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Some Implications of Increased Cooperation in World Oil Conservation
Stephen P. A. Brown and Hillard G. Huntington

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Lori L. Taylor

The Dynamic Impact of Fundamental Tax Reform Part 2: Extensions
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In this article, Stephen Brown and Hillard Huntington combine recent studies of world oil markets and the nascent literature on damage estimates from carbon dioxide (CO_2) emissions to derive cost and benefit curves for the reduction of these emissions through cooperative programs of oil conservation. Their analysis shows that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue rather than a conceptual one. The current evidence suggests that over the next two decades, the Organization for Economic Cooperation and Development will have an incentive to reduce its oil consumption and the associated CO_2 emissions by more than is optimal from a world perspective. During this period, extending cooperation to the oil-importing developing countries may push oil conservation too far.

Does the United States Still Overinvest in Housing?

Lori L. Taylor

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Savvy investors allocate their resources across different types of investments to maximize their returns; savvy societies do likewise. Just as with the private sector, society maximizes the return on its investments when risk-adjusted social rates of return equalize across all types of investments. Unfortunately, whereas market arbitrage ensures that risk-adjusted private rates of return equalize, no similar mechanism exists to guarantee that risk-adjusted social rates of return are also equalized. Thus, society may invest relatively too much in some types of capital and relatively too little in others. The relatively low risk-adjusted social rate of return to housing led many researchers to conclude that the United States overinvested in housing before 1986.

Much has changed in the U.S. housing market since 1986, however. In this article, Lori L. Taylor extends previous analyses to examine the case for overinvestment in housing in the post-1986 period. Her analysis of risk-adjusted social rates of return indicates the U.S. economy could grow faster if society shifted more of its resources away from housing and into high school education and, especially, nonhousing fixed capital. Thus, the evidence suggests that despite substantial reform, the United States continues to overinvest in housing.

The Dynamic Impact of Fundamental Tax Reform Part 2: Extensions

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In this second of two articles on the economic impact of fundamental tax reform, Gregory Huffman and Evan Koenig extend their earlier framework for analyzing how the adoption of a flat-rate consumption tax would affect the economy over time. They argue that if tax reform is to be successful in stimulating investment and raising long-run living standards, then it is important that ways be found to avoid increasing the rate of labor-income taxation. Increases in labor-income tax rates can undo the positive economic effects of a cut in the rate of capital-income taxation. Conversely, cuts in labor-income tax rates reinforce savings incentives and contribute to higher steady-state levels of consumption. Huffman and Koenig also demonstrate that the economy's immediate response to tax reform is muted—and the overall adjustment process can be substantially prolonged—when firms find it expensive to add quickly to their stocks of plant and equipment.

Some Implications of Increased Cooperation in World Oil Conservation

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In this article, we evaluate the extent to which increasing cooperation beyond the Organization for Economic Cooperation and Development (OECD) to limit CO_2 emissions through oil conservation is desirable from a world perspective.

The classic problem of free riding arises when nations act to curtail emissions of carbon dioxide (CO_2) and other potential greenhouse gases. When damages from emissions are global rather than local, countries that do not participate in policies directed at reducing global climate change receive the benefits of other countries' actions without incurring the costs.

Past research and game-theoretic analyses have emphasized the gains from eliciting the cooperation of developing countries in an effort to limit global CO_2 emissions (Bohm 1993; Brown and Huntington 1994b; Eyckmans, Proost, and Schokkaert 1993; Hoel 1991b and 1994; Manne and Rutherford 1994; and Welsch 1995). Broader participation reduces the costs of achieving any given target of emissions reductions among those nations engaged in the coordinated policies. In essence, the cost curve for countries reducing their emissions shifts downward as participation expands to include more countries.

Recent estimates of possible climate-change damages allow us to examine the impact of cooperation on the optimal strategy for reducing CO_2 emissions. Because increased participation lowers the costs of coordinated policies to reduce emissions, it is likely to increase the amount of conservation that the participants would see as cost effective for any given set of estimates of the benefits of reducing emissions and avoiding environmental damage. Whether increased cooperation yields too little or too great a reduction in emissions from a world perspective depends critically upon the level of damage estimates—an empirical issue that at the moment is highly uncertain.

Reduced usage of fossil fuels, through higher efficiency equipment and changing economic structures and lifestyles, is the principal vehicle for CO_2 emissions abatement. Policies that discourage the use of coal, oil, and, to a lesser extent, natural gas contribute to reduced emissions of greenhouse gases and hence lower the potential damages from climate change. Analysis of abatement policies affecting the oil market can seem complex, because actions taken by one country or group of countries are likely to influence oil consumption in other parts of the world through their effect on the world oil price.

In this article, we evaluate the extent to which increasing cooperation beyond the Organization for Economic Cooperation and Development (OECD) to limit CO_2 emissions through oil conservation is desirable from a world perspective. To accomplish this task, we derive cost and benefit curves from recent studies of world oil markets and the nascent literature on the damages arising from changes in the world climate. Our analysis shows that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue rather than a conceptual one. In addition, the current evidence suggests that over the next two decades, the OECD will have an incentive to reduce its oil consumption by more than is optimal from a world perspective — even when its actions are evaluated on a precautionary approach to reducing CO_2 emissions.[1]

Table 1
Baseline World Oil Market Conditions, 2010

	Quantity (10^6 bbl/day)[a]	Price elasticity[b]
Consumption		
OECD	45.6	–.47
C/EE/FSU[c]	15.3	–.15
OPEC	7.1	–.30
Other LDCs	17.9	–.30
Total	85.9	
Production		
OECD	15.4	.43
C/EE/FSU[c]	15.3	.30
OPEC	42.7	*
Other LDCs	12.2	.40
Discrepancy[d]	.3	n.a.
Total	85.9	

[a] Midprice case from EIA's *1993 International Energy Outlook*. Price is \$29.30 per barrel (1991\$).
[b] Percent change in quantity for each 1 percent change in price. Based on Energy Modeling Forum (1991), except for C/EE/FSU, which is based on the authors' judgment.
[c] China, Eastern Europe, and the former Soviet Union.
[d] Includes net stock withdrawals.
* OPEC responds to hold a constant market share. See text.

ESTIMATING THE COST OF OIL CONSERVATION

As in several previous studies, we use a welfare-theoretic framework built on top of a simulation model of the world oil market to compute cost curves for oil conservation under alternative assumptions about which countries are participating in the policy. The curves indicate how participants' costs change as the level of conservation increases. The cost curves include the direct resource costs associated with shifting inputs from other sectors into energy conservation activities, the wealth transfers associated with changes in the oil price, and the effects of increased oil consumption in nonparticipating countries.

The World Oil Market

Our analysis divides the world into four regions: the industrialized OECD countries; China, Eastern Europe and the former Soviet Union (C/EE/FSU); OPEC members; and other less developed countries (other LDCs). The simulation model is calibrated to reproduce the oil price, production, and consumption data shown in Table 1. The data in the table represent one of many possible oil-market outlooks for the year 2010. It is based on the midprice case in the U.S. Energy Information Administration's (EIA) *1993 International Energy Outlook*.[2]

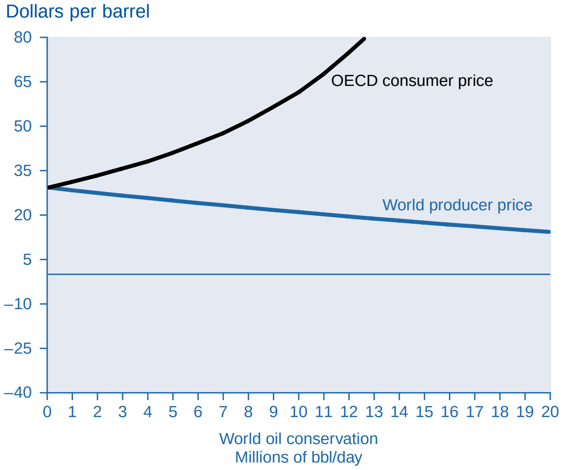
The projected oil demand conditions depend on a variety of assumptions about economic growth, prices of competing fuels, and the extent of oil-saving technological change in the absence of price changes. The supply conditions outside of OPEC member countries incorporate assumptions about the resource base, engineering constraints on developing resources, and producer-country taxes and policies. In these projections, OPEC members satisfy the excess demand, but adjust the next period's price in response to market tightness.

Table 1 also summarizes representative estimates of the long-run supply and demand responses to price for the major regional areas in the analysis. They represent mean estimates derived from an Energy Modeling Forum study (1991), which compared ten major world oil market models, and are similar to those used by the EIA in developing the projections shown in the first column. The estimates in the table were used in construction of the simulation model.[3]

The responses for the C/EE/FSU region are judgmental. Their production and consumption decisions are likely to be influenced greatly by the forces of economic transition, resulting in smaller responses to changes in world oil prices than found in other regions. In fact, if the supply and demand responses for the C/EE/FSU were made comparable to responses for other country groups, the conservation scenarios considered here would push world oil prices sufficiently low that we would estimate these economies would import significant quantities of oil. We consider this result untenable and therefore assume a smaller response to price than for other countries. To the extent that these countries yield a greater response to price, the estimated costs of achieving various world conservation targets without cooperation from these countries would be larger than reported here.

The response of oil producers within OPEC is highly uncertain. To date, formal modeling of OPEC decisions has been far from reliable. OPEC appears to operate like an imperfect cartel during some periods but not during others.[4] The OPEC countries appear to be about

Figure 1
Oil Price Under an OECD Conservation Tax



as uncomfortable with a rapidly increasing market share (as accompanied the relatively low prices in the 1960s) as they are with a rapidly decreasing market share (as occurred in the aftermath of the price hikes of the late 1970s and early 1980s). The analysis presented here assumes that OPEC acts to maintain a constant market share.[5]

The Cost of Conservation

We examine conservation policies by reducing oil consumption in participating countries below the levels shown in Table 1 and allowing the world oil price to adjust to restore a balance between oil supply and demand conditions. Analytically, we use a tax to reduce oil consumption in the participating groups of countries. The tax approach assumes that conservation measures are applied across all end uses.

As shown in Figure 1, an oil conservation tax applied in the OECD acts to depress the world oil price while it boosts the oil price faced by consumers in the OECD. A reduced world oil price has two important effects. It yields transfers from oil exporting countries to oil importing countries that operate to offset some of the costs that OECD incurs by imposing conservation policies. It also stimulates oil consumption in countries not participating in the conservation efforts.

Using values from the simulations, we construct cost curves using Equation B.4 from the box titled "Some Analytics of Oil Conservation." This methodology follows a welfare-theoretic approach previously employed by Brown and Huntington (1994a) and Felder and Rutherford (1993). The resulting cost curves take into account the direct welfare costs of a country's conservation efforts, transfers of wealth from oil exporting to oil importing countries, and the effect that lower world oil prices will have in stimulating oil consumption in nonparticipating countries. The cost curves also take into account the economic cost of OPEC cartelization.[6]

Construction of the cost curves depends critically on the assumptions used. In particular, assumptions that world oil production or OECD oil consumption is more responsive to price would tend to work against the conclusions presented below. Nonetheless, sensitivity analysis using a range of plausible assumptions about the outlook for 2010 and the responsiveness of consumption and production to changes in price yielded overall conclusions similar to those reported below.

To maintain the emphasis on the substantial difference in market response to the inclusion of additional countries, our analysis abstracts from a number of important considerations that would be incorporated in a more refined analysis. These considerations include alternative policies for distributing conservation goals across countries (Whalley and Wigle 1991, and Brown and Huntington 1994b); the design of taxes and redistributive mechanisms (Hoel 1991b); and an explicit accounting for different types of goods (Felder and Rutherford 1993, and Pezzey 1992). We also abstract from the effects of preexisting energy taxes and other taxes. Preexisting taxes could be reduced to offset some of the costs of a new conservation policy (Hoel 1991b) or be left in place, which would affect the estimated costs of imposing a new conservation policy (Newberry 1992).

Similarly, for some LDCs, removing subsidies to the energy sector could reduce energy use and improve economic efficiency, which contrasts to our assumption that conservation is achieved through taxes that impose costs on the economy. Alternatively, some LDCs may have supply-constrained energy consumption, and the costs of their conservation efforts would be higher than we estimate here.

DIFFERING INCENTIVES FOR OIL CONSERVATION

In Figure 2, the cost curve labeled "World" shows how much each additional barrel of world oil conservation costs all nations collectively. The construction of this curve assumes that conservation is first adopted wherever it is cheapest. The curve incorporates the efficiency losses resulting from the OPEC cartel restricting output below free market levels, as well as the direct costs associated with shifting resources

Some Analytics of Oil Conservation

We use a welfare-theoretic approach to derive formulas for the marginal cost of oil conservation. For any country (or country grouping), social welfare in the oil market is the sum of its consumer and producer surpluses:

$$W_i = \int_0^{Q_{Di}} P_{Di}(Q)dQ - P_W Q_{Di} + P_W Q_{Si} - \int_0^{Q_{Si}} P_{Si}(Q)dQ. \quad \text{(B.1)}$$

In the above equation, W_i denotes the welfare country *i* obtains from the oil market, Q_{Di} the quantity of oil demanded in country *i*, P_{Di} country *i*'s demand price (the market's marginal valuation of consumption excluding externalities) at each quantity (Q), P_W the world price of oil, Q_{Si} the quantity of oil production in country *i*, and P_{Si} country *i*'s oil supply price (marginal cost of its oil production excluding externalities) at each quantity (Q).

THE COST OF GROSS CONSERVATION

If the marginal cost of conservation is defined as the welfare lost in country *i*'s oil market by reducing its oil consumption on the margin, the negative of the first derivative of W with respect to Q_D yields the marginal cost of conservation:

$$MC_i = P_{Di} - P_W + \frac{\partial P_W}{\partial Q_{Ci}} Q_{Mi}. \quad \text{(B.2)}$$

In the above equation, MC_i denotes the marginal cost of conservation, Q_{Ci} the quantity of conservation (where $\partial Q_{Ci} = -\partial Q_{Di}$), and Q_{Mi} the quantity of net oil imports for country *i*. As Equation B.2 shows, the gross marginal cost of oil conservation is the difference between the domestic and world prices of oil ($P_{Di} - P_W$) minus the transfer obtained by reducing the price of imported oil ($\partial P_W/\partial Q_{Ci}$ is negative).

THE COST OF NET CONSERVATION

The net effect of conservation actions taken by a country or group of countries is the quantity of its conservation minus the induced change in oil consumption in the rest of the world. The change in oil consumption in nonparticipating countries depends on how their consumption is affected by a change in the world oil price and how the conservation actions in the participating countries affect the world oil price. Therefore, the relationship between a change in participant conservation and the net change in world oil conservation can be expressed as

$$\frac{\partial Q_{CW}}{\partial Q_{Ci}} = 1 - \frac{\partial Q_{DX}}{\partial P_W} \cdot \frac{\partial P_W}{\partial Q_{Ci}}. \quad \text{(B.3)}$$

In the above equation, Q_{CW} denotes world oil conservation and Q_{DX} the quantity of oil consumption by nonparticipating countries.

Following Felder and Rutherford (1993) and Brown and Huntington (1994a), Equations B.2 and B.3 can be combined to express the marginal cost of net world oil conservation for country (or country grouping) *i*. Specifically, multiplying the marginal cost of the gross conservation in country *i* by the net change in world conservation resulting from country *i*'s conservation yields

$$MC_{Wi} = \left(P_D - P_W + \frac{\partial P_W}{\partial Q_{Ci}} Q_{Mi}\right) \cdot \left(1 - \frac{\partial Q_{DX}}{\partial P_W} \cdot \frac{\partial P_W}{\partial Q_{Ci}}\right)^{-1}. \quad \text{(B.4)}$$

In the above equation, MC_{Wi} denotes the marginal cost net world oil conservation to country *i*.

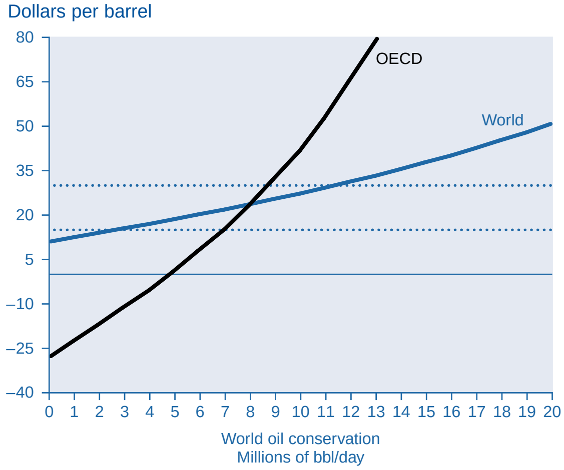
As Equation B.4 shows, the effects that cooperative oil conservation has on the cost of oil imports and on nonparticipant oil consumption are related through the world oil price. As cooperative conservation lowers the world oil price, it reduces the cost of country *i*'s oil imports and brings about an increase in nonparticipant oil consumption. If conservation has no effect on the world oil price, however, both the cost of oil imports and nonparticipant oil consumption will remain unchanged.

toward oil conservation. The world curve does not incorporate any transfers, because any transfers the oil-importing nations obtain through the lower oil prices induced by conservation are exactly offset by transfers away from oil producers. The curve starts above zero to incorporate the economic efficiency losses associated with OPEC restricting its output.

The cost curve labeled "OECD" shows how much each additional barrel of world conservation costs the OECD countries if only they act to conserve oil. As such, this curve is constructed to reflect the increase in non-OECD consumption that will result from lower world oil prices induced by unilateral OECD action to conserve oil. At lower levels of oil conservation, the cost to OECD is negative because lower prices fostered by its conservation efforts transfer wealth from oil exporting nations to the OECD. At about 5 million barrels per day of world oil conservation, the marginal cost reaches zero and is positive thereafter.

Although the OECD cost curve lies below the world cost curve at lower levels of conservation, it rises more sharply with conservation for two reasons. The wealth transfer to the

Figure 2
Marginal Cost of World Oil Conservation



OECD becomes smaller as greater conservation reduces imports. In addition, the direct costs increase more sharply for the OECD curve than for the world curve because conservation projects can be selected from only OECD countries rather than worldwide. As a consequence, for conservation levels of about 8 million barrels per day and higher, the OECD cost curve lies above the world cost curve.

The OECD and world cost curves illustrate that the oil-importing OECD countries, acting as a group, have an incentive to select a level of oil conservation that is not optimal from a world perspective. Whether unilateral OECD action that is unmatched by other countries leads to too much or too little emissions reduction, however, cannot be determined by the cost information alone. This issue can be resolved only by knowing the estimated benefits of (or damages avoided by) oil conservation.

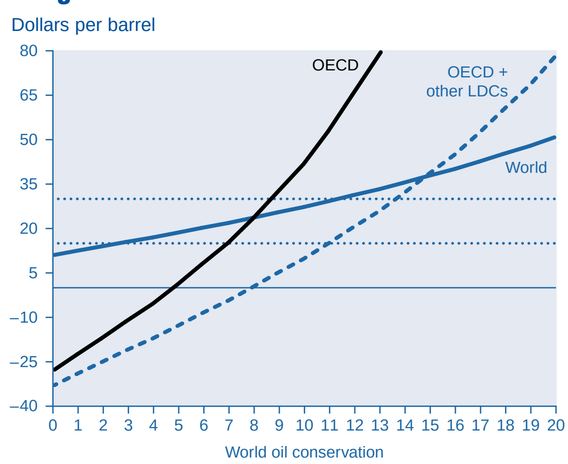
Previous analysis suggests a flat marginal damage curve. Summarizing the previous literature, Peck and Teisberg (1992) explain that marginal damage costs are essentially unaffected by the emissions levels in any given decade. This conclusion rests on the finding that temperature change depends upon gas concentration, which is not greatly affected by the emissions levels in any given decade. We adopt this characterization by assuming horizontal damage curves that depict a constant level of benefits for any level of oil conservation.

Figure 2 also illustrates the situation for two hypothetical marginal benefit curves—one at $15 per barrel and one at $30 per barrel. When the marginal benefits of oil conservation are below about $24 per barrel, the OECD has an incentive to pursue more conservation than is optimal from the world perspective, as is illustrated along the $15 marginal benefit curve. In this range, the $15 curve intersects the OECD marginal cost curve to the right of its intersection with the world marginal cost curve. Unilateral OECD action could result in too much oil conservation from a world perspective.

Moreover, at benefit levels below about $24 per barrel, cooperation from the group of oil-importing countries previously identified as "other LDCs" will exacerbate the discrepancy between what is optimal from a world perspective and what participants would have the incentive to choose. As shown in Figure 3, cooperation between the OECD and the other LDCs shifts the participant's cost curve for world oil conservation from the one labeled "OECD" to the one labeled "OECD + other LDCs."[7] At benefit levels below about $24 per barrel, the equilibrium amount of oil conservation selected by the participating countries will be even greater—producing even more abatement of CO_2 emissions than would be optimal from a world perspective.

When the benefits are above about $24 per barrel, the OECD has an incentive to pursue less oil conservation than is optimal from a world perspective, as is illustrated along the $30 benefit curve. Under these conditions, the marginal benefit line intersects the OECD's marginal cost curve to the left of its intersection with the world's marginal cost curve. Unilateral OECD action could result in too little oil conservation. Some limited cooperation from developing countries could help ameliorate this problem by shifting the cost curve outward, but full cooperation from all developing countries would shift the curve far to the right, and the participants

Figure 3
Marginal Cost of World Oil Conservation



would seek more conservation than would be optimal from a world perspective unless the benefits of oil conservation were more than about $37 per barrel.

THE BENEFITS OF REDUCING CO_2 EMISSIONS

Damage estimates for CO_2 are in their infancy. Economic evaluations attempt to monetize both market and nonmarket impacts of greenhouse gas concentrations, and the resulting estimates vary considerably. Key uncertainties include the dynamics of the carbon cycle governing the effect of emissions on concentrations, the effect of concentrations on temperature change, and the consequences of temperature change on market and nonmarket damages. Differences in discount rates for evaluating potential impacts over horizons of 100 years or more account for a significant part of the differences in damage estimates. Finally, estimates vary depending upon the decade for which they are computed; estimated damages increase for later decades.

Table 2 reports estimates from several prominent studies providing monetized estimates of the marginal damages arising from CO_2 emissions in the decade 2001–10. Researchers usually report their estimates in U.S. dollars per ton carbon (tC), as shown in the first column. We convert these estimates to U.S. dollars per barrel of oil in the second column. In oil-equivalent terms, the mean damage estimates range from about $1 to $3 per barrel across different studies. Emphasizing the dramatic uncertainty in these estimates, the Fankhauser study (1994) provides a range from less than $1 per barrel to almost $6.50 per barrel, depending upon key parameter assumptions.

Hope and Maul (1996) use two economic-environmental assessment models—Intera and PAGE—to provide similar estimates to the range shown by Fankhauser without specifying the decade for their analysis. Using the PAGE model and what they identify as "the inner uncertainty range" of the Intera model, they find that damages from marginal CO_2 emissions range from $12 to $45 tC for the PAGE model and from $3 to $50 tC for the Intera model. The outer uncertainty range found with the Intera model—which should be accorded a very low probability because it combines many events, each of which is accorded only a 5 percent probability by experts—is $0 to $270 tC. Hope and Maul suggest that policymakers who take the threat of global warming seriously should use a precautionary principle and penalize sources of CO_2 with the high estimates found with the PAGE model or the inner uncertainty range of the Intera model, which would amount to $5.63 (PAGE) or $6.50 (Intera) per barrel of oil.

Even for those taking a precautionary approach to reducing CO_2 emissions, the available damage estimates fall well below $24 per barrel of oil. Combined with the cost curves of oil conservation presented above, these damage estimates suggest that unilateral action by the OECD will lead to excessive oil conservation and that adding oil-importing LDCs would exacerbate the problem.[8] At $0 to $33.75 per barrel, the outer uncertainty range found with the Intera model emphasizes the possibility (but low probability) of higher damage estimates and thus indicates the need for further study of the benefits of reducing CO_2 emissions.

Table 2
Estimated Damages from CO_2 Emissions for 2001–10

Study	$/tC*	$/bbl†
Nordhaus (1991a,b)	7.3	.89
Nordhaus (1992)	6.8	.85
Peck and Teisberg (1993a,b)	12–14	1.46–1.71
Fankhauser (1994)		
Mean	22.8	2.78
5th percentile	7.4	.90
95th percentile	52.9	6.45

* Adapted from Fankhauser (1994).
† Authors' estimates based upon a conversion factor of $8/tC equals $1/bbl.

CONCLUSION: THE COSTS OF EXTENDING COOPERATION

The preliminary evidence suggests that during the next two decades, OECD action to conserve oil to reduce CO_2 emissions is likely to result in more oil conservation than is optimal from a world perspective. For the OECD, cooperative oil conservation would reduce world oil prices and yield wealth transfers from oil-exporting countries to the oil-importing countries undertaking oil conservation policies. These wealth transfers are sizable and positive for the OECD nations, which collectively are heavily dependent upon oil imports. For relatively small oil-conservation strategies, as are suggested by the nascent literature on the damages from CO_2 emissions, these wealth transfers will dominate the direct costs of conservation and lead to excessive conservation from a world perspective. This result contrasts sharply with the standard perspective that unilateral OECD action is likely to lead to insufficient oil conservation.

Under these conditions, extending cooperation to the oil-importing developing countries will exacerbate the problem. Participants' costs will be reduced, leading to even larger discrepancies between emissions levels chosen by the self-interested participants and those seen as optimal from a world perspective.

These seemingly anomalous results are obtained precisely because the nations most likely to cooperate in conserving oil are likely to exclude the oil-exporting nations and thus ignore the costs that conservation imposes on the latter group. From a world perspective, transfers to energy-importing countries are exactly offset by transfers from net-energy-exporting countries. From the more limited perspective of the oil-importing countries participating in a coordinated energy conservation policy, these wealth transfers are not offset but operate as an incentive to conserve energy and reduce emissions. Because CO_2 damages are currently unpriced in the market, these additional incentives to conserve oil may be a good thing. Nonetheless, the current estimates of the costs of CO_2 damages are not high enough to justify concern that OECD countries do not have sufficient incentive to act unilaterally to reduce emissions.

These preliminary conclusions depend very critically upon the size of estimated damages from CO_2 emissions. If future estimates of damages should prove to be higher by a factor of 5—a possibility suggested by the outer uncertainty range of the Intera estimates—the analysis could be reversed. In such a case, our cost estimates would suggest that OECD countries would not have sufficient incentives to conserve oil, and eliciting cooperation from oil-importing LDCs could improve the outcome from a world perspective. In this respect, one implication of our analysis is that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue rather than a conceptual one.

In addition, our conclusions pertain only to CO_2 emissions with a global impact. The local and regional benefits from reducing energy use (the damages avoided from local pollution) may well be more important than the benefits derived from global strategies to reduce worldwide environmental threats (see Hall 1990, 1992).

NOTES

Work was conducted while Huntington was visiting the Judge Institute of Management Studies, University of Cambridge. Preliminary versions of this research were presented at the Texas A&M Colloquium on Energy Use and Sustainable Economic Growth and the annual meeting of the U.S. Association for Energy Economics. The authors would like to thank Irma Gomez, Chris Hope, Paul Leiby, John Weyant, and Mine K. Yücel for helpful comments, without implicating them in the conclusions.

1. The current analysis is limited to oil conservation and does not consider interfuel substitution. Substantial interfuel substitution could alter the analysis.
2. Although the EIA's 1993 outlook is dated, particularly in the $29.30 per barrel price forecasted for 2010, sensitivity analysis using a range of plausible assumptions about the outlook for 2010 yielded overall conclusions similar to the results reported below.
3. The estimates are taken from Huntington (1992, 1993).
4. Griffin (1985) and Dahl and Yücel (1991) provide empirical estimates of OPEC behavior that are broadly consistent with this view.
5. A sensitivity analysis using alternative assumptions that allow modest adjustments in OPEC's market share confirm our general findings. In the extreme, OPEC could maintain a given price and accept a substantial loss in market share in the face of reduced demand. Under these conditions, the OECD would not obtain wealth gains from lower oil prices with which to offset the direct costs of unilateral oil conservation policies.
6. To obtain the full cost of world conservation to the world in the presence of OPEC cartelization, we add marginal loss in producer surplus that results from OPEC restricting its output. That is the share of world oil coming from OPEC multiplied by the difference between the world price of oil and OPEC's full production costs including user costs.
7. The cost curve is constructed to reflect the gains in nonparticipant oil consumption that will result from lower world oil prices induced by the cooperative action to conserve oil. As such, it reflects participant costs of world oil conservation.
8. Sensitivity testing, through the use of parameters to replicate the behavior of several of the prominent energy models that participated in a recent Energy Modeling Forum study (1991), yielded qualitatively similar results.

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Does the United States Still Overinvest In Housing?

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The risk-adjusted social rate of return remains substantially lower for housing than for other types of investment.

Savvy investors allocate their resources across different types of investment to maximize their returns; savvy societies do likewise. Just as with the private sector, society's returns are maximized when risk-adjusted social rates of return equalize across all types of investment (Auerbach 1983; Hendershott 1987). After all, if these rates of return are not equal, society could increase its income by shifting resources from low-return investments into those with a higher return.

Unfortunately, while market arbitrage ensures that risk-adjusted private rates of return equalize, no similar mechanism exists to guarantee that social rates of return do the same. Thus, society may invest relatively too much in some types of capital and relatively too little in others.

History suggests that the United States overinvests in housing. Estimates of the social rate of return are substantially lower for housing than for other types of investment. Mills (1989) finds the social rate of return to housing was only 20 percent of that to nonhousing fixed capital, on average, over the period 1929–86. McMahon (1991) extends the scope of Mills' analysis to find that the social rate of return to housing was also substantially lower than that to education over the period 1967–86. Researchers have concluded from this type of evidence—together with evidence on the relative risk of housing investments—that the United States overinvested in housing before 1986 (for example, Mills 1989; McMahon 1991; and Hendershott 1989).[1]

Much has changed in the U.S. housing market since 1986, however. For example, the Tax Reform Act of 1986 (TRA 86) greatly reduced the tax benefits of owner-occupied housing (Follain, Hendershott, and Ling 1991, 1992; Hoyt 1992). Changes in tax depreciation and passive loss provisions under TRA 86 also increased the effective tax on rental housing (Follain, Hendershott, and Ling 1987). Furthermore, declining inflation rates have made housing less valuable as a hedge against inflation and reduced the effective tax on capital gains. All these changes could have altered the relative social rate of return to housing.

In this article, I extend Mills' and McMahon's analyses to examine the case for overinvestment in housing in the post-1986 period. I examine the social rates of return for investments in housing, nonhousing fixed capital, and education over the period 1975–95 and find no evidence that the relative social rate of return to housing has risen since 1986. I then examine the appropriate risk adjustment for each type of investment and derive risk-adjusted social rates of return. While the evidence suggests that previous analyses may have overstated the relative riskiness of investment in housing, I cannot reject the hypothesis that the risk-adjusted social rate of return remains substantially lower for housing than for other types of investment. Therefore, the evidence suggests that despite substantial reform, the United States continues to overinvest in housing.

SOCIAL RATES OF RETURN

The social rate of return to any investment is the interest rate at which the present value of social benefits from an investment exactly equals the present value of its social costs. The social benefits and costs equal the private benefits and costs plus any benefits or costs to society in general. For example, public high school students do not pay tuition or for books, so their private cost of education is essentially the opportunity cost of their time. However, the government does pay the teachers and buy the books, so the social cost of an investment in high school education equals the private cost of the students' time plus the government's expenditures. Similarly, while students might count their after-tax income gains as the only benefit of additional schooling, the social benefits include any gains in tax revenue.

Social Rate of Return to Housing

The social return to housing describes the total benefits to society from an investment in housing capital. Mills (1989) estimates the social rate of return to housing in the United States (R_h) using data on aggregate rents and capital gains as his measures of benefits and data on the housing stock as his measure of housing capital. Formally,

$$R_h = \frac{H}{K_h \bar{p}} + p_{h,t+1} - p_{h,t}, \qquad (1)$$

where H is net housing product (total payments to housing net of depreciation but gross of taxes) in period t, K_h is the real housing stock in period t (net of depreciation), $\bar{p}$ is the net national product deflator, and $p_{h,t}$ is the housing stock's constant-dollar price per unit in period t.[2]

If aggregate rents and capital gains reflect *all* the social benefits to investment in housing capital, and *only* those benefits, Mills' strategy generates good estimates of the social rate of return to housing. However, if rents and capital gains do not capture all the benefits to housing investment, his approach underestimates the social rate of return to housing. Similarly, if rents reflect more than the returns to housing capital, his approach overestimates the social rate of return to housing. Mills' estimation strategy is undoubtedly vulnerable to both types of measurement error.

Consider first the possibility that aggregate rents and capital gains fail to capture all the benefits to housing investment. While all the private benefits to housing investment should be reflected in rents and capital gains, many have argued that one type of housing investment—home ownership—generates positive externalities (see the discussions in Rosen 1985 and Green and White 1997).[3] Homeowners clearly have more incentive than renters to keep their property from becoming an eyesore and to resolve neighborhood problems. In addition, Green and White (1997) find that, compared with the children of renters, the children of homeowners are less likely to drop out of school or become teenage mothers.[4] However, because the lion's share of the benefits to continuation in school accrue to the person receiving the education, only a fraction of the benefits Green and White identify can be considered *externality* benefits to home ownership.[5] More important, any externalities to home ownership that enhance neighborhood conditions are likely to be capitalized into neighborhood property values. To the extent that the externality benefits of home ownership are capitalized into residential property values, they will be reflected in aggregate measures of residential rents and capital gains. Therefore, it is unlikely there are substantial unmeasured benefits from investment in housing.

The case is much stronger for the proposition that rents reflect more than the returns to housing capital. Economists have long recognized that locational characteristics—like air quality or the proximity to a central business district—can be capitalized into the prices people pay for housing. Thus, the rent a person pays for housing equals the sum of the rent paid for the characteristics of the structure (for example, the square footage or the number of bathrooms), plus the rent paid for the characteristics of the location (for example, the distance to downtown or the beach). Payments for structural characteristics are returns to housing capital; payments for locational characteristics (other than housing externalities) are not. To the extent that residential rents include payments for locational characteristics, they overstate the returns to housing capital (structures). Conventional wisdom suggests that payments for locational characteristics are a significant part of residential rents.

In sum, there is only weak evidence that positive externalities cause market rents to significantly underestimate the social returns to housing capital. There is relatively strong evidence that locational rents cause market rents to significantly overestimate the social returns to housing capital. Therefore, it is highly likely that Mills' estimation strategy overestimates the social rate of return to housing capital.

Fortunately, a simple modification to Mills' strategy can correct for the overestimation. Recognizing that net housing product includes payments to land as well as payments to housing capital and assuming the social rate of return to housing capital equals the social rate of return to residential land, Equation 1 becomes

$$(2) \qquad R_h = \frac{H}{K_h\bar{p} + A_h\bar{p}} + p_{h,t+1} - p_{h,t},$$

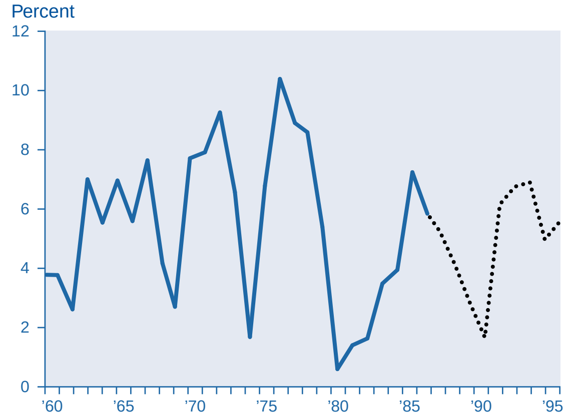
where A_h is the value of residential land.

I use Equation 2 and revised versions of Mills' data sources to estimate the social rate of return to housing for the period 1960–95. The net housing product data, which come from the national income and product accounts, include space rents for all types of housing except transient hotels, motels, clubs, schools, and other group housing (U.S. Bureau of Economic Analysis, 1997a). The net housing stock data, which come from the estimates of fixed reproducible tangible wealth, include the value of structures but not the value of any residential land (U.S. Bureau of Economic Analysis, 1997b).[6] Because Ibbotson and Siegel (1984) argue that estimates of the housing stock should be increased by 20 percent to account for the value of land, I assume $A_h = 0.20K_h$.

Interestingly, despite the many changes that should have reduced private investment in housing, I find no evidence the social rate of return to housing has risen since 1986.[7] The aggregate annual return to housing averaged 5.4 percent between 1960 and 1986 and has averaged a statistically equivalent 4.9 percent since 1986 (*Figure 1*).

Although the social rate of return to housing may not have changed significantly since 1986, two other dimensions need investigating before we can conclude that the United States continues to overinvest in housing. First, we need to consider possible changes in the social rates of return to nonhousing fixed capital and education. Second, we need to consider the relative risks associated with housing and other investments. Only with this additional information can we conclude that the risk-adjusted social rate of return to housing remains significantly below that to other types of investment.

Figure 1
Social Rate of Return to Housing in the U.S.



Social Rate of Return to Nonhousing Fixed Capital

The social rate of return to nonhousing fixed capital describes the total social return to an investment in equipment and nonhousing structures. Observing that net national income can be decomposed into payments to labor and payments to capital (disregarding payments to land), and that payments to capital can be further decomposed into payments to housing capital and to nonhousing capital, Mills estimates the social rate of return to nonhousing fixed capital as

$$(3) \qquad R_k = \frac{\hat{Y} - \overline{W}N - H}{K_k\bar{p}} + p_{k,t+1} - p_{k,t},$$

where $\hat{Y}$ is net national product, $\overline{W}N$ is total labor compensation, K_k is the real nonhousing fixed capital stock in period t (net of depreciation), and $p_{k,t}$ is the constant-dollar price per unit of the nonhousing fixed capital stock in period t. As with housing, Mills' estimation technique yields good estimates of the social rate of return to nonhousing fixed capital if nonhousing product (net national product excluding net housing product and labor compensation) captures *all* the returns to nonhousing fixed capital, and *only* those returns.

There is reason to believe this condition does not hold. A number of researchers posit externality benefits from investment in nonhousing capital, although few find empirical evidence of significant effects (see De Long and Summers 1991, 1994; Auerbach, Hassett, and Oliner 1994;

and the discussion in Summers 1990). To the extent that there are externality benefits from investments in nonhousing fixed capital, the aggregate rate of return would understate the social rate of return.

Furthermore, nonhousing product undoubtedly exceeds the actual returns to nonhousing fixed capital. As with housing product, nonhousing product includes commercial rents that represent payments for locational as well as structural characteristics. Similarly, the agricultural and mining components of nonhousing product include returns to natural resources as well as industry capital. To the extent that nonhousing product includes returns to land rather than capital, the aggregate rate of return would overstate the social rate of return to nonhousing fixed capital.

More pervasively, Mills' measure of nonhousing product includes proprietors' income that largely reflects returns to the labor and entrepreneurial efforts of business owners. Unfortunately, the extent to which proprietors' income reflects labor compensation rather than returns to the private capital of proprietors is unknown.[8] Aggregate returns to nonhousing fixed capital that include proprietors' income probably overstate the social rate of return, whereas aggregate returns excluding this income probably understate it.

Again, I modify Mills' analysis to estimate the social rate of return to nonhousing fixed capital. Assuming that the rate of return to nonresidential land is the same as that to nonhousing capital, Equation 3 becomes

$$(4)\quad R_k = \frac{\hat{Y} - \overline{W}N - H - (1-\alpha)I}{K_{ke}\overline{p} + K_{ks}\overline{p} + A_k\overline{p}} + p_{k,t+1} - p_{k,t},$$

where I is proprietors' income, α is the fraction of proprietors' income that is a return to capital, A_k is the value of nonresidential land, K_{ke} is the value of nonhousing equipment, K_{ks} is the value of nonhousing structures, and $K_{ke} + K_{ks} = K_k$. As with housing, I assume that $A_k = 0.20K_{ks}$. To bias the analysis against a finding of overinvestment in housing, I also assume that none of the proprietors' income represents a return to capital ($\alpha = 0$).

Figure 2 compares the social rates of return to nonhousing fixed capital and housing. Clearly, between 1975 and 1995 the social rate of return to nonhousing fixed capital greatly exceeded the social rate of return to housing capital. At no time since 1975 has the rate of return to housing capital been within 5 percentage points of the rate of return to nonhousing fixed capital.

Furthermore, as is the case with housing, the aggregate social rate of return to nonhousing fixed capital has not changed significantly since 1986. The average since 1986 (12.99 percent) is statistically equivalent to the average from 1975 through 1986 (13.65 percent).

Social Rate of Return to Education

The social rate of return to education describes the total benefit to society of an investment in human capital. The two methods commonly employed to estimate the rate of return to investment in education—the internal rate of return method and the earnings function method—yield similar estimates for the United States (Taylor 1994). However, the internal rate of return method is better suited to generating annual estimates. Therefore, as in McMahon (1991), the internal rate of return method is used here.

This method involves directly calculating the interest rate at which the present value of the expected social benefits from education equals the present value of the expected social costs. In general, economists use earnings differentials at age t (E_t) to measure the expected social benefits. Per pupil expenditures plus the opportunity cost of student time constitute the expected social costs (C_t). Therefore, the social rate of return is the interest rate (r) that solves Equation 5,

$$(5)\quad \sum_{t=1}^{T-1} \frac{E_t}{(1+r)^t} = \sum_{t=1}^{T-1} \frac{C_t}{(1+r)^t},$$

where T is age at retirement (65).[9]

The internal rate of return to education is a good estimate of the social rate of return if wages reflect *all* the benefits to education, and

Figure 2
Social Rates of Return to Housing and Nonhousing Fixed Capital

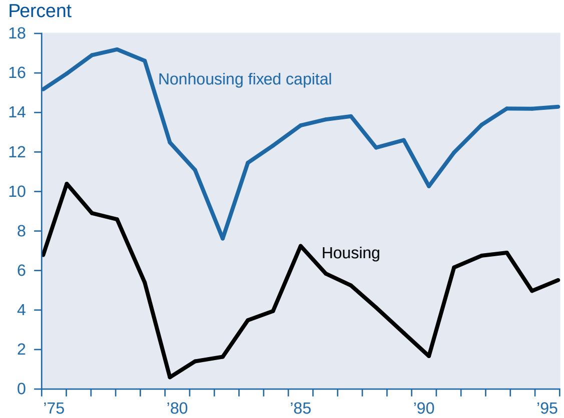


Table 1
Volatility of Rates of Return

	Housing	Nonhousing fixed capital (excluding proprietors' income)	High school education	College education
1975–95				
Mean (percent)	5.31	13.37	10.82	8.50
Standard deviation	2.46	2.32	.88	.73
CV	46.35	17.34	8.14	8.57
1975–86				
Mean (percent)	5.35	13.65	10.72	8.12
Standard deviation	3.19	2.87	.70	.72
CV	59.60	21.02	6.57	8.90
1987–95				
Mean (percent)	4.91	12.99	10.96	9.00
Standard deviation	1.76	1.35	1.11	.32
CV	35.89	10.40	10.09	3.61

only the benefits to education. Researchers have identified a number of probable nonwage benefits to education (McMahon 1987a,b; Taylor 1992; and Behrman and Stacey 1997), but no consensus has developed about their magnitude. If there are significant nonwage benefits, the internal rate of return to education will underestimate the social rate of return. On the other hand, if the wage increases associated with more education reflect greater innate abilities in addition to school effects, the internal rate of return will overestimate.[10] Earnings function estimates, which can better control for innate student characteristics (but not for nonwage benefits), suggest that the internal rate of return method modestly overestimates the social rate of return.

I calculate the internal rate of return to high school and college education for U.S. males using data on annual expenditures per full-time-equivalent student in the United States (U.S. Department of Education 1996a,b) and data on average annual earnings according to education levels and age groups (U.S. Bureau of the Census, annuals 1975–96).[11,12]

As Figure 3 illustrates, the internal rate of return to high school exceeded that to college in the United States over the period 1975–95.[13] The internal rates of return averaged 10.8 percent for a high school education and 8.5 percent for a college education. Furthermore, except for the high inflation period of 1975–78, both rates exceeded the social rate of return to housing.

Interestingly, while the internal rate of return to high school has remained statistically stable since 1975, the rate of return to college has been drifting upward. The internal rate of return to college averaged 8 percent from 1975 to 1986, but increased to an average of 9 percent from 1987 to 1995.[14] Relative to the rate of return to housing, however, the increase is insignificant.

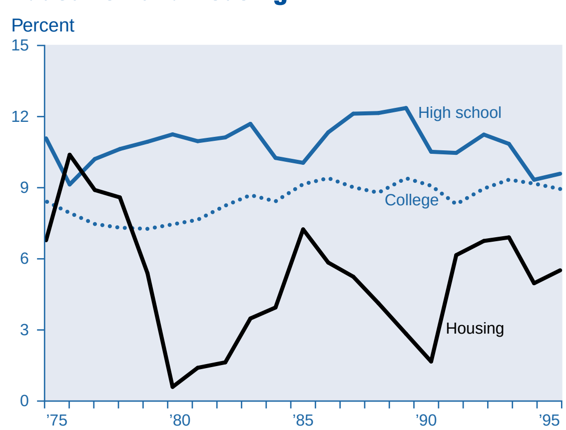
RISK ADJUSTMENTS

Risk-averse investors require that a risky investment earn a higher rate of return than a certain investment. The additional return, or risk premium, compensates them for the risk of holding the uncertain asset. Thus, to estimate the risk-adjusted rate of return to an investment, one subtracts the appropriate risk premium from the market rate of return. Similarly, to estimate the risk-adjusted social rate of return to an investment, one subtracts the appropriate risk premium from the social rate of return.

As a rough cut at the comparative risk premium for housing, Mills (1989) examines the volatility of aggregate returns. Because the coefficient of variation (CV) for housing greatly exceeds the CV for nonhousing fixed capital (*Table 1*), Mills concludes that the risk premium for housing should exceed that for nonhousing fixed capital.[15] Applying the same logic, the risk premium for housing should also exceed the risk premiums for education.

By this criterion, the relative risk premium for housing has grown since 1986. The variances for a college education and nonhousing fixed capital have fallen significantly, while their mean returns have either increased (college) or remained unchanged (nonhousing fixed capital).[16] Meanwhile, both the variances and the means for housing and high school education have remained unchanged.[17] Thus, investment in nonhousing fixed capital and college education

Figure 3
Social Rates of Return to Education and Housing



appears to have become less risky, while investment in housing and high school education appears no less risky.

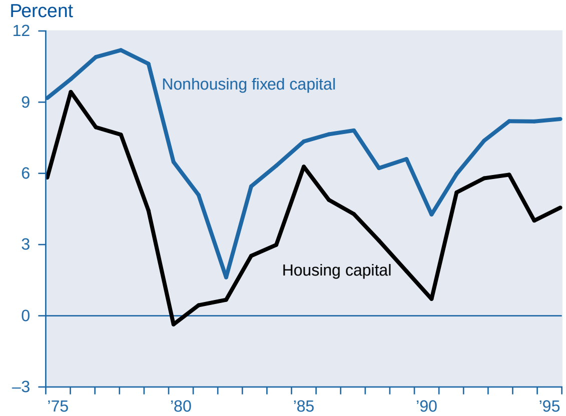
However, Mills' CV-based conclusions about the relative riskiness of housing investment are inconsistent with much of the relevant literature. Other researchers estimate that real estate risk is about half that of stocks (see the discussions in Chinloy 1992). Hendershott (1989) calculates that over the period 1946–82, the average ex post risk premium for housing was 40 percent of the average ex post risk premium for common stocks and only 25 percent of the average ex post risk premium for over-the-counter stocks. Chinloy's estimates of stock market betas imply that residential real estate is only 16 percent to 26 percent as risky as stocks (Chinloy 1991, 1992).[18]

In Mills' defense, stock market risk probably overstates the risk to investment in nonhousing fixed capital. Commercial real estate is a significant component of nonhousing fixed capital, and historically it has been less risky than equities. Furthermore, leverage makes equity returns more volatile than capital returns. Hendershott argues that "assuming no correlation between debt and equity returns and a one-third debt-to-capital ratio, a five-percentage-point change in capital value would translate into a seven-and-one-half change in equity value."[19] On the other hand, equity risk premiums decline as firm size increases (Campbell 1996), and small firms tend to be underrepresented in the data used to estimate stock market risk.

If housing commands a smaller risk premium than other types of investment, one cannot know whether the risk-adjusted social rate of return to housing is lower than that to other investments without estimating the magnitude of those risk premiums. To stack the deck in favor of housing, I use the equity premium to measure the risk premium for nonhousing fixed capital and 16 percent of the equity premium to measure the risk premium for housing capital. Estimates of the risk premium for education come directly from the education literature.

The equity premium is the difference between the rate of return on a portfolio of stocks and the rate of return on a benchmark U.S. Treasury instrument like the one-month Treasury bill (for example, Campbell 1996) or the five-year Treasury bond (for example, Blanchard 1993). Campbell (1996) calculates that the annualized equity premium averaged between 5 and 7 percentage points over the period 1952–90. Blanchard (1993) argues that the expected equity premium peaked at well

Figure 4
Risk-Adjusted Social Rates with a 6 Percentage Point Equity Premium



over 10 percentage points in the late 1940s and—except for a run-up coinciding with the high-inflation periods of the late 1970s—generally declined until the mid-1980s. By Blanchard's estimation, the equity premium was less than 6 percentage points during the latter half of the 1970s, turned negative during much of the 1980s, and ranged between 2 and 3 percentage points in the early 1990s.[20]

Given the social rate of return estimates in Figure 2 and assuming that the risk premium for housing is 16 percent of the equity premium, any equity premium of less than 8 percentage points implies that the average risk-adjusted social rate of return to housing was less than the average risk-adjusted social rate of return to nonhousing fixed capital over the period 1975–95. Assuming an equity premium of 6 percentage points (the midpoint of Campbell's range and the upper bound on Blanchard's estimates for 1975–95), the risk-adjusted social rate of return to nonhousing fixed capital has averaged more than 75 percent higher than that to housing capital since 1975 (*Figure 4*).[21] Assuming a smaller equity premium, or a larger stock market beta for housing, would increase this ratio. While one could argue that the equity premium has either widened or narrowed since 1987 (depending on the point of reference), the evidence clearly suggests that the risk-adjusted social rate of return to nonhousing fixed capital continues to greatly exceed that to housing.

The evidence also suggests that the risk-adjusted social rate of return to a high school education exceeds that to housing. Groot and Oosterbeek (1992) estimate that the educational risk premium for U.S. males is less than 2 percentage points. Campbell's (1996) analysis implies an educational risk premium of 2.4 percentage points.[22] Low and Ormiston's (1991) preferred specification for risk aversion implies an educational risk premium for males of 3.5 percentage points. Assuming the residential risk premium is 1 percentage point (an assumption consistent with an equity premium of 6 percentage points and a housing premium equal to 16 percent of the equity premium), an educational risk premium of less than 5.25 percentage points implies the risk-adjusted social rate of return to a high school education is significantly greater than that to housing. Of course, if the residential risk premium exceeds 1 percentage point, then the case for relative overinvestment in housing is even stronger.

By contrast, the evidence suggests that the risk-adjusted social rates of return to a college education and housing may be similar. Again assuming that the residential risk premium is 1 percentage point, an educational risk premium less than or equal to 3 percentage points implies the risk-adjusted social rate of return to housing is lower than that to college. An educational risk premium between 3 and 5.5 percentage points implies that housing and college earn equivalent risk-adjusted social rates of return, while an educational risk premium above 5.5 percentage points implies that housing earns a higher risk-adjusted social rate of return than does a college education.[23] Thus plausible estimates of the educational risk premium give conflicting signals, and any conclusion about the relative, risk-adjusted rates of return to college and housing depends strongly on the assumptions about the educational (and residential) risk premiums.

CONCLUSIONS AND POLICY IMPLICATIONS

The evidence for the period 1975–95 indicates that the risk-adjusted social rate of return to housing is comparable to the risk-adjusted social rate of return to a college education, and is significantly lower than the risk-adjusted social rates of return to nonhousing fixed capital and to a high school education. Furthermore, despite major changes in the tax treatment of investment and the inflationary environment, there is no evidence the differential between housing and other types of investment has narrowed since 1986. Therefore, one is led to the conclusion that the United States continues to overinvest in housing.

Of course, it could be argued that the evidence does not capture all of the externality benefits of investments in housing, nonhousing fixed capital, and education. If the unmeasured benefits of housing investment are large enough relative to the unmeasured benefits of other types of investment, the amount of U.S. investment in housing might be allocatively efficient. However, the unmeasured benefits to housing would have to nearly equal its measured benefits before one could reach such a conclusion. Assuming the unmeasured benefits to nonhousing fixed capital are negligible, the unmeasured benefit to housing investment would have to top $220 billion per year (or $300 per month for each owner-occupied home) to support the current allocation of resources.

Absent such large unmeasured benefits from investment in housing, the evidence suggests the U.S. economy could grow faster if society shifted more of its resources away from housing and into high school education and, especially, nonhousing fixed capital. Therefore, given that the government has other mechanisms through which it can redistribute income to achieve its equity goals, policies that encourage such a shift would be socially desirable. Possible candidates for such reform would include the inflation indexing of nonhousing capital gains or the expansion of investment tax credits. Policies that reduce the favorable tax treatment of housing could also enhance social welfare by making these lower return investments less attractive. Conversely, policies that increase the relative attractiveness of investments in housing could reduce social welfare by inducing investors to shift resources away from nonhousing fixed capital.

NOTES

Thanks to Steve Brown, Steve Prowse, and Mine Yücel for helpful discussions, and to Victor Rozenblits for research assistance.

1 Other researchers have followed alternative routes to the same conclusions. See, for example, Hendershott (1987); Mills (1987); Rosen (1985); or Alm, Follain, and Beeman (1985).

2 Because estimates of gross stocks of fixed capital are no longer available, I cannot extend Mills' analysis of gross rates of return.

3 Positive externalities are social benefits that do not accrue to the participants in a market transaction.

4 Green and White consider and reject the possibility that these results arise from selection bias.

5 Green and White also do not consider the costs associated with continuation in school.

6 These data incorporate improved estimates of depreciation and as such are not as vulnerable to criticism as the estimates Mills (1989) uses. While the earlier estimates of the net capital stock presume straight-line

depreciation, the estimates I use presume a geometric pattern of depreciation (for a discussion of the new depreciation estimates, see Katz and Herman 1997). Compared with the estimates available to Mills, these data show much slower depreciation of structures and thus much larger estimates of the net capital stock.

[7] This conclusion is consistent with Follain, Leavens, and Velz (1993), who also find no evidence that tax reform had reduced the returns to rental housing.

[8] Summers attributes two-thirds of proprietors' income to labor rather than capital when calculating social returns to capital (Summers 1990, 118).

[9] For a further discussion, see McMahon (1991).

[10] For a further discussion of potential biases in estimates of the rate of return to education, see Weale (1993).

[11] For a more complete discussion of the data and methodology, see Taylor (1994).

[12] The use of such aggregate data undoubtedly introduces measurement error. It is used here for consistency with McMahon's analysis comparing the returns to housing and education prior to 1986. Cohn and Hughes (1994) find that, at the college level, controlling for individual characteristics and self-selection biases leads to substantially higher estimates of the internal rate of return to education.

[13] I reject the hypothesis that the means are equal at the 1 percent level.

[14] The difference in means is significant at the 1 percent level.

[15] The coefficient of variation is the standard deviation divided by the mean (and multiplied by 100 for ease of exposition).

[16] The hypothesis that the variances are equal across the two periods is rejected at the 5 percent level.

[17] The hypothesis that the variances are equal across the two periods is not rejected at the 10 percent level.

[18] Although Ibbotson and Siegel (1984) found evidence of substantial non-beta risk to U.S. real estate over the period 1947–82, Chinloy's estimation results are mixed. His study of the California real estate market between 1979 and 1989 suggests potentially significant non-beta risk, but his study of the San Francisco market between 1976 and 1986 finds no such effect.

[19] Hendershott (1989, 215).

[20] Blanchard (1993, 97).

[21] Assuming that the equity premium is 6 percentage points and the residential risk premium is 16 percent of the equity premium, the hypothesis that the means of the two risk-adjusted rates of return are equal is rejected at the 1 percent level.

[22] The risk premium for human capital is calculated from Campbell's annual data assuming that the coefficient of relative risk aversion is 5.3 and the ratio of human wealth to total wealth is 0.66. My thanks to John Campbell for his assistance with these calculations.

[23] Assuming a 6 percentage point equity premium, any of these plausible estimates of the educational risk premium imply that the risk-adjusted social rate of return to college is significantly below the risk-adjusted social rate of return to either nonhousing fixed capital or high school.

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The Dynamic Impact of Fundamental Tax Reform Part 2: Extensions

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Our results suggest that if tax reform is to be successful in stimulating investment and raising long-run living standards, then it is important that ways be found to keep the consumption tax rate at or below the current rate of labor-income taxation.

In Part 1 of "The Dynamic Impact of Fundamental Tax Reform," we described a few of the proposals for moving to a consumption-based taxation system. Advocates of this type of tax reform cite two advantages. First, it would simplify the tax code by imposing a single consumption tax rate and eliminating many of the deductions and exemptions that exist in the current tax scheme. This simplification, in turn, would reduce compliance and enforcement costs and thereby make the tax collection system more efficient. Second, by shifting from an income-based to a consumption-based tax, this reform would increase the incentive to save and invest, as opposed to consume. These incentive effects could lead to a subsequent increase in growth. Our emphasis is more on the second of these claimed advantages, as we focus on the aggregate economic effects of tax reform.

The economic models presented here differ from the model described in Part 1 in that they allow for variable work effort—not just a variable capital stock. This change adds substantial realism to our analysis and brings it into closer conformity with the efforts of others.[1] We ignore international capital flows, earnings uncertainty, and investment in training and education—each of which may be quantitatively important.

Our results suggest that if tax reform is to be successful in stimulating investment and raising long-run living standards, then it is important that ways be found to keep the consumption tax rate at or below the current rate of labor-income taxation. Like labor-income taxes, consumption taxes distort labor-market decisions. Consequently, a consumption tax imposed at a high rate may be worse than a low-rate income tax; the additional labor-market distortion caused by the consumption tax may undo the positive economic effects of the cut in the rate of capital-income taxation.

In this article we first describe the nature of preferences and technology in our economy. We then show how eliminating the existing labor and capital taxes and replacing them with a consumption tax would affect such variables as capital, employment, and interest rates. These results generally hold true for a wide range of economies. We also illustrate how various configurations of tax rates, preferences, and technology could alter the economy's response to tax reform. For example, we demonstrate that the economy's immediate response to tax reform is muted—and the overall adjustment process is substantially prolonged—if firms find it expensive to add quickly to their stocks of plant and equipment. The reader interested primarily in these illustrations may wish to focus on the section entitled "Some Specific Examples," which contains these results. Also, in the box entitled "Growth Effects" we describe circumstances under which tax reform might have a permanent impact on the economy's growth rate.

DESCRIPTION OF THE ECONOMY

It is useful to consider and analyze tax reforms within a concrete economic model. In particular, we describe a few variants of neoclassical growth models used to analyze issues in dynamic economies, such as growth or business cycles. For the most part, we abstract from issues related to sustained growth by assuming that the trend growth rate is determined exogenously. In this case, all quantitative results should be interpreted as deviations from some trend growth rate. For convenience we also abstract from any uncertainty.

It is useful, but by no means necessary, to assume that the total tax bill is paid by households. We show in the box entitled "The Equivalence of Tax Regimes" that this assumption is actually not inconsistent with a world in which the firms pay corporate profits taxes. Effectively, the household tax bill in our model includes what in reality is a corporate tax. This is a useful simplification.

The Consumer's Problem

We consider an environment in which all households are identical so that we may abstract from the distributional consequences of tax reform. This assumption allows us to carry out our analysis in per-capita terms. To facilitate the study of the different tax regimes, we first present an analysis of the economy in the presence of capital and labor taxation. We then show how the introduction of a consumption tax changes the decisions of households and firms.

We assume that households have identical preferences characterized by the following utility function:

$$\sum_{t=1}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} U(c_t, 1-n_t).$$

Here c_t and n_t represent the amount of consumption and employment in period t. Additionally, ρ represents the households' pure rate of time preference. We assume that each household has one unit of time that can be used for either work or leisure and that the household cares about acquiring more of the consumption good (c_t) and leisure ($1 - n_t$). Moreover, we assume that there is a capital tax rate of τ_p and a labor tax rate of τ_w.[2] At date t, the typical household has k_t units of capital, which is rented to the typical firm. The households have budget constraints that are written as

$$(1) \quad c_t + \Delta k_t \leq (1-\tau_w) w_t n_t + (1-\tau_p) r_t' k_t + \eta_t .$$

The right side of this equation represents after-tax income. The left side represents consumption plus saving in the form of investment in new capital. Here r_t' is the pretax return to capital, net of depreciation, that is paid to households for the capital rented by the firm.[3] The household pays tax on this capital income and consequently receives $(1-\tau_p)r_t'$ units of after-tax income per unit of capital. Similarly, w_t is the pretax wage paid by firms, and $(1-\tau_w)w_t$ is the after-tax wage paid to workers. It is assumed that capital used by the firm depreciates at the rate δ per period. The term Δk_t refers to the change in the capital stock that results from period-t investment. Lastly, η_t represents a lump-sum transfer payment from the government, which includes all revenue derived from government taxation.[4]

In each period, households must make decisions concerning how much to work and invest. Having made these decisions, the level of consumption is determined by default from Equation 1. The employment decision by consumers must satisfy the following equation:

$$(2) \quad (1-\tau_w) w_t U_1(c_t, 1-n_t) = U_2(c_t, 1-n_t),$$

where $U_i(\cdot)$ denotes the marginal utility with respect to the i'th argument. Equation 2 states that the marginal return from working an extra hour, calculated in units of utility and taking taxes into account, must equal the marginal disutility from doing so.

The optimality condition that characterizes the investment decision takes the form

$$(3) \quad U_1(c_t, 1-n_t) = \left(\frac{1}{1+\rho}\right) U_1(c_{t+1}, 1-n_{t+1}) \left[1 + (1-\tau_p) r_{t+1}'\right].$$

This condition states that the marginal after-tax return to investing another unit, calculated in terms of utility, must just equal the marginal cost of giving up one unit of consumption.

The Firm's Problem

We assume there are many identical firms. Each firm has access to a technology for producing the consumption good, written as

Growth Effects

Supporters of the move to a consumption-based taxation system argue that one of the benefits of such a system is that it would increase the economy's growth rate. There are legitimate reasons for this view. A consumption tax would deter individuals from consuming and eliminate the present distortion in the capital-income tax, which discourages saving or investment. In other words, this investment would increase the capital stock, which would, in turn, increase the future level of output. Furthermore, the removal of taxation on capital income makes it even more rewarding to invest in capital, because the return would be higher.[1]

The welfare consequences of these growth effects could be substantial. That is, economic agents would be willing to pay a lot to receive the benefits from a relatively small increase in the growth rate.

Before quantifying this effect, it is also important to acknowledge factors that may mitigate it. First, some forms of capital investment are already subject to (relatively) favorable tax treatment. Investment in housing is already encouraged through interest deductibility and reduced capital-gains taxation. Additionally, some forms of investment in human capital are already treated favorably.

To give some content to this analysis, it is useful to consider a model of endogenous growth in which the equilibrium growth rate is determined by the economic decisions of agents. To illustrate the potential growth benefits from eliminating the capital-income tax, consider the simple economy below in which employment is held fixed. Suppose that all agents have preferences given as

$$\sum_{t=1}^{\infty}\left(\frac{1}{1+\rho}\right)^{t}\left(\frac{c_t^{1-\sigma}}{1-\sigma}\right), \qquad \text{(B.1)}$$

where $(1/\sigma) > 0$ is the intertemporal elasticity of substitution and is assumed to be a fixed parameter. Here c_t represents consumption in period t. Labor does not enter either the utility or production functions.

The technology for the economy can be written as

$$c_t + k_{t+1} = Z_t k_t^{\theta},$$

where k_t is the capital stock in period t and Z_t the technology shock in period t. Implicitly, we assume a 100 percent depreciation rate and that Z_t is a function of the average capital stock in the economy. In particular, if K_t is the average capital stock, then $Z_t = AK_t^{1-\theta}$. The logic behind this specification is that an agent's productivity is positively influenced by the capital or investment undertaken by other agents in the economy. This specification can be justified in that some firms or individuals are more productive if there are other firms or individuals with high levels of human or physical capital. For example, manufacturers of automobiles or televisions can make a better product if they also have access to better electronic or microchip technology. Similarly, research scientists as well as various organizations or coalitions of agents (football players, for example) are more productive if they can work alongside other productive individuals.

An analysis of this economy shows that the growth rate g is

$$g = (1/\sigma)\log\left(\frac{\theta A(1-\tau_p)}{1+\rho}\right).$$

This equation illustrates that the growth rate is related to parameters ρ, θ, and A. In particular, the smaller ρ is, the larger the level of saving or investment will be and, consequently, the higher the growth rate will be. Similarly, the higher θ or A is, the greater the incentive to save or invest will be, and the higher the growth rate will be. However, the higher the tax rate, the lower the return to investment, and therefore the lower the growth rate will be. Table 1 gives some examples of the growth rates for output that result for various parameter values.

In this economy, we can show that the return to a unit of extra investment is $A\theta(1-\tau_p)$. Hence, a higher tax rate reduces the after-tax return to investment. In this model, the rate of return to investment is pinned down by these parameters.

When the capital-income tax is replaced by a consumption tax, the growth rate formula given above reduces to

$$g = (1/\sigma)\log\left(\frac{\theta A}{1+\rho}\right).$$

The rate of return to investment is then written as θA. Hence both the growth rate and the rate of return are higher with the consumption tax than with the capital tax.

Generally, in any model in which agents have the preferences as given by Equation B.1, the net after-tax rate of return on investment (r) and the growth rate are linked by the following: $g = (1/\sigma)\log[r/(1+\rho)]$. Thus, any policy that raises the growth rate g of the economy is also likely to raise the after-tax rate of return to investment. That is, it is incompatible to simultaneously have high growth rates and low rates of return. Of course, this relationship also implies that if σ is small, then there are potentially large growth effects that can be derived from policies that raise the rate of return to investment.

This example and the results presented in Table 1 suggest that eliminating capital-income taxation would have a substantial impact on the economy's growth rate. In fact, the results contained in the table almost certainly exaggerate the potential impact of tax reform. Moreover, it should be noted that this framework abstracts from some other features that can be of substantial import. For example, there is no human capital in the model, and it could be argued that reducing the rate of taxation on human capital is at least as important as that of physical capital. Stokey and Rebelo (1995) and Lucas (1990) study a model that has human and physical capital and analyze the impact that reductions in the capital-income tax rate can have on the economy.[2] Given some reasonable parameterizations for their model economy, they find that there is little reason to think that this type of tax reform would significantly increase the growth rate of aggregate output. The reasoning appears to be that although physical capital is an important ingredient in the production process, human capital is even more important. The impact of policies that could facilitate or encourage capital accumulation is always important in promoting growth. However, it is perhaps more important to promote the accumulation of human capital if the goal is to increase the growth rate of aggregate output. Nevertheless, these models imply that the impact on welfare of reducing the rate of capital-income taxation can be fairly substantial, even if the impact on growth is small.

NOTES

1 There are also other models, sometimes referred to as the neoclassical growth models, in which the asymptotic growth rates are independent of the tax rate on capital. However, the framework specified in this box is not a model of this type.

2 Cassou and Lansing (1996) conduct a related experiment. Within the context of a model that includes both human and physical capital, they analyze how moving from a progressive income tax regime to one with a flat tax rate on income would affect the equilibrium growth rate. Their quantitative results hinge on the values of a few of the parameters of the model.

Table 1
Growth Rates

	σ = .5 (percent)	σ = 1 (percent)	σ = 10 (percent)
τ_p = .50	–2.2	–1.1	–10.9
τ_p = .25	9.3	4.6	–.5
τ_p = 0	30.3	15.2	1.5

NOTE: All growth rates are calculated for θ = .35, $\left(\frac{1}{1+\rho}\right)$ = .95, A = 3.5.

$f(k_t, n_t)$, using capital and employment. The typical firm maximizes profits, which are given as

$$f(k_t, n_t) - w_t n_t - (r'_t + \delta)k_t.$$

Written in this manner, profits are calculated in units of the consumption good. This formulation allows the firm's problem to be written without any tax parameters. Profit maximization dictates that the firm must equate the marginal product of labor to the real wage rate:

$$f_2(k_t, n_t) = w_t. \quad (4)$$

The optimization condition for the choice of capital requires that the marginal product of capital equal the marginal cost of capital. This condition is formally written as

$$f_1(k_t, n_t) - \delta = r'_t. \quad (5)$$

A Consumption Tax

Now consider the elimination of the capital and labor taxes and the replacement of them with a consumption tax. The beauty of the formulation presented above is that the firm's problem is not changed by this tax reform. However, the budget constraint for the individual consumers is changed from Equation 1 to

$$c_t \leq [r'_t k_t + w_t n_t - \Delta k_t + \eta_t](1 - \tau). \quad (6)$$

Here τ is the consumption tax rate, calculated so that tax revenue is divided by the consumption base *inclusive* of the amount of the tax.[5] Clearly, Equation 6 says that consumption will equal the after-tax value of income, less investment or saving.

The optimization condition for employment is then determined as

$$(1 - \tau)w_t U_1(c_t, 1 - n_t) = U_2(c_t, 1 - n_t).$$

Working an extra unit produces w_t units of income (measured in real units). However, this extra revenue purchases only $(1 - \tau)w_t$ units of extra consumption since the consumption tax must be paid on such purchases. It should be noted that a comparison of this last equation with Equation 2 reveals that the effects of the labor and consumption taxes on the optimality condition for employment are identical. Both of these taxes work to discourage work effort and consumption and instead encourage the agents to take more leisure. The optimization condition for capital accumulation is written as

$$U_1(c_t, 1 - n_t) = \left(\frac{1}{1+\rho}\right) U_1(c_{t+1}, 1 - n_{t+1})(1 + r'_{t+1}).$$

Compare this equation with Equation 3, which is the counterpart with the tax on capital. As can be seen, there is now no tax on the return to capital.

We now focus on the analytical or qualitative details of the tax reform. We show how various variables respond—in both the short and long run—to the change in tax rates. This analysis is inherently detailed because of the complex nature of the equilibrium responses of so many variables. The reader interested primarily in the quantitative illustrations of this experiment may skip the following sections and go directly to "Some Specific Examples."

TAX REFORM IN AN ECONOMY WITH ENDOGENOUS LABOR SUPPLY: THE GENERAL CASE

In Part 1, in which we assumed the labor supply to be exogenously fixed, we found that we could trace paths of consumption and the capital stock through time using a simple phase diagram. Here we discuss how the results presented in Part 1 must be modified if households can choose the number of hours they work.

Labor Market Equilibrium

Equation 2 can be rearranged to give the supply price of labor as a function of the tax rate on labor income and the *marginal rate of substitution* between leisure and consumption:

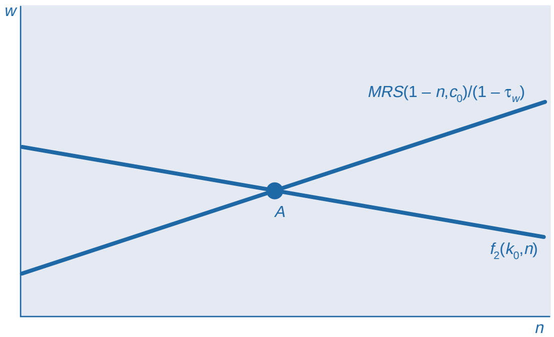
$$w = MRS(1 - n, c)/(1 - \tau_w), \quad (7)$$

where $MRS(1 - n, c) \equiv U_2(c, 1 - n)/U_1(c, 1 - n)$. It is standard to assume that leisure and consumption are both normal goods or, equivalently, that the marginal rate of substitution is decreasing in its first argument and increasing in its second.[6] Equation 7 then implicitly defines a labor-supply function. The supply price of labor is increasing in the quantity of labor supplied, in consumption, and in the tax rate on labor income. In Figure 1, the labor-supply schedule is upward sloping for given values of c and τ_w.

We assume that the production function $f(\cdot,\cdot)$ exhibits constant returns to scale and is increasing in both capital and labor. Then Equation 4 implies that the demand price of labor is a decreasing function of the number of hours per worker and an increasing function of the amount of capital per worker. In Figure 1, the labor-demand curve is negatively sloped for any given capital stock k.

Equilibrium in the labor market must occur at a point like A, where the labor-supply and labor-demand curves intersect. Of course, point A represents only a partial equilibrium in the labor market, since the level of consumption

Figure 1
Partial Labor Market Equilibrium



(which was held constant when we drew the labor-supply schedule) is not predetermined in our economy. As the level of consumption increases, the labor-supply schedule shifts upward, moving point A to the northwest along the labor-demand curve. Intuitively, households want more leisure to accompany their increased consumption. Increases in τ_w also shift the labor-supply schedule upward, moving point A back along the labor-demand curve. In this instance the higher tax penalizes work effort, which results in a fall in labor supply. By contrast, increases in the capital stock shift the labor-demand schedule proportionately to the right, moving point A to the northeast, along the labor-supply schedule.

In summary, equilibrium hours are increasing in the capital stock and decreasing in both consumption and the tax rate:

$$n = \phi(k, c, \tau_w), \tag{8}$$

with $\phi_1 > 0$ and ϕ_2, $\phi_3 < 0$. Because the labor-supply schedule is upward sloping, equilibrium employment varies less than in proportion to the capital stock. Formally, $\phi_1/(n/k) < 1$. By using Equation 8 to eliminate hours of work from our model, we can construct a diagram helpful for analyzing how consumption and the capital stock vary through time in response to tax reform.

The Dynamics of Capital and Consumption

Capital. Output is either consumed by households or the government, or is channeled into capital investment: $f(k,n) = c + g + i$. It follows that net investment, Δk, will be positive if, and only if, $c < f(k,n) - g - \delta k$. The identical condition held in Part 1. There, hours of work were fixed. Here, we can substitute from Equation 8 to obtain

$$\Delta k > 0 \Leftrightarrow c < f[k, \phi(k, c, \tau_w)] - g - \delta k. \tag{9}$$

For given levels of government purchases and the labor-income tax rate, the equation $c = f[k, \phi(k, c, \tau_w)] - g - \delta k$ gives those combinations of capital and consumption that are sustainable in the sense that they are consistent with an unchanging capital stock. Much as in Part 1, an increase in the capital stock will increase sustainable consumption, provided that the net marginal product of capital, $f_1 - \delta$, is positive.[7] In Figure 2, the schedule labeled "$\Delta k = 0$" is upward sloping over the relevant range. However, whereas in Part 1 the sustainable level of consumption was independent of tax policy, now an increase in the labor-income tax rate reduces the representative household's willingness to work, shifting the $\Delta k = 0$ schedule downward.

Consumption. If we assume that the household utility function is additively separable between consumption and leisure, then the marginal rate of substitution between consumption today and consumption tomorrow will depend only upon the levels of consumption today and tomorrow. If we further assume that current and future consumption are normal goods, Equation 3 says that consumption will be rising over time if, and only if, the after-tax return on capital exceeds the rate of time preference:

$$\Delta c > 0 \Leftrightarrow (1 - \tau_p)r' > \rho.$$

Using Equation 5 to eliminate the return on capital:

$$\Delta c > 0 \Leftrightarrow (1 - \tau_p)[f_1(k, n) - \delta] > \rho. \tag{10}$$

The same condition held in Part 1. However, now that hours are endogenous rather than fixed, we must substitute from Equation 8 to eliminate employment from Equation 10. This substitution yields

$$\Delta c > 0 \Leftrightarrow (1 - \tau_p)[f_1(k, \phi(k, c, \tau_w)) - \delta] > \rho. \tag{11}$$

Figure 2
Dynamics of the Capital Stock

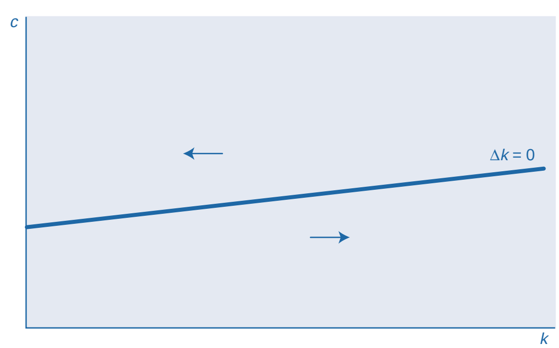
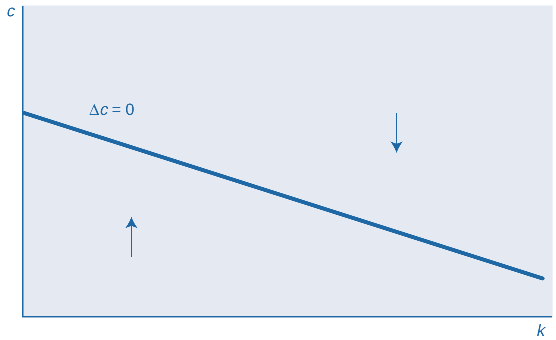


Figure 3
Dynamics of Consumption



For given tax rates, the equation $(1 - \tau_p)[f_1(k, \phi(k, c, \tau_w)) - \delta] = \rho$ gives those combinations of capital and consumption that are consistent with an unchanging level of consumption. As noted above, although equilibrium hours are increasing in the capital stock, hours rise less than in proportion to capital ($\phi_1/(n/k) < 1$). It follows that k/ϕ is increasing in the capital stock and, hence, $f_1(k, \phi(k, c, \tau_w))$ is decreasing in the capital stock. We also know that households like to accompany a higher level of consumption with additional leisure ($\phi_2 < 0$). Therefore, k/ϕ is increasing in consumption, and $f_1(k, \phi(k, c, \tau_w))$ is decreasing in consumption. Since the marginal product of capital is decreasing in both k and c, the equation $(1 - \tau_p)[f_1(k, \phi(k, c, \tau_w)) - \delta] = \rho$ traces out a downward-sloping schedule in $k \times c$ space. In Figure 3, this schedule is labeled "$\Delta c = 0$." To the right (above) the schedule, the after-tax rate of return on capital is less than the rate of time preference, and consumption falls through time. To the left of (below) this curve, the after-tax rate of return on capital is high enough that households are willing to defer consumption. Hence consumption rises over time.

Just as in the case in which hours of work are exogenously fixed, a cut in the capital-income tax rate shifts the $\Delta c = 0$ curve to the right. However, changes in the labor-income tax rate also shift the $\Delta c = 0$ curve. In particular, a cut in the labor-income tax rate increases the supply of labor, which tends to increase the marginal product of capital. To offset this increase, the capital stock (or consumption) must rise. In other words, the $\Delta c = 0$ curve now shifts to the right (upward) in response to a cut in τ_w, much as it shifts to the right in response to a cut in τ_p.

Capital and Consumption, Combined. Figure 4 combines the information in Figures 2 and 3. Arrows show the direction of movement for the different combinations of consumption and capital. The economy has a unique steady state—point E—at which consumption and capital are both constant. Point E is a saddle-path equilibrium: for each initial capital stock there is a unique optimal level of consumption. In the diagram, if the economy starts at capital stock $k_A < k_E$, then households choose consumption level $c_A < c_E$ and, over time, the economy follows the dotted path from point A toward point E. Similarly, if the economy starts at capital stock $k_B > k_E$, then households choose consumption level $c_B > c_E$ and the economy follows the dotted path from point B toward point E.

The Effects of Tax Reform

We can use our phase diagram developed above to analyze the effects of fundamental tax reform on the time paths of consumption and the capital stock. First, capital-income taxes are eliminated, with no change in the labor-income tax rate.[8] Then, we briefly consider how the analysis would change if it were possible to lower the labor-income tax rate or necessary to raise it.

A Constant Labor-Income Tax Rate. We assume that the economy begins in a steady-state equilibrium in which both labor income and capital income are taxed. In Figure 5, this steady state is point E. Suddenly, the tax on capital income is eliminated. Suppose that the labor-income tax rate is unchanged. (As a practical matter, most reform proposals call for the elimination of enough tax loopholes so that the labor-income tax rate would, in fact, remain roughly constant.) In this case, the $\Delta k = 0$ curve remains fixed, while the $\Delta c = 0$ schedule shifts unambiguously to the right. It follows that the economy's steady state must shift to the northeast: in our diagram, the new steady state is at point E'. Just as in an economy with exogenously fixed labor hours, the long-run effect of

Figure 4
Combined Dynamics of Consumption and Capital

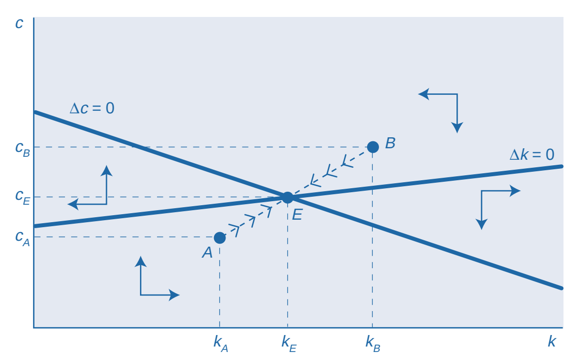
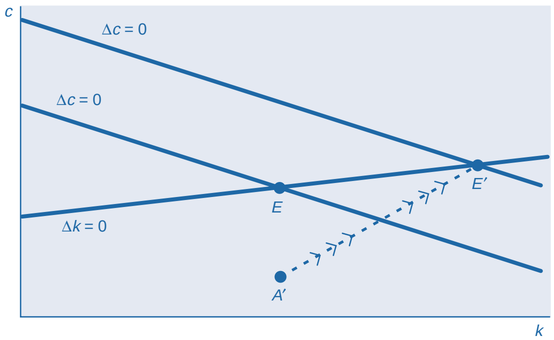


Figure 5
Consumption Drops in Response to Tax Reform, then Consumption and Capital Increase



fundamental tax reform is to raise both consumption and the capital stock.

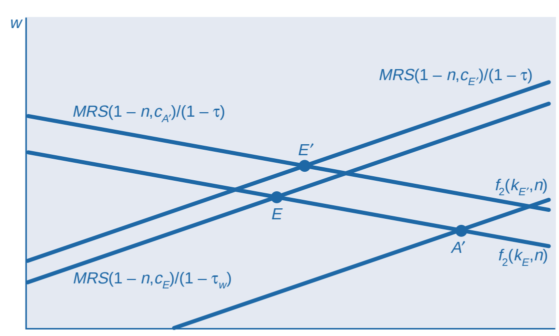
In the short run, the aggregate capital stock is fixed and the interest rate adjusts to eliminate any excess demand for capital. Consumption, by contrast, is free to jump when tax reform goes into effect. As shown in Figure 5, consumption must jump downward to put the economy on the saddle path leading to E': the immediate effect of tax reform is to move the economy from point E to point A'. Thus, here—as in an economy with exogenously fixed labor hours—the immediate effect of fundamental tax reform is a decrease in consumption. Then, as capital gradually accumulates, the economy follows the saddle path from A to E'.

Figure 6 illustrates the labor market's response to tax reform. The initial equilibrium is at point E. When tax reform first goes into effect, we know that consumption falls (from c_E to $c_{A'}$) while the capital stock remains unchanged. The fall in consumption implies a rightward shift in the labor-supply schedule. Intuitively, by working harder, households can prevent consumption from falling by as much as would otherwise be necessary. The fact that the capital stock is initially unchanged means that the labor-demand curve is also initially unchanged. In Figure 6, therefore, the economy moves from point E to point A': work effort increases and the real wage falls. Through time, as consumption and the capital stock gradually increase, the labor-supply schedule shifts to the left and the labor-demand schedule shifts to the right. Indeed, since consumption eventually rises above its initial steady-state level, the labor-supply schedule ends up to the left of its original position. In the new steady state, the real wage is clearly higher than it was originally. Whether work effort rises or falls relative to the initial steady state is ambiguous. In Figure 6, the new steady state is at point E'.

In Part 1, we showed that replacing the current income tax system with a consumption tax causes the after-tax return on capital to jump upward in the short run. Indeed, it is this jump—the result of the elimination of the corporate income tax—that induces households to defer consumption. Gradually, as the capital stock increases, the after-tax return on capital falls back to its original level. This pattern of movement in the after-tax return on capital also holds in an economy with endogenous work effort. Indeed, the initial upward jump in the after-tax return is even greater than in an economy with fixed work effort. The after-tax return on capital rises not only because of the elimination of the corporate income tax, but also because people initially respond to tax reform by working harder, thereby raising the marginal product of capital. As capital accumulates, the marginal product of capital falls, and the after-tax return on capital approaches its original level. Whether the new steady-state capital stock is above or below what it would have been with a fixed labor supply is ambiguous, since it depends upon whether work effort rises or falls in steady state.

Tax Reform When the Labor-Income Tax Rate Changes. Until now, we have assumed that the labor-income tax rate is unchanged following tax reform. If this assumption is invalid, the economy's response to tax reform may be markedly different from that described above. If, for example, eliminating the capital-income tax requires that the tax rate applicable to labor income be increased, then the $\Delta c = 0$ schedule in Figure 5 will not shift quite so far to the right following tax reform and, in extreme cases, might actually shift to the left. Moreover, the

Figure 6
Effects of Tax Reform on the Labor Market



Δk = 0 schedule shifts downward. Consequently, it is quite possible for the postreform steady-state level of consumption to be lower than the prereform level of consumption. Whether the steady-state level of capital rises or falls is also ambiguous.

If the labor-income tax rate is *lower* postreform than it is prereform, then the $\Delta c = 0$ schedule in Figure 5 will shift strongly to the right, and the $\Delta k = 0$ schedule will shift up. For some parameterizations, the latter effect is so strong that consumption itself actually jumps upward rather than downward immediately following tax reform. Additional, more gradual increases in consumption follow as the economy moves along the saddle path leading to the new steady state. The steady-state capital stock necessarily increases.[9]

Review and Outlook. We have seen that the qualitative effects of tax reform in an economy with endogenous work effort differ little from those in an economy in which labor effort is fixed—*provided that the tax rate on labor income is unchanged.* The most important difference between the fixed-effort and the variable-effort cases is that with fixed effort, households must cut back on consumption if they wish to increase their saving, whereas with variable effort, households have the option of increasing their saving by cutting back on leisure. Typically, households will choose to cut both leisure *and* consumption immediately following tax reform.

If tax reform is to be successful in stimulating investment and raising long-run living standards, then it is critical that ways be found to avoid increasing the rate of labor-income taxation. Increases in the labor-income tax rate can negate the positive economic effects of cuts in the capital-income tax rate. Conversely, cuts in the labor-income tax rate reinforce savings incentives and contribute to higher steady-state levels of consumption.

Specific illustrations of the effects of tax reform are provided below for a variety of assumptions about the new labor-income tax rate. We also simulate the effects of tax reform on an economy in which each firm finds it expensive to make rapid changes to its capital stock, and in one in which each firm finds that the larger the capital stocks held by others, the more productive its capital becomes.

SOME SPECIFIC EXAMPLES

To obtain quantitative estimates of the short- and long-run consequences of tax reform, it is necessary that we adopt some precise specifications for preferences and technology. Accordingly, consider an economy in which agents' preferences are determined by the utility function

$$U(c_t, 1 - n_t) = \log(c_t) + \log(1 - n_t), \quad (12)$$

and in which aggregate output is determined according to the following technology:

$$f(k_t, n_t) = k_t^{\theta} n_t^{1-\theta}. \quad (13)$$

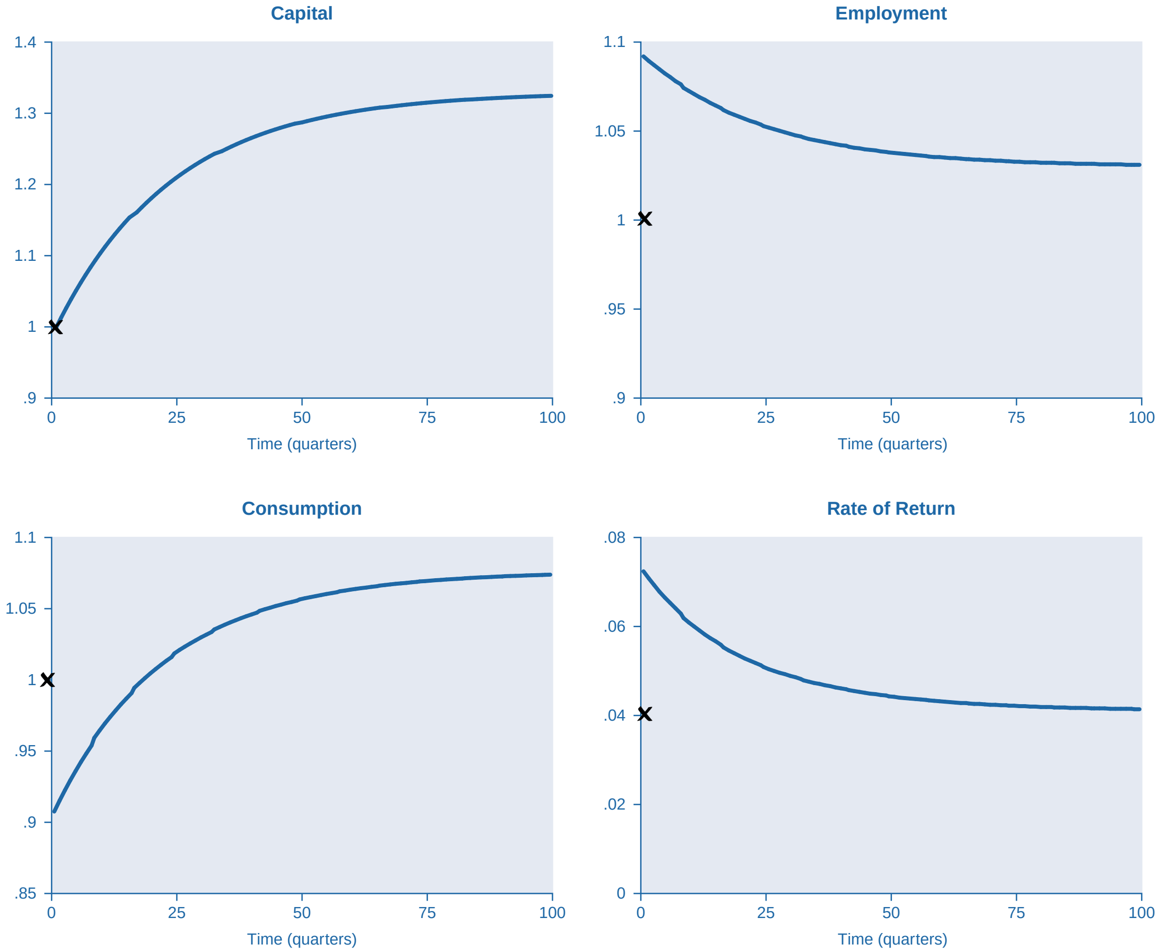
The parameter δ will continue to denote the depreciation rate of capital. It is useful to consider an economy in which a period is a quarter and the parameter values are $\rho = 0.01$, $\theta = 0.35$, and $\delta = 0.02$. These specifications imply that the annual average real interest rate is about 4 percent and that the annual depreciation rate is approximately 8 percent. They also imply that capital's share of aggregate income is 35 percent, which is approximately what it is in the data. Lastly, they imply that in the model with the current levels of taxation imposed, individuals spend approximately one-third of their available time working, which would appear to be an acceptable prediction.

It is useful to look at a few experiments in which the labor and capital tax rates are eliminated and replaced with a consumption tax. Consider first an economy that initially has an effective capital tax rate of 35 percent and a labor tax rate of 35 percent. Assume that this economy is in its steady state. We arbitrarily assume that the tax reform is implemented in period 1. That is, during this period, the capital and labor taxes are eliminated and the consumption tax is implemented at a 35 percent rate.[10]

Figure 7 illustrates the impact of the reform on the capital stock, employment, consumption, and the after-tax interest rate (rate of return to capital). In these figures the × denotes the initial level of the variable. As can be seen, the tax reform leads to an increase in investment, which produces a subsequent increase in the capital stock. This increase raises the wage rate in the economy, which leads to a substantial increase in the employment level. The increased investment is partially financed by a decrease in consumption that occurs concurrently with the tax reform. Although consumption falls, it subsequently grows to its new steady-state level, surpassing its previous level after four and one-half years.[11] Additionally, the after-tax return to capital rises because of the reform, but subsequently falls.

It is of interest to compare the initial pre-

Figure 7
Effects of Imposing a 35 Percent Consumption Tax



reform levels of some variables with their resulting values after they have converged to the new steady state, even though this convergence takes a long time. After the reform, employment increases 3 percent. Moreover, since both the capital stock and employment have risen, aggregate output rises 12.6 percent. Wages, or the marginal product of labor, rise by 9.4 percent.[12]

Some concern exists that eliminating the existing income and payroll taxes may require a tax rate higher than 35 percent on consumption. Figure 8 shows the responses of variables to a tax reform requiring a consumption tax rate of 45 percent.[13] As can be seen, the responses are more pronounced than those in Figure 7. Consumption falls substantially more in the short run and never recovers its original level. Similarly, employment initially rises but then falls below the original level. As a result of the reform, the capital stock grows—although not as much as it does in Figure 7 because of the comparatively high tax rate. An unfortunate byproduct of this type of reform is that aggregate output exhibits a substantial fall of about 2.6 percent at the time of the reform and only recovers to surpass its prereform level after eight years. Therefore, one should not assume that all tax reforms that entail a movement to a consumption-based tax system must immediately increase aggregate output.

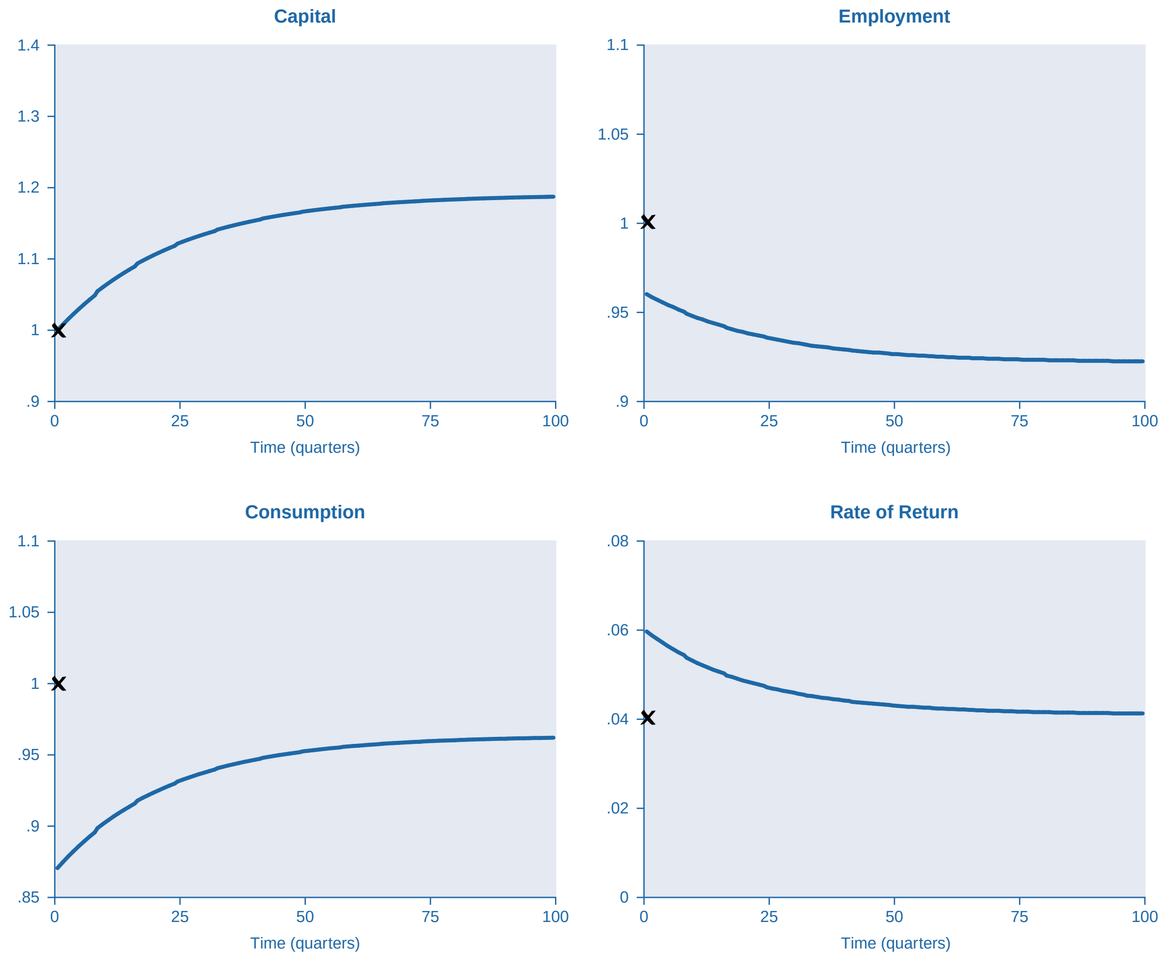
It is interesting to compare the resulting values of some important aggregates for prereform and postreform tax regimes with this higher consumption tax. After the reform, employment *decreases* 7.8 percent. Since the capital stock rises and employment falls, aggregate output rises only 0.8 percent. Wages rise 9.4 percent.

As evident in each of these examples, the economy converges to a new steady state, but this convergence does not take place overnight. It is relatively complete after 50 periods, or about 12 years.

It is also useful to consider one last experiment. Suppose that the technology is such that there are adjustment costs to accumulating

Figure 8

Effects of Imposing a 45 Percent Consumption Tax



capital—that is, costs that inhibit the accumulation of capital too quickly. These costs are captured by altering the production technology as follows:

$$f(k_t, n_t) = k_t^{\theta} n_t^{1-\theta} - (k_{t+1} - k_t)^2. \tag{14}$$

The quadratic term in this constraint reflects a penalty for accumulating capital too quickly.[14] Assume that the preferences are given by Equation 12. Again, we consider eliminating the labor and capital tax rates and replacing them with a consumption tax of 35 percent. Compare these results in Figure 9 with those in Figure 7. Because of the adjustment costs, the accumulation of capital and the growth in consumption are much slower. As a result of the slow responses of investment and capital, employment also does not respond as dramatically to the tax reform.

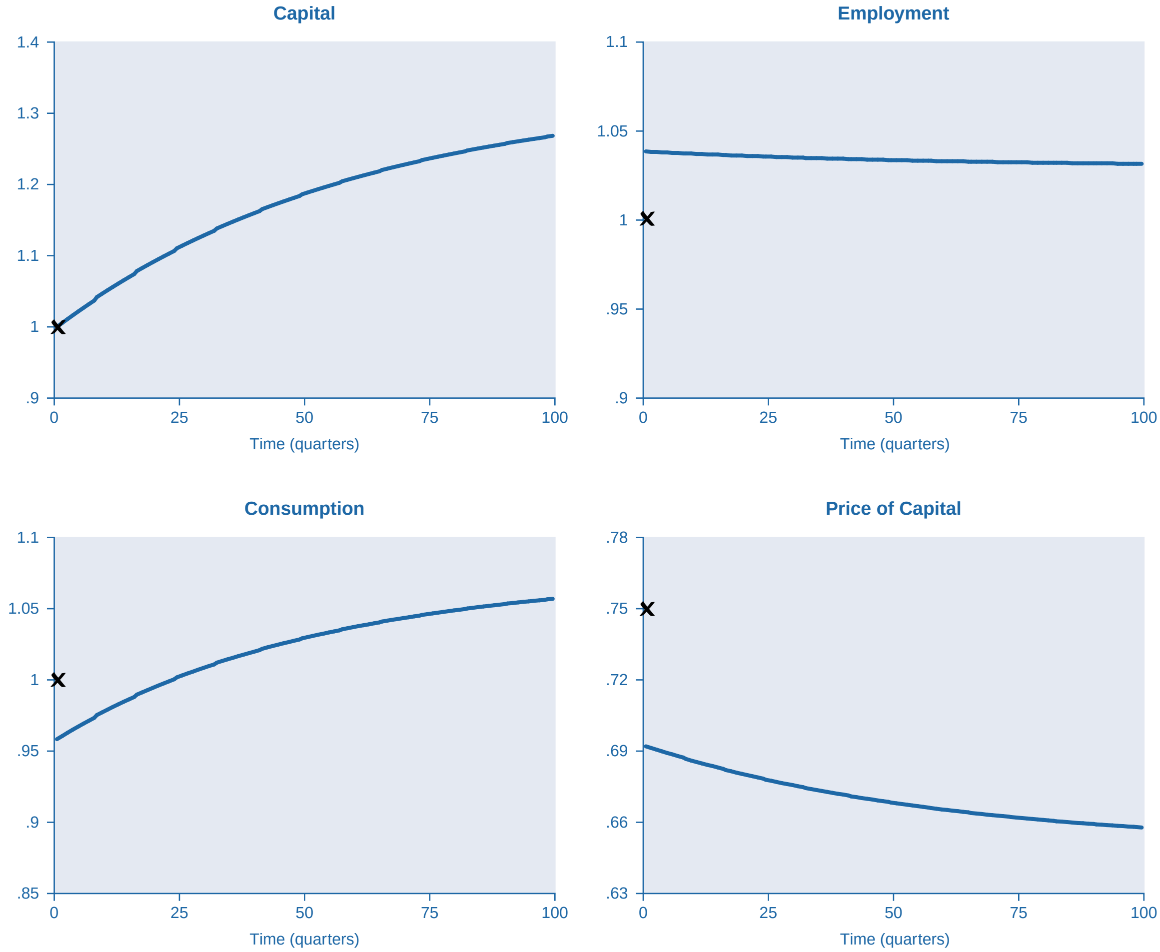
The *real* price of capital, measured in units of the consumption good, is[15]

$$P_t = [1 + 2(k_{t+1} - k_t)](1 - \tau). \tag{15}$$

Along a path where the capital stock is growing (that is, $(k_{t+1} - k_t) > 0$) the price of capital will be greater than $(1 - \tau)$, because the adjustment costs impede the accumulation of capital by making it more costly, relative to consuming. Conversely, along a path where the capital stock is declining, the price of capital will be below $(1 - \tau)$.

Figure 9 also shows the path of the price of capital. This path reflects the value or price of a unit of capital, measured in units of the consumption good. This price is 0.75 in the equilibrium with the old tax system, assuming a dividend tax rate of 25 percent.[16] With no adjustment costs, the price would immediately fall to 0.65 after the tax reform. This reflects the fact that a unit of capital is worth only this fraction of a unit of the consumption good since the consumption tax must be paid out of the proceeds. With adjustment costs, the imposition

Figure 9
Imposing a 35 Percent Consumption Tax with Capital Adjustment Costs



of the consumption tax would cause the price of capital to fall, but not as dramatically. The need to augment the capital stock, in the presence of the adjustment costs, leads to a price for the capital stock that is higher than it would be otherwise. Nevertheless, because of the accumulation of capital, this price falls slowly as the economy converges to its new steady state. It is possible to increase the price of capital by multiplying the squared term in Equation 14 by a coefficient that is greater than unity. If capital adjustment costs are sufficiently high, it is possible that the tax reform would temporarily increase the price of capital because the adjustment costs have this effect. However, this increase is only temporary and the price of capital must subsequently fall.

FINAL REMARKS

We have presented a fairly standard dynamic framework within which the effects of tax reform can be studied. This framework allows for variable work effort as well as a variable capital stock. Using it, we show that moving from an income-based tax system to a consumption-based tax system can be expected to stimulate savings, investment, and work effort in the short run and lead to an increased capital stock and, ultimately, a higher standard of living in the long run. A key assumption is that the postreform rate of consumption taxation does not exceed the current rate of labor-income taxation. Since consumption spending is less than income, keeping the consumption tax rate at or below the current rate of labor-income taxation will generally require either that existing tax loopholes be eliminated or that existing government programs be cut. If the tax rate assumption is violated, the disincentive to work may be strengthened as a result of tax reform—potentially strengthened to the extent that consumption never recovers its prereform level. In extreme cases, the capital stock may actually

The Equivalence of Tax Regimes

As stated in the article, no generality is lost by assuming that all taxes are paid by the household. Consider a regime in which the firm pays corporate profits taxes. We show that this regime is equivalent to another in which the household pays the taxes.

Under a profits tax, the after-tax cash flow of a firm can be written as

$$\pi_t = (1 - \tau_p)\,[f(k_t, n_t) - w_t n_t - \delta k_t] - \Delta k_t,$$

assuming that all investment is financed out of retained earnings. Here τ_p is the tax rate on profits, and Δk_t is investment financed out of retained earnings of the firm. The optimization condition for profit maximization implied by choosing the optimal employment level is

$$f_2(k_t, n_t) = w_t.$$

The optimization condition for profit maximization implied by optimal capital accumulation is that the firm equate the after-tax return to investment with the rate of return. This can be written as

(A.1) $$(1 - \tau_p) f_1(k_t, n_t) = r_t,$$

where r_t is the after-tax rate of return. That is, the consumer will still have to pay a dividend tax if these earnings are distributed to him as dividends. The profit function above can be equivalently written as[1]

(A.2) $$\pi_t = (1 - \tau_p)\,[f_1(k_t, n_t) - \delta] k_t - \Delta k_t.$$

The budget constraint for the agent can be written as

(A.3) $$c_t \le (1 - \tau_w) w_t n_t + (1 - \tau_d)\pi_t + \eta_t.$$

This equation means that the wealth or income for the individual to consume consists of labor income plus the value of the dividends paid by the firm. These dividends consist of the profit from the current period, net of taxes paid and investment undertaken by the firm. Combining Equations A.1 and A.2 with A.3 produces

(A.4) $$c_t + \Delta k_t (1 - \tau_d) \le (1 - \tau_w) w_t n_t + r_t k_t (1 - \tau_d) + \eta_t$$

or

(A.5) $$c_t + \Delta k_t' \le (1 - \tau_w) w_t n_t + (1 - \tau_p) r_t' k_t' + \eta_t,$$

where $k_t' = k_t(1 - \tau_d)$ and $r_t' = r_t/(1 - \tau_p)$. Here r_t' is the pretax return. Equation A.4 is now identical to Equation 1, with k_t' replacing k_t. The only difference is that under this scheme, in which investment is financed through retained earnings and there is a dividend tax, one unit of capital equals $(1 - \tau_d)$ units of consumption. The transformation in going from Equation A.4 to Equation A.5 reflects this notion.

NOTES

[1] The assumption that the production function $f(k_t, n_t)$ is constant return to scale implies that

$$f(k_t, n_t) = \left[\frac{\partial f(k_t, n_t)}{\partial k_t}\right] k_t + \left[\frac{\partial f(k_t, n_t)}{\partial n_t}\right] n_t.$$

decline over time rather than increase following the adoption of a consumption tax.

For reasonable assumptions about tax rates, the real price of capital falls as a result of tax reform. When individual firms are able to costlessly adjust their capital stocks, the entire price decline is immediate. Otherwise, some fraction of the decline occurs gradually as the economy approaches its new steady state. The after-tax return to capital is likely to shoot up even more in an economy with variable-labor effort than in an economy with fixed-labor effort.

NOTES

We are grateful to Carlos Zarazaga for his comments and suggestions.

1. See Becsi (1993), Wynne (1997), and, especially, Cooley and Hansen (1992). Like these authors, we use a representative agent, infinite-horizon model. For alternative approaches, see Engen, Gravelle, and Smetters (1997) or Joint Committee on Taxation (1997).
2. This notation is consistent with that in Part 1, where τ_w and τ_p are the income tax rates applicable to wages and corporate profits, respectively. Interest and dividend income was taxed at the rate τ_d in our earlier article. But changes in τ_d have no effect on the behavior of agents, so we drop it from the model presented here. The price of capital *is* affected by τ_d, however, and when we discuss the price of capital, we assume that $\tau_d = 0.25$ under the current income tax. See the box entitled "The Equivalence of Tax Regimes."
3. The after-tax interest rate, r, in Part 1 is related to r' by the formula $r = (1 - \tau_p)r'$.
4. It could alternatively be assumed that the government revenue is thrown away. However, changing the tax rate would then mean that the government is changing the amount of its consumption. The approach adopted here permits us to focus exclusively on the substitution effects produced by the presence of the taxes.
5. This approach makes it easy to compare the consumption tax rate with current income tax rates, since the latter are defined as tax revenue divided by the tax-inclusive income. An alternative way to write this budget constraint is $(1 + \tau^*)c_t + \Delta k_t \le r_t' k_t + w_t n_t + \eta_t$. It is easily shown that $\tau = [\tau^*/(1 + \tau^*)]$, so that $\tau \le \tau^*$.
6. For example, for the preferences given below by Equation 12, it is easy to show that $MRS(1 - n, c) = c/(1 - n)$. A good is said to be "normal" if a relaxation of the household budget constraint, with no change in relative prices, leads to an increased demand for the good.
7. Formally, $\partial c/\partial k = (f_1 - \delta + f_2\phi_1)/(1 - f_2\phi_2)$. For $\partial c/\partial k > 0$, it is sufficient that $f_1 - \delta > 0$.
8. A consumption tax can be implemented by combining a wage tax with a tax on a firm's cash flow. (This approach is advocated by Hall and Rabushka 1995.) The cash flow tax is nondistortional, so we can ignore it when tracing the economy's response to tax reform. For our purposes, the adoption of a consumption tax is equivalent to eliminating taxes on capital income while continuing to tax wage income.
9. Consider the effects of a cut in the labor-income tax rate, holding the capital-income tax rate constant. (We already know how changes in τ_p affect the capital

stock.) Equation 11 says that the steady-state capital–labor ratio is unaffected by a cut in τ_w. But if steady-state consumption is to increase (as our phase diagram says it must), then the steady-state levels of capital and labor cannot both fall. Hence, both must increase.

10 As discussed in Part 1, current average marginal rates of profit and wage taxation are approximately 35 percent. A 35 percent Hall–Rabushka-style consumption tax would be sufficient to replace the revenues raised by the current income and payroll taxes, provided most existing tax deductions and tax credits are eliminated.

11 It should be noted that the convergence in this economy is faster in this case than if there were no labor entering the production technology. (See the example in Koenig and Huffman 1998). In the present case, the level of output can be augmented by increasing employment, which enables the capital stock to move more quickly to its new steady-state level. Because households seek to smooth the path of consumption, they are willing to work especially hard in the years immediately following tax reform.

12 This framework does not allow the tax rate to influence the long-term rate of growth, which is assumed to be exogenously determined. For a simple model in which the growth rate is influenced by the tax rate, see the box entitled "Growth Effects."

13 Such a high marginal tax rate might be required if the consumption tax were accompanied by a demogrant — a lump-sum transfer payment from the government — or if certain categories of consumption were excluded from the tax base.

14 Unfortunately, while there is a general consensus among economists that capital adjustment costs are important, there is no consensus on just how big they are. Since we have made no serious effort to calibrate our adjustment-cost equation to real-world data, our simulations are useful solely for what they have to say about the *qualitative* impact of capital adjustment costs on the economy's response to tax reform.

15 Roughly speaking, with appropriate substitutions Equation 6 can be written as $c_t = (1 - \tau)[k_t^{\theta} n_t^{1-\theta} + (1 - \delta)k_t - (k_{t+1} - k_t)^2 - k_{t+1}]$. Taking the total derivative of this expression to calculate the price as $-dc_t/dk_{t+1}$ yields Equation 15.

16 See note 2.

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