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THE OPTIMAL TAX RATE FOR CAPITAL INCOME IS NEGATIVE

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ABSTRACT

We examine the problem of optimal taxation in a dynamic economy with imperfectly competitive markets. We find that the optimal tax system will tend to provide subsidies for the purchase of capital goods to offset gaps between price and marginal cost. The average tax on capital income will be negative, even if pure profits are not taxed away and even if the alternative distortionary taxes have an *infinite* efficiency cost. These arguments hold even if it is necessary to tax consumption goods which also sell above marginal cost; the difference is that capital goods are intermediate goods and consumption goods are final goods. Since observed markups are greater for equipment than for construction, this analysis justifies the Investment Tax Credit's discrimination in favor of equipment over structures.

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1. Introduction

The problem of optimal taxation of income in dynamic economies has been analyzed extensively, but primarily under the assumption of perfect competition. In this paper, we examine the nature of optimal taxation in a dynamic model with preexisting distortions such as those associated with imperfect competition. Our main finding is that while the optimal tax policy taxes labor income, pure profits, and consumption, it does not tax capital income. Furthermore, the optimal policy, in the long run, subsidizes firms' purchases of capital goods to overcome distortions due to imperfect competition which push prices of capital goods above marginal cost.

The basic idea is intuitively a combination of two well-known ideas. First, in markets where price exceeds marginal cost because of market power, subsidies can be used to offset the distortions if a lump-sum tax is available. This is an old result, going back to Robinson (1934)[1]. Second, the optimal policy derived in Diamond and Mirrlees (1971) taxes only final goods, not intermediate goods. More precisely, they show that with a flexible set of tax instruments any intermediate good distortion can be replaced with less damaging final good distortions. In combination, these principles indicate that final goods are taxed in the optimal policy to finance corrective subsidies of any intermediate good which is sold at a price above marginal cost.

In the presence of a lump-sum tax, these results are obvious; however, the assumption of lump-sum taxation renders the result a theoretical curiosum, of no substantive economic interest. In this paper we formally examine this intuitive argument in dynamic models of economic growth, and discuss its implications for tax policy in models with distortionary taxation, calibrated with estimates of the distortionary cost given by recent work on distortionary taxation in dynamic economies. The special considerations for intermediate goods are important for income taxation theory once we make

[1]The recent analysis of Barro and Sala-i-Martin (1992) is an instance of the general Robinson result since it assumed the availability of a lump-sum tax.

a key observation: taxation of capital income is the same as a tax on the purchase of capital goods. Specifically, a tax rate of τ on the net cash flow generated by a unit of capital is equivalent to a sales tax of $1/(1-\tau)$ on the purchase the capital. This paper combines this view of capital income taxation with the presence of market power, to arrive at a striking implication: the optimal long-run tax on capital income is negative, *even if the distortionary cost of raising revenue is infinite*!

The observation that capital income taxation is an intermediate good tax has not been used much in income tax theory arguments but it helps to put a number of results in perspective. Many authors have investigated optimal factor income taxation in perfectly competitive economies, generally finding that with time-invariant tastes, flexible sets of instruments, and equal social and private rates of time preference, the optimal capital income tax rate is zero. This has been established in a wide variety of models; Diamond (1973), Atkinson and Sandmo(1980), and King(1980) demonstrate this for overlapping generations models and separable utility, and Judd (1985) shows this for time-autonomous Uzawa tastes and a heterogeneous population of infinitely lived agents. Once we adopt the intermediate good taxation analogy, these results follow intuitively from Diamond–Mirrlees.

Many authors of policy tracts have argued for consumption taxation over income taxation; however, their arguments often ignore the optimal tax literature. Instead they emphasize the simplicity of a uniform consumption tax or preach that it is morally superior to tax people for what they take from society, consumption, instead of taxing them for what they produce[2]. However, this paper shows that we need to go further than eliminate intermediate goods taxation. Since we instead want to implement intermediate goods subsidies, it would appear that we want to keep an income tax structure to facilitate such subsidies.

There are important qualifiers to both the zero long-run tax result and to the

[2]Two prominent examples of such advocacy are Bradford, and Hall and Rabushka. While I am sure that most of these authors were aware of the Diamond–Mirrlees results, neither book includes that paper, nor any paper on optimal taxation, in their citations of the academic literature.

Diamond-Mirrlees production efficiency result. The Diamond–Mirrlees rule against intermediate good taxation disappears if the set of permissible final good taxes is restricted. Similarly, Jones et al. (1993) show that the optimal long-run rate may be nonzero when markets or the available policy instruments are incomplete, or if wealth is in the utility function, in which case wealth is a final good as well as an intermediate good. The other qualifier is that the Diamond-Mirrlees production efficiency result is modified when there are rents; however, production efficiency still obtains when there is 100% taxation of pure profits. Similarly, the optimal tax on capital income is positive in the short–run when capital income is mostly a quasi–rent earned by the initial capital stock. While many have noted conditions where Diamond–Mirrlees does not hold exactly, the economically substantive question is whether Diamond–Mirrlees is a good benchmark or whether the deviations are so large as to render Diamond–Mirrlees' insights of no value. We strongly argue the former in this paper.

There has also been work on optimal taxation with imperfect competition; however, the focus has been on incidence in static models with only final goods. Myles (1989) examined optimal taxation with imperfect competition, but did not examine general equilibrium with both intermediate and final goods. We focus on the role of intermediate goods and dynamic entry in the determination of optimal tax policy in dynamic general equilibrium.

We adopt an infinitely lived representative agent framework, but add distortions to the conventional model. The representative agent framework will imply that social and private discount rates are equal, but the distortions from imperfect competition will produce rent flows which may alter both the zero-distortion and production efficiency arguments. We examine these issues in two dynamic general equilibrium models. First, we show exactly how monopolistic distortions affect capital allocation in a completely specified general equilibrium model of monopolistic competition. The basic structure is taken from the model of monopolistic competition of Dixit and Stiglitz (1977) but generalized to allow both differentiated consumption goods and differentiated intermediate goods. The second model we examine is a more general one with multiple capital goods and preexisting distortions in their allocation. While the second model assumes a reduced, but rather general, form for the distortions, it allows us to examine issues related to the tax treatment of various kinds of capital, and the role of entry assumptions.

The basic intuition of this paper is that market distortions act like a privately imposed tax on purchasers of intermediate goods, and that the optimal tax rate net of such private taxation and explicit public taxation is close to zero when there are sufficient tax instruments. In this paper, we show that this is exactly true when all pure profits are taxed away, or when there is free entry, or when the marginal efficiency cost of tax revenues is zero. The intuition is clear: if profits are consumed by fixed costs, then the zero profit, free-entry oligopoly entry equilibrium is equivalent to having a competitive market and imposing a tax to finance the fixed costs, a policy which, according to Diamond–Mirrlees, is suboptimal for intermediate goods. Since no one extreme case is realistic, we show that in general the optimal tax system moves a substantial direction in this direction even when we make conservative assumptions concerning profits taxation, entry and the cost of funds.

We then discuss the implications of our analysis for various tax policy issues. If all intermediate goods were affected symmetrically by market power, a uniform subsidy of capital income would be an appropriate corrective policy. This subsidy could take many forms, including an investment tax credit and accelerated depreciation (perhaps expensing of all investment expenditures). We will make no essential distinction between tax credits and favorable depreciation rules; hence, when we speak of tax credits we are implicitly also including equivalent alternatives which include accelerated depreciation. However, examination of the empirical work on price-cost margins shows that capital goods are sold at a variety of price-cost margins; hence, a nonuniform subsidy, however, implemented, is in order. This analysis argues strongly against the "level playing field" approach to tax design as conventionally pursued, deriving instead the true "level playing field" criterion. Furthermore, the empirical work shows that equipment industries have substantial price-cost margins, whereas the construction industry is close to being competitive. This shows that the investment tax credit as implemented over the past thirty years correctly discriminates in favor of equipment. We argue that these observations constitute a more robust foundation for such equipment-focussed pro-growth policies than the Keynesian stimulus arguments often used to justify the ITC.

These results also have many implications for optimal policy in growing economies. While the growth models we examine converge to a steady state output level, it is clear that the results have nothing to do with the absence of steady-state growth, and, like every other result on tax and fiscal policy, apply equally to models with and without steady-state growth. In particular, some results concerning productive efficiency hold along the path as well as at the steady state. Therefore, the arguments have several implications for R&D and growth policies. We argue that subsidizing the purchase of new capital goods subsidies is a more appropriate tool for encouraging R&D than an R&D tax credit, and that the optimal ITC in a growing economy would be applied more liberally to new equipment relative to used equipment. The distinction between final and intermediate goods is also important for R&D policy issues since comparisons with other results indicate that R&D will be biased towards consumption goods.

There are also trade policy implications. The international trade interpretation of our model indicates that optimal equipment subsidies would discriminate in favor of domestically produced equipment if such subsidies are imposed unilaterally. Even better would be a multilateral subsidy would be best if the innovation producing economies would cooperate.

While the analysis below and the models underlying it is only a first cut at the problem of market power[3] and optimal taxation, it demonstrates that tax policy

[3]This is *not* a paper on antitrust policy, and its recommendations are not meant to be a substitute

discussions should be reoriented in their focus. Income tax analyses usually proceed along the lines of the Haig-Simons approach: define economic income correctly and tax it. Consumption tax advocates generally appeal to the homily that it is best to tax an individual according to what one takes from the economy, not by what one produces. Both approaches generally assume competitive markets. The optimal tax analysis of this paper argues that capital income taxation is a tax on intermediate goods, remember that such goods are often sold in imperfectly competitive markets, and take heed of the Diamond-Mirrlees principle against price-cost distortions in markets for intermediate goods.

2. The Basic Intuition

We first discuss the basic intuition using some simple diagrams.

First, we recall Robinson's analysis of subsidizing a monopolist. In Figure 1, we have a monopolist facing a demand curve D and marginal cost mc. The monopolist will produce where the marginal revenue curve, MR, cuts mc, a quantity less than the efficient output where D crosses mc. However, a 50% subsidy will cause the demand curve to move up to D_{sub} and marginal revenue to MR_{sub}. With this subsidized demand, the new monopoly output will be where MR_{sub} crosses mc, which is the efficient output.

After making this observation, Robinson disparaged the kind of subsidy policy suggested by this analysis. Her criticism focussed on the income distribution consequences of subsidizing monopolists' income and of implementing the "correct" policy of financing these subsidies by taxing away the extra monopoly rents. However, these concerns are not always applicable. For example, if fixed costs eat up the gross profits leaving the monopolist with no rents, then these concerns are of far less importance. In any case, Robinson's concerns are better addressed in a very different model since representative agent analysis such as ours abstracts from distributional issues.

The other logical problem with Robinson's analysis is the implicit assumption that

for antitrust policy. The connections with antitrust policy are discussed below.

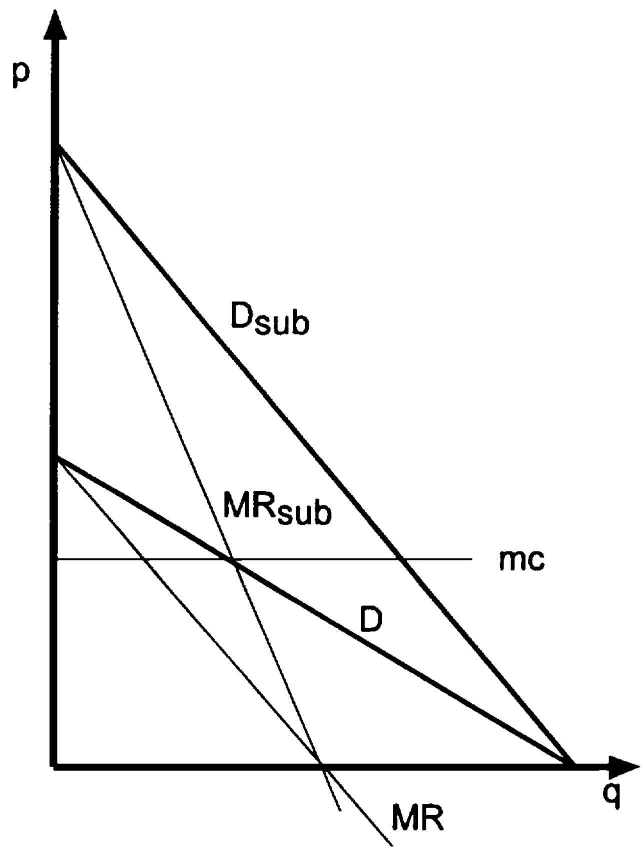

Figure 1: Subsidizing a "Monopolist"

Figure 1:

there are lump-sum taxes. In reality, some goods must be taxed in a distortionary fashion. If all goods sell above marginal cost, as they do in the model I examine below, then not all goods can be subsidized. We have to prioritize the distortions, aggravating some with taxation in order to subsidize others. The first part of that decomposition may be to tax competitively supplied goods; I do not examine that question here since in a modern industrial society few final goods are produced in competitive markets. Our intuition fails us when it comes to trying to decide which imperfectly competitive goods to tax. The inverse-elasticity rule, another basic intuition from partial equilibrium analysis, argues for heavier taxation of goods with relatively low elasticity of demand. However, those would also be the goods with the high margins we want to reduce. It would seem hopeless to find a robust decomposition of goods are taxed in an optimal tax system and those which are not.

It is at this point that the logic of Diamond and Mirrlees enters our argument. One way to interpret their finding that intermediate goods are not taxed in an optimal tax system is that there is lexicographic ordering to distortions with any distortion in intermediate goods being worse than any distortion to consumption goods. While this is an exaggeration, it emphasizes a key feature of their productive efficiency result: with sufficient policy instruments, the optimal tax structure will not distort production. It also emphasizes that the relative elasticity logic of partial equilibrium analysis is severely flawed. For our purposes, it is convenient that elasticities nowhere enter this Diamond-Mirrlees intution.

This paper combines the Robinson and Diamond-Mirrlees analyses to arrive at a hybrid rule. As argued above, the Diamond-Mirrlees analysis applies here since capital is an intermediate good. The combination leads to a simple rule: tax final consumption goods to finance subsidies of capital goods sold under imperfectly competitive conditions.

This is not a complete tax rule. In particular, it says nothing about the taxation of different imperfectly competitive consumption goods. The models below abstracts from this issue by making various symmetry assumptions, and we leave that generalization to later work. However, our basic intuition seems to be leading us to concluding that the intermediate good – final good distinction is robust and, to the extent necessary for the policies discussed below, implementable, whereas trying to determine which final goods to tax most heavily is generally an impractical task so we might as well treat them symmetrically.

The discussion of the previous paragraphs presents intuition for our results, but certainly is not a demonstration of them. We now move to formal dynamic general equilibrium models which support these arguments.

3. A Dynamic Model of Monopolistic Competition

We first examine a model where differentiated goods are used in consumption and investment. We assume a continuum of goods, indexed by $i \in [0,1]$. Output of good i is produced by labor input, l_i, and a capital aggregate, X_i. We let k_j^i, $j \in [0,1]$, denote the amount of capital stock of good j used to produce good i, and define the capital aggregate to be

$$X_i \equiv \left(\int_0^1 (k_i^j)^{1-\eta} \, dj \right)^{\frac{1}{1-\eta}}$$

Output of good i is

$$y_i = f(X_i, l_i)$$

Note that f does not depend on i; this implies a convenient symmetry which we will exploit heavily in this model. The CES specification implies that the elasticity of demand for each capital good is η^{-1}.

The goods are also consumed. The representative agent has utility

$$\int_0^\infty e^{-\rho t} u(C(t), l) \, dt$$

where l is labor supply, and $C(t)$ is a consumption aggregate

$$C(t) = \left(\int_0^1 c_i(t)^{1-\eta} \, di \right)^{\frac{1}{1-\eta}}$$

where $c_i(t)$ is the consumption of good i at time t. The key property of this utility function is that the elasticity of consumption demand for each good is η^{-1}, independent of price and the level and allocation of consumption. The equality and constancy of the elasticity of substitution is assumed for simplicity and presumably not crucial to any of the results.

Each firm produces a unique good and puts it to two uses. First, it maintains and adjusts a stock of its good, and rents this stock to other firms, where it is used in production, and, second, it sells new output of its good to consumers who consume it immediately. This formulation assumes no adjustment costs; the absence of adjustment costs is appropriate since the focus of this paper is long-run properties of optimal policy. We will also assume no physical depreciation of capital, a simplification which affects no result. We are assuming that there is no stock aspect to consumer demand to avoid unnecessary complications of consumer stockholding. By assuming rental of the stock to other firms, we avoid the durable goods monopoly problem (see Stokey, 1981, and Bulow, 1982). Alternatively, we could assume that each firm can commit to a dynamic price policy and sell its output to firms. The key fact is that we assume a market structure which implies that the price of the output is the monopolistically competitive price, and the rental assumption makes the analysis below a bit simpler. As long as all firms face the same tax environment and rates, the actual ownership has no effect on anything[4].

We have assumed that the elasticity of substitution across goods is the same for both consumption and production uses; this is done only to keep the analysis simple. In the general case with different elasticities for consumption and production use, the foregoing would be essentially unchanged by making the (reasonable) assumption that each firm could price discriminate between final good consumption and intermediate good use.

[4]We will abstract from the lease vs. ownership questions which are studied in the financial literature.

3.1. The Firm's Problem. We first examine the representative firm's problem. Each firm is the sole producer of one of the goods. It chooses the price (or quantity) of its good as a monopolist, but it takes as given the prices of all other goods. Each firm uses all other goods as inputs and competes with all other goods in the consumption market and capital equipment rental market.

Let k_i denote the aggregate amount of good i which is accumulated as a capital stock and owned by firm i. Suppose that at time t, $R_i(k_i,t)$ is the rental rate for good i when firm i rents k_i units of the stock, and $P_i(c_i,t)$ is the price of consumption sales when firm i sells c units of output to consumers. Firm i's objective is to choose c_i, k_j^i, and l_i to maximize the market value of the firm's net cash flow:

$$\begin{aligned} \max_{c_i,L_i,k_j^i} & \quad \int_0^\infty e^{-\int_0^t r}\left(R_i(k_i,t)K_i + P_i(c_i,t)c_i - wl_i - I_i\right)dt \\ \dot{K}_i &= F(X_i,l_i) - c_i \equiv f(X_i,K_i,l_i) - c_i \end{aligned}$$

where $I_i \equiv \int_0^1 R_j(k_j,t)k_j^i\,dj$ is the total rentals paid by firm i to other firms for equipment rental, r is the required rate of return. The best way to think about the firm is that it borrows debt at the rate r to cover equipment rental and wage expenditures, and pays out all net earnings to its equity holders. The Hamiltonian for firm i is

$$H(k_i,\phi_i,l_i,c_i,k_j^i) = R_i(k_i,t)k_i + P(c_i,t)c_i - wl_i - I_i + \phi_i\left(f(X_i,l_i) - c_i\right)$$

where ϕ_i is the marginal value of the stock of good i to firm i. The first-order conditions for firm i's choice of each k_j^i is

$$0 = -R_j(k_j,t) + \phi_i f_X(X_i,l_i)(k_j^i)^{-\eta}X_i^\eta \tag{1}$$

which shows that the elasticity of rental for capital good j by firm i is η for all capital goods by all firms. The first-order condition for firm i's choice of c_i is

$$0 = \left(P_i(c_i,t) + c_iP_i'(c_i,t)\right) - \phi_i$$

where the prime mark refers to differentiation with respect to c. The costate equation is

$$\dot{\phi}_i = r\phi_i - (R_i(k_i,t) + k_i R_i'(k_i,t)) \tag{2}$$

where the prime mark refers to differentiation with respect to k_i.

3.2. The Consumer-Investor. The representative individual faces the problem

$$\begin{aligned} \max_{c_i} \quad & \int_0^\infty e^{-\rho t} u(C(t), l) \\ \dot{A} \;=\; & \bar{r}A - \int p_i c_i di + \bar{w}l + (1 - \tau_\Pi) Div \end{aligned}$$

where A is his interest-paying assets, Div is the rate of dividends on his ownership of the monopolistic firms, τ_Π is the rate of taxation on dividends, $\bar{r}$ is the after-tax rate of return on interest-paying assets, $\bar{w}$ is the after-tax wage rate, c_i is consumption of the good i priced at p_i, and l is his labor supply. We are assuming that all agents hold the per capita amount of equity and debt in each firm, and that there is no trade in equity. The no-trade assumption is largely a matter of convenience in this representative agent model. The only trading we have to worry about is firms repurchasing their equity or other firm's equity to convert dividends into capital gains for individuals. We rule out these transactions (or, more precisely, we assume that the prohibitions on these tax-avoidance strategies are enforced) to avoid complications which are not central to this paper's concerns.

If we let λ denote the shadow price of assets for the representative individual, his solution satisfies

$$\dot{\lambda} = \lambda(\rho - \bar{r}) \tag{3}$$

where $\bar{r}$ is the after-tax rate of return on capital income. We assume that the individual pays tax on both labor and investment income, the latter being comprised of both corporate debt and corporate equity. Consumption demand and labor supply must satisfy the conditions

$$\begin{gathered} 0 = u_C C^\eta c_i^{-\eta} - p_i \lambda \\ 0 = u_l + \lambda \bar{w} \end{gathered}$$

From these first-order conditions we can solve for l and c in terms of $\lambda, \bar{w}$, and the vector of prices, p, implying that

$$\begin{aligned} c_i &= C(\lambda, \bar{w}, p) \\ l &= L(\lambda, \bar{w}, p) \end{aligned} \tag{4}$$

The consumers' inverse demand function, $P(c, t)$, is the same for each good and becomes

$$P_i(c_i, t) = u_C C^{\eta} c_i^{-\eta} \lambda^{-1}$$

which is a constant-elasticity demand function.

3.3. Equilibrium. We have assumed symmetry among all firms, all inputs, and all consumption goods. Therefore, in equilibrium all firms will charge the same price to all other firms for equipment rental, and the same price to all consumers. Furthermore, the demand conditions above showed that the elasticity of demand is η^{-1} in both markets for all firms. Therefore, the common price equals marginal cost times $(1-\eta)^{-1}$. All this implies that in equilibrium, all firms use the same amount of inputs, produce the same level of output, accumulate the same level of capital for rental, and that the capital stock equals the level of debt-paying assets. Hence,

$$k_i^j = X_i = k = A$$

where k is the aggregate average capital stock per type. In equilibrium, the consumption aggregate equals the average consumption across goods,

$$C(t) = c_i(t)$$

Without loss of generality, we can choose consumption good 1 to be numeraire; since all goods sell at the same price, we conclude

$$\forall i \ (p_i = 1)$$

These facts further imply that the private shadow value of wealth equals the marginal utility of consumption,

$$0 = u_C - \lambda$$

which in turn implies that the inverse demand function reduces to

$$P_i(c_i, t) = C(t)^\eta c_i^{-\eta}$$

For firms, the symmetry implies a simple rental demand equation:

$$R_i(k_j, t) = (1+\eta) f_X(k(t), l(t))\ k(t)^\eta\ k_i^{-\eta}$$

where l is the average labor use across firms. From the firm's consumer sales decision, we find that the firms' common shadow price on capital, ϕ, equals

$$\phi = cP'(c,t) + P(c,t) = 1 - \eta$$

which, since η is constant, implies $\dot{\phi} = 0$. These expressions, combined with the firm's costate equation, (2), and demand equation, (1), implies

$$r(1-\eta) = R_i(k_i, t) + k_i R_i'(k_i, t) = (1-\eta)^2 f_X(k(t), l(t))\ k_i^{-\eta}\ k(t)^\eta$$

which, upon imposing the equilibrium condition $k_i = k$, implies

$$r = (1-\eta) f_X(k, l)$$

This formula implies that the marginal product of capital equals the interest rate grossed up by the markup factor $(1-\eta)^{-1}$. Efficiency would set $r = f_X$; hence, the monopolistic competition generates an important distortion.

If we define τ_D to be the personal tax on interest income, then $\bar{r} = r(1-\tau_D)$, we find that

$$(1-\eta)(1-\tau_D) f_X(k, l) = r(1-\tau_D) = \bar{r}$$

This expression shows that monopolistic competition affects the net return to capital the same as a second tax rate of η. This justifies our analogy between taxation and monopolistic competition in our intuitive argument above.

We now combine the capital demand equation with the consumer-investor behavior equations, noting that r is the common rate of return faced by both groups, to derive the real equilibrium. We assume that government expenditures are zero, therefore, aggregate investment equals output minus consumption:

$$k = f(k, L(\lambda, \bar{w}, 1)) - C(\lambda, \bar{w}, 1) \tag{5}$$

In equilibrium, the investor-consumer Euler equation, (3), becomes

$$\dot{\lambda} = \lambda(\rho - (1 - \tau_D)(1 - \eta) f_k(k, L(\lambda, \bar{w}, 1))) \tag{6}$$

The two equations, (5) and (6), together with the definitions of C and L in (4), and boundedness of k and λ, define the dynamic equilibrium path for consumption, labor supply, and output for any dynamic path of τ_D and $\bar{w}$.

The other salient fact of equilibrium is the presence of pure rents, specifically the monopolistic rents collected in the form of dividends by equity owners. The presence of rents alters the Diamond-Mirrlees prescription against intermediate good taxation. In fact, Stiglitz and Dasgupta (1971) demonstrated the more general proposition that if pure profits are taxed away then there the it is optimal to have no taxation of intermediate goods even if there were decreasing returns in production. Strictly speaking, the Stiglitz-Dasgupta result does not apply here since the pure profits here are due to imperfect competition, not decreasing returns. However, we will see that the same result holds.

Since price is 1 and price equals $(1 - \eta)^{-1}$ times marginal cost, the marginal cost is $1 - \eta$ in equilibrium, and total pre-tax profits equal $\eta f(k, L(\lambda, \overline{w}, 1))$. These are pure rents of the firm, paid to the owners of the firm as dividends, and then taxed at the rate τ_Π. The household sector therefore receives two payments from the firms, the rental of capital and the after-tax dividends.

This implies that the if B is the stock of bonds, then B evolves according to

$$\dot{B} = \bar{r}B - f(k, L(\lambda, \bar{w}, 1)) + \bar{r}k + \bar{w}L(\lambda, \bar{w}, 1) + (1 - \tau_{\Pi})\eta f(k, L(\lambda, \bar{w}, 1))$$

The bond equation follows from the observation that the deficit must equal interest payments minus total output plus net-of-tax factor payments and net-of-tax dividend distributions. This expression is useful since it distinguishes between the competitive return on capital investment, k, and the income stream which is associated with the monopoly rents, $\eta f(k, L)$.

Since there are no government expenditures, we are assuming that the initial level of debt is positive and its service requires distortionary taxation. The results below would be no different if we added government expenditure and make the usual assumption that its presence affects neither production nor any marginal rate of substitution among the consumption goods and leisure.

3.4. The Optimal Taxation Problem. The optimal taxation problem is to maximize the dynamic utility of the representative agent given the limited tax instruments and the competitive equilibrium they produce. Let $\bar{r}$ be the after-tax return on investment and $\overline{w}$ be the after-tax wage rate. Also let $v(\lambda, \bar{w}) \equiv u(C(\lambda, \bar{w}, 1), L(\lambda, \bar{w}, 1))$ be the utility function expressed as a function of the current marginal utility of consumption and the after-tax wage rate. The optimal tax problem becomes

$$\begin{aligned}
\max_{\bar{r}, \bar{w} \geq 0} \int_0^\infty & \quad e^{-\rho t} v(\lambda, \bar{w}) \\
\dot{k} &= f(k, L(\lambda, \bar{w}, 1)) - C(\lambda, \bar{w}, 1) \\
\dot{\lambda} &= \lambda(\rho - \bar{r}) \\
\dot{B} &= \bar{r}B - f(k, L(\lambda, \bar{w}, 1)) + \bar{r}k + \bar{w}L(\lambda, \bar{w}, 1) + (1 - \tau_{\Pi})\eta f(k, L(\lambda, \bar{w}, 1)) \\
\lim_{t \to \infty} |B| &< \infty
\end{aligned}$$

The restriction on the growth of B is the usual one to prevent Ponzi schemes.

The Hamiltonian[5] of this problem is

$$\begin{aligned}H = &\, v(\lambda, \bar{w}) + \theta(f(k, L(\lambda, \bar{w}, 1)) - C(\lambda, \bar{w}, 1)) \\ &+\psi\lambda(\rho - \bar{r}) \\ &+\mu(\bar{r}B - f(k, L(\lambda, \bar{w}, 1)) + \bar{r}k + \bar{w}L(\lambda, \bar{w}, 1) + (1 - \tau_{\Pi})\eta f(k, L(\lambda, \bar{w}, 1)))\end{aligned}$$

where θ, ψ, and μ are the planner's shadow prices of k, λ, and B.

We have not yet explained how $\bar{r}$ (which fixes τ_D since $(1-\tau_D)(1-\eta)f_X = \bar{r}$) and τ_{Π} are related. We will examine two cases regarding the determination of τ_{Π}. In the case of a corporation, we can tax profits at a rate different from interest income. We assume that the total taxation of profits is fixed independently at τ_{Π}. It is obvious that the optimal tax rate on the pure profits in this model, as in other similar models, is 100%. We now examine the optimal choice for τ_D.

For a fixed profits tax rate, the costate equation for θ in our optimal taxation problem becomes

$$\dot{\theta} = \rho\theta - \theta f_k - \mu(\bar{r} - f_k(1 - (1 - \tau_{\Pi})\eta))$$

Observe that θ, the public shadow price of the capital stock, is positive, that μ, the shadow price on public debt, is negative, and that -μ/θ is the marginal efficiency cost of funds. The term $-\mu/\theta$ is also known as the marginal excess burden of taxation (MEB); the social cost of funds would equal $1 - \mu/\theta$, that is, the private cost of a dollar of taxation equals the dollar of revenue plus the MEB. The steady state of the costate equation, when combined with the equilibrium expressions for $\bar{r}$ and f_k, yields the following theorem.

Theorem 1. *The optimal tax on profits is 100 %. If the profits tax rate is fixed at τ_{Π}, the optimal tax rate on interest in the steady state equals*

$$\tau_D^{opt} = -\frac{\eta}{1-\eta}\frac{1-\tau_{\Pi}\ \mu/\theta}{1-\mu/\theta}$$

[5]The more proper way to proceed is to rewrite the bond equation as an integral equation imposing the natural present value condition for the government's budget constraint, and analyzing the resulting isoperimetric problem. This procedure yields the same answer.

In particular, it is negative whenever products are differentiated and the marginal cost of funds is finite.

The optimal tax rate in Theorem 1 is simple. If the efficiency cost of taxation is zero then the optimal tax completely neutralizes the monopolistic price distortion. It is straightforward to show that the optimal tax rate on profits is 1, in which case the optimal policy is to eliminate the monopolistic price distortion.

In any case, the optimal policy is almost always a subsidy. Even when $MEB = \infty$, the point where revenue is being maximized, the optimal subsidy equals τ_Π of the rate which would eliminate the price-cost distortion. This is quite remarkable since this says that one keeps the subsidy even when the cost of funds to finance the subsidy is infinite! This nicely illustrates the strength of the Diamond–Mirrlees prohibition against distortions in intermediate goods. Only when $MEB = \infty$ and $\tau_\Pi = 0$ does the subsidy disappear.

We will next examine a simpler tax structure. Suppose that there were no business taxation, and that all taxation is at the personal level, and profits and interest are taxed at the same rate. In this case, we have τ_Π fixed by

$$1 - \tau_\Pi = 1 - \tau_D = \bar{r}/((1-\eta)f_X)$$

and the costate equation for θ becomes

$$\dot{\theta} = \rho\theta - \theta f_K - \mu(\bar{r} - f_X + \frac{\eta}{1-\eta}\bar{r} - \frac{\eta}{1-\eta}\bar{r}\frac{f f_{XX}}{f_X f_X}))$$

If we define σ to be the elasticity of substitution between X and l in production, θ_K and θ_L to be the *competitive economy's* capital and labor shares, then $\frac{f f_{XX}}{f_X f_X} = -\frac{\theta_L}{\sigma\theta_K}$. When we combine the steady-state expressions of the differential equations with the monopolistically competitive equilibrium condition $(1-\eta)(1-\tau_D)f_k(k,l) = \bar{r}$, we have the following theorem.

Theorem 2. *If all investment income is taxed at the same rate, the optimal tax rate* *in the steady state equals*

$$\tau_D^{opt} = \tau_\Pi^{opt} = -\frac{\eta\left(1 + \frac{\mu}{\theta}\frac{\theta_L}{\sigma\theta_K}(1-\eta)\right)}{(1-\eta)\left(1 + \frac{\mu}{\theta}\frac{\theta_L}{\sigma\theta_K}\right) - \frac{\mu}{\theta}}$$

This is a rather complex expression. Some special cases make it clearer. If MEB is zero, then the tax rate on both investment income and pure profits is negative, equal to -$\eta/(1-\eta)$, and completely eliminates the monopolistic distortion for capital goods. This does not imply that all monopolistic distortions are eliminated if MEB is small, since the subsidies must be financed, presumably by taxing labor income, which increases the distortion between leisure and consumption[6]. If capital and labor are perfectly substitutable then the tax rate is $-\eta/(1-\eta-\mu/\theta)$, which is also negative and still eliminates a substantial portion of the monopolistic distortion if the MEB is small.

This case is included more for pedagogical reasons than for substantive economic reasons. Tax policy can and does differentiate between profits and capital subsidies. Therefore, the first case of a profits tax rate independent from a capital income tax rate is the sensible one. We shall focus on that case in our discussion below. There are many ways to implement this distinction. For example, subsidizing investment or granting favorable depreciation treatment, would also reduce price-cost margins separately from taxing investment income. Most tax systems are sufficiently flexible to distinguish between the taxation of capital income and the subsidization of investment, in which case Theorem 1 is relevant. Theorem 2 emphasizes the point that such distinctions are very important in eliminating price-cost margins.

3.5. Quantitative Importance. While our optimal tax formula is clean, it is not clear that the subsidy is economically significant when we use reasonable values for η, the markup, and the marginal excess burden (MEB), -μ/θ. Barro and Sala-i-Martin assume that MEB=0 and that the compensated labor supply was perfectly

[6]Exactly what happens in the steady state depends on the steady state level of government debt and on the transition phase, which is beyond the scope of this paper.

inelastic; both assumptions are implausible and lead to nonrobust results. If we assume that MEB=0 in our model with elastic labor supply we also get the result that the optimal labor tax would be negative to counter the monopolistic distortions in the consumption goods market. In our model with equal markups in the intermediate and final goods markets we would come to the conclusion that everything should be subsidized at the rate $-\eta/(1-\eta)$; if we had assumed that consumption goods were marked up more, than they would receive the higher subsidy. Therefore, under the MEB=0 case there is no favoritism shown for capital goods. However, the MEB=0 case is an absurd one to look at since it would imply everything is being subsidized, a situation inconsistent with dynamic budget balance and the usual condition of a positive stock of public debt.

To determine whether the optimal subsidy is significant, we compute it for reasonable values of η and μ/θ. We assume $\eta \in [.1, .4]$; this range is suggested by the empirical literature on price-cost margins (we will discuss this literature in more detail below). The range for MEB is taken from Judd(1987). The dynamic equations above are essentially the same as for the competitive model in Judd (1987) where we add the price–cost margins to the explicit tax rates to get the total effective tax rate. Therefore, the results in Judd (1987) for a competitive model are roughly appropriate. Since there is often only a small capital goods distortion in the long-run of the optimal tax policy, MEB is nearly the same as the marginal excess burden in a competitive model with only labor taxation, and is therefore confined to the interval $[0, 1]$ for almost all estimates of labor supply elasticities, price–cost margins, and tax rates in U.S. experience[7].

Table 1 shows that even if the shadow price of funds is nontrivial, the optimal tax substantially reduces the monopolistic distortion. In Table 1 we assume that the

[7]See Judd, 1987, for a long list of empirically estimated labor supply elasticities and labor tax rates used there to compute MEB. It would be somewhat better to compute the optimal dynamic path of all tax rates, but that would take us far from the focus of this paper on the general value of capital subsidies.

profits tax is zero, .5, or 1.

Table 1: Optimal Tax Rates

	τ_Π:	0				.5				1.0
η	MEB:	.2	.4	.7	1.0	.2	.4	.7	1.0	$[0, \infty)$
$-.1$		$-.09$	$-.08$	$-.07$	$-.06$	$-.10$	$-.10$	$-.09$	$-.08$	$-.11$
$-.2$		$-.21$	$-.18$	$-.15$	$-.12$	$-.23$	$-.21$	$-.20$	$-.19$	$-.25$
$-.3$		$-.36$	$-.31$	$-.25$	$-.21$	$-.39$	$-.37$	$-.34$	$-.32$	$-.47$
$-.4$		$-.56$	$-.48$	$-.39$	$-.33$	$-.61$	$-.57$	$-.53$	$-.50$	$-.67$

Table 1 illustrates a number of points. First, the zero profits tax case is the extreme case where the subsidy is lowest. When the profits tax is 100% the subsidy is highest and brings price down to social cost. Second, the optimal subsidy is nontrivial in most cases. Even in the most pessimistic case where there is a zero profits tax and MEB is 1.00 along the optimal tax policy, the optimal subsidy still eliminates half of the monopolistic price-cost margin.

3.6. Interpretations. While our model made some simplifying assumptions, a number of equivalent results are also clear. The subsidies we found above are paid directly to the investors. That is clearly not necessary. These subsidies could also be paid to the firms in the form of investment tax credits or, if we had depreciation, accelerated depreciation schedules. In this simple model, we cannot make these distinctions; the more general model in the next section will allow us to make these distinctions.

Our simple, symmetric monopolistically competitive model clearly demonstrates a number of important points. First, optimal tax policy puts a priority on countering the monopolistic price distortions in capital good markets, even at the expense of aggravating the distortions in final goods markets. Our model makes this particularly clear since each good has a final good use and intermediate good use, and only the intermediate good use is subsidized.

Second, the desired subsidies are quantitatively important even when pure profits are lightly taxed and the social cost of funds is large. We will next examine a generalization of these points to somewhat more general situations, which will allow us to examine more detailed issues of optimal tax design.

4. General Distortions

We next examine a more general model with multiple capital stocks and potentially more complex distortions. The previous section examined a specific model with particular pattern of product differentiation and oligopoly behavior, and was strongly symmetric. While it made the main points in a simple and completely rigorous fashion, it ignores many factors which we would like to bring in to the discussion. In the next model, we focus on heterogeneities across capital goods so that we can distinguish between subsidies to saving in general and good-specific subsidies. We will also examine the non-steady state behavior of tax policy as well as the long-run policy. To avoid game-theoretic complexities, we do not solve any specific model of imperfect competition; instead we specify market distortions in a simple reduced form, but general, fashion. While the reduced form specification for the pre-existing market distortions is not based on a completely specified model of market structure and conduct, the reduced form is general, presumably representing several alternative specifications of imperfect competition, and allows us to examine a much wider range of tax policy issues. In fact, this approach aims to determine the features of optimal policy which are robust across alternative specifications of market structure and conduct.

4.1. Model. We assume that there is one good used for both consumption and investment. There is one capital stock with several capital uses and an elastic labor supply. Net output is $y = f(K, l)$ where $K \in R^n$ is the vector of capital inputs and l is the labor input. We assume that capital is putty-putty; that is, each period begins with an aggregate stock of capital, k, which is allocated over the n types of capital. Since our focus is on the long-run tax policy, this helpful simplification should not affect our results relative to more realistic specifications incorporating adjustment costs. Net output of the one good is divided between consumption, c, and net investment, $\dot{k}$.

We assume that there are several tax instruments. First, labor income is taxed at the rate τ_L. Second, individuals pay taxes on their capital income at the rate τ_K. Third, there is a tax, τ_i,on the income of type i capital. We also assume that there is a distortion in the allocation of each type of capital; specifically, the imperfectly competitive market structure for the capital goods causes an equilibrium distortion for capital of type i to reduce the private return of using factor i by the factor $\pi_i(k, \tau, l, c)$ if the aggregate capital stock is k, the aggregate labor supply is l, and aggregate consumption consumption is c. If $\bar{r}$ is the after-tax return to capital for an individual, then capital is allocated so as to satisfy the equations

$$\begin{gathered} (1-\tau_K)(1-\tau_i-\pi_i(k,\tau,l,c))f_{K_i}(K,l)=\bar{r} \\ \textstyle\sum_i K_i = k \end{gathered} \tag{7}$$

Note that these equations fix both K, the allocation of capital, and τ_K, the general capital income tax rate given the capital-specific taxes, the net return on investment, the pattern of distortions, and the total amount of capital and labor. The previous model was an example of a constant distortion; this formulation allows various forms which may arise with different modes of imperfect competition, different tastes and technologies, and different sources of distortions.

We make no assumptions about π, except those implicitly necessary for the technical details of the arguments below. This is very important to note. We have made no assumptions concerning Cournot or Bertrand or other modes of oligopolistic competition. We have not assumed a fixed number of firms; in fact, π includes the possibility that there is entry of firms if there are pure profits to be made. Such entry can be differentiated or undifferentiated. The only assumption we are making is that the imperfect competition distortion depends solely on the current factor supplies and the current prices and taxes. This is not without substance; in particular, it rules out dynamic fixed costs of the oligopolistic firms and related phenomenon such as learning curves.

Let $\overline{w}$ be the after-tax wage rate. As above, the representative individual faces the problem

$$\max_{c_i} \quad \int_0^\infty e^{-\rho t} u(c,l)\, dt$$
$$\dot{A} = \bar{r}A - c + \bar{w}l + (1 - \tau_{\Pi})Div$$

The individual's Hamiltonian is

$$u(c,l) + \lambda(\bar{r}A - c + \bar{w}l + (1 - \tau_{\Pi})Div)$$

where we let λ denote the shadow price of assets for the representative individual. The solution satisfies the intertemporal Euler equation

$$\dot{\lambda} = \lambda(\rho - \bar{r})$$

Labor supply and consumption demand in each period is determined by the first-order conditions

$$\begin{aligned} -\overline{w}u_c(c,l) &= u_l(c,l) \\ u_c(c,l) &= \lambda \end{aligned} \tag{8}$$

The net result of the first-order conditions for consumption, labor supply, (8), and capital allocation, (7) is that the momentary equilibrium values for consumption, labor supply, capital allocation, and the capital income tax are functions of $\tau, \overline{w}, \lambda$, and k:

$$\begin{aligned} c &= C(\overline{w}, \lambda) \\ l &= L(\overline{w}, \lambda) \\ K &= K(\tau, \overline{w}, \lambda, k) \\ \tau_K &= T_K(\tau, \overline{w}, \lambda, k, \bar{r}) \end{aligned}$$

We are implicitly assuming that these momentary equilibrium functions exist in the distorted economy. We will also assume that the momentary equilibria are locally determinate and smooth.

Suppose that the government chooses a time path for the tax policy instruments. Then the dynamic evolution of the economy can be expressed by two equations. First, net investment equals output minus consumption,

$$\dot{k} = f(K(\tau, \overline{w}, \lambda, k), L(\lambda, \bar{w})) - C(\lambda, \bar{w})$$

Second, the personal shadow price of capital obeys

$$\dot{\lambda} = \lambda(\rho - \bar{r})$$

These two equations together determine the dynamic evolution of the economy once the dynamic pattern of tax rates and net-of-tax factor returns are fixed.

4.2. Optimal Taxation. Define $v(\lambda, \bar{w}) \equiv u(C(\lambda, \overline{w}), L(\lambda, \overline{w}))$. The optimal tax problem chooses the after-tax factor returns and the type-specific capital taxes to maximize the representative agent's utility subject to the economy following an equilibrium dynamic path and long-run budget balance. This is expressed as the optimal control problem

$$\begin{aligned}
\max_{\bar{r}, \bar{w}, \tau_i} \int_0^\infty & \quad e^{-\rho t} v(\lambda, \bar{w})\, dt \\
\dot{k} & = f(K(\tau, \overline{w}, \lambda, k), L(\lambda, \bar{w})) - C(\lambda, \bar{w}) \\
\dot{\lambda} & = \lambda(\rho - \bar{r}) \\
\dot{B} & = \bar{r}B - f(K(\tau, \overline{w}, \lambda, k), L(\lambda, \bar{w})) + \bar{r}k + \bar{w}L(\lambda, \bar{w}) + \Pi(\tau, \overline{w}, \lambda, k) \\
\lim_{t \to \infty} |B| & < \infty
\end{aligned}$$

where $\Pi(\tau, \overline{w}, \lambda, k)$ is the after-tax dividends (pure profits) received by households. We assume that the profits tax rate is fixed independently of the other tax rates.

As before, we form the Hamiltonian of the problem ignoring the boundedness condition on bonds,

$$H = v(\lambda, \bar{w}) + \theta(f(K(\tau, \overline{w}, \lambda, k), L(\lambda, \bar{w})) - C(\lambda, \bar{w})) + \psi\lambda(\rho - \bar{r})$$
$$+\mu(\bar{r}B - f(K(\tau, \overline{w}, \bar{r}, \lambda, k), L(\lambda, \bar{w})) + \bar{r}k + \bar{w}L(\lambda, \bar{w}) + \Pi(\tau, \overline{w}, \lambda, k))$$

and solve for the stationary points of the corresponding state-costate system.[8]The costate equation for θ is[9]

$$\dot{\theta} = \rho\theta - \theta f_j K^j_k + \mu(f_j K^j_k - \bar{r} - \Pi_k)$$

and the costate equation for μ is

$$\dot{\mu} = \mu(\rho - \bar{r})$$

The first-order condition with respect to τ_i is

$$0 = (\theta - \mu) f_j K^j_{\tau_i} + \mu \Pi_{\tau_i} \tag{9}$$

The Hamiltonian reveals an important detail. Since $\mu < 0$, the Hamiltonian reveals that anything which increases the pure profits term, holding fixed the pure profits tax, τ, will reduce the value of the Hamiltonian. Intuitively, this occurs because an increase in profits, holding fixed the state variables, takes income away from investment income and wage income, which form the other components of the tax base. Another way of viewing it is that pure profits are, in this formulation, similar to lump-sum transfers from the government to agents, a transfer which increases the necessary tax burden. In any case, the results below are easier to understand when we remember that an increase in pure profits is bad.

[8]Again, the more proper way to proceed is to rewrite the bond equation as an integral equation imposing the natural present value condition, and analyzing the resulting isoperimetric problem. This procedure yields the same answer.

[9]We use the Einstein summation notation; that is $a^i b_i \equiv \sum_i a^i b_i$.

Short-Run Optimal Policy. The condition (9) is essentially the short-run optimality condition, which must hold at all times. We first consider its implications. The condition (9) is understood when we remember that pure profits are bad. The first term is the product of $\theta - \mu$, the marginal social value of an increase in output, and the change in output due to a momentary change in τ_i, and the second term is the social cost of the change in pure profits due to a change in τ_i. The condition (9) says that the value of extra output due to a tax change must be balanced by the value of the impact on pure profits. For example, if a tax change reduced pure profits, we would pursue it even to a point where it reduced output. If a tax change increased pure profits, the optimal policy would stop even when a further change would increase output.

With (9), we can analyze the importance for the optimal tax rates of entry into oligopolistic markets, even though we do not assume any particular oligopoly model. In the previous model, we assumed a fixed collection of firms; this is clearly unrealistic. Pure profits do lead to entry, which will substantially reduce the flow of pure profits, $\Pi(\tau, \overline{w}, \lambda, k)$, to households. We will first consider the case of free instantaneous entry, where $\Pi(\tau, \overline{w}, \lambda, k) \equiv 0$. This implies $\Pi_k = \Pi_{\tau_i} = 0$, which reduces the first-order condition, (9), to $0 = (\theta - \mu)\ f_j K^j_{\tau_i}$ for each τ_i. However, at the optimal choice for τ_i the Hamiltonian is concave in τ_i, implying that $\theta - \mu \neq 0$. Therefore,

$$f_j K^j_{\tau_i} = 0 \tag{10}$$

for each τ_i. This condition can be interpreted as saying that the reallocation of capital which results from a marginal tax on capital of type i, $K^j_{\tau_i}$, should lead to no change in total output, where that change equals $f_j K^j_{\tau_i}$.

We can say much more under the assumption of local determinacy of equilibrium. Since total capital is fixed at any moment, the vector of all 1's is a solution for x_i to $x_j K^j_{\tau_i} = 0$, as is any multiple; therefore, the matrix $K^j_{\tau_i}$ is singular. If momentary equilibria are locally determinate, the matrix $K^i_{\tau_j}$ is of rank $n - 1$. Since $K^j_{\tau_i}$ is of rank $n-1$, the vector of all 1's and its multiples must exhaust the solutions to $x_j K^j_{\tau_i} = 0$. But we saw above that optimality implied (10). Therefore, the f_j vector must be proportional to a vector of ones, which is the same as saying that the f_j's are equated. Therefore, if there is free entry, the optimal tax policy permits no productive distortion in the allocation of capital *at any point in time*, with taxes and subsidies continuously neutralizing preexisting distortions.

Without free entry, the implications are muddier, but the optimal tax condition for τ_i still has some interesting implications. First, if $K^j_{\tau_i}$ is a symmetric matrix and Π_{τ_i} is proportional to a vector of 1's, a situation which would arise in symmetric specifications of the several sectors, then the f_j are again equalized. This is implied by (10) and the $n-1$ rank of $K^j_{\tau_i}$. This condition is particularly surprising since we get the efficiency result without free entry and without making any particular game theory assumptions about imperfect competition. While this kind of symmetry is not a compelling description of reality, it does argue that the important factor is not the presence of pure profits but the deviation from symmetry.

More generally, we get less precise results without zero-profit free entry. Second, if the marginal rent terms, Π_{τ_i}, are small, then the average marginal productivity effect of a tax change, $f_j K^j_{\tau_i}$ must also be small, implying that we get close to productive efficiency. Third, if the shadow price of funds is small, we still find that $f_j K^j_{\tau_i}$ must be small for each τ_i, again implying near productive efficiency at all times. The final special case is taxing away all pure profits, implying $\Pi(\tau, \overline{w}, \lambda, k) \equiv 0$ as in the free entry case.

Therefore, there will be substantial deviation from productive efficiency only if the shadow price of funds, entry barriers, nontaxation of profits, and asymmetries are *all* significant. The fact that we need all of these factors for substantial productive inefficiency strengthens the case for productive efficiency. Of course, the quantitative importance of this proviso remains to be investigated, requiring the solution of more completely specified imperfectly competitive markets.

Long-Run Optimal Policy. We next turn to the long-run properties of the optimal tax policy. The steady state equation for θ is

$$0 = \theta(\rho - f_i K_k^i) + \mu(f_i K_k^i - \overline{r} - \Pi_k)$$

This condition says that the social value of the extra output from extra capital, $\theta f_i K_k^i$, and the social value of its *net* contribution to revenue, $\mu(f_i K_k^i - \overline{r} - \Pi_k)$, must be balanced against the time cost of investment, $\theta\rho$. In the steady state, $\rho = \overline{r}$. Under (instantaneous) free entry, $\Pi_k = 0$ and the f_i are equalized. The steady-state equation reduces to $0 = (\theta - \mu)(\rho - f_i K_k^i)$. Since $\theta > 0 > \mu$, we conclude that

$$\rho = \overline{r} = f_i$$

for each capital stock type i. Therefore, all type-specific distortions in the capital allocation are neutralized by the type-specific capital taxes and there is no net taxation of capital investment in the long run. If we don't have free entry, we still have the conditions

$$\rho - f_i K_k^i = \frac{\mu}{\theta - \mu}\Pi_k$$

which states that the gap between ρ and the social product of an extra unit of capital, $(\rho - f_i K_k^i)$, is to be proportional to Π_k, the incremental effect of capital on pure profits, with a common proportionality constant across types of capital. We also see that

$$f_j K_{\tau_i}^j = \frac{\mu}{\mu - \theta}\Pi_{\tau_i}$$

which states that the marginal productive inefficiency as tax rate τ_i is changed, $f_j K_{\tau_i}^j$, is to be proportional to the marginal pure profit, with more productive inefficiency when the marginal cost of funds, μ, is larger relative to the social value of output, $\mu - \theta$. Note also that the sign of the productive inefficiency, $f_j K_{\tau_i}^j$, is the same as the sign of the marginal profit effect; that is, if an increase in a tax increases pure profits, then an increase in that tax will, at the optimum, increase output.

The following theorem summarizes our arguments.

Theorem 3. *Assume that the equilibrium under the optimal tax policy is locally determinate at all times. If either there is free entry into the markets for capital goods* ($\Pi = 0$), *or the cost of funds,* μ, *is zero or if the technology and pre-existing distortions are symmetric* ($K^j_{\tau_i}$ *is a symmetric matrix, and* $\Pi_{\tau_i} = \Pi_{\tau_i j}$ *for all* i, j), *then the optimal tax policy equates the marginal product of capital across all uses at all times. Furthermore, under free entry all preexisting distortions of capital allocation are completely neutralized by offsetting taxes and subsidies in any steady state of the optimal policy.*

Again, we find that taxes should equalize distortions in the capital goods market across capital goods under free entry or symmetry or zero cost of funds, and with free entry even neutralize them completely. While none of these conditions are likely to hold in reality, the first result is still interesting since equalization of distortions will not be part of policy only when the cost of funds is large, there is substantially restricted entry, and there is substantial asymmetry, a set of conditions which appear to be strong.

However, it must be acknowledged at this point that a more quantitative discussion of these points similar to that above for the simpler model would be a more complicated exercise for this model and is beyond the scope of this paper. While we cannot argue that all models with distortions will reduce to dynamic general equilibrium models of this form, it is a reasonable conjecture to believe that we have covered an important class of such models. In the sections below we will turn to interpreting the general principle, address comparisons with the static Diamond-Mirrlees principle, discuss the likely magnitude and structure of the optimal subsidies, and the implications for tax policy debate.

5. Interpretations and Generalizations

The general principal of these results is that intermediate goods should not be taxed in the long-run, and if there are distortions arising from imperfect competition, subsidies should be used to subsidize each intermediate good so that the post-subsidy price is equal to the social cost of the good. In this section, we shall discuss how this compares with previous results, issues of implementation, and various interpretations of the results.

5.1. Implementation Problems. Implementing the fully optimal policy would be quite problematic, requiring the measurement of the markup of each intermediate good. However, this analysis can still be the foundation for useful tax changes.

We can still partially implement this policy. The most critical information needed to choose the subsidy rates are the price-cost margins. Many economists have tried to measure these margins (we will discuss the results below); while they may come to somewhat different answers, the exercise is a technical one, arguably within the capacity of the U.S. Treasury. It is true that each firm will want to claim that it's output is sold at a high margin. However, if the categories are defined sufficiently broadly, no individual firm will want to alter its prices to create distorted data. Also, a firm's claim that it gouges its customers may arouse resentment among its customers, and an industry's argument that its member firms gouges their customers would not be viewed favorably by the agencies charged with enforcing the antitrust laws. Similarly, the Treasury Department uses engineering and economic data to determine depreciable lives for asset type. Each firm will want the Treasury to think that the equipment it produces does not last long, but no individual firm will want its customers to believe this. Even though Congress may not choose to implement economic depreciation, the Treasury information is important in their deliberations. Similarly, it is conceivable that Treasury could produce the technical information needed to guide tax policy in the directions implied by this analysis.

The fully optimal policy would impose a different subsidy on each different good. This is impractical, just as is giving the correct depreciation treatment to each machine. The way we solve the problem for depreciation is to group assets into a few dozen categories within which it is reasonable to assume similar depreciation; a similar (maybe even the same) grouping could be used to allocate capital subsidies. Such groupings would eliminate the incentives any one firm has to distort the data analysis, and would still generate substantial benefits. Below, we will argue that the simple distinction between equipment and structures is one which can be beneficial.

5.2. Implications for Research and Development Policy. When we consider the possible sources of market power, the rationale for subsidizing certain kinds of capital accumulation becomes clearer. Suppose that the markups are just manifestations of patent-holding innovators reaping the profits necessary to offset their R&D costs. Remember what a patent is. Whether a patent holder actually produces a good or licenses it, the essential fact is that a patent grants the holder the right to assess a tax on the purchasers of the patented good. A patent is essentially a modern form of tax farming.

Therefore, a patent taxes a good's users to finance the fixed costs of innovation. This, however, contradicts the spirit of the Diamond-Mirrlees principle. The Diamond–Mirrlees principle says that any pure public good, such as the fixed cost of inventing an intermediate good, should be financed by taxation of final goods. It is not important that, under a patent system, the tax revenues from taxing a good goes to cover its fixed costs, and that the taxing is done by private agents. The result of a patent system as it applies to intermediate goods is inappropriate taxation of intermediate goods. Therefore, the real result here is that there should be no net taxation in the long run of intermediate goods, and that the explicit government subsidies should neutralize the taxes implicit in a patent.

These arguments show that subsidizing the purchase of new capital goods subsidies is a more appropriate tool for encouraging R&D than an R&D tax credit. It is the purchase subsidy, not the development subsidy, which corrects the price-cost gap in the market for technologically advanced equipment. The R&D credit may then be used to create the correct share of resources allocated to R&D, but since the rate of R&D expenditure may be less than, equal to, or greater than the optimal expenditure level (see Judd, 1985) it is unclear if R&D should be subsidized or taxed. Also note that the subsidy we derive here was optimal even though it does not encourage innovation. If we added innovation to our model, such as in Judd(1985), then the subsidy would have even greater social value, likely strengthening the case for the subsidy.

The differences between our results here and those in Judd (1985) also indicate the importance of distinguishing between intermediate and final goods when discussing R&D policy. In the model of Judd (1985), infinite–life patents resulted in implementing the first–best allocation between invention and consumption; however, it assumed only final good innovation. Here, we find inefficiently low levels of intermediate good output. The natural conjecture is that R&D is biased towards final goods with relatively too little incentive for intermediate good innovation, further strengthening the case of intermediate good subsidies. Further analysis is needed to establish that conclusion.

5.3. Antitrust Policy. The presence of monopolistic competition is the key source of inefficiency in our model, and the subsidy to investment is a way of bringing price down to marginal cost. Another way would be to eliminate the market power through antitrust policy and let the competitive market force price down to marginal cost. However, if there were fixed costs of production, then competition cannot push price down to marginal cost, and having firms specialize in differentiated goods is desirable. Therefore, a conventional antitrust policy would not be appropriate. While we did not explicitly model fixed costs, it is obvious that if we added fixed costs the optimal tax results would be unchanged since no marginal condition is affected by fixed costs. As noted above, extending the model to include innovation would allow for a richer analysis; antitrust policy would also be of questionable value since the point of a patent is to give incentives for innovation. Therefore, it is often not appropriate to attack the price-cost distortions through antitrust policy.

On the other hand, if the market power had nothing to do with fixed costs or innovation, then the model does seem to say something about antitrust policy. Our analysis appears to indicate that distortions in capital goods markets are more damaging than distortions in consumer goods markets, implying that antitrust policy should give priority to intermediate goods markets. While it is interesting, it is beyond the scope of this paper to investigate this thought further.

5.4. The Transition to the Long Run. Our main results concern only the long run of the optimal tax policy. A legitimate criticism of this kind of focus is that it ignores the transition process. Transition analysis is generally ignored because it is difficult to treat precisely and because we expect that the results depend on special assumptions. While we do not endeavor here to give a complete analysis of the transition path, and future work will be necessary to determine quantitative aspects, we do know the qualitative features of the transition, and have some evidence of its importance.

In our model, the optimal short-run tax rate on capital will surely be high because it is largely a tax on the inelastically supplied capital stock in place at the initial time. The only limit is that a tax on income in excess of 100% will cause capitalists to withdraw their capital from the market. The optimal tax rate will initially be 100%, but then will fall to zero. There are good reasons to believe that the transition to the long-run will be relatively fast. First, Judd(1987) showed that when we use conventional estimates for the critical parameters, the welfare cost of capital taxation is high even over small horizons of a few years. Jones et al.(1993) demonstrate rapid convergence to the long-run tax policy for reasonably calibrated examples. While these studies assumed competitive models, our analysis shows that the dynamics of the distorted economies are similar to competitive economies, indicating that the period during which optimal policy differs significantly from the long-run policy is also short.

These studies also ignored the many considerations which argue that tax policies cannot have large anticipated falls in tax rates. First, the depreciation of real-world equipment depends somewhat on use; therefore, if the current tax rate is very high and it is known that future rates will be lower, a firm will turn off some machines and possibly buy new ones, taking the depreciation allowances at the current high rate but using these machines only in the future when the income will be taxed at a lower rate. These considerations will make the short-run supply of capital much more elastic than the zero elasticity assumed in the simple models. Second, firms will take various measures to move income into the future and expenses into the present. For example, they will want to make large contributions to pension funds in the early high-tax years, and reduce these contributions in the later years. These factors will keep the optimal short-run rate from being high, and will make the short-run tax rates on capital income much closer to the long-run optimal rate of zero.

The transition will affect the long run outcome. If there is an initial period of high tax rates on capital income, there will be an initial surplus which essentially endows part of the long-run subsidy on capital income. In the extreme case, this initial surplus may finance all of the long-run subsidy. However, this is unlikely because of the problems with a high-tax-rate initial phase. More typically there will be continuing taxation of consumption and/or labor income which will finance most of the long-run subsidy.

For some issues the transition phase looks like the steady state. This was seen in the general model in Section 3, where many of the policy results were true at all times, not just in the steady state. This was particularly true of the desirability to use tax policy to offset differential price-cost margins across various capital goods. Hence, many of the critical points we make are true at all times, not just in the limit.

5.5. Long-Run Growth. The models above display no steady state growth. However, that is of little importance since, by proper choices of production functions and other structural elements, the differences between our model and a model with steady state growth can be made arbitrarily small over any finite horizon. As long as the social and private objective includes discounting, the policy differences between our model and similar ones with steady state growth will also be arbitrarily small. Furthermore, adding steady-state growth in the fashion typical of the current literature (represented by Jones et al.) would be pointless since these models typically focus on very special linearly homogeneous models which do not allow for the intersectoral differences which we study above. These special models often lead to nonrobust results because of the assumptions needed to get positive steady state growth rates (see Judd(1996) for some examples).

One could add elements to this model to make it more similar to endogenous growth models. Product innovation, human capital accumulation, knowledge spillovers, learning-by-doing, and process innovation are such elements. However, it is unlikely that any of these considerations will alter the results in this paper. The primary reason is that the logic for subsidizing capital income appeals primarily to the static efficiency considerations in Diamond-Mirrlees. If we add a dynamic consideration important for the growth process, such as innovation, the optimal policy will also add an instrument, such as patent policy or R&D subsidies. Only if our instruments are restricted in relevant and economically reasonable ways will the Diamond-Mirrlees result be substantially altered when we move to more complex growth models.

5.6. Materials and Maintanence Expenditures. Our analysis has not explicitly treated materials; more generally, we ignore all inputs other than capital and labor, as is typically done in tax analyses. This is a limitation since materials constitute a substantial portion of any firm's costs (roughly half for manufacturing), are also sold in imperfectly competitive markets, but would not qualify for capital subsidies. We have, however, treated them implicitly. The aggregate production function $f(K, \ell)$ could be thought of as a reduced form expressing output as a function of inputs, treating materials as intermediate goods which have been produced but then consumed in the production of the final goods. In that case, $f(k, \ell)$ assumes efficiency in the materials markets and there are no distortions other than the ones we examine. While a complete analysis remains to be done, some conjectures seem to be safe.

The primary concern is that a subsidy for capital but no parallel subsidy for materials would twist inputs inefficiently towards capital. While this would be a concern, it ultimately depends on the elasticity of substitution between materials and capital. If they were perfect complements, then subsidies would produce no inefficient change in the material/capital mix. As long as materials and capital are complementary inputs, one would expect the net effect of any capital subsidy to be an increase in materials demand, which would improve efficiency whenever those materials are priced above marginal social cost. In this case, the general case for a capital subsidy would not be altered substantially even if a parallel subsidy for materials is not possible. In fact, the case is strengthened; if the materials markets are distorted but the capital subsidy increases materials use, then the materials goods distortions are also partially relieved and efficiency improves. Therefore, the optimal capital subsidy is arguably greater if capital and materials are complements (as is indicated by most empirical studies) and subsidies for materials are not offered.

Maintainence costs are also ignored in our analysis. Hiring labor and buying materials to increase the lifetime of old equipment is a substitute for buying new machinery. Since the labor is hired at the true marginal cost and expensed but investment costs more than the social marginal cost and is only depreciated, there is a double bias against new investment. Again, it appears that including this feature will only strengthen our conclusions.

5.7. International Trade Implications. While the models above ignored international trade explicitly, some simple aspects of trade in capital goods can be analyzed. In the general model, we could imagine that some of the domestic capital stock, k, and domestic labor are used to produce an exported good which is sold to finance the importation of the services of type j_M capital. The distortion in the sale of type j_M capital, π_{j_M}, would be nonzero only if the importers had market power over the rental of that capital in the importing country. The price-cost gap of the foreign producer is not relevant since the import price is the true cost of the machine to the importing country.

If a country is a small country then the world price of an imported capital good is the social cost for the country. In this case, the small country should not subsidize the imported capital goods as long as the internal price equals the world price. Even if it produced capital goods which were perfect substitutes for the imported goods, standard trade theory still applies and there should still be no subsidy. Therefore, the analysis above gives little support for investment tax credits and the like in small or developing countries.

However, if the small country merged with a (presumably large) country which produces intermediate goods, then our analysis indicates that the optimal policy for the merged country would subsidize the capital used in the former independent small country. This indicates that there would be some incentive for the two countries to coordinate investment policies. Furthermore, this coordination proposition obtains also for coalitions of large countries. Therefore, there should be an international agreement to subsidize investment affected by imperfect competition.

Such coordination is not always possible. The final interesting question is the optimal policy for a capital-producing and -exporting country which also imports some capital goods. If it had no effect on terms of trade, then the answer is again clear: the capital subsidies should be limited to domestically produced capital goods which are sold at prices above their marginal cost. However, if it has market power in the export markets for capital goods, as would be natural to assume here, then it does have an effect on the terms of trade.

All of these arguments are complicated by multinational firms. If foreigners own a domestic firm which produces a monopolized capital service, the rent goes to the foreigners and the true social cost to the domestic government is the monopoly price; hence, no subsidy is justified. Symmetrically, if domestic citizens own a foreign factory which then imports the capital good back to the owners' country, then such imports should be subsidized because the true marginal cost to the country is the production cost at the foreign factory, not the monopolized price. A complete analysis of optimal policy must take into account international structure of ownership, and is beyond the scope of this paper.

These arguments indicate that there is much to be explored regarding trade policy. International trade economists have investigated both the positive and normative aspects of trade policy in the face of oligopolistic international markets, but they generally work in partial equilibrium frameworks which ignore distinctions between intermediate and final goods. Further work is needed to answer the important related trade policy questions.

5.8. Current vs. Optimal Tax Policy. Even if the optimal policy is infeasible, these results do indicate the costs of alternative feasible policies and the correct direction for tax policy reform. The literature on tax reform has nearly exclusively focused on the costs of capital taxation in a competitive economy and argued that the optimal tax rate on capital income is zero, whereas current U.S. tax policy imposes a substantial tax on many forms of capital income. The results in this paper indicate that current policy is even farther from optimal policy than indicated by the competitive model. Since the efficiency costs of a tax are roughly equal to the square of the tax, our results also indicate that the efficiency costs of current tax policy are greater than those implied by the competitive model. For example, if the current effective tax rate is 30 %, but the optimal subsidy is 30%, then (using our quadratic rule-of-thumb) the gain from an optimal policy is four times the gain from eliminating the 30% tax in a competitive model. Furthermore, even if the only feasible policy reform is reducing the capital income tax rate to zero, this analysis increases the estimated benefits of that reform. In our example, the gain from moving the 30% tax down to zero in our monopolistically competitive model is three times the gain from such a change in the competitive model. This quadratic approximation is of course rough, but it points out the substaintial change in our evaluation of even conventional tax policy changes when we move from a competitive model to a noncompetitive one.

6. The Investment Tax Credit

We next apply our results to evaluate the Investment Tax Credit (ITC). If all capital goods entered symmetrically into production and the distortions were uniform across the various types of capital, then a savings subsidy would be an adequate policy in a closed economy[10]. However, this is not the case. In this section we will examine the ITC as an instrument which partially implements the corrective tax policy.

The investment tax credit (ITC), first introduced in 1962, has been frequently adjusted over the past thirty years. The ITC gives firms a tax credit proportional to their purchase of equipment, but not structures. The initial rate has fluctuated between zero and ten percent over the past thirty years, and was eliminated in 1986. Initially, its justification was to improve productivity by replacing old equipment with new, and to stimulate 'autonomous demand'. Because of the implementation lags, few would still take the Keynesian stimulus arguments seriously. Also, the supporters of the ITC have not provided an argument why the economy is inefficiently slow in turning over the capital stock, nor do they explain why the ITC should apply only to equipment.

6.1. Structures versus Equipment. Critics of the ITC have argued that the ITC biases investment inefficiently against structures. Our analysis suggests otherwise. The analysis above shows that the subsidy should be higher for intermediate goods which have higher margins. Both the consideration of the structure and conduct of equipment and construction industries and empirical estimates of price-cost margins suggest that the margins in equipment exceed those in construction.

First, equipment makers engage in substantial R&D effort, and equipment often embodies new technology protected by patents and/or trade secrecy. The ratio of private R&D expenditures to sales is highest, being about 4%, in the SIC categories of machinery, electrical equipment, and instruments. Equipment can also be substan-

[10] Since the closed-economy assumption is also inappropriate for the U.S., savings incentives would be an inappropriate policy in any case.

tially differentiated, enhancing market power. The production of new equipment is also likely to exhibit learning-by-doing.

Construction firms, however, engage in very little R&D. While buildings are differentiated, the construction firms do not specialize to the extent equipment manufacturers do. Typically, several firms will bid on each construction job. The structure and conduct of the construction industry therefore indicates a competitive outcome. The ITC does enhance productivity in construction because construction firms may increase their productivity by using new equipment for which they receive a tax credit, a benefit which is passed onto the buyer of a structure in a competitive market. However, if the construction services are themselves supplied competitively, then they should receive no subsidy.

This view of the equipment and construction industries is consistent with the empirical estimates of Hall (1986). In fact, the competitive hypothesis cannot be rejected for construction whereas it is for the machinery categories and instruments. Both the Hall study and that of Domowitz et al. (1988) indicate that the margins in the equipment sectors are substantial in size, lying generally between 15% and 40% of the price. The empirical Industrial Organization literature also yields similar estimates (see, e.g., Appelbaum, 1982). These margins may seem large. Fortunately, our discussion here does not rely critically on these estimates of price–cost margins. R&D expenditures are 3–6% of sales for many types of equipment (see Scherer, 1980), implying (under the assumption of nonnegative profits and nondecreasing long–run returns to scale) an equivalent lower bound for the gap between long–run marginal cost and price. This lower bound plus a conservative estimate for learning curve and economies of scale effects, and other long–run fixed costs puts us in a range relevant for our policy discussions. Therefore, even under conservative readings of the empirical evidence, the gap between the construction and equipment industries is substantial, and the gap between price and marginal cost is surely nontrivial, being on the order of actual ITC rates used in the past.

Critics of the ITC have relied on the competitive model for their analysis. The competitive assumption is surely incorrect for many manufactured goods, particularly many of the types of equipment associated with technological advancement. The basic argument here is that if the construction industry is competitive but equipment industries are imperfectly competitive, then the market allocation is inefficient and the ITC for equipment which has been often implemented partially corrected the problem, albeit unintentionally.

While our discussion has focused on the ITC, accelerated depreciation could also be used to accomplish the same effects. Our focus on the ITC is driven only by the ways in which the ITC and depreciation rules have been conventionally used. The key observation is that tax relief should be related to the price-cost margins.

6.2. The ITC, New Equipment, and the Equipment Replacement Cycle. The original ITC proposal was only for the purchase of new equipment, not used equipment. A straightforward extension of our analysis provides an economic rationale for the restriction to new equipment. A new type of equipment is likely to incorporate the newest technology and to be differentiated with respect to used equipment, to new production of old models, and to other new equipment. Since imitation is less likely, the producer of a new model is better able to charge above marginal cost. The used equipment market is more likely to be competitive. Therefore, a tax preference for newly produced equipment is partially a preference for new types of equipment, which are more likely to be priced above marginal cost.

Even if old varieties are no longer available, the ITC will still help. In deciding when to replace an old piece of equipment no longer being produced with a new variety, a firm will compare the present value of the extra output with the price of the new machine. Typically, the new machine will be priced above marginal cost, and that margin will decline over time. The result will be a replacement time later than is socially optimal, implying that the capital stock will be older and less productive than is socially optimal, as was argued by the initial proponents of the ITC.

6.3. The ITC as Countercyclical Policy. The ITC has often been thought of as a countercyclical tool. However, critics have pointed out that the ITC cannot be a useful countercyclical tool because of implementation lags in policy and in investment. In fact, the net effect may be that it has often been procyclical. None of what we have said disputes this.

While the analysis above focused on the long run, the generalization to a stochastic model is clear. The basic point is that tax policy should neutralize price-cost margins. Therefore, if margins are procyclical., as conventional wisdom argues (see Scherer), then the neutralizing subsidies should also be procyclical. This point shows how our approach is substantively very different from the Keynesian style of argument which has been used to support the ITC.

When we combine the basic intuition with empirical evidence, it is unclear what the proper cyclicity is. Domowitz et al. argue that margins are generally procyclical, but that durable goods' margins tend to be countercyclical. However, the margin to which our argument applies is to the gap between the marginal cost and price of the rental service. Since the price of a durable good is the present value of its rental services, countercyclical margins on durable goods prices is consistent with procyclical margins on the rental services with appropriate interest rate movements; hence, the empirical work does not address the correct issue for our purposes. If both rental service margins and nondurable goods margins are procyclical then the ITC should be procyclical; otherwise, the nature of the proper ITC is unclear. In any case, the weak empirical evidence does not currently support a countercyclical ITC under the theory developed above.

7. Conclusions

We have examined dynamic models with distortions. The robust finding is that distortions of intermediate goods markets, both tax induced as well as market structure induced, are to be ameliorated in the long run. In the face of permanent market power, tax policy should subsidize capital formation in proportion to the distortion.

Since equipment markets are more distorted by market power, partly because of R&D expenditures, the optimal tax subsidy looks similar to the investment tax credit, which has been occasionally part of the U.S. tax code, and would be implemented on a permanent basis. We also show that entry into oligopolistic markets strengthens these conclusions. While the models we examined were simple and further analysis is needed, it is clear that these considerations will have a significant impact on the optimal tax policy.

References

[1] Appelbaum, E. "The Estimation of the Degree of Oligopoly Power," *Journal of Econometrics*, **19** (1982): 287–299.

[2] Atkinson, Anthony B., and Agnar Sandmo. "Welfare Implications of the Taxation of Savings," *The Economic Journal* **90** (September, 1980).

[3] Barro, Robert J., and Xavier Sala-i-Martin. *Review of Economic Studies* **59** (No. 4, 1992): 645–661.

[4] Bradford, David. *Untangling the Income Tax*, Harvard University Press, 1986.

[5] Bulow, Jeremy. "Durable Goods Monopolists," *Journal of Political Economy* **90** (1982):314-332.

[6] Diamond, Peter A. and Mirrlees, James A. "Optimal Taxation and Public Production," I, *American Economic Review*, **61** (1971), 8-27.

[7] Diamond, Peter A. "Taxation and Public Production In a Growth Setting," in *Models of Economic Growth*, J. A. Mirrlees and N. H. Stern (eds.), pp. 215-234, London, Macmillan.

[8] Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen, "Business Cycles and the Relationship between Concentration and Price-Cost Margins," *Rand Journal of Economics* **17** (Spring 1986a), 1–17.

[9] Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen, "The Intertemporal Stability of the Concentration-Margins Relationship," *Journal of Industrial Economics* **35** (Sept. 1986b), 13–34.

[10] Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen, "Oligopoly Supergames: Some Empirical Evidence on Prices and Margins," *Journal of Industrial Economics* **36** (June 1987c), 379–398.

[11] Hall, Robert E. and Alvin Rabushka. *Low Tax, Simple Tax, Flat Tax*, (McGraw-Hill, New York), 1983.

[12] Hall, Robert E. "Market Structure and Macro Fluctuations," *Brookings Papers on Economic Activity,* (2, 1986), 285-322.

[13] Jones, Larry E., Rodolfo E. Manuelli, and Peter E. Rossi. "On the Optimal Taxation of Capital Income", 1993, mimeo.

[14] Judd, Kenneth L., "On the Performance of Patents," *Econometrica* **53** (1985), 567–585.

[15] Judd, Kenneth L. "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of Public Economics* **28** (October, 1985):59-83.

[16] Judd, Kenneth L. "The Welfare Cost of Factor Taxation in a Perfect Foresight Model," *Journal of Political Economy* **95** (August, 1987).

[17] Judd, Kenneth L. "Optimal Taxation and Spending in General Competitive Growth Models," mimeo, 1996.

[18] King, Mervyn A. "Savings and Taxation," in G. A. Hughes and G. M. Heal, (eds), *Public Policy and the Tax System*, Allen & Unwin, London.

[19] Myles, Gareth D. "Ramsey Tax Rules for Economies with Imperfect Competition," *Journal of Public Economics* **38** (1989): 95-115.

[20] Robinson, Joan. *The Economics of Imperfect Competition,* London: MacMillan. 1934.

[21] Scherer, F. M., *Industrial Market Structure and Economic Performance,* (Second Edition), Rand McNally: Chicago (1980).

[22] Stiglitz, Joseph E., and Partha Dasgupta. "Differential Taxation, Public Goods, and Economic Efficiency, *Review of Economic Studies* 38 (1971), 151-174.

[23] Stokey, Nancy. "Rational Expectations and Durable Goods Pricing," *Bell Journal of Economics* **12** (1981):112-128.