Australian Journal of Agricultural Economics, Vol. 38, No. 3 (December 1994), pp 251-268

UNDERINVESTMENT AND TIMBER RIGHTS: AN EXAMINATION OF THE EARLY TASMANIAN AND VICTORIAN TIMBER INDUSTRIES*

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This paper distinguishes between the hypothesis that the Victorian government developed a reputation for easy renewal of timber rights, so that the lack of clearly defined site sizes and the short-term nature of these rights did not matter, and the hypothesis that tenure and site size as written in law was the major determinant. A model of a firm's investment choice when there is uncertain tenure is developed to examine the effect of changes in the tenure prospect on capital intensity. The predictions of this model are then used to assess the competing hypotheses with reference to data on capital labour ratios and legislation regarding tenure and site size laws in Victoria and Tasmania from 1890 to 1927.

Introduction

Prominent forestry historians have expressed the view that underinvestment by sawmilling firms in the early timber industries of Victoria and Tasmania was a significant problem. Kemp (1982) argued that the lack of forest land allocated to the timber industry led to 'gross inefficiencies' in Tasmania where 'much of the backbreaking work of carrying timber was avoidable, tramways were put in the wrong places, and the industry did not adopt the best methods available'. According to Carron (1985), also commenting on the situation in Tasmania; 'Sawmillers had no protection against 'timber poaching' by other sawmillers or persons' and, in those circumstances their reluctance to invest substantially in equipment was understandable. Indeed, sawmillers were often the victims of selectors whose job it was to allocate land to different uses, since these people would take up blocks nearby to sawmills and charge high access fees.

* I would like to thank Richard Schmalensee, Oliver Hart, John Dargavel, Ken Groves, and Hans Husum for useful discussion concerning this paper. Thanks also to the Olin Foundation for financial support while this was written, and to the Economics Group at RSSS, ANU for providing a place to work on this and other papers over the winter of 1992. All remaining errors are the author's.

Underlying these claims appears to be the idea that the security which a firm enjoyed over timber yielding lands near the mill was weak, and that this led to reluctance to spend on specific capital. Following this line of argument, it might be concluded that if sawmilling firms could gain the rights to nearby land for a reasonable period of time, the incentive to invest would improve. There does not appear to have been any empirical investigation concerning underinvestment and its potential causes in these early forestries. This paper's primary contribution is to fill that gap. Capital expenditure and labour data, and a description of legislation affecting the supply security that timber firms enjoyed over the period 1890-1927, are used to asses the claims of underinvestment.

A model of a small firm which makes specific investments and which faces an uncertain time horizon of supply is developed. The model is constructed specifically to generate predictions concerning the data which is available from Victoria and Tasmania, in that it considers the impact of uncertain supply when there are two factors — specific capital and non-specific labour. Previous work on the effect of imperfect contracts on investment has primarily considered the case of one factor.

The main hypothesis examined is that longer tenure and larger sizes of supply sites led to higher levels of capital investment relative to labour, and that Victoria suffered from relative underinvestment for part of the sample period due to short tenure and poorly specified site size. A leading alternative hypothesis is that Governments developed a reputation for easy renewal of short term rights and adequate sized sites, which facilitated investment. Other explanations for underinvestment such as a lack of policing or an exogenous lack of availability of capital are considered as well, though data on these factors is very sparse. The likely impact on social welfare of the licensing system through investment and the rate and method of harvesting is also discussed.

Background: The Forest Sawmilling Industry 1890-1927

The Victorian gold rush, which began with discoveries in 1851, was a major factor in the development of sawmilling. The increase in demand for wood which accompanied the rush, and the movement of labour to the goldfields from just about every activity including timber cutting, meant that manual methods of timber production such as pit-sawing were replaced by the more capital-intensive method of sawmilling in Victoria and Tasmania.

In these states,[1] modern forestry practices which emphasise the regrowth of forest for future exploitation were non-existent. In Victoria in 1874, the Minister for Lands and Agriculture tabled a paper which wrote of the licensing system that 'no more effective method of legalizing the

[1] Victoria and Tasmania shall be referred to as states when both time periods — before federation and after federation — are concerned.

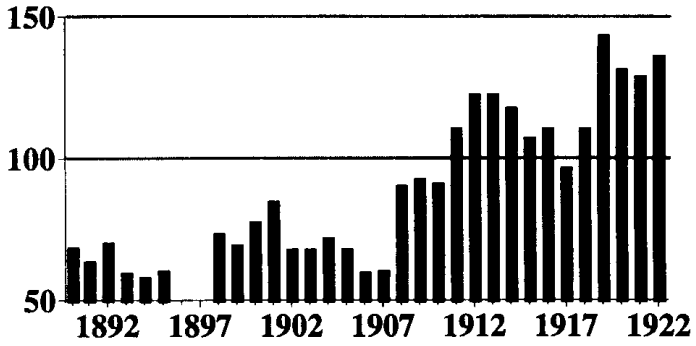
destruction of timber could have been devised'(Carron 1985 p. 63). In 1897 a Victorian Royal Commission was conducted to examine the use of the forest resource, which concluded, among other things, that 'Forestry in the sense in which the word is understood in France and Germany — the maintenance in perpetuity of tracts of woodland bearing live timber of commercial value . . . to ensure a continuous supply — has not yet been attempted in any scientific manner in Australia' (Moulds 1991 p. 27).

Although entry into the industry in Tasmania and Victoria required a license or a lease, the data, at least for Tasmania, suggest that new licenses may not have been difficult to obtain. In Figure 1 we see that the number of establishments in Tasmania fluctuated markedly, and that there was particularly strong growth after 1907.

The combination of high demand following the gold rush, the absence of modern forestry practices, and the relative ease of entry to the industry over the period in Tasmania and Victoria suggest that these states suffered from over-exploitation typical of a common property resource with only partly restricted entry.

FIGURE 1

Number of Firms — Tasmania 1890-1922



Source: Statistics of the Colony of Tasmania (1890-1900), Statistics of the State of Tasmania (1901-1922)

The Forest Mill: Capital and Supply Security[2]

The forest sawmilling industry in these states in the late 19th and early 20th centuries consisted mainly of relatively small mills, compared to today's standards, which were located near sources of timber supply, and roads, rail or wharves for transport of their produce. Once trees promising a good yield of wood were located in the forest, they were cut down using axes or saws. Logs were placed on wooden rails or tramways, and teams

[2] Facts and impressions in this section are from Carron (1985), Dargavel (1988) (and thesis), Moulds (1991) and Row (1977).

of bullocks and sometimes horses were used to drag them to a mill, often 3-5 kilometers away. When they arrived at the mill, logs were lifted to be cut — if necessary by a steam winch — to a waiting saw, usually circular and also steam driven. Small steam engines were often used because of their transportability, and because they could be fueled by sawmill waste. Some companies found it necessary to shift them to more promising areas of the forest once one area had been cleared of the best trees. Tramways on which logs were hauled were more permanent structures and were sometimes extended. New ones were built to access new forest when necessary.

A prevalent product of a typical mill was rough cut green timber, which was sold for further processing. Mills also produced split palings among other things. Produce was taken by road or tramway to rail or seaport facilities to transport them to their final destination.

As in recent times, sawmill managers and potential managers in these early days faced the problem of deciding how much capital to invest in their firm when sources of timber, and in some cases leases to the land upon which mills were built were not guaranteed in written law for the useful life of the capital. The usefulness of capital was in part dependent on location since mills built near roads, railways, wharves, and the source of timber were more productive due to lower transportation costs. Tramways were also investments which had a component that was specific to the forest site. Although in some cases tramways, engines, and other capital were moveable, this would always be costly, and some fraction of the investment would therefore be sunk. Thus, sawmilling capital while durable, had a degree of site specificity.

Taking the laws which affect security of supply as given, we could imagine sawmilling firms having to decide how much specific capital to invest in the business. For example, firms were faced with deciding where to build tramways and how extensive to make them, and choosing between permanent, location-specific equipment, and the alternative smaller transportable mill equipment.

Supply Security

A significant area of land on which mills were built, and from which timber was sought, was owned by the state. Rights of access to timber yielding land was determined by licences, timber leases, and through Acts of Parliment. These arrangements usually specified locality, the size of the site, and the length of time over which trees could be obtained from the land — or tenure. Other factors may have also potentially had an impact on supply security. In Victoria in 1908, the establishment of a State Forests Department to oversee the forestry may have improved the allocation and enforcement of rights to timber yielding land. Policing in general would also have had an impact on supply security. Section 4 below contains a detailed discussion of the variation in the terms of leases and licences, and considers issues such as policing and the finer details of the regulation of sawmilling activities.

The laws which govern supply security display significant variation in both tenure and the size of the site offered. In particular, tenure varied markedly over the period 1890-1927, and between the adjacent states of Victoria and Tasmania. Higher tenure was also usually positively correlated with larger site size.

In some circumstances, such as for the Geeveston Tramways and Timber Leases Act 1901, laws were enacted to grant long timber leases to specific companies. In others, it is not clear that specific companies were targeted. Nevertheless, if firms were not convinced that their rights of supply would automatically be renewed, legislation which increased the tenure granted by these means would likely be perceived by an individual firm as increasing the probability that it would obtain longer tenure. The model below has been developed to analyse the effect on a firm's capital and labour of a shift in probability towards higher tenure.

The Model

There has been a significant amount of work done on the effect of imperfect contracts on investment when there is one specific factor. However, both capital and labour data is availiable on Tasmanian and Victorian forestries. To make best use of the available data it is necessary to analyse the problem and generate predictions for the case where there are two factors. Below, a model is developed to examine the effect of imperfect contracts, specifically inadequate tenure, in the case of specific capital and non-specific labour.

As Figure 1 suggests, the sawmilling industry in each state consists of many small firms. The representative mill is modelled as having a technology summarised by the production function $F(K,L,\beta)$, where L is labour, K is capital, β represents the forest resource[3] ($F_\beta > 0$), and where $F_K > 0$, $F_L > 0$, $F_{KK} < 0$ and $F_{LL} < 0$. The production function is assumed to exhibit constant returns to scale in K, L, and β, and to be concave in K and L. We will assume that firms take β as given, and consequently that milling firms can make rents which are attributable to this fixed resource.

Since the Tasmanian and Victorian industries consisted in large part of numerous small mills, firms are assumed to be perfectly competitive and face a product price which we normalise to unity. For simplicity, we ignore the small amount of market power a firm may have had, for example due to closeness to local markets. Because of the presence of alternative work for mill workers such as farming, we assume that the wage rate w is taken as given by mill owners. The interest rate r, is also assumed to be beyond the influence of firms.

Tramways, mills, steam winches and other equipment are the components of an aggregate measure of capital which is denoted K. The speci-

[3] For simplicity, the forest resource is modelled in the most simple manner possible: as a fixed factor in the production of timber. Thus we imagine β as representing a measure of the timber yielding potential of the forest.

ficity of capital is captured by the assumption that once an investment K has been made at one particular site, part of the investment is sunk: if the firm must move to another site, the 'salvage value' of capital is $G(K) < K$. We assume that $0 < G'(K) < 1$, which means that an extra unit of capital invested grants less than an extra unit in salvage. Marginal salvage value is assumed to be decreasing (so $G''(K) < 0$) to capture the notion of diminishing returns to scale from the productive activity of salvage.

For simplicity, capital is assumed to be infinitely durable but is only useful at a particular site until time T, because, for example, all the best trees have been removed. In effect, we assume the tract of forest is no longer viable beyond this date. After time T, an amount $G(K)$ of capital is salvaged, and the mill moves to another site.

If the firm could be guaranteed a site for the entire time period T, then it would solve the following investment problem (where β is dropped from the production function for notational convenience):

$$(1) \qquad \underset{K,L}{Max} \left\{ -K + \int_0^T (F(K,L) - wL)e^{-rt}dt \right\}.$$

It is assumed that the firm does not have such a guarantee, and will lose its site at some uncertain date $\tau \in [0,T]$. If it must change sites, we assume that it re-invests in the milling business the amount K of capital (at another site) which again lasts T periods and is subject to uncertain tenure τ. Let V denote the net present value of a milling firm. Under the assumptions made, V is defined as follows:

$$(2) \qquad V \equiv \underset{K,L}{Max}\, E \left\{ -K + (F(K,L) - wL) \int_0^\tau e^{-rt}dt + e^{-r\tau}[V + G(K)] \right\}.$$

The term $-K + (F(K,L) - wL) \int_0^\tau e^{-rt}dt$ is the value of the investment if it remains at its initial site until time τ, and the expression $e^{-r\tau}[V + G(K)]$ is the present value of the sum of investment at some new site, V, and the salvage value from the old site. The firm's problem is derived algebraically from (2) as

$$(3) \qquad \underset{K,L}{Max} \{-K + (F(K,L) - wL)(1 - \alpha) + \alpha G(K)\},$$

where $\alpha = E(e^{r\tau})$.

The first-order-conditions for this problem are;

$$(4) \qquad -1 + (1 - \alpha)F_K(K,L) + \alpha G_K(K) = 0,$$

$$(5) \qquad (1 - \alpha)(F_L(K,L) - w) = 0.$$

Let l (for 'law') be an index of government policy such that if $l_1 > l_0$ then l_1 represents an improvement in tenure over l_0. A high level of l could

represent either a more favourable law or a belief by firms that the government will renew their licenses. A more favourable law (or belief) increases the probability that tenure exceeds an arbitrary level τ, if $\psi(\tau,l)$ is the cumulative density function for tenure time given the law l, and $l_1 > l_0$, then $\psi(\tau,l_1) < \psi(\tau,l_0)$.

It is demonstrated in the appendix (A) that α is a decreasing function of l. We can find the effect of an improvement in tenure on the capital-labour ratio $\kappa \equiv \frac{K}{L}$ by differentiating the first-order-conditions with respect to α:

$$(6) \qquad \frac{d\kappa}{d\alpha} = \frac{F_{LL}(F_K - G_K)L + (F_K - G_K)F_{KL}K}{((1-\alpha)F_{KK} + \alpha G_{KK})(1-\alpha)F_{LL} - (1-\alpha)^2 (F_{KL})^2}.$$

(See appendix A for details).

The term $F_K - G_K$ is positive from the first order condition (4) and because the marginal salvage value of capital is less than unity by assumption (see appendix, A). Since the denominator is positive, this means that the capital labour ratio is decreasing in α if F_{KL} is negative, or if F_{KL} is positive and sufficiently small. The intuition is straightforward: if the likely length of tenure falls, then capital is decreased because the firm is more likely to have to move at an earlier date, with a subsequent loss due to the fact that its salvage value is less than K. If the effect of lower K is to raise the marginal product of labour, (i.e., if $F_{KL} < 0$) then L rises and hence κ falls. If the effect of lower K is to lower the marginal product of labour then L falls: κ rises provided L does not fall by too much (i.e. if $F_{KL} < 0$ is small).

Empirical Investigation of the Tenure — Capital Relationship

We will refer to the hypothesis that written laws were the most important determinant of tenure and the size of the timber supply sites offered to individual firms, as the legislation hypothesis. The label 'legislation' is intended to capture the idea that the rights had to be codified for them to be believed by firms. A leading alternative, that Governments developed a reputation for renewal of short term rights over appropriate tract size, shall be referred to as the reputation hypothesis. Alternative explanations shall also be discussed. It was demonstrated in the simple model above that under reasonable assumptions, capital-per-worker will increase when there is an improvement in the prospect of increased tenure. We would also expect such an effect from larger allocations of land for

timber supply.[4] The history of changes in legislation for Victoria and Tasmania provides us with significant variation in tenure and site size, between these states and across the period 1890-1927. If these changes represent shifts in actual tenure and site size enjoyed by firms, then we would expect to see corresponding shifts in κ. However, if the reputation hypothesis holds and firms were confident of renewal, changes in the laws would have no effect on κ.

Data Sources

There are two main data sources used in the empirical investigation below. Information on the content of licences and leases,[5] and administrative practice regarding the use of forest resources in Victoria and Tasmania are available from Dargavel, Goddard and Caton (1987;2;3). These papers are comprehensive descriptions of legislation of state parliments, and also refer to the associated regulations, and apparent administrative practice.[6] While material on legislation and regulations are readily obtainable from official records, information on administrative practices such as policing from nearly a century ago is sparse, and by its nature, impressionistic. While potentially important, the possible influence of changes in all types of administrative practice would require meticulous historical research, and is beyond the scope of the current paper.[7]

The other major sources of data are the statistical records of the Tasmanian and Victorian governments.[8] Information was collected on capital investments, employment, and wages, among other things.[9] This data is discussed below under 'Capital and Labour Data'.

[4] The conditions sufficient for this are straightforward to establish using (4) and (5) to solve for $\frac{d\kappa}{d\beta}$. Essentially and $F_{K\beta}$ and $|F_{LL}|$ must be sufficiently large.

[5] Legislation from state parlimentry papers and associated regulations describe in detail the terms of the licences and leases.

[6] Legislation describes substantive factors affecting the sawmilling industry, while the regulations primarily cover quite specific detail. For example, The legislation focuses on tenure length and site size. Regulations contain such things as descriptions of the allowable radius of trees which can be cut, and specific areas and species which were sporadically not allowed to be cut, and fees for various licences for various forms of activities. For information on these details in Victoria see Carver 'Forestry in Victoria 1838-1919'. A finely detailed analysis of the effects of the particulars of the regulations is not the aim of the present study.

[7] Much of the data on administrative practice that is available has been compiled in Dargavel et al. Unfortunately, due mainly to scarcity, it is not comprehensive enough to be used in the present study. One of the purposes of the current paper is to consider administrative practice indirectly, however. It examines the question of whether timber rights were automatically renewed, or if long term rights were needed.

[8] See the appendix B and C for details.

[9] The appendix B contains a description of the process whereby this raw data was converted into capital intensity data.

Tenure Data and Supply Security

Victorian legislation providing security for the land on which mills were built pre-dated Tasmanian laws by thirty years. The Lands Act of 1862 granted lessees with 3 acres on which to build the mill and a lease of 7 years. The Amending Act of 1865 and the Land Act of 1869 increased the lease time to 21 years. The first such legislation in Tasmania was the Crown Lands Act of 1890 which provided a 14 year lease. While such legislation helped to secure the physical site of the mill, and should consequently have improved supply security, its effect is likely to have been limited, since the source of timber itself was not guaranteed.

Rights other than those which specified (small) lease areas for mills potentially had a larger impact on supply security. Timber licences with a one year duration were issued in Victoria after 1862 and in Tasmania after 1881. Licences were issued to individuals, and would be renewed provided holders were in 'good standing' with administrators, and if the land in question was not designated by government for agriculture.[10] Timber leases, as opposed to leases aimed purely at accomodating mill buildings, were also issued in Victoria in subsequent years. These leases specified land, acreages, and tenure. Acts affecting tenure and site size aimed at specific companies were introduced in Tasmania.

The first laws having a significant impact on tenure and site size were enacted in Tasmania in the Crown Lands Amendment Act of 1895:

> '. . . the Commissioner of Crown Lands [may] . . . issue to any person a Timber License, authorising such person to enter upon and obtain timber for sawmilling purposes from any Crown Land which may have been proclaimed by the Governor in Council a Timber Reserve under the said Act. Every such license shall be issued in respect of an area not exceeding 500 acres for a term not exceeding 5 years . . .'

Over the next seven years, a series of Acts were introduced which had an even greater effect on written tenure and site size in Tasmania. The Crown Lands Amendment Act of 1898 increased the maximum size of a supply area to 5 000 acres and the maximum time period to 21 years. In 1900 an amendment[11] was passed allowing for the previously restricted activity of obtaining timber within 5 miles of any mining field, and granting a license holder 10 years tenure over a 100 acre site. The string of legislative changes culminated in two private acts which offered very long tenure over large tracts of land to two big companies. The Geeveston Tramways and Timber Leases Act of 1901 allowed the company 21 years tenure over a forest and an option for renewal for a further 21 years. The Tasmanian Timber Companies Act of 1902 granted an area of approxi-

[10] Lack of supply security was exacerbated by the fact that land which had been thinned of trees was more attractive to farmers. Such land would be more likely to be selected by authorities for agriculture rather than for continued logging. The hypothesis of this paper is that the short term nature of rights made problems such as these worse.

[11] *Crown Lands Amendment Act 1900.*

mately 21,217 acres to the Tasmanian Timber Corporation, in return for royalties, and also allowed 21 years tenure with a further 21 year option for renewal.[12]

In contrast, the Victorian experience with tenure saw the it lag behind Tasmania. The one year renewal system for licenses was in force throughout the period from 1890 to 1927. Acreages attached to these licences did not appear to have been specified, though attempts were made through the introduciton of Local Forest Boards in 1890. The local boards system subsequently collapsed. Tenure was not increased until 1907 when the Forest Act, which came into operation on the first of January 1908, granted 7 year leases for areas not exceeding 1,000 acres. Thus, while individual cutters had short tenure through licences, the Forest Act saw an increase in tenure and site size for firms through leases. This Act also saw the setting up of a State Forests Department, the charter of which was to oversee the exploitation of timber on unoccupied Crown lands, to charge royalties, and to issue and enforce all leases and licences. The introduction of the forests department may have also improved the policing of existing arangements. Eleven years later in 1918, the Forest Act increased tenure to 12 years and the area to 3,000 acres.

To a rough approximation, for the years 1895 to 1907, Tasmania offered longer tenure and larger site sizes. In Victoria over this period, the one year licence system for individual cutters determined tenure length faced by timber firms. The years from 1908 to 1918 saw Victoria increase tenure and site size, as written in law, to levels closer to those of Tasmania.

If the legislation hypothesis is correct, the theory presented earlier predicts that there should have been more capital-per-worker invested in Tasmania relative to its potential than Victoria for the years 1895 to 1907, and for an evening out of the difference to hold for the years 1908 to some time after 1918. Alternatively, if the reputation hypothesis is correct there should be no effect on capital-per-worker. These hypotheses, and alternatives, are examined below.

Capital and Labour Data

The data period 1890-1927, used in the analysis below, was chosen to cover the differences in laws affecting supply of timber between the two states. The year 1890 was the first year in which data on the value of capital invested in forest sawmills was collected in both states. The sample series chosen ends before the start of the great depression, and

[12] Some of these acts specified minimum capital requirements. While it could be argued that such arrangements forced firms to increase their capital investment, the requirements were likely the outcome of negotiation by the firms who would have been willing to make such investements in any case if sources of supply were secure. Capital requirements may also have been aimed at preventing land speculation by companies with ulterior motives.

before the advent of pulp and paper mills in Tasmania in the 1930s. These events would have complicated the analysis.

As well as containing data on the value of capital invested in forest sawmills, statistical registers for Tasmania and Victoria over 1890-1927 contain figures for the number of workers in the industry in each state. One method of assessing the predictions of the model of section 3 is to construct (real) capital-per-worker series, and to examine how they move in response to actual and anticipated changes laws affecting tenure and site size. Provided other factors such as prices and wages are unchanged, and provided that measurement errors inherent in the historical series are not too large, we can use the data as a source of supportive evidence in the choice between the reputation and legislation hypotheses. Unfortunately, these other factors did vary significantly, for example the Boer war and WWI are likely to have affected wages, and the financial crisis of 1893 is likely to have affected the ability of firms to find capital. A separate examination of the capital-per-worker series for each state is therefore unlikely to yield such clear-cut responses as the theory suggests.

To address this problem, the data should somehow to be purged of other factors which may obscure the effect of tenure-related changes in legislation. Since Tasmania and Victoria are geographically reasonably close, sawmilling firms in each state are likely to have shared similar technology. Tasmanian and Victorian mills also appeared to have traded to some extent in the same product market, and the possibility of labour mobility should have provided some link between labour markets. Thus it can be argued that product prices, technical know-how, and to some extent wages in these two states should be reasonably closely correlated, subject to transportation costs.

We can purge the data of the effect of common additive shocks by examining the difference between capital value per-worker for each state.[13] Any remaining differences between the two series will be due to state-specific factors such as differences in tenure prospects, prices and wages (inter alia). If product, labour and capital markets are reasonably closely linked, then we can attribute differences in the series to tenure prospects, site size, and other state-specific factors. Figure 2 is a graph of the difference between capital-per-worker in Tasmania and capital-per-worker in Victoria.[14] By inspection, the difference between the two series appears to be positive before 1907 after which time it is closer to zero or perhaps negative.[15] This observation is consistent with the legislation

[13] The appendix section C contains tables of the capital intensity data used.

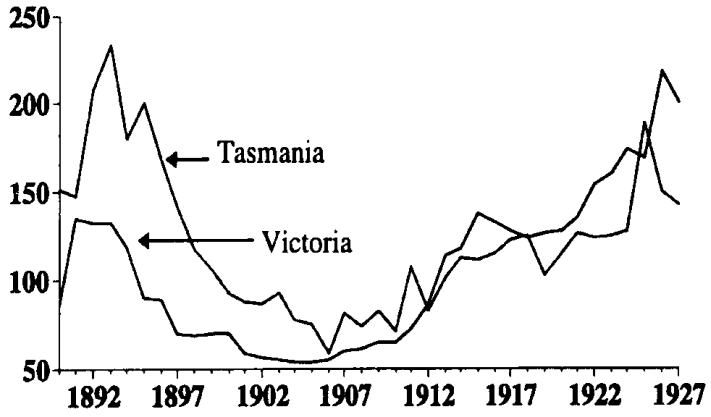
[14] Detailed discussion of the construction of the capital-per-worker series from raw data is contained in the appendix.

[15] A simple empirical test supports the hypothesis that the difference between the series is positive before 1907 and non-positive after 1907. See appendix part B for this test and a discussion.

hypothesis. That is, before 1907, the Victorian government did not develop the reputation of automatic renewal of licences, and the granting of sufficient sized tracts of land for the purpose of timber supply. Legislation which codified these rights was required, and after 1907 when this was achieved in Victoria, it appears that Victorian and Tasmanian capital intensities were closer together.

FIGURE 2

Capital Intensity — Tasmania and Victoria 1890-1927



Source: See Table 1.

The data are also consistent with other specific factors which could have influenced the difference in these ratios. For example if policing in Tasmania was better than that in Victoria from 1895-1907, or if real wages were higher or interest rates were lower in Tasmania, a similar pattern may be observed. Unfortunately, data on wages of sawmill workers were not collected in the statistical registers of Tasmania or Victoria. A thorough econometric analysis could be conducted if reliable series (or good proxies) were available.

If factors other than tenure were responsible for the difference between the series, they would have to have coincided closely with changes in the tenure laws. While policing in Victoria could well have improved after the introduction of the State Forests Commission in 1907, to explain Figure 2 in terms of policing alone, it would be necessary to argue that it was more lax in Victoria than in Tasmania from 1895 to 1907. Historical evidence suggests that policing may have been somewhat lax in both states over this period.[16]

[16] See the chapters on Victoria and Tasmania in Carron (1985) for an impression on policing in these states. Of course, policing would have to have been somewhat effective for any legislation to be enforced.

A particular puzzle in Figure 2 is why the Tasmanian series exceeds the Victorian series before 1895. One explanation is that the fourteen year leases for mill sites in Tasmania in 1891 may have given firms more confidence about their sources of supply. It is also possible that there was some anticipation of a change in legislation before 1895. The financial crisis of 1893 may also have been a factor, if Victoria was hit relatively harder by the crisis than Tasmania, so that capital was harder to raise there.

Tenure Laws and Welfare

The available data is consistent with the hypothesis that laws which grant short levels of tenure and uncertain site size to sawmilling firms lead to low capital-labour ratios. Thus, a direct welfare cost of this policy was relative under-investment in capital and over-investment in labour. Short tenure may have had even larger indirect effects. Historical evidence such as the 1897 Royal Commission (Moulds 1991 p. 27), the comments by the minister for lands and Agriculture in Victoria in 1874 (Carron 1985 p. 63), and the moderately easy entry into the industry, suggest that the licensing system may also have been associated with inefficient timing of harvest. If a firm is given uncertain tenure and entry is relatively easy, it is in the interest of timber firms to adopt wasteful silvicultural practices in order to extract the most value from the forest in the shortest period of time. A similar conclusion can be drawn if the size of the supply areas is uncertain.

The tenure policy may have also had some impact in impeding development. If instead of being allocated licences, timber-cutting firms were sold property rights to the forest, then once the land became more valuable for agricultural uses, it would be sold; in the meantime, the firm could cut trees in such a way as to make the value for the future farmer as high as possible. Since there does not appear to have been an obvious way in which a timber-cutting firm could capture the benefits of land 'correctly cleared for agriculture', it is unlikely that this happened.

Concluding Comments

In this paper a model was developed to analyze the incentive which timber-cutting firms have to invest in specific capital and choose levels of non-specific labour when tenure is uncertain. The hypothesis that the Victorian government developed a reputation for easy renewal of licenses and sufficient site size, does not appear to be consistent with the available data for the period 1895-1927. Instead, the data is supportive of the hypothesis that the length of tenure and the size of sites as written in law had a major influence on investment. The introduction of the State Forests Department may also help explain the data, in that an increase in capital intensity also coincided with this event. Generally, policies of short forest tenure and small or uncertain site size seem to have lead to inefficiently low levels of capital and high levels of labour. It is also probable that such

policies encouraged timber cutting firms to adopt poor silvicultural practices.

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Appendix

A: Proofs

(A1) Proof that α is a decreasing function of l.

Now $E(e^{r\tau};l) = \int_{t=0}^{t=\tau} e^{-rt}\, dH(\tau,l)$. Since $e^{-r\tau}$ is a decreasing function of τ, and $\psi(\tau,l_1)$ F.O.S.D. $\psi(\tau,l_0)$, we have $\alpha(l_1) = E(e^{r\tau};l_1) < \alpha(l_0) = E(e^{r\tau};l_0)$ (see Laffont [1989] p. 32).

(A2) Finding $\frac{d\kappa}{d\alpha}$

To find the effect of an increase in α on $\kappa = \frac{K}{L}$, we must totally differentiate the first order conditions (4) and (5). This yields

(1.1) $$(1-\alpha)[F_{KK}K' + F_{KL}L'] - F_K + G_K + \alpha G_{KK}K' = 0,$$

and

(1.2) $$F_{LK}K' + F_{LL}L' = 0.$$

Applying Cramer's rule gives

(1.3) $$K' = \frac{F_{LL}(F_K - G_K)}{|H|}$$

and

(1.4) $$L' = \frac{-(F_K - G_K)F_{LK}}{|H|}$$

where

$$|H| = \det\begin{bmatrix} (1-\alpha)F_{KK} + \alpha G_{KK} & (1-\alpha)F_{KL} \\ (1-\alpha)F_{KL} & (1-\alpha)F_{LL} \end{bmatrix},$$

which is positive by the assumptions $F_{KK} < 0$ and $F_{LL} < 0$ and the concavity of F in K and L. The derivative $\frac{d\kappa}{d\alpha}$ is found by substituting the terms (1.3) and (1.4) in $\frac{d\kappa}{d\alpha} = \frac{K'L - L'K}{|H|}$

(A3) Proof that $F_k - G_K > 0$.

From the first-order-condition (4) we get

(1.5) $$F_k = \frac{1 - \alpha G_k}{1 - \alpha}.$$

By assumption $G_K < 1$ and so by (1.5), $F_K > 1$, which gives the desired result.

B: Data

The data on capital and labour were constructed from raw data collected from Statistics of Tasmania and Statistics of Victoria 1890-1927. They were constructed as follows:

Victoria

(i) Capital

Raw data from statistics of Victoria on the 'value of plant and machinery' in the sawmilling industry was available annually from 1890 to 1915 inclusive and for the financial years from 1916/17 to 1926/27 inclusive (an observation was missing for 1915/16).

(ii) Labour

Raw data on the average number of hands employed is also available from Statistics of Victoria. The series is annual from 1890 to 1915 inclusive, with 1905 and 1906 missing, and in financial years from 1916/17 and 1926/27 inclusive with 1915/16 missing.

Tasmania

(i) Capital

Statistics of Tasmania provides annual data on the value of plant and machinery for the years 1890 to 1922, with missing observations for 1896 and 1897. Financial year data from 1923/24-1927/28 are also provided with 1922\23 missing.

(ii) Labour

The series on average number of workers employed exhibts the same pattern as for capital, including missing observations.

Data manipulations

To construct complete or 'adjusted' series, dX was used to interpolate the missing observations (averages of the years either side of the missing observations are used), and to make the financial year data annual.

Series of the value of capital per (average) worker for each state were constructed by dividing the (adjusted) capital value series by the (adjusted) average number of worker series. Assuming that the cost of capital was the same between states, that the forestries were similar, and that the same technologies were available, the difference between these series provides an estimate of the difference in capital intensity between the states. Figure 2 is the result. The adjusted data on the value of capital per worker for each state are presented in Table 1.

C: Empirical Verification

TABLE 1
Capital Value Per Worker
*Tasmania and Victoria 1890-1927**

Year	Victoria	Tasmania	Difference	Rank **
1890	85.79	151.84	66.06	
1891	135.34	146.90	11.56	
1892	131.94	207.32	75.37	
1893	132.21	232.85	100.64	
1894	118.93	180.37	61.44	
1895	89.24	200.09	110.85	
1896	88.38	167.91	79.52	
1897	69.51	140.90	71.39	
1898	68.68	117.92	49.24	
1899	69.45	106.33	36.88	
1900	69.99	92.59	22.59	
1901	57.63	87.49	29.86	
1902	55.83	86.36	30.53	
1903	54.23	91.77	37.54	
1904	52.86	77.67	24.81	
1905	53.28	75.10	21.82	
1906	54.27	58.56	4.29	
1907	59.32	80.92	21.60	RANK**
1908	60.36	73.47	13.12	9
1909	64.17	82.52	18.35	11
1910	65.01	71.10	6.09	5
1911	71.91	106.64	34.73	17
1912	85.69	82.39	–3.30	2
1913	113.10	100.90	–12.20	8
1914	117.30	112.19	–5.11	3
1915	137.02	111.21	–25.81	14
1916	131.82	115.01	–16.81	10
1917	127.03	122.33	–4.71	4

Year	Victoria	Tasmania	Difference	Rank **
1918	123.59	125.33	1.74	1
1919	125.97	102.77	-23.19	13
1920	127.03	114.85	-12.18	7
1921	134.87	126.19	-8.68	6
1922	154.27	122.99	-31.28	15
1923	160.00	125.41	-34.59	16
1924	174.13	126.97	-47.15	18
1925	168.61	189.58	20.97	12
1926	217.31	150.10	-67.21	20
1927	200.38	142.36	-58.02	19

* Source: Statistics of the Colonies of Tasmania and Victoria (1890-1900), Statistics of the States of Tasmania and Victoria (1901-1927). See also appendix on data manipulation.
**For the Wilcoxen signed rank test. See appendix.

The hypothesis that the difference between the capital-labour ratio in Tasmania and Victoria is positive from 1890-1907 (inclusive) is very straightforward to test using the Wilcoxen signed-rank test.[17] Since all the differences are positive, there is no need to calculate the test statistic. This is clearly seen from inspection of the data in Table 1 or Figure 2.

Inspection of the data for the years from 1908-1927 (inclusive) suggests that the difference between the Tasmanian and the Victorian ratio is not positive and might in fact be negative. Therefore, we test the null hypothesis that the difference is zero against the alternative that the difference is negative. The Wilcoxen signed rank test yields a statistic $S_n = 55$ for N = 20. The null hypothesis is rejected at the 5% level, but would be accepted at the 2.5% level.

To summerise, the results are that the Tasmanian ratio exceeded the Victorian ratio before 1908, and (possibly) fell below it after 1908 (inclusive). These results are supportive of the hypothesis that the tenure as granted by law in these states was the predominant determinant of investment, and that the government in Victoria at least did not develop the reputation for easy renewal of licences before 1908.

The statistical tests are quite rudimentary, and are not intended to be a substitute for a rigorous econometric analysis. However, to gain much more insight, other data which helps explain the capital labour ratios such

[17] Recall that in this test the differences are number ranked from smallest to largest, and the statistic is the sum of the ranks of the positive differences. If this sum is large it supports the hypothesis that the true difference is positive. Strictly speaking this test assumes that the differences are not correlated, thus it should be interpreted with caution here.

as real wage and interest rate data for timber cutting firms is needed. Unfortunately, available series or proxies are incomplete or of quite poor quality. There is incomplete data on minimum wages for these states over the sample period, however it is improbable that wages in the timber milling industry were effectively regulated. There is also incomplete data on labour expenditure and average number of workers, but the wages series yielded from these has a very high variance, possibly due to measurement error.