



Forest property taxation under the generalized Faustmann formula[☆]

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ABSTRACT

This article represents the first part of a two-part series on forest taxation and valuation. In this first part, I derive the formulas for five types of forest property taxation under the generalized Faustmann formula. They are the unmodified property tax, the site value tax, the flat property tax, as well as the gross and net forest revenue productivity taxes. The impacts of these taxes in terms of fiscal neutrality and tax burden are then examined. Fiscal neutrality examines whether the imposition of a tax will affect management decisions. Tax burden measures the magnitude of the reduction in the value of the land, known as the site burden, and that of the forest as a whole, known as the forest burden, as a result of the imposition of a property tax on forestland of different productivities. Analytical results indicate that all forest property taxes are theoretically not fiscally neutral. They will all shorten the optimal harvest age. This is in sharp contrast to the results under the classic Faustmann formula under which the latter 4 types of taxes are all known to be fiscally neutral. In terms of tax burden, the unmodified property tax, the flat property tax and the gross forest revenue productivity tax impose a heavier site burden on less productive land than on more productive land. The forest burden is age dependent. At age 0, all but the flat property tax imposes a lighter burden on less productive land. At the optimal harvest age, the unmodified property tax, the flat property tax and the gross forest revenue productivity tax impose a heavier burden on less productive land. The net forest revenue productivity tax imposes a heavier tax burden on the less productive land when the annual management cost is small. When the annual management cost is significant, the tax burden could become lighter on the less productive land. Only the site value tax imposes a lighter site and forest burden on the less productive land consistently.

1. Introduction

Ever since the seminal work of Fairchild (1935), over the years the classical Faustmann formula, also known as the land expectation value formula has served as the basis of many forest taxation studies. Textbooks and articles addressing this topic include, for example, Amacher et al. (2009), Butler et al. (2012), Chang (1983), Englin and Klan (1990), Gamponia and Mendelsohn (1987), Jackson (1980), Johansson and Lofgren (1985), Kilgore (2014), Klemperer (1976), Koskela and Ollikainen (2001), Ollikainen (2014), Trestrail (1969), Williams (1974), and Zhang and Pearse (2011). Chang (1982) presented a complete set of classical land expectation value formulas under various types of taxation as well as provided rigorous and comprehensive analyses of their management impact. The classical Faustmann formula, however, came with stringent assumptions that the same stumpage prices, stand volume, regeneration cost, and interest rate must repeat themselves rotation after rotation. Chang (1998) relaxed these assumptions and presented the generalized Faustmann formula. Since then, several articles have been published dealing with its applications

to uneven-aged management (Chang and von Gadow, 2010), uneven-aged management with carbon sequestration (Parajuli and Chang, 2012), even-aged management with carbon sequestration and economic fluctuations (Susaeta et al., 2014) and its relation with Pressler formula (Chang and Deegen, 2011). In Chapter 3 of the Handbook of Forest Resource Economics edited by Kant and Alavalapatti (2014), Chang (2014a) consolidated most of the above results and presented additional new findings. Moreover, forest valuation under the generalized Faustmann formula without taxation has been published (Chang, 2014b). What has been missing is a discussion on forest taxation under the generalized Faustmann formula. This paper addresses this particular topic and examines their implications in terms of fiscal neutrality and tax burden. Fiscal neutrality examines whether the imposition of a tax will affect management decisions. It matters because if the tax is not fiscally neutral, it could potentially alter the optimal harvest age and result in a deadweight loss (Harberger, 1964; Hausman, 1981). Tax burden examines the percentage loss in property value as a result of the imposition of a tax. It matters because if a tax imposes a heavier burden on less productive than more productive land, it may

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cause landowners to scale back or even abandon forestry activities altogether on the former, thus causing unintended land use changes.

Following Chang's (1982) classification, forest property taxes can be separated into

1. The unmodified property tax (UPT) under which the value of the land and the trees are taxed every year.
2. The site value tax (SVT) under which only the value of the land is taxed every year.
3. The forest productivity tax (FPDT) under which the tax is imposed every year on the forest based on a measure of its productivity, typically some measure of its average annual growth. Two types of forest productivity tax are in use – a gross forest revenue productivity tax (GFRPT) based on the average gross annual revenue and a net forest revenue productivity tax (NFRPT) based on the average net annual revenue.
4. The flat property tax (FPT) under which the same amount of property tax is collected on the forest property regardless of its value or productivity.

In the United States, for example, Kentucky imposes nominally an unmodified property tax, Michigan imposes a flat property tax, Texas imposes a gross forest revenue productivity tax, and Louisiana imposes a net forest revenue productivity tax. In this paper, the impact of the above taxes on the optimal harvest age and tax burden will be examined. To carry out such tasks, the generalized Faustmann formulas with forest taxation are developed first.

2. Formulas

In this section the formulas under various types of forest property taxation are derived and presented together.

2.1. The unmodified property tax (UPT)

For notational simplicity, the case for LEV_1 , the land expectation value at the beginning of the first rotation will be presented. LEV_i for any rotation i can be derived similarly. Under the generalized Faustmann formula with the unmodified property tax, let x_1 be the percent tax rate on the value of the land and y_1 percent tax on the value of the standing trees for the first rotation. Further, let

LEV_1 be the land expectation value at the beginning of the first rotation;

LEV_2 the land expectation value at the beginning of the second rotation,

$V_1(t_1)$ be the stumpage value at age t_1 of the first rotation;

C_1 be the regeneration cost for the first rotation;

$A_1(s_1)$ be the net yearly income for year s_1 , $0 \leq s_1 \leq t_1$;

r_1 be the interest rate expressed in percent for the first rotation.

As shown in Appendix 1, when the value of standing timber is properly assessed and taxed every year,

$$LEV_{1UPT} = \frac{[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp((r_1 + y_1)(t_1 - s_1)) ds_1 - C_1 \exp((r_1 + y_1)t_1) + (LEV_2 - LEV_{1UPT})]}{[\exp((r_1 + y_1)t_1) - 1]} \frac{r_1 + y_1}{r_1 + x_1} \quad (1)$$

Further derivations of Eq. (1) yield the LEV_{1UPT} as

$$LEV_{1UPT} = \left[\frac{(r_1 + y_1)}{(r_1 + x_1) \exp((r_1 + y_1)t_1) - x_1 + y_1} \right] \left\{ V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp((r_1 + y_1)(t_1 - s_1)) ds_1 - C_1 \exp((r_1 + y_1)t_1) + LEV_2 \right\} \quad (1a)$$

Eqs. (1) and (1a) represent the most general forms of the generalized Faustmann formula with forest property taxation. In practice, the

tax rate on the values of the land and that of the trees are the same for the unmodified property tax. As such, $x_1 = y_1$, Eq. (1a) becomes Eq. (2)

$$LEV_{1UPT} = \left[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp((r_1 + x_1)(t_1 - s_1)) ds_1 - C_1 \exp((r_1 + x_1)t_1) + LEV_2 \right] \exp(-(r_1 + x_1)t_1) \quad (2)$$

When neither land nor trees are taxed, the above Eqs. (1) and (1a) revert to Eq. (3), the familiar generalized Faustmann formula without taxation below.

$$LEV_{1no\ tax} = \left[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) + LEV_2 \right] \exp(-r_1 t_1) \quad (3)$$

similar to Eqs. (7)–(8) in Klemperer (1996).

2.2. The site value tax (SVT)

The site value tax collects $x_1\%$ tax on the value of the land annually. As a special case of the unmodified property tax with $y_1 = 0$, Eqs. (1) and (1a) become Eqs. (4) and (4a) respectively.

$$LEV_{1SVT} = \left(\frac{r_1}{r_1 + x_1} \right) \frac{[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) + (LEV_2 - LEV_{1SVT})]}{[\exp(r_1 t_1) - 1]} \quad (4)$$

$$LEV_{1SVT} = \left[\frac{r_1}{(r_1 + x_1) \exp(r_1 t_1) - x_1} \right] \left[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) + LEV_2 \right] \quad (4a)$$

2.3. Flat property tax (FPT)

The flat property tax collects the same amount of \$X property tax per acre per year, regardless of the quality or value of the site. As such it can be expressed as

$$LEV_{1FPT} = \left[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) \right] \exp(-r_1 t_1) - X_1 \int_0^{t_1} \exp(-r_1 s_1) ds_1 + \exp(-r_1 t_1) LEV_2 = \left[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) \right] \exp(-r_1 t_1) - X_1 \left(1 - \frac{\exp(-r_1 t_1)}{r_1} \right) + LEV_2 \exp(-r_1 t_1) \quad (5)$$

$$LEV_{1FPT} = \frac{[V_1(t_1) + \int_0^{t_1} A_1(s_1) \exp(r_1(t_1 - s_1)) ds_1 - C_1 \exp(r_1 t_1) + LEV_2 - LEV_{1FPT}]}{(\exp(r_1 t_1) - 1)} - \frac{X_1}{r_1} \quad (5a)$$

2.4. The forest productivity tax

Two types of forest productivity tax are in use – a gross forest revenue productivity tax (GFRPT) based on the gross average revenue per year and a net forest revenue productivity tax (NFRPT) based on the net average revenue per year by deducting an annual management cost from the gross average revenue.

2.4.1. Gross forest revenue productivity tax

Generally, some measure of the forest productivity forms the basis for forest productivity tax. In many cases, the mean annual increment is

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