coefficients on variables of interest are extremely sensitive to the other policy variables included in the regressions. Accordingly, it would be wise to conclude by noting that while this background paper has highlighted some of the statistical regularities that have been identified by the empirical literature on economic growth, labor supply, and capital investment, a country's growth performance is affected by the entire set of macroeconomic policies it follows. Focusing on the effects of some policies and neglecting others ignores the potentially rich interactions among them. Moreover, country growth performances are also affected by a variety of factors, many of them exogenous, that will attenuate the impact of even the best-designed fiscal packages.

FOUR SIMPLE MODELS OF ECONOMIC GROWTH

This appendix will describe four simple yet widely used models of economic growth. Covering the material in roughly chronological order, it will begin by discussing the Harrod-Domar model,[53] one of the most widely known models of economic growth in the pre-Solow period. The next section will review the Solow growth model, which has come to epitomize the neoclassical approach to economic growth. The third and fourth sections will then look at two models of so-called "endogenous growth," which differ from the neoclassical model of growth in that they allow for long-run increases in the per capita level of output without having to resort to exogenous factors such as technological progress. The third section will review a model based on increasing returns to scale due to externalities related to the stock of physical capital in the economy, while the fourth section will look at a model based on increasing stocks of human capital.

A.   The Harrod-Domar Model

Harrod and Domar make three assumptions that are essential to their model:

• Savings are an exogenous, constant fraction s of output;

• The number of units of physical capital required to produce a single unit of output is an exogenous constant v, while the number of units of labor required to produce a single unit of output is also an exogenous constant; and

• The supply of labor grows at a constant, exogenous, proportional rate n.

From these three assumptions, Harrod and Domar show that equilibrium growth with full employment of both capital and labor is possible if and only if $s=nv$.

It is easy to show why this condition must hold. As equilibrium saving equals investment, by definition $sY=I$, where I is investment. Thus, $s=I/Y$. Assuming (for expositional ease) that there is no depreciation of the stock of physical capital, the instantaneous change in the stock of physical capital, $\dot{K}$, will be equal to investment. Substituting $\dot{K}$ for I and multiplying the right-hand side by K/K gives

$$s = \frac{\dot{K}}{K}\frac{K}{Y}.$$

The second term on the right-hand side, K/Y is the capital/output ratio, which is by assumption equal to the constant v. With fixed input ratios, full employment of capital and labor can only be maintained if each grows at the same rate. Thus, the rate of growth of the

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[53]Based on the work of Harrod (1948) and Domar (1947).

capital stock, $\dot{K}/K$, must equal the rate of growth of the labor supply, n. Making these substitutions yields

$$s = nv$$

which is Harrod and Domar's full employment equilibrium growth condition.

Suppose that $s>nv$. In that case, the capital stock is growing more rapidly than is labor (the economy is oversaving) and, with fixed input ratios, the economy will face a labor shortage. The supply of labor will dictate the rate of output growth, and excess capital will accumulate. When $s<nv$ too little is invested, the economy is short of capital, and labor is unemployed. Only when $s=nv$ can full employment of both factors be maintained.

The problem is that in the Harrod-Domar model, s, v and n are *exogenous, independent, and fixed*. That means that we should expect to find that $s=nv$ only in pathological cases. In particular, steady employment ratios for capital and labor should be a rarity, while in fact they are more often the norm. Therefore, at least one of s, n, and v must be allowed to vary, and to do so in a way that tends to reinforce equilibrium, or to move the economy toward the condition $s=nv$.

B. The Solow Model

As Solow (1970) notes, if the classical economists were asked which of s, v, and n were the most likely to vary endogenously, they might have picked n, the rate of population growth. Following Malthus, they could have argued that when $s>nv$, labor scarcity would lead to rising worker incomes and higher birth rates, while when $s<nv$ excess supply of labor would lower wages and birth rates. In each case, n would adjust to ensure that $s=nv$.

Alternatively, one could argue that savings would adjust. For example, suppose that the marginal propensity to save out of capital income exceeds the propensity to save out of labor income. In periods of undersaving, the shortage of capital would lead to rising capital incomes and a higher aggregate savings rate, moving the economy back to equilibrium. During periods of oversaving, the decline in capital incomes would reduce the savings rate, also moving the economy back to equilibrium.

Instead, the Solow model assumes that s and n are fixed but that v is variable, with output being produced by a constant returns to scale production function where the input ratios may vary. By virtue of the fact that the production function $F(K,L)$ has constant returns to scale,

$$\frac{1}{v} = \frac{Y}{K} = F\left(1, \frac{L}{k}\right) = f(z)$$

where $z=L/K$. It can be shown that df/dz is greater than zero and d^2f/dz^2 is less than zero. If $s>nv$ then, as before, capital is growing faster than labor. If both are fully employed L/K must fall, which implies (since $df/dz > 0$) that $f(z)$ falls and v rises. Thus, excess saving in the

economy implies a decline in the capital/labor ratio and a rise in the capital/output ratio until $s=nv$. When $s<nv$ the supply of capital grows too slowly, L/K rises, and v falls, again ensuring that $s=nv$.

A somewhat more rigorous proof of this proposition could take the following form: because $v^{-1}=f(z)$, differentiating with respect to time yields

$$-\frac{\dot{v}}{v^2}=f'(z)\dot{z}$$

where dot over a variable represents its derivative with respect to time. Rearranging, substituting for v and multiplying by z/z yields

$$-\frac{\dot{v}}{v}=\eta(z)\frac{\dot{z}}{z} \tag{1}$$

where $\eta(z)$ equals the elasticity of output with respect to z (and lies between 0 and 1). Differentiation with respect to time of v and z yields

$$\frac{\dot{v}}{v}=\frac{\dot{K}}{K}-\frac{\dot{Y}}{Y} \tag{2}$$

$$\frac{\dot{z}}{z}=n-\frac{\dot{K}}{K}. \tag{3}$$

Substituting equation (1) into equation (3) yields

$$\frac{\dot{v}}{v}=\eta(z)\left[\frac{\dot{K}}{K}-n\right] \tag{4}$$

which illustrates that v increases when the capital stock grows more quickly than labor, falls when the capital stock grows more slowly than labor, and is constant when capital and labor grow at the same rate. Combining equation (2) and equation (4), subtracting n from each side, and rearranging yields

$$\frac{\dot{Y}}{Y}-n=[1-\eta(z)]\left(\frac{\dot{K}}{K}-n\right) \tag{5}$$

which illustrates that when the capital stock grows more quickly than does the labor supply, output will do so as well. It also illustrates that when the capital/labor ratio is constant, capital, labor, and output all grow at the same rate. In the steady state, the rate of population growth determines the rate of output and capital stock growth. A higher savings rate will alter the capital/output and capital/labor ratios, but will not affect the rate of output growth. A rise in s induces a fall in z and a rise in v until $s=nv$ once again. In the new steady state, the economy has more capital and the same amount of labor, and, therefore, has a higher level of output. However, the rate of growth of output is unchanged. The effect on output of a rise in the savings rate at time t_s is illustrated in Figure 1, below. In the figure, the jump in the savings rate induces a movement to a higher output path, but the long-run growth rate, the

Figure 1. Solow Growth Model: Effects of an Increase in Savings at t_s
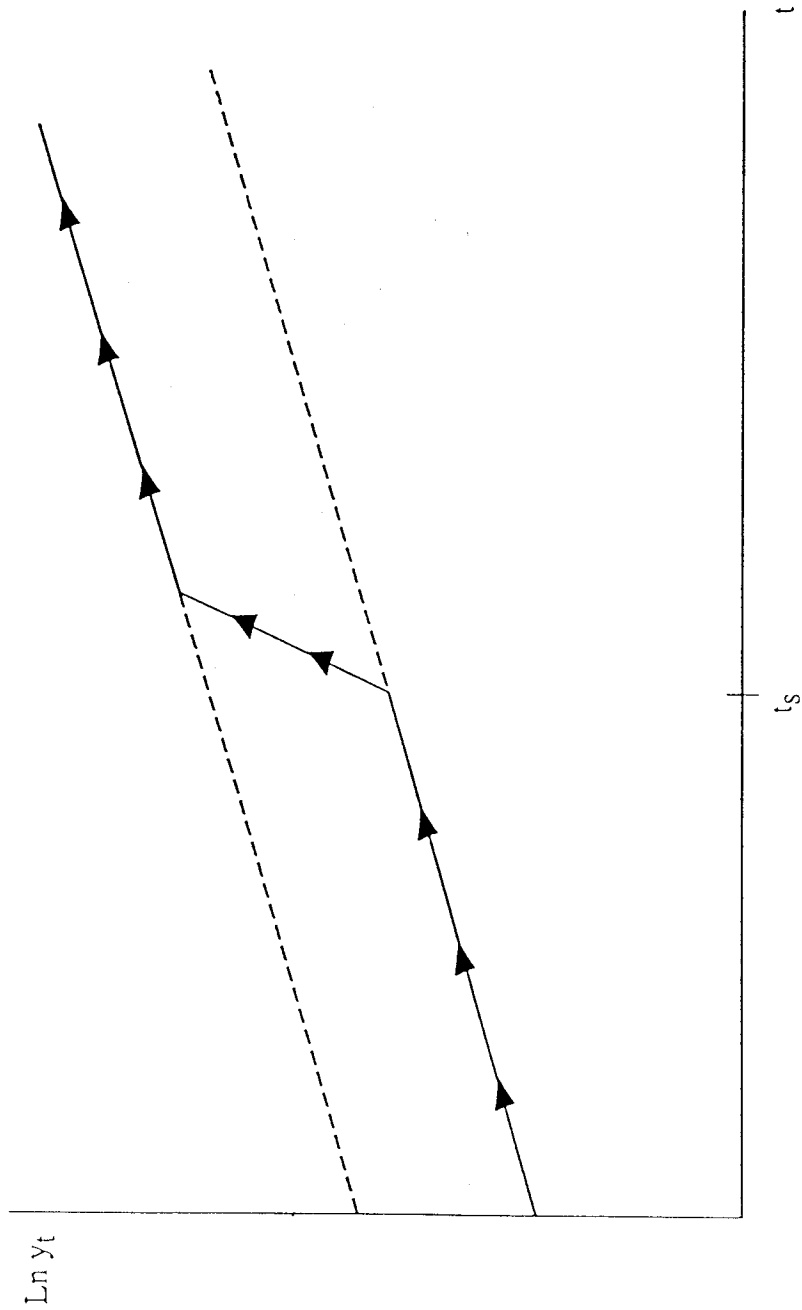
slope of the path, is unchanged after the adjustment to the new steady state. Since Y and L grow at the same rate in this model, per capita output, Y/L, is constant. Output grows only by enough to offset population growth, keeping all per capita ratios constant.

Solow does not model consumer behavior explicitly, assuming instead only that consumers save a constant fraction s of their incomes. However, it is easy and useful to introduce consumer behavior into his model. Consider the following model:

$$U = \int_0^\infty U(c_t)e^{-\rho t}dt \tag{6}$$

$$\dot{K_t} = F(K_t, L_t) - C_t \tag{7}$$

$$\dot{L_t} = nL_t \tag{8}$$

where in equation (6) utility is defined in terms of per capita consumption and ρ is the discount rate used by the infinitely lived consumer. By a standard rearrangement equation (7) can be put in per capita terms as well:

$$\dot{k_t} = f(k_t) - c_t - nk_t$$

where $f(k) = F(K/L, 1), df/dk > 0, d^2f/dk^2 < 0$. Using equation (6) and equation (9), we can form the present value Hamiltonian

$$H = U(c_t) + \theta_t[f(k_t) - c_t - nk_t]$$

which yields three first order conditions:

$$u'(c) = \theta \tag{10}$$

$$\dot{\theta} = \rho\theta - \theta f'(k) + \theta n \tag{11}$$

$$\dot{k} = f(k) - c - nk \tag{12}$$

From equation (11), the $\dot{\theta} = 0$ locus in (θ, k) space is defined by

$$f'(k) = \rho + n \tag{13}$$

which is a vertical line at the optimal capital labor ratio k^*. To find the $\dot{k} = 0$ locus, notice from equation (10) that as θ goes to infinity, $u'(c)$ also goes to infinity, which implies that c goes to

zero. If k is to remain equal to zero as c goes to zero, it must be the case that $f(k)-nk$ goes to zero, too. Now,

$$\frac{d[f(k)-nk]}{dk} = f'(k)-n \tag{14}$$

which at the $\dot{\theta}=0$ locus (where $f'(k)-n=\rho$) is unambiguously positive, meaning that at

that point the $\dot{k}=0$ locus must have a negative slope. Because $f''<0$, to the left of

the $\dot{\theta}=0$ locus the slope must also be negative, while continuity of $f'(k)$ ensures that it will

be negatively sloped at some points to the right of $\dot{\theta}=0$. As θ goes to infinity k goes to zero

and vice versa, making $\dot{k}=0$ a negatively sloped locus in (θ,k) space, asymptotic to both axes

(see Figure 2).

It can be shown that there is a single, stable equilibrium path leading to a constant capital/labor ratio k^* and a constant per capita output $f(k^*)$. The constant equilibrium θ^* implies from equation (10) that there is a constant per capita consumption level c^*. Thus in the long-run equilibrium

$$\frac{\dot{C}_t}{C_t} = \frac{\dot{K}_t}{K_t} = \frac{\dot{Y}_t}{Y_t} = \frac{\dot{L}_t}{L_t} = n$$

and aggregate consumption, the aggregate stock of capital, output, and the labor supply all grow at the constant exogenous rate n.

The "problem" in this model that makes per capita steady-state growth impossible is the presence of decreasing returns to capital. If we take equation (11) and let $n = 0$ to abstract

from the effects of population growth, then $f'(k)=\rho$. Since $F(K,L) = Lf(k)$,

then $F_K = Lf'(k)L^{-1}$ and equation (11) becomes $F_K=\rho$. Investment in physical capital will

occur in this model only until the marginal product of capital equals the discount factor. Beyond this point there is no incentive to invest further because the marginal return to additional investment, the discounted future utility it will allow, is insufficient to compensate the investor for foregoing additional current consumption. Once $F_K = \rho$, additional investment will occur only if the marginal product of the existing capital stock is somehow increased, due either to exogenous technological change or to endogenous factors not present in the Solow model.

Figure 2. Solow Growth Model: Equilibrium Dynamics
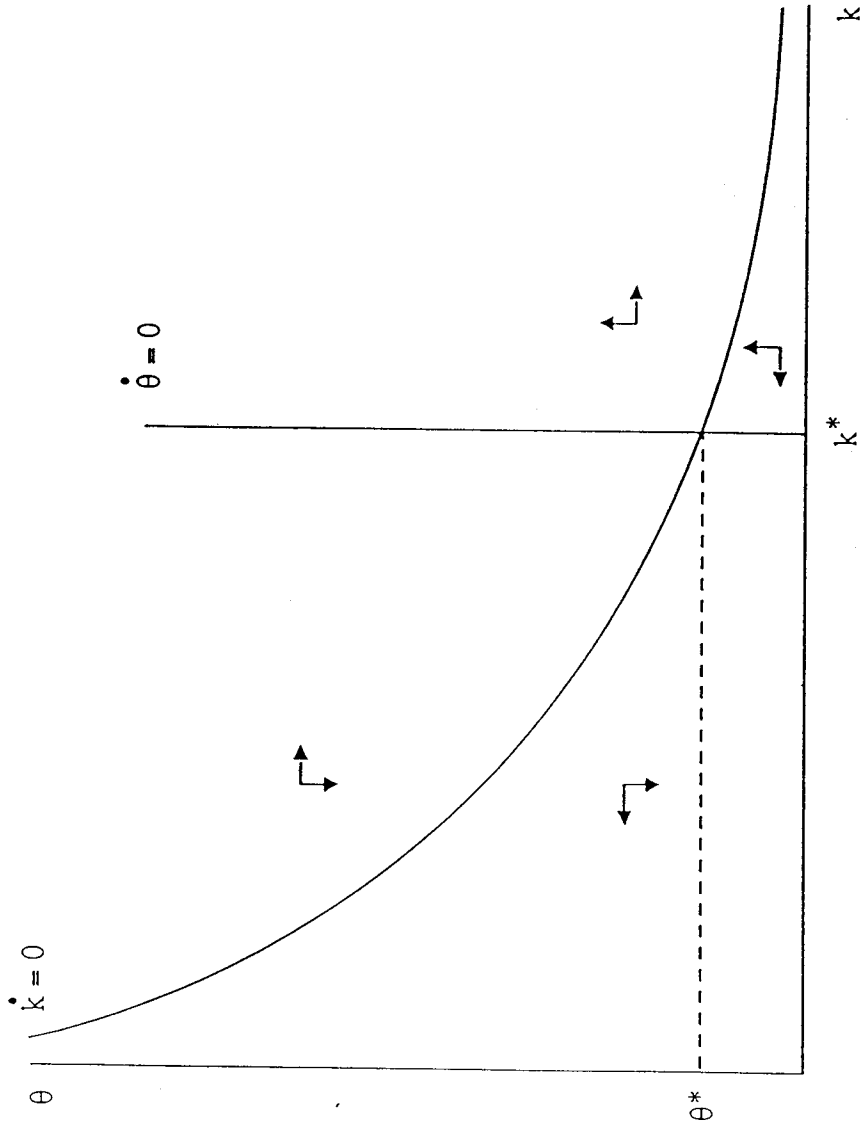
C. A Model with Constant Returns to Physical Capital

Following Romer (1986), suppose that due to the presence of externalities in the production function for output, per capita output depends not only on the per capita stock of capital but also on the total stock of capital available to the economy. In that case, equation (9) would take the form

$$\dot{k}_t = f(k_t, K_t) - c_t - nk_t \tag{15}$$

and the new Hamiltonian would be

$$H = u(c_t) + \theta_t [f(k_t, K_t) - c_t - nk_t]$$

yielding equation (15) plus the following two equations as first order conditions:

$$u'(c) = \theta$$

$$\dot{\theta} = \rho\theta - \theta f_k(k, K) + \theta n.$$

Letting $u(c) = \ln c$ and $f(k, K) = k^\alpha K^\gamma$, and assuming that there is no population growth and that individuals take the total stock of capital in the economy as given when they make their investment decisions,[54] the first order conditions become

$$c^{-1} = \theta \tag{16}$$

$$\dot{\theta} = \rho\theta - \alpha\theta k^{\alpha-1} K^\gamma$$

$$\dot{k} = k^\alpha K^\gamma - c.$$

Finally, since all individuals face the same maximization problem and will choose the same k, we can replace k with Nk, where N is the size of the population. The first order conditions for equilibrium therefore become equation (16) plus

$$\dot{\theta} = \rho\theta - \alpha\theta k^{\alpha+\gamma-1} N^\gamma \tag{17}$$

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[54]In other words, firms consider themselves sufficiently small that their investment decisions do not affect aggregate investment, much as perfectly competitive firms assume that their output decisions do not alter industry output. This assumption is critical to ensuring the existence of a price-taking equilibrium.

$$\dot{k} = k^{\alpha+\gamma}N^{\gamma} - c.$$

If $\alpha+\gamma<1$, then as in the Solow model equation (17) defines the $\dot{\theta}=0$ locus in (θ,k) space while equation (18), after replacing c with θ^{-1} by virtue of equation (16), defines the $\dot{k}=0$ locus. As before, the economy would converge to a constant capital/labor ratio and a constant per capita level of output. However, if $\alpha+\gamma=1$, then $\dot{\theta}/\theta=\rho-\alpha N^{\gamma}$ and so long as $\alpha N^{\gamma}>\rho$ there is no $\dot{\theta}=0$ locus, no steady-state value of k, and no constant level of per capita output. Instead, θ grows at the constant rate $-g=\rho-\alpha N^{\gamma}$. From equation (16), $-\dot{c}/c=\dot{\theta}/\theta$, so that per capita consumption grows at the constant rate g. From equation (18) this implies that the per capita stock of capital (and thus the aggregate stock of capital) also grow at the rate g. And, since $Y=K^{\alpha+\gamma}L^{\alpha-1}=KL^{\alpha-1}$ aggregate and per capita output also grow at the rate g. Finally, notice that

$$f_k = \alpha k^{\alpha-1}K^{\gamma} = \alpha k^{\alpha+\gamma-1}N^{\gamma} = \alpha N^{\gamma} = \rho+g$$

so the steady-state equilibrium interest rate in this model exceeds the discount factor. Accordingly, individuals are always willing to invest in additional physical capital, and over time output grows without bound. Thus, this "endogenous growth model" allows for perpetual increases in output per capita.

It can also be shown that the growth rate in this model is influenced by fiscal policy. Suppose that a proportional tax is levied on output at a rate τ (and that the revenues from the tax are not returned to the population). In that case, equation (17) would take the new form

$$\dot{\theta} = \rho\theta - \alpha\theta N^{\gamma}(1-\tau).$$

Thus, θ grows at the rate $-g'=\rho-\alpha N^{\gamma}(1-\tau)$ and output, consumption and the capital stock all grow at the rate $g'=\alpha N^{\gamma}(1-\tau)-\rho$ which is less than the rate without the tax (and could even be negative if τ is sufficiently large). By reducing the incentive to invest in physical capital the tax lowers the path of K and output growth falls. By way of comparison, in the Solow model the presence of the tax changes equation (11) to

$$\dot{\theta} = \rho\theta - \theta f'(k)(1-\tau) - n\theta.$$

Thus, the $\dot{\theta}=0$ locus is defined by $f'(k)(1-\tau)=\rho+n$. Compared to the model with no tax

this implies that the $\dot{\theta}=0$ locus is shifted to the left in (θ,k) space, with a higher marginal

product of physical capital and a lower long-run per capita stock of capital k^*. The tax affects the level of output in the economy, reducing the incentive to invest in physical capital and thereby, reducing the size of the per capita stock of capital. However, because

the $\dot{\theta}=0$ locus still exists, there is still a long-run equilibrium value of $k,k^{*'}$. The tax affects

the *level* of income but not the *rate* of per capita growth, which is still zero. (The effects of a tax in the Solow model are illustrated in Figure 3.)

D. A Model with Human Capital

The previous model assumed constant returns to physical capital to generate long-run per capita output growth. Alternatively, long-run per capita output growth could be driven by increases in the stock of human capital, which could increase the marginal productivity of the existing stock of physical capital, inducing further investment in K.

Following Uzawa (1965) and Lucas (1988) assume that there are N_t identical workers, each with skill level h_t. Output depends on the total stock of human and physical capital devoted to its production. For physical capital this is the entire stock of capital, but human capital must be allocated between the production of output and the production of additional human capital. Thus, the production function for output takes the form

$$Y_t=F(K_t,u_tN_th_t)$$

where u_t is the fraction of the day that labor spends producing output[55] while the production function for human capital takes the linear form

$$\dot{h}_t=\delta(1-u_t)h_t.$$

The linearity of the production function for human capital is essential as it implies that a constant amount of time spent in study ensures a constant rate of human capital

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[55]In fact, Lucas adds an additional term, h_a^γ to the production function for final output to capture the idea of increasing returns to scale arising from externalities related to the average level of human capital in the economy. While, as illustrated in the remainder of this section, this term is not necessary to generate long-run per capita output growth, it does allow his model to offer an explanation why labor will tend to emigrate from capital poor countries to capital rich ones, even when capital is fully mobile.

Figure 3. Solow Growth Model: Effects of a Tax on Output
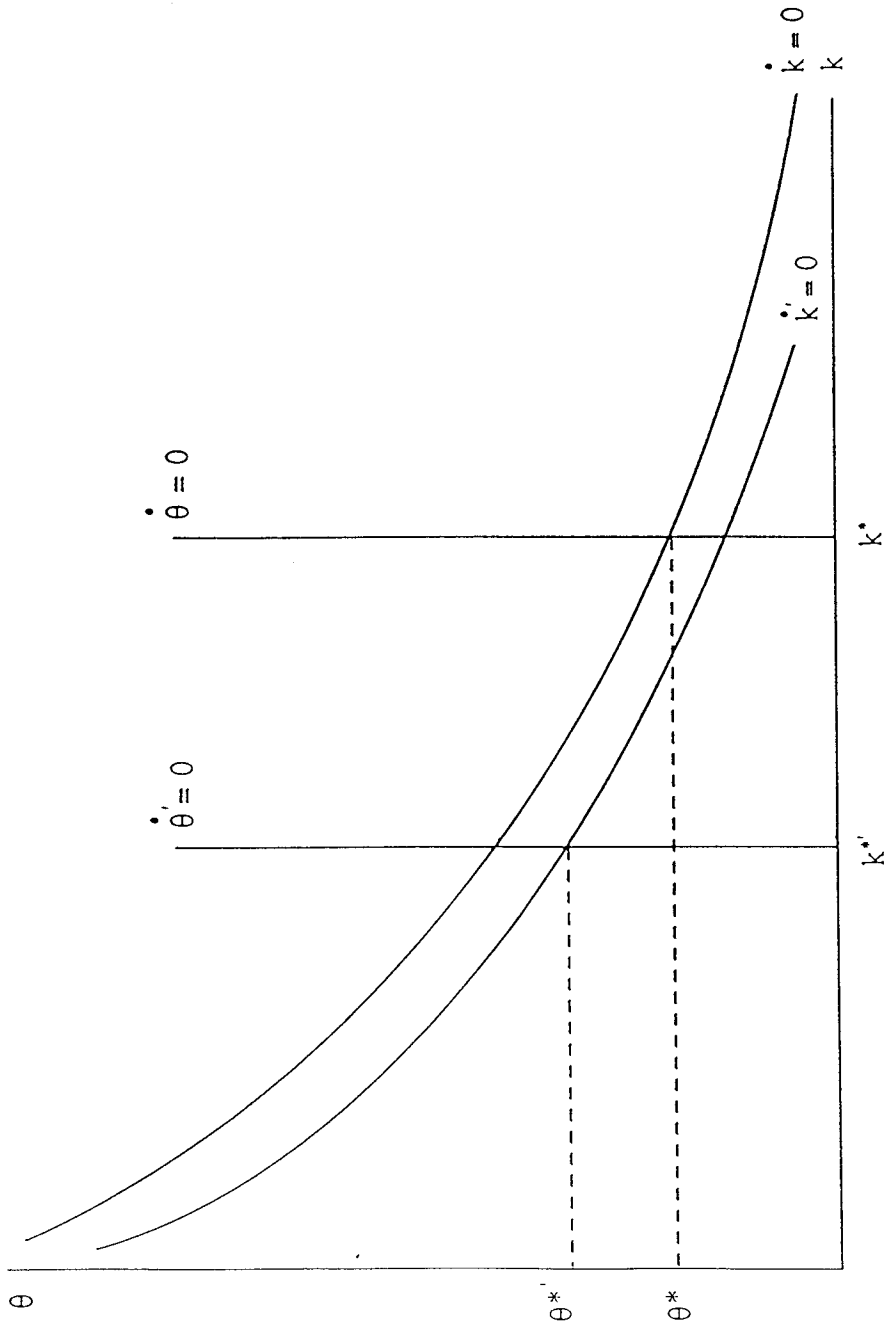
accumulation. If return to further study were decreasing (i.e., if the coefficient on h_t were less than one) at some point investment in human capital would cease, with the return on additional time at study being insufficient to compensate for foregone output.

If C_t is per capita consumption at time t, then total consumption is equal to $N_t c_t$. If we define aggregate utility as $U = \int_0^\infty \frac{N_t}{1-\sigma}[c_t^{1-\sigma}-1]e^{-\rho t}dt,$ the present-value Hamiltonian (with a constant population) is

$$H = \frac{N}{1-\sigma}[c_t^{1-\sigma}-1]+\theta_{1t}[F(K_t, u_t Nh_t)-Nc_t]+\theta_{2t}\delta h_t(1-u_t)$$

yielding first order conditions

$$c^{-\sigma}=\theta_1 \tag{19}$$

$$\dot\theta_1 = \rho\theta_1 - \theta_1 F_K \tag{20}$$

$$\dot\theta_2 = \rho\theta_2 - \theta_1 F_2 uN - \theta_2\delta(1-u) \tag{21}$$

$$\theta_1 F_2 Nh = \theta_2\delta h \tag{22}$$

$$\dot K = F(K, uNh) - Nc$$

$$\dot h = \delta h(1-u).$$

From equation (19), $\frac{\dot\theta_1}{\theta_1} = -\sigma\frac{\dot c}{c},$ while substituting equation (22) into equation (21) yields $\frac{\dot\theta_2}{\theta_2} = \rho-\delta.$ Thus, the $\dot\theta_2 = 0$ locus does not exist, meaning that there are no steady-state values of K, Y, c, or h. If a steady-state equilibrium exists where $\frac{\dot\theta_1}{\theta_1} = \frac{\dot\theta_2}{\theta_2}$ then $\frac{\dot c}{c} = \frac{\delta-\rho}{\sigma}$ and as long as $\delta > \rho$ per capita consumption will grow at a constant rate in the long-run equilibrium. In fact, output and the stock of physical capital each also grow at the rate $\frac{\delta-\rho}{\sigma}$. From

equation (20), $F_K = \rho - \frac{\dot{\theta}_1}{\theta_1} = \delta > \rho,$ so the rate of interest always exceeds the discount factor, and

individuals are always willing to invest in additional physical capital. One way to interpret the results of this model is that with K/K and $\dot{h}/h$ always equal and u constant, the ratio of physical capital to effective labor supplied to the production of output, K/uNh, is constant. Thus, as in the Solow model the economy converges to a constant capital/labor ratio. However, because *effective* labor increases in every period due to the linear production function for human capital, the per capita stock of physical capital continues to grow and long-run growth of per capita output occurs. Because the growth rate depends explicitly on δ, the parameter that determines the productivity of the human capital sector of the economy, any government policy that makes the education sector more productive directly increases the growth rate of per capita output.

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