TIME, TAXES, TURNOVER, AND INTENSITY

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I welcome the occasion to discuss comments by Thomson and Goldstein (24) on my "Tax-induced Slow Turnover of Capital" (9), (8). The subject warrants continued recycling, which they have done a service to attempt. They have done some disservice by erring on several points, which, however, it is my pleasure to correct.

To narrow the issues, I first identify matters of agreement. There are more than meet the eye. T & G's litigious style differentiates their product more than the content warrants.

They agree that what they call an excise or severance or "gross" tax is biased in favor of long life.1/ They qualify this by toying with a "Single Cycle Case" in which there is no bias, but the model is a nonesuch, even though the proof based on it has become a cliché of introductory capital theory. Site is permanent, and since their approach is invariably to maximize site value, they must always do so in perpetuity, if only by allowing a site salvage value in a speciously one-cycle model. So we may miss all their "Single Cycle Cases." They err (plausibly) in thinking my cases are "Single Cycle" -- of which more later. There really are no single cycle cases, except where land is abandoned after one pass. Life goes on.

1/ In current American forestry usage an ad valorem harvest tax on stumpage is called a "yield" tax. In 1967 (9) I used "severance" tax, and T & G repeat my usage. In forest usage "severance" taxes are specific, so it was an unhappy choice. I now comply with field usage and call this a "yield" tax, where forest examples are used. However my subject was taxation of all capital, not forests alone, so "excise" is a good term. "Gross," which T & G favor, is too gross. Yield taxes are based on stumpage, which is the value of logs in the woods net of harvest costs.

They also agree that a tax on land income is neutral. They bury this by mislabelling their land tax an "Income Tax" (24, "D," Table 1, p. 32). The base of this tax "D" is $[V_m - Pe^{im}]$ (their notation, p. 32), that is harvest value less planting costs compounded to maturity. The compounding means interest on P is also deducted from the tax base, leaving nothing in the base except the pure net product of the site.

They do not explain why they call this the "income tax." The Federal income tax would resemble it if planting costs were expensable in year zero: this deduction would then have the same present value as deducting compounded planting costs (Pe^{im}) in year m (maturity). Some European taxes come close to this. But the income tax as we know it in the United States requires the taxpayer to capitalize P and wait until maturity to deduct it (subject to some chiseling). This is my usage in the article which T & G purport to be discussing. It is their tax "C", which they variously call "net severance," "capital gains," and "net tax" -- a babble of tongues all at odds with current usage. The confusion could mislead many readers, and creates a cover for their mislabelling a land tax -- their "D" -- as the income tax.

They follow my argument that conclusions about tax bias are affected by assumptions about shifting. In their heat of contention they suppress what I said, but interested readers may consult the record, pp. 312-314, and for emphasis my concluding sentence, p. 323, "... the neutrality is impaired by shifting, and the only part of the income tax that may be made perfectly neutral is the part that falls on land income." See also the next set of citations.

They agree that taxes _not_ on land may often be shifted into lower land values. (9, notes 2 and 5, 8, p. 179, n. 12; p. 184, n. 17; pp. 187-90; pp. 195-97; p. 282; p. 411; and especially pp. 419-20). I close by noting I have only scratched the surface of the relations between interest and rent and "regard this as of first priority for extended treatment in a sequel." (p. 420) It is splendid that T & G followed my lead, however ineptly; it would have been gracious of them to acknowledge it, rather than pick a fight. Incidentally I have also followed my own suggestion (3, 187-97 _et passim_ and 10).

Finally, I can hardly dissent from their revelation of Faustmann's formula to which I originally guided them during a correspondence (7) they omitted from their credits, and which I used in the work attacked (8, p. 420). Gentleman Jack Hirshleifer is too generous when in the work which T & G laud he credits me with having "rediscovered" the formula (13, p. 89, n. 45), and Peter Pearse is too modest when, in the work T & G cite as their authority, he says he is bringing my monograph (4) to a wider audience (20, p. 178), but of such excesses T & G are free. Their Appendix, at any rate, is a passable restatement of my 1957 monograph (4) and I cannot deny it.

This broad area of agreement being established, we may zero in on the few substantial differences. I will not squander space on their hasty craftsmanship: their internal contradictions, unsupported pronouncements, selective reading, appeals to authority, discourtesy, captious digressions, shifting definitions, misimputation of meaning, suppression of material information, and quarrelsome temper. These will be self-evident to the careful reader, and tedious to the casual one.

I will dwell on four issues of substance: present value vs. internal rate of return; bias of the income tax; the bias of the property tax; and allocative effects of tax loopholes for land.

A. Present value vs. internal rate of return

T & G take an adamant line against letting taxes lodge on the rate of return. They reason as follows: "Assume ... a constant interest rate, ..." (24, p. 27). Only this and nothing more. It is hardly enough, even in a matter of faith and morals. The T & G criticism follows trivially from assuming that taxes are shifted off capital while I assumed not. Their case against me is not that I reasoned wrong, but that I entertained an heretical assumption.

It is not news that assumptions affect conclusions. I show later that my assumptions fit the circumstances I had in mind; and theirs change the results less than they allege. But as to their attack, it is only an exploration of the differences that stem from switching an assumption. They puff it up into something more general, but never discuss the basis of their difference, the choice of assumptions. They do not comment on my discussion of this choice, which is explicit (8, pp. 312-14, and other citations above). So the critical aspects of their paper are only a courtroom device and at once deflated.

Let me paraphrase what I said about the choice of assumptions and tax incidence. I distinguish an open and a closed tax jurisdiction. An open one is too small to affect world interest rates, so <u>i</u> is hard fixed, exogenous, given, and absorbs no taxes. The capital supply is infinitely elastic.

Prices and wages are also given, for consistency. Land is the equity interest in the jurisdiction, so all taxes are shifted into lower land rents. In this jurisdiction I find all taxes except on land value to be unneutral, as they drive marginal land from use, and abort all marginal activities, including timely renewal of sites (9, pp. 312-14; 8, pp. 195-97, 282).

As an interesting corollary, since land pays all taxes anyway, it would be possible to replace all taxes in an open economy by one on land values (3, pp. 187-92). (I wonder if T & G are aware they are so close to that position?)

A closed tax jurisdiction on the other hand is a large one where the supply of capital is not very elastic, so some taxes lodge on capital and lower the post-tax rate of return. Most of my analysis, and the only part that T & G read, dealt with this assumption.

I do not take a hard line that only the closed case is relevant. On the contrary I lean more toward the open case: I just do not fall prostrate with T & G. Circumstances alter cases. The circumstances dictating my emphasis on the closed economy were several.

First, I was discussing Federal taxation. I know we have a balance of payments problem and a world capital market, and I would welcome a modified model which allowed for high elasticity of capital supply. But at the national level the United States is so large in the world there is less than infinite elasticity and we should make some concession to that in building models.

Second, I was criticizing the income tax and gave it the most favorable assumption, to anticipate a defense. It is child's play to show all taxes but a land value tax are biased in an open jurisdiction, because they drive marginal land out of use and block out all marginal investments. The advocate of income taxes replies that capital supply is inelastic: investors hang in there at a lower rate of return. My article shows that if that defense be so, then the income tax has a time bias, so either way it's a loser. If it can't drive investors away, it drives them into longer maturities. My target was income-tax idolatry; I was influenced by a wish to communicate with the large group whose support of the income tax rests on their assuming inelastic capital supply.

I go on to show that assuming national capital supply inelastic makes us conclude that a neutral national tax on property income would count unrealized accruals as current income. T & G flatter me to suggest this is my own crank. I merely rediscovered the wheel. Haig (12, pp. 7ff.), Simons (23, pp. 61-62, 206), Pechman (21), Musgrave (18, pp. 44, 60), Vickrey (26), the Canadian Carter Commission (22, p. 39), Brazer, Sneed, Blum, Steger, Surrey, White (25) and the Ford Foundation (2) all have priority. I <u>am</u> out alone in noting that the property tax, considered as a national institution, is tantamount to a tax on Haig-Simons property income. Analytically the conclusion is obvious, but is not likely to draw much support from income tax reformers committed to "Revenue Sharing" to lower the property tax (an inconsistency I wish <u>they</u> would explain or, better, abandon). I also suggest that a local property tax, while not ideal, is better than a local income tax. T & G evidently mistook my conditional for an absolute, and my meliorative for a superlative. The differences are important, but may assume too much of the unsubtle reader. Certainly they require a careful reader. Here at any rate is what I said:

"Let us summarize. Our accrued income tax, and the property tax that it resembles, are neutral intertemporally if capital absorbs the full tax without shifting. If capital emigrates to escape the tax, the emigration is itself a tax-induced misallocation, and the tax is not neutral. Only a tax on land, which cannot emigrate, can be fully neutral. But if society does tax interest income, our accrued-income tax base preserves intertemporal neutrality among investments at that higher rate of time-discount appropriate to the tax-induced scarcity of capital. Thus the accrued-income basis is distinctly superior to the realized-income basis of taxation, containing an important element of neutrality which the latter lacks, and the possibility of complete neutrality under the special and unrealistic assumption of nonemigration and nonshifting, or under the realistic assumption that the property tax base be modified to exempt improvements.

Historical opposition to and criticism of the property tax has resulted from the tax's making very visible the destructive effects of taxing the income of a mobile, migratory input like capital. That has been especially true in forestry. But shifting to the realized-income basis makes the tax no less destructive, only less conspicuously so. The income tax drives capital into longer maturities. It also sloughs the tax burdens of property onto labor, which lacks equally effective means to avoid taxes." (9 , pp. 313-14).

Third, I was writing about general income taxes and not taxes on timber considered alone. My subject was not timber taxation as such, but taxation of property income. Timber exemplified appreciating capital. There was also full salvage capital and depreciating capital and land. Yet T & G never got it. Their talk of forward shifting has a micro-economic flavor (24, p. 38) and they even have a case where equilibrium obliterates the "forests." In context of my work which they are ostensibly discussing that should read "obliterates the United States." T & G remain staunchly obtuse not to see that the supply of capital in general is less elastic than the supply for one industry in one jurisdiction; and again not to see that forward shifting is a partial concept that is a retreat from the issues of incidence of general taxes.

To add to the confusion, T & G let the light in in one sentence -- only to shut it right out. "Property taxes on all assets, by contrast, lower the interest rate -- $\underline{i}$ falls as $\underline{p}$ (the tax rate) rises -- so that the bias leaves the forest and lodges in the capital market" (24, p. 40). They return forthwith to belabor me with renewed vigor for pursuing that thought. I do not understand their self-contradiction. They might.

Fourth, to let the tax lodge in the rate of return is to let one abbreviate the analysis by omitting land. As T & G point out, if $\underline{i}$ won't give, then one must ask what else can absorb the tax and the answer requires using the more complete Faustmann framework, which is essentially a way of adding a third factor of production, land, to the inputs with claims on the product. Simplification has its dangers, of course. It has seduced most analysts of capital theory and income taxation into omitting land from their studies, to their great loss. I am pleasantly surprised that others are reversing the usual roles and insisting that I give more attention to land. But I show below that one may add land to the analysis, using Faustmann's framework, let the tax lodge in the rate of return -- and not change my original basic finding of bias to long life.

Fifth, to assume that the tax lodges in rate of return is actually a compromise assumption in which some tax is borne by land rent. That is, if site value be assumed constant, and taxes lodge in rates of return, then it must be that land rent (a) is being taxed. Otherwise land values would rise (4, pp. 53-55).

T & G say several times that I am violating the rule that investors seek to maximize present value. They are wrong. To pursue, as I did, the assumption that yield and income and property taxes may lodge in the rate of return is not to assert that individual managers should or do maximize internal rates of return. Those are separate questions.

In terms of managers' maximizing present values, my points would be rephrased along these lines. When taxes lodge in the rate of return, $r < i$, where $\underline{i}$ is pretax and $\underline{r}$ is post-tax rate of return. Investors now maximize the present values of their post-tax income using the lower rate $\underline{r}$. At this lower rate, longer cycles rise in present value relative to shorter ones, so the preference for different investments is reordered in favor of longer ones.

As before, assume a pretax equilibrium with $R = e^{im}$, and PVR = 1, where PVR $\equiv$ present value of R. Apply a yield tax, and assume a trial $\underline{r}$ is struck by the market, $r < i$. Now

$$PVR = e^{im}(1 - t)e^{-rm} = (1 - t)e^{(i-r)m} \qquad (1)$$

PVR is an increasing function of $\underline{m}$, so long as $r < i$.

Now more reshuffling is needed, with resources pouring out of short investments into long ones, until \$1. invested in any maturity has a PV = \$1; and so on, just as before. This is all implicit in the original approach. If it helps some readers to have it spelled out this way, good.

I do not take a hard line on the issue of whether managers should maximize present values or internal rates. I have shown elsewhere that the two methods yield identical results in perfect markets, provided the analyst does the job right (4, pp. 52-58). "Doing the job right" means using Faustmann's formula or an equivalent means of including all inputs in the calculation.

Faustmann's formula is historically associated with the approach of maximizing present value, but that is incidental. Connotation must not be taken for denotation. The essential point is to enter a term for land which is an input in year zero and is fully salvaged at maturity. Then we can maximize the internal rate of return honestly.

Using T & G's notation[2/] and solving for i, Faustmann's formula becomes:

$$e^{im} = \frac{V_m + W}{P + W} \qquad (2)$$

or

$$i = \frac{1}{m} \ln \frac{V_m + W}{P + W}$$

where V_m is harvest value

W is site value

P is planting cost

m is maturity.

The reason calculations of internal rate of return have a bad name is that most of the calculators omit or understate W (site value), thus over-

2/ As a courtesy to readers on whom T & G have already imposed an extra burden of shifting from my original notation to theirs.

stating the internal rate (and with it the contribution of management, the wisdom of projects being promoted, etc.). We need be wise as serpents in bewaring that everyday fraud, and a good practical way is to insist on maximizing present site value. But that is no reason to make a quarrelsome medieval school of the matter. Mathematically the principles are equivalent. Which to use is a matter of judgment and circumstances, which I have discussed elsewhere (4, pp. 51-58).

T & G thought I must be analyzing a single cycle case. It is an understandable impression, but wrong. Note that when we define i in the Faustmann we are assuming an "infinite recycle" by entering a salvage value for land (W) in the numerator of (2). The salvage value of land is always based on "infinite recycling," more familiarly known as capitalization. I let W = 0 in (2), which then devolves to the simpler internal rate definition most people use. This simplified the prose and deferred land to a sequel, as I carefully noted. But it did not imply a "single cycle case." To let a constant equal zero is not to deny it. My case dealt with infinite recycles, but on marginal land.

My basic finding of bias does not depend on this simplifying assumption. Since T & G raise the point, let us enrich the analysis by pursuing it. Using their notation, let $W > 0$. Now V_m has to cover interest on W (but not recovery of W, which is separate) plus recovery of P with interest, so

$$V_m = (P + W)e^{im} - W \qquad (3)$$

Note that this is simply Faustmann recycled, that is (2) again, solved for V_m.

For the yield tax:

$$e^{rm} = \frac{V_m(1-t) + W}{P + W} \qquad (4)$$

Substituting (3),

$$e^{rm} = e^{im}(1 - t) + t \frac{W}{P+W} \tag{5}$$

(5) gives an excellent overview of factors affecting the bias of general excise taxes. Several points stand out.

First, this is like my original (3) [cited by T & G (24, p. 34) and renumbered (7)] but using their notation and with the addition of a parameter ($t \frac{W}{P+W}$) to the right side.

Second, the addition of $t \frac{W}{P+W}$ moderates but does not eliminate the bias in favor of longer life. The reasoning is the same as with my original equation (4), (9, p. 310). When P = 0 it is like the income tax case exactly.

Third, (5) devolves to the original case when W = 0, that is for marginal land. Here, bias is a maximum. As W rises relative to P, the parameter grows in its tempering influence to a maximum when P = 0, and/or W is very high. The decline in r is least, and the sensitivity of r to m is least, when P = 0.

(5) tells us the yield tax is biased in favor of a high ratio of $\frac{W}{P}$. That means it is harder on poorer land, and harder on intensive culture on all land. It favors understocking, substituting land for labor.

This is interesting new information, a new dimension to the picture. The tax deters not only frequent inputs of planting labor but also heavy inputs. But it does not change the original finding of a bias in favor of long life.

Next let us analyze the income tax. Here,

$$e^{rm} = \frac{V_m(1-t) + W + tP}{P + W} \tag{6}$$

Substituting (3),

$$e^{rm} = \frac{(P+W)\ (1-t)e^{im} + t(P+W)}{P + W} = e^{im}(1 - t) + t \qquad (7)$$

(7) is the same as my original income tax equation (4) because P and W drop out. (7) tells us a general income tax, to the extent it lodges in $r < i$, is biased in favor of longer cycles, but this bias is independent of $\frac{W}{P}$, that is of land quality and intensity of use. (We will see that this conclusion changes when the tax lodges in site value (W): then the bias is for $\frac{W}{P}$).

No matter how you analyze tax incidence, someone will nip at you for not doing it his way, and the analyst must be prepared to entertain various assumptions and explain why he chose those he did. The above tools are versatile and should be adaptable to many circumstances.

B. Bias of the Income Tax when $\underline{i}$ is Fixed

T & G seem to accept my mathematics. They agree, in their own endearing way, that the internal rate of return after yield taxes is an increasing function of life. They do not pick a nit from my finding that the internal rate of return after income taxes is an increasing function of life, and in the context this would seem to imply unreserved endorsement. Under their preferred assumption of a fixed $\underline{i}$, they agree that a yield tax is biased in favor of long cycles, as it also is under my original assumptions. They also agree that a tax on land income (their "D") is neutral, as I found. That narrows the issues. In their Table 1, p. 32, we have dismissed their "single cycle" cases as imaginary. There remains in all of Table 1 only one point of difference, therefore. Their II, C, which they should call the income tax (as I discussed),has no effect on life. This is I believe their prime contribution. I cannot dispute it, being on record to the same effect (10). Their formula in Table 1 is mathematically sound, as far as it goes, which is not far enough.

First, they might have derived it for us. Let π = site value after income tax when $\underline{i}$ is fixed.

$$\pi = \frac{V_m(1-t) - Pe^{im} + tP}{e^{im} - 1} = \frac{Pe^{im}(1-t) - Pe^{im} + tP + W(e^{im} - 1)(1-t)}{e^{im} - 1}$$

$$= W(1 - t) - tP \qquad (8)$$

π is not an explicit function of $\underline{m}$, seeming to indicate lack of time bias. I will show this is only specious.

(8) seems to suggest that the time-bias of a general income tax disappears in an open jurisdiction, and hangs completely on assuming the tax lodges in the interest rate. I believe this would be an overstatement. Time-bias is reduced when $r = i$, being replaced by a direct bias against P. But the bias against P is also a bias against shorter cycles, as I show next.

The bias against P stands out by looking at the percentage reduction, (p.r.) of site value caused by the tax.

$$\text{p.r.} = \frac{W - \pi}{W} = t\frac{W + P}{W} \qquad (9)$$

p.r. is greater than the tax rate (for $P > 0$), and rises with $\frac{P}{W}$, which raises our suspicions at once. On marginal land p.r. is infinite -- this land is sterilized. All land is sterilized for which $\pi < 0$. From (8) that is all land where:

$$t(W + P) > W$$

or

$$t > \frac{W}{W+P} \qquad (10)$$

Clearly this is not a neutral tax in general. If it cannot drive capital into longer maturities it drives it away altogether.

Of course landowners may now reconsider the level of P. Some may just survive, and all optimize by lowering P, that is by using their land less intensively. This is another way of perceiving that the intensive margin of land use is sterilized, just like the extensive. In general, (9) shows that the hierarchy of land uses will be reordered, with less intensive uses replacing more intensive ones. Consider two rival land uses that are equally matched in bidding for land, but differ in intensity, measured by P. Imposing an income tax weights the balance heavily in favor of the lower P. More generally, consider a spectrum of rival land use plans being considered for any given site. The drop in the present values of the alternative plans is an increasing function of P. Of rival uses that bid equally for a site before taxes, the income tax tilts the advantage to those using less P.

T & G "finesse these complexities" (24, p. 28, n. 1) by assuming P constant. That is their privilege, like trumping a partner's ace, but it does lose the game. Evidently they made this move thinking otherwise, for they say taxes leave P unchanged if taxes lodge in rents (*ibid.*). But (8), (9) and (10) indicate a sharp bias against P on every quality of land. (8) is a simple extension of their present value formula II, C, in their Table 1 (24, p. 32), where taxes are assumed to lodge in the present value of land, i.e. in rents.

So the income tax is not neutral under their preferred assumption of constant *i*. Its anti-labor bias is expressed directly, as a force against heavy labor inputs, instead of indirectly as a force against frequent labor inputs. In fact the proper assumption lies between theirs and the other extreme, so actual effects are some mixture of the two kinds of anti-labor bias.

This leaves the question of whether and how a lower P value (planting input) affects time bias. T & G say it "depends on the type of tree," (ibid.) and let it go. In fact, the bias against labor destroys the argument for intertemporal neutrality. Lower P means longer life. I will give several arguments.

As an opener, a reliable clue to general findings is always to look at marginal and slightly supramarginal land. Marginal land connotes low dollar yields, but that is only one of three reasons why land may be of low value. The other two are high costs (P) and long life (m). Referring to (8), it is apparent that the income tax drives out lands and/or uses of lands that are marginal by virtue of high P sooner than others which **are marginal** by virtue of low yields or slow growth. Indeed, the tax is not biased at all against the lazy grower who lets nature do all the work, leaving P = 0.

More generally, there are three reasons why lowering P will lengthen the growth period. The explanations are long, but fundamental and worth study.

1. Capacity of site. A site has a limited capacity to hold trees and let them grow.

We are used to thinking of factor proportions in terms of fixed, short cycles of investment and recovery -- cycles so short we treat input and output as simultaneous. With this conditioning, we easily follow the line of thinking that the primary function of more P is to get more final output, V_m.

And this does make sense when m is to be short anyway. If P is small the site is partly empty. To balance factors calls for more growing stock, of which P is the only source. A small ΔV_m returns ΔP with interest; and the site is responsive because underoccupied.

But when m is to be long, it requires a large ΔV_m to return ΔP with interest. Take Faustmann's formula (2 or 3), hold site value (W) constant. Now $\frac{\partial V_m}{\partial P}$ tells us by how much V_m must respond to ΔP in order to justify ΔP.

$$\frac{\partial V_m}{\partial P} = e^{im} \qquad (11)$$

To get the feel of this, let i = .072, at which rate e^{im} doubles every 10 years, beginning from unity. That is, $e^{.072m} = 2^{m/10}$. So if m = 60, $e^{im} = 2^6 = 64$. This means the extra dollar spent on planting must add $64 to stumpage value to pay off; and conversely, a dollar saved in year zero is as good as $64 of harvest. So naturally when cycles are to be long the premium is on minimizing P.

Now it is thinkable to get a 64-fold increase, given sixty years. The problem is, the site gets crowded if P and m are both high. This is a matter of diminishing returns. The value of growing stock is given by (3). A representative value for P in the Pacific Northwest is $100 per acre; the same for W (19, T. 3-7 and pp. 3-13). If $e^{im} = 64$, V_m= $12,700. At a stumpage price of $100 per MBF that represents 127 MBF. 100 MBF is about all the Douglas-fir that can be crowded on one acre. As a ratio, $\frac{V_m}{W}$ equals a topheavy 127. So growth must halt.*

*These figures are subject to wide current variation, and even greater forecast variation. There is a rule of thumb that Douglas-fir physical growth on Site I (the best) has a mean of one MBF per year. At this rate it would never reach 100 MBF in time to pay 7.2% on $200. But the owners forecast higher prices and enjoy special tax situations, which make the figures possible as given. They are illustrative primarily. The facts are from Walter Mead (17). The conjectures are mine.

(3) shows that V_m is an increasing function of both m and P. Given W, and given a ceiling on V_m, P and m are substitutes. Adding to one is an alternative to the other. Either alone crowds a site, both together are too much.

So when an income tax motivates landowners to reduce P, it tends to lead them to use more time (m) in place of P to fill up the site before harvest. Thus the income tax lengthens cycles.

A good way to perceive these relations is in terms of the stumpage to regeneration ratio, V_m/P. For long cycles to compete with short ones, the grower must raise that ratio. To avoid overcrowding the site he must hold down the stumpage value, V_m. To do both at once, he holds down P. Thus low values of P go with long cycles. The grower might also increase V_m/P by raising V_m. But so long as he makes any of the adjustment by lowering P, why, lower values of P go with longer cycles.

The simplest way to grasp the present point is to see that at maturity the stumpage to site ratio, V_m/W, tends to be about the same regardless of life, because of site crowding. Higher P causes earlier crowding and earlier harvest.

2. Initial outlays speed harvests

When m is long, say 60, so $\frac{\partial V}{\partial P}$ is 64, and $\frac{V}{W} = 127$, we have seen that more P is not very productive if used to raise V. But it is very productive if used to shorten m. That is another option, and an attractive one. Cutting m by 1/6, or 16.7%, from 60 to 50, cuts e^{im} in half and approximately doubles site value (W). It is equivalent approximately to doubling V_{60} from \$12,700 to \$25,500 (using the parameters of our previous example).

Examine Faustmann's formula, solved for W (12).

$$W = \frac{V_m e^{-im} - P}{1 - e^{-im}} \qquad (12)$$

Considering just the numerator, shortening m by 10 years is as good as doubling V_m (assuming $e^{im} = 2^{m/10}$). Actually, shortening m is even a trifle better because it also lowers the denominator, but this is just a dollop unless m is down below 30 or so.

More generally,

$$\frac{\partial m}{\partial P} = \frac{-1}{i(P+W)} \qquad (13)$$

(13) may be rewritten

$$\Delta m \cong \frac{-\frac{\Delta P}{(P+W)}}{i} \qquad (14)$$

Δm is unity when $\frac{-\Delta P}{P+W} = i$. So (14) says that reducing m by one year is as good as reducing P by i(P + W). For example, when P + W = \$200, one year off life is as good as \$14 off P.

Similarly,

$$\frac{\partial m}{\partial V} = \frac{1}{i(V + W)} = \frac{1}{ie^{im}(P+W)} \qquad (15)$$

and

$$\Delta m \cong \frac{\frac{\Delta V}{(V+W)}}{i} = \frac{\frac{\Delta V}{e^{im}(P+W)}}{i} \qquad (16)$$

(16) says that one year off life is as good as adding $ie^{im}(P+W)$ to V.

In the example, with m = 60, ΔV = .07 x \$12,800 or \$895.

Note also that the absolute values of the partials (13) and (15) are decreasing functions of P. The more P has been added, the less the drop in life needed to be as good as a drop in P or rise in V. That shows increasing returns to P when used to shorten life. That is, the more P is applied, the greater is the benefit of still more P provided it can be used, and is used, to speed the recovery of capital already sunk.

Likewise, the partials are decreasing functions of W. The better the land, the greater the benefit of recovering its unreaped harvests quickly.

The above analyzes tradeoffs among P, V, and m to keep W constant. To confirm and round out the findings, let W be the dependent variable. W is very sensitive to m, when P and V are fixed. It gives a sense of proportion to break down W as follows:

$$W = \frac{V_m}{e^{im}-1} - \frac{P}{1-e^{-im}} \qquad (17)$$

With m = 60 and i = .072 as before

$$W = \frac{V}{63} - \frac{P}{63/64} \qquad (18)$$

Cutting m to 50 more than doubles W by lowering the first denominator to 31 (and hardly changing the second denominator).

More generally,

$$\frac{\partial W}{\partial m} = \frac{-i(P+W)}{1-e^{-im}} \qquad (19)$$

(19) says that reducing m by one year adds about \$14 to W, using the same numbers as before. This is consistent with Equations 13-16. For low values of m the denominator becomes materially less than one, meaning a year off m adds more than \$14 to W (but of course shortening m becomes progressively harder as m shortens).

The upshot: when m is long it is feasible and productive to use more P to shorten m, but not to raise V_m. This implies that high P values go with short m values; and therefore that the income tax, by forcing lower P values, lengthens cycles.

Now let us look at how P is used in the field to shorten m.

One way is by thick planting, including control of weed trees, cattle and rodents, and preparing soil for a good catch or take of seeds. The heavy stocking causes much growth per acre in the early years, followed by early crowding. Crowding slows growth. Slow growth on a large base prompts harvest.

Harvest is often deferred by thinning. But thinning is a partial harvest -- completing one short sub-cycle -- and/or an investment in an early future harvest -- beginning another short sub-cycle.

Choice of spacing is important. If one plans on long life he need not space trees so close, for they will need room as they grow. On the other hand, Christmas trees and nursery stock are jammed tight together. David Klemperer, Forest Economist with Associated Oregon Industries, writes that it costs more to start an acre of Christmas trees than an acre of saw timber.(14).

The reverse is understocking, the result of thin planting. The income tax fosters understocking by holding down P. Forestry literature describes a "trend to normality" of understocked stands (16, Table 12, and p. 28; 1 ,and bibliography; 28; 27, and bibliography). Understocked stands lay on little wood per acre at first because there is little growing stock. But as the trees grow they expand into ample space. So in middle years when heavy stands exhaust their space, thin ones keep growing. Fast growth on a small base defers harvest. More bluntly, you can get away without regenerating forest land if you are willing to wait longer for harvest.

A second general way for P to shorten m is by very directly giving growth a head start. A high cost regeneration is to plant seedlings from nursery stock, aged about four years. Another high cost method is to avoid clear cutting and save the saplings as you take the riper trees. Both practices obviously get the new generation off to a flying start. Early harvest, rather than stumpage volume, is the primary gain.

Medium cost regeneration entails seeding, with accompanying spending on scarifying the soil to improve the probability of a good take; fencing out cattle; rodent control; hardwood control; burning brush, followed by fire control; fertilization; removing weed trees, including slow-maturing ones; and so on.

Low cost regeneration comes right down to zero. Many forest acres are managed, or mismanaged, this way. A major penalty is the slow start. Natural regeneration, even from seed trees left standing, takes 7 - 15 years for Douglas-fir in Oregon (19, pp. 3-11). In addition, hardwoods start faster and invade an open site, causing understocking (ibid., pp. 3-12; 15).

Natural seeding also means the owner has no control of seed quality. Research in forest genetics has produced faster-maturing strains; but the landowner must expend some cost to buy and plant them.

In terms of factor balance and proportions, long cycles are inherently wasteful. They begin with raw land and little capital. The land is barren during a long initial period of underuse. Then growing stock accumulates, until in later years there is a topheavy imbalance, with more stock than the site can carry.

When a manager goes to work on land, he naturally applies stock where there has been too little -- to the barren early years. Filling that early void with growing trees naturally also brings them sooner to maturity.

3. The need to fill the site

A small volume of growing stock cannot yield a surplus large enough to pay land rent. On long cycles, stock grows large with time, and the lost rent of the slow early years is diluted by averaging with later years. On short cycles, the necessary stock must be applied by investing in regeneration. Otherwise there can only be a meager harvest.

Of course even a meager harvest might pay the rent (support a high land value) if received frequently and with little cost. The limit however is that to pay rent that way, the short cycles would have to achieve unrealistically high rates of annual growth. Growth must pay rent (interest on W) as well as interest on stock, and if the stock is small the growth rate must be high.

A precise mathematical statement is almost essential to confirm the reasoning. Let x be the annual growth rate connecting P and V.

$$e^{xm} = \frac{V_m}{P} \qquad (20)$$

Substituting (3) and solving for x:

$$x = \frac{1}{m} \ln \left[e^{im} \left(1 + \frac{W}{P}\right) - \frac{W}{P} \right] \qquad (21)$$

(21) defines values of x required to cover all charges: interest, rent, and cost recovery.

x is a decreasing function of m. Note that (21) is the same in form as Equation (4), of my 1967 article (9, p. 310). The several expositions used there may be adapted here as well, *mutatis mutandis*. The mutation is that t of the original becomes $-\frac{W}{P}$; and the change of sign reverses the effect of the parameter. Appendix I proves the case. It is better than the previous proof (8, p. 106).

When m is large, $x \to i$. When m is small, x can become uncomfortably high, if $\frac{W}{P}$ is large -- that is if little stock is applied to good land. The way to hold down x when m is small is to apply more P. Table 1 is a numerical example calculated from (21).

Table 1. Values of x, the growth rate connecting regeneration cost (P) and harvest value (V_m).

$$e^{xm} = \frac{V_m}{P} = e^{im}(1 + \frac{W}{P}) - \frac{W}{P} \qquad (i = .072)$$

m	e^{im}	$(\frac{W}{P} = \frac{1}{5})$		$(\frac{W}{P} = 1)$		$(\frac{W}{P} = 5)$	
		e^{xm}	x	e^{xm}	x	e^{xm}	x
1	1.07	1.08	.08	1.14	.14	1.42	.42
2	1.15	1.18	.08	1.30	.14	1.90	.32
3	1.23	1.27	.08	1.46	.13	2.38	.29
5	1.41	1.50	.08	1.82	.12	3.94	.25
10	2.0	2.2	.078	3	.11	7	.20
20	4	4.6	.076	7	.10	19	.15
30	8	9.4	.074	15	.09	43	.13
40	16	19	.073	31	.09	91	.11
50	32	38	.073	63	.08	187	.10
60	64	76	.072	127	.08	379	.10

More generally,

$$\frac{\partial x}{\partial P} = \frac{-1}{mP\left[\frac{P}{W}\frac{1}{1-e^{-im}} + 1\right]} \quad (22)$$

$\frac{\partial x}{\partial P}$ is a decreasing function of both m and P. That means when m is small, x is more sensitive to P, a point evident in Table 1 as well. By applying more P to short cycles one reduces x. With long cycles, x is low by virtue of high m, and insensitive to P (unless P is nearly zero).

Summing up, P and m cannot be small together without making x become unattainably high. Therefore for short cycles one must raise P; and for low planting inputs one must lengthen m. The result is that low P values go with high m values. The income tax that forces down P therefore and thereby lengthens m.

It is easy to get buried in difficult details. What emerges from it all is sweeping and simple. If m is already long, P is most productive when used to shorten m; if m is already short, P is most productive when used to raise V. So P and m are inversely related: low P means long cycles.

Therefore the income tax, by virtue of its bias against P, is also biased against shorter cycles, even in the circumstance of perfectly elastic supply of capital.

C. Bias of the Property Tax

If taxes lodge fully in r, the rate of return after taxes, and t is the property tax rate, then r + t = i, where i is the no-tax rate of return.

The base of the property tax is asset value, the same as the base that earns interest. It follows quite directly from those assumptions that the property tax would be neutral. The taxpayer uses (r + t) where before he used i in making choices. My original article could be summarized as an exploration of that theme. Curiously, T & G concede the point (24, p. 40), although they don't let it interfere with their train of thought.

Primarily, they emphasize that the property tax shortens cycles, assuming i is fixed. Their methods do not do. First they lean on authorities -- Groves, Fagan, and Macy. These were writing at the time from a local viewpoint, implicitly assuming i to be fixed. But in 1967 Groves came to my support (11). Second, T & G maximize the value of a single-cycle case (their Equation 9a, p. 40), abandoning their basic method of maximizing land value. Third, they emphasize marginal conditions at end-of-cycle, ignoring effects on starting-up time. Net result: partiality leading to error.

Let us define site value net of property taxes on trees, assuming i is fixed. We will see that the alleged bias to short life is weak, but there is a strong bias against labor and indirectly therefore against short life.

Let θ be site value after a property tax on trees which lodges in site value.

$$\theta = W - t \sum_{n=1}^{m} \left[\frac{V_n}{e^{in}} \right] \frac{1}{1-e^{-im}} \qquad (23)$$

Substituting (3), and summing,

$$\theta = W - t \left[(P + W) \frac{m}{1-e^{-im}} - \frac{W}{i} \right] \qquad (24)$$

The percentage reduction of site value is:

$$\text{p.r.} = \frac{W - \theta}{W} = t \quad \left(\frac{P}{W} + 1\right) \frac{m}{1 - e^{-im}} - \frac{1}{i} \qquad (25)$$

Several conclusions follow from sensitivity analysis of (25). To save space, I present these without the steps of proof.

1. p. r. > t.

2. p. r. is an increasing function of P, and is very sensitive to P. The taxpayer abates the full force of the tax by applying less P. This is true at all m, but moreso at longer m. So the property tax discourages full stocking. We have already seen that lower P values tend to lengthen cycles.

3. p.r. is a decreasing function of W. The tax is harder on poorer lands, and sterilizes marginal lands.

4. p.r. is an increasing function of m, but only a weak one. The fraction $\frac{m}{1 - e^{-im}}$ ranges upwards from a minimum of $\frac{1}{i}$ when m = 1 to maxima negligibly greater than m for m over about 50 (and limited by limits on m). It is a badly balanced tax literature which has emphasized this weak effect and excluded the stronger bias against P. Indeed, the strong anti-labor bias may overcome the weak anti-waiting bias and lengthen cycles -- that is indeterminate here.

To explain this in literary form, the property tax penalizes having capital on the land over a whole cycle of growth, not just at the end. Indeed it is relatively harder on early capital than late capital, because the former is taxed earlier and more often. So its strongest effect is to hold down P, which tends to lengthen life. Then, at that lower level of stocking, it is mildly biased in favor of short life. The net effect is the resultant of the two vectors, and the first one is not subject to simple generalization.

D. Allocative effects of exempting land income

T & G conclude by seeming to agree that land taxes are neutral. Captious to the end, they turn this into a gibe by dismissing my complaints about how land income escapes the income tax as improper "equity arguments." It is not clear if they are really obtuse or just posturing, but I patiently respond.

1. Equity is important. Why do we have an income tax at all instead of a heavy poll tax? It's something about fair shares, ability to pay, and all that. The fact that wealthy landowners pay lower effective rates than lowly wage earners has a lot to say about how fit this tax may be for its alleged redistributive purpose. The fact that unearned rents, increments and enrichments taken from the community are taxed lower than services rendered to the community by human effort offends another equity concept.

2. Exempting land income necessitates higher taxes on other income, increasing allocational bias.

3. Land income is exempt by virtue of loopholes to use which landowners misallocate land. I discussed several examples in the papers at issue (8, pp. 30, 410, 413-14, 416-24) and many more elsewhere (5, 3).

T & G here as elsewhere indicate a belief that taxes must be neutral if they take land rent. It is a good instinct gone wrong. Rent is a surplus that may be tapped without excess burden by skillful policy, but which may also be and is being impaired by the clumsy tax methods we actually have (6).

In general, taxing wages while exempting land causes land to be substituted for labor. Land is used less intensively. The results are several. One is to spread out land settlement, increasing the length of streets and all linkage lines. Another is to reduce the aggregate demand for labor, disemploying people.

4. Land values are made and broken by public policy and works. The income received for rendering useful services is called "ordinary" and is fully taxed. The income received for expending money and effort to influence government to help develop one's land is called a "capital gain" and virtually exempt. "Produce," says the fisc, "and your income is half mine. But lobby, bribe, wine and dine, influence, corrupt, beg and whine, and the resulting increase of land values is all thine." It affects how people spend time.

In fine, I have shown four things.

A. The choice between maximizing present value or internal rate of return is one of circumstances and judgment, not theology.

B. Maximizing present value instead of internal rate reduces time bias of income taxes, but increases anti-labor bias, which turns out to be a time bias as well.

C. Maximizing present value instead of internal rate prevents the property tax from being neutral, but its bias is more against labor and less against slow cycles than usually believed.

D. Exempting land income is a serious allocative as well as equity matter.

The importance of this topic should not be lost in the detail. The major point is that the tax system in various ways intercedes in market choices and lowers demand for labor. With unemployment never conquered, and re-emerging as national problem number one, it is worth suffering with the tedium to confirm the new implications that emerge for tax policy.

The maligned property tax scores high, and the land part very high. Income taxes score so-so, and only that well because fast write-off may make the income tax resemble a land tax. Excise taxes flunk.

These are controversial findings. I hope they provoke more discussion to resolve any questions.

APPENDIX 1*

Proof that required growth rate, x, is a decreasing function of life, m.

$$e^{xm} = \frac{V}{P} = e^{im}\left(1 + \frac{W}{P}\right) - \frac{W}{P} \equiv \theta \qquad (1)$$

$$xm = \ln \theta \qquad (1,a)$$

To Prove: $\frac{dx}{dm} < 0$

$$g \equiv \frac{d \ln\theta}{dm} \text{ is } \frac{\theta'}{\theta}\text{, the growth rate of } \theta(m) \qquad (2)$$

$$\ln \theta = \int_0^m \frac{d \ln\theta}{dm} = \int_0^m g dm \qquad (3)$$

Substituting (1,a)

$$x = \frac{1}{m} \int_0^m g dm \qquad (4)$$

By inspection of (4) and the Theorem of the Mean, x must be falling if g is monotonically falling, i.e. if $\frac{dg}{dm} < 0$.

$$g' = \frac{d}{dm}\left[i + \frac{Wi}{P\theta}\right] = \frac{-W}{P}\, i\, \frac{\theta'}{\theta^2} < 0 \qquad \left(\frac{W}{P} > 0\right) \qquad (5)$$

$$\therefore \quad \frac{dx}{dm} < 0$$

Q.E.D.

*With thanks to Matt Gaffney, Jr., John Hoven, and Steve Hanke.

Note that this proof may be applied to the income tax case by replacing $\frac{W}{P}$ with -t (tax rate). It may be substituted for (8) Appendix 1.

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