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# **FRINGE PRICING DECISIONS: A THEORETICAL ANALYSIS OF TICKET PRICING IN THE THEATRE MARKET**

**SHAWN ERKER\***

## **I. INTRODUCTION**

Originating in 1982, and based upon the Edinburgh festival of the same namesake, the Edmonton Fringe Festival was the first festival of its kind in North America. As a ten day festival in the middle of the summer, the Edmonton Fringe was an opportunity for both amateur and touring professionals to perform theatre for a built in audience. Today, the Canadian Association of Fringe Festivals (CAFF) boasts over a dozen member festivals in as many cities, stretching from the west coast of Canada to Montreal. Each festival is required to abide by the “spirit” of the aesthetic, including one provision that states that “The audience must have the option to pay a ticket price, 100% of which goes directly to the artists” (CAFF, 2011). Despite the intention of such a provision, the necessity of each festival (which operate as non-profits) to maintain a steady revenue stream results in some semantic parsing of what exactly is meant by “100% going towards the artist”. In an attempt to avoid renegeing on moral commitments to the artists and CAFF itself, many festivals have instituted alternate price schemes to split revenues earned from each production towards both the artist and the festival. This introduces the question of whom, between the artist and the festival, benefits more under competing price schemes and whether there exist an optimal price scheme for all parties.

The two price schemes of focus in this paper are the surcharge instituted by the Edmonton Fringe Festival in 2007, and the “button” price scheme, or two-tariff scheme, of the Saskatoon

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Fringe Festival. In Edmonton, the standard ticket price of \$12 goes directly to the artist. However, the festival instituted a surcharge of \$2 on every ticket sold. This effectively raises the price of each show to \$14, from the point of view of the consumer. Therefore, demand should be affected accordingly, despite the semantic labeling of a \$12 ticket price.

In Saskatoon, the festival instituted a policy of requiring each patron to first purchase a button for \$5 that must be worn when attending any production of the festival. These buttons act as a sort of \$5 entrance fee, along the lines of an amusement park or local fair; the proceeds of which go towards the festival. This is in addition to the linear \$10 ticket price for each show.

Normative moral arguments aside, there are certain implications of the festival's chosen price scheme. If the demand for theatre at the festival is elastic, the increase in total price from either a surcharge or a button will decrease total revenue (total profits in this sense being the total revenue derived from the ticket sales, regardless of whether it goes to the artist or the festival). The artist's first best option is clearly the lack of any price imposed by the festival whatsoever. If a price must be imposed then the second best option, from the point of view of the artist, is whatever scheme has the least negative impact on attendance.

Since the festival operates as a non-profit, and is therefore satisfying a fixed need with revenue generating prices imposed upon theatre patrons, does a two tariff price scheme diminish attendance compared to a linear surtax, or vice versa? Is the demand for theatre at these festivals elastic or inelastic? What are the characteristics of the market for theatre, what are the characteristics of those purchasing? These are the issues that will be addressed in this paper.

To offer context, data was collected from four Fringe Festivals within Canada for the years 2005-2010. This data was composed of ticket sales, separated into both advance and rush, as well as general attendance data.

The second part summarizes an introduction to non-linear

pricing and reviews some important literature on the subject. The third part discusses the important economic literature on theatre and the lively arts. The fourth part discusses the data collected and the implications of such. The fifth part introduces a model to explain consumer behaviour under the imposed conditions of either the Edmonton Price Schedule or Saskatoon's. Finally, some conclusions derived from the literature, the data, and the model will be discussed and some possible future areas of research suggested.

## II. WHAT IS A FRINGE FESTIVAL

Each Fringe Festival in Canada operates in a similar manner. The festival is held for ten days in one city. Artistic companies apply for a limited number of spots and are selected using a random draw, or a process of first come first served. The artists pay a fixed fee that covers the cost of renting the venue. As well, the artists cover their own production costs. The Festival provides a pool of consumers that are generated from the festival's publicity, and just simply because people like attending festivals. The artistic companies then compete with one another among the pool of customers provided by the festival for attendance. The benefit from the point of view of the artist comes twofold: First, the pool of festival attendees is generally larger than any small company could afford to advertise to on their own, as well the pool of customers are already primed and biased towards seeing theatre (generally). Second, since the festival is able to rent a venue for multiple companies over the ten days, they are essentially able to buy "in bulk" and keep the venue rental costs at a fraction of what they normally would be when they are passed on to the artist.

The artists are generally a mix of local, national, and international theatre companies. These companies are generally small, from one to four people, and have low fixed production costs. They usually perform new or untraditional works, mostly scripted. The Canadian festival is set up like a "tour", though each city holds

its own independently produced festival. The co-ordination between these festivals, however, allows a timeline to develop, where companies will travel from one city to the next. Starting in Montreal in May, the festivals run one after the other going from east to west. Because of the nature of the festivals, artists often have little choice in whether or not to perform in a certain city. The decision is usually an “all or nothing” proposition, since the fixed costs of developing a show, and of course travelling to Canada if it is an international company, necessitate taking in as many festivals as possible. If, for example, Saskatoon’s method of imposing a fixed entrance fee among theatre patrons were to negatively affect the artist’s profits, there is little room for the artist to perform elsewhere or partner with another festival. For example, if the company finishes in Winnipeg and plans on performing at Edmonton’s festival two weeks later, the company has little choice but to also perform in Saskatoon in the interim, or else do nothing, even if Saskatoon’s festival is itself inefficient.

Presumably, if the festival were taking advantage of the artistic companies, or simply utilizing an inefficient price scheme due to ignorance, you would see a flight of companies from the festival in favour of a more profitable atmosphere. However, unless another festival was to develop in a competing city at the same time as Saskatoon, the artistic companies are presumably “captured” and forced to abide by the imposed price schedule. While other festivals do exist and compete in this manner (such as Calgary’s which runs nearly simultaneously as Saskatoon’s) it may take an extended period of time for these new festivals to develop a pool of attendees that the artists may draw upon, preventing any short term migration from an inefficient festival to one operating in a more artist conducive manner. It is therefore possible that, for example, the Saskatoon nonlinear price scheme is inefficient relative to other festivals.

### **III. NONLINEAR PRICING SCHEMES**

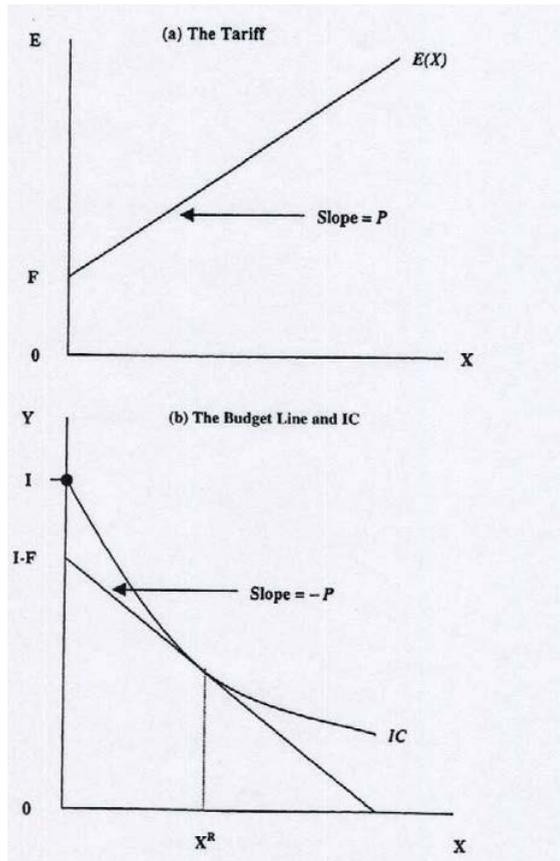
Most consumers regularly encounter two part tariffs of one sort or another. Many subscription services, such as cellular phones or television cable packages, include a lump sum startup fee followed by linear rates tied to usage. For example, COSTCO membership requires annual fixed rates that consumers pay in order to partake in the lower, linear, bulk grocery and product costs available. Price schedules such as this one have various implications for both buyers and sellers.

A traditional, single, linear price imposed upon a buyer results in a marginal cost equal to average cost. The slope of the total cost line, in this case, is equal to the price of the product and consumers will purchase each product until marginal utility of price is equal among all products in a purchase bundle. A nonlinear, two-tariff price imposes a single lump sum before any units can be purchased, and then a linear price for each unit purchased afterwards. In this case, marginal cost does not equal average cost. In their article “Introducing Nonlinear Pricing into Consumer Choice Theory”, DeSalvo and Huq (2002) illustrate the two part tariff price, as seen in Figure 1 (a), as:

$$E = F + PX$$

Where the total expenditure,  $E$ , is a function of the lump sum fixed fee  $F$  and a linear rate  $PX$ ; where  $P$  is the linear price and  $X$  is the quantity purchased.

The authors go on to discuss the implications of such a price schedule. The fixed fee will prevent anyone from purchasing a near zero quantity of the product. The cost of entering the market borne from the first tariff will prevent those with low preferences from purchasing at all. A consumer whose preference is low enough that the marginal utility of purchasing one unit is less than  $F + P$  would be better off not entering the market. These consumers would have a reservation quantity, shown as  $XR$  in Figure 1 (b).

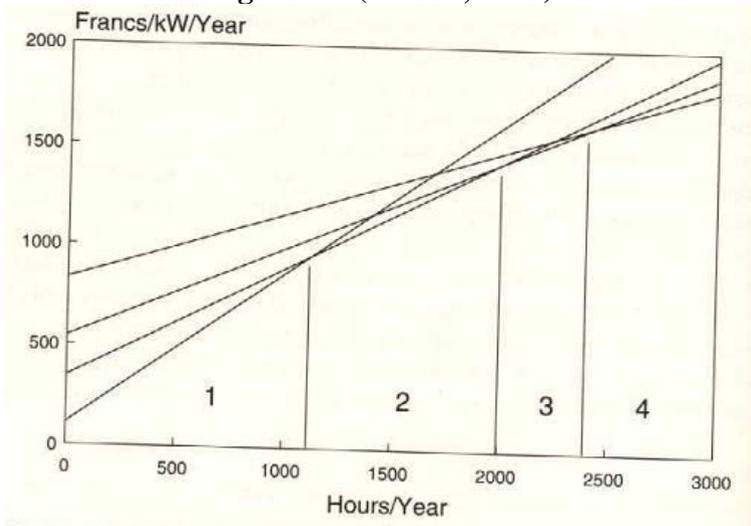
**Figure 1 – (DeSalvo and Huq, 2002)**

The implication of this reservation quantity upon a scenario, such as the one seen in the Saskatoon Fringe Festival, is clear. A lump sum fixed fee will prevent some patrons from entering the market. Those with a reservation quantity low enough will not purchase the button and will not see a single show, this lowers the pool of consumers from which artists will draw upon and devalues the festival from the point of view of the artist. What is not clear is whether, when comparing to the alternative of a larger single tariff

(the Edmonton surcharge), the two tariff schedule results in a smaller total quantity demanded. It is possible that the makeup of consumers in the market, those that demand live theatre in the first place, have a large reservation quantity. In this case, the smaller linear price of the Saskatoon schedule will result in a larger quantity demanded from each individual.

Robert Wilson, in his book “Nonlinear Pricing”, discusses various examples of nonlinear pricing in everyday life. He illustrates the two-part tariffs used by the French energy company *Electricité de France*, shown in figure 2. It can be seen that those packages with a higher fixed fee, the intercept, are coupled with a lower marginal rate, the slope.

**Figure 2 – (Wilson, 1993)**



He explains, “The [price schedule] can be interpreted as a collection of four two part-tariffs, each consisting of a monthly fixed charge plus an energy charge” (1993, p. 31). A higher fixed fee is packaged with a lower linear price; allowing consumers to purchase based upon their own consumption habits. In this case, a consumer

that requires heavy energy use at peak times will choose a package with a higher fixed fee in order to avoid the heavy linear rates associated with peak period power consumption. Under this price schedule the seller is also able to pass along much of its fixed fees to the consumer.

The supplier, EDF in this case, has different fixed and linear costs associated with different supply schedules; the tariff schedules encourage consumer behavior that complements these production constraints. When peak periods require more energy, EDF relies upon coal and other production sources with low startup and high linear costs. Sources such as nuclear power have lower linear costs, but require a substantial startup investment that precludes any cyclical use patterns. The high fixed fees associated with heavy energy consumption allows EDF to utilize their nuclear supply more effectively and punish unpredicted heavy use, which requires the use of additional coal production, with heavy linear rates passed on to the consumer.

At its heart, the implication of a lump sum fixed tariff, in addition to a second linear tariff, is an attempt by the seller to siphon as much consumer surplus away as possible. However, effective price schedules do so in a manner appropriate to the context. In this case, the two-tariff price schedule is used to influence consumer behavior, but more importantly it is used to pass along fixed costs. Wilson elaborates on this observation by solving for an optimal fixed fee using a reservation quantity  $q^*$  under a two-tariff schedule. “ $P_0$  is the amount that makes a customer purchasing  $q^*$ , at the uniform price  $p^* = p(q^*)$  indifferent whether to purchase at all.” (1993, p. 91). He goes on to show the fixed fee,  $P_0$ , as a function of the surcharge  $\hat{p}$ , such that the same number of customers purchase each unit  $q \leq q^*$ .

$$P_0 = \int_0^{q^*} [\hat{p}(q, q^*) - p^*] dq$$

The optimal choice of  $q^*$  then maximizes the total profit contribution:

$$N(p^*, q^*) \cdot [P(q^*) - C(q^*)] + \int_{q^*}^{\infty} N(p(q), q) \cdot [p(q) - c(q)] dq$$

Where the first term is the profits derived from the optimal fixed fee and the term in the integral includes the profits derived from the marginal linear charges. Taking the derivative with respect to  $q^*$  and setting equal to zero, we find the optimal fixed fee  $P_0$  (which is  $P(q^*)$  in the optimum).

$$P(q^*) = C(q^*) + \left[ \frac{q^*}{K(q^*)} \right] \cdot \int_0^{q^*} \frac{\partial \hat{p}}{\partial q^*}(q, q^*) dq$$

From this, we can see that “if the fixed cost is nil, namely  $C(0) = 0$ , then the solution of this condition is  $q^* = 0$ , indicating that the fixed fee [ $P(q^*)$ ] is also nil” (1993, p. 91). This suggests that if the supplier endures no fixed costs in production, the appropriate price schedule includes no fixed fee. Applying this conclusion to the Saskatoon Fringe Festival, there are some interesting implications.

The Saskatoon Fringe incurs zero marginal costs as “production” increases - “production” in this sense being the theatrical performances. Since any costs associated with the show itself are born by the artistic company, the Festival’s production costs associated with theatre is the cost of assembling the pool of theatre goers. These costs are incurred months before the festival, and include advertising, permits, etc. which can be seen as fixed costs. From this point of view it would seem appropriate for the fringe to set:

$$P(q^*) = C(q^*)$$

Where  $C(q^*)$  is the per-capita fixed costs associated with the theatre productions. This implies, contrary to Edmonton's surcharge, zero marginal fees on each ticket sold.

If one were to see the Saskatoon button as an entrance fee that grants the purchaser access to the shows available, this price schedule resembles that of a traditional amusement park. Walter Oi, in his seminal work on the subject "A Disneyland Dilemma" (1971), described the economic implications of such. At the time, Disneyland charged both an entrance fee to its park as well as a marginal fee per ride, essentially a two-tariff system. In his article, Oi proposes that the choice available to the owner of a park such as Disneyland is whether to charge a high lump sum admission fee, and give rides away for free (such as the current price schedule employed by Disneyland), or whether to let people into the park for nothing and "stick them with high monopolistic prices for the rides" (1971, p. 77). The other option is of course a two-tariff middle ground. Pigou's perfect first-degree price discrimination structure globally maximized monopoly profits by extracting the entire consumer surplus. In this scenario, the producer is able to know the preferences of each consumer and extract their surpluses through the fixed fee. Such a price schedule is both impossible and illegal, implying that any actual nonlinear price scheme must be inherently inferior, though conceptually similar.

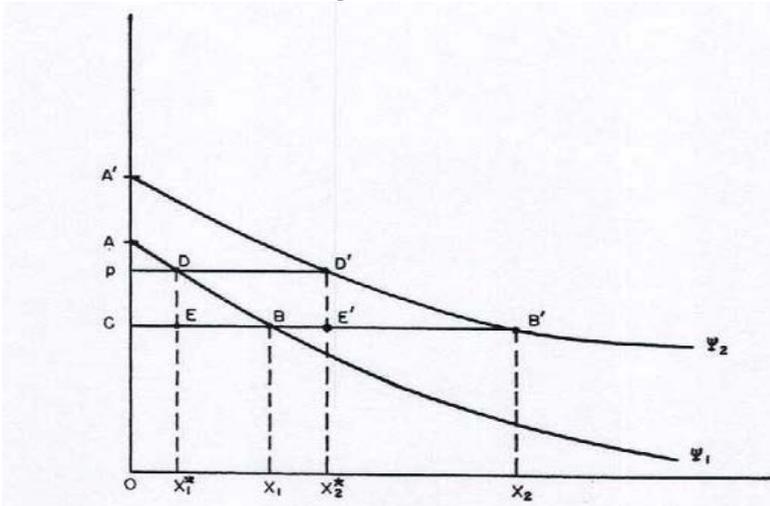
Oi diagrams a typical demand function for two consumers, a "low demand" consumer  $\Psi_1$  and a "high demand" consumer  $\Psi_2$ . In this model, shown in Figure 3, the park sets its entrance fee equal to the consumer surplus of  $\Psi_1$ , described as  $(ABC)$ .  $\Psi_2$  therefore ends up with a consumer surplus of  $(A'B'BA)$ . The park then sets marginal price equal to marginal cost  $C$ .

This implies that pricing each marginal unit below marginal cost can be efficient if the gain received from the imposition of a higher lump sum tax is more than the revenue lost on each unit sale. Shown in Figure 4,  $P$  is less than  $C$  and the increase in total profits is shown as  $E'BDD'$ .

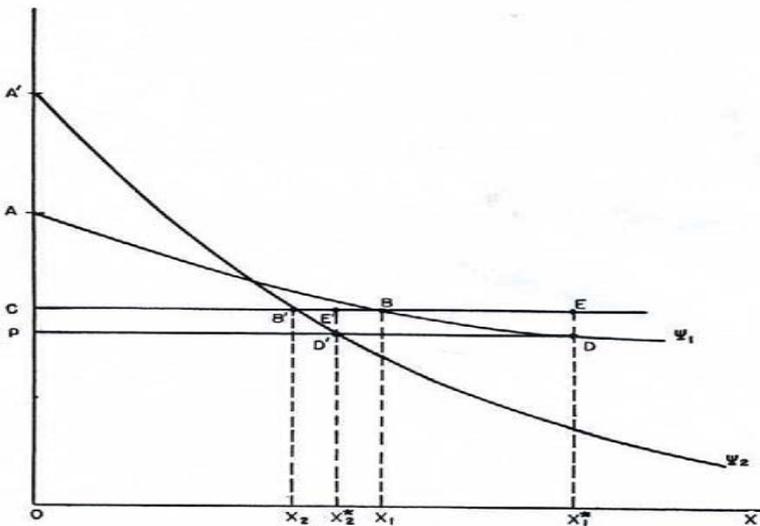
This suggests that the profit maximizing price schedule can sometimes be associated with a higher lump sum tariff coupled with a lower marginal tariff. In the case of the Saskatoon Fringe Festival, however, where two suppliers are putting two different tariffs on the same product, this optimal scenario reduces one supplier's revenues at the expense of the other. In fact, it can be inferred that an optimal scenario from the point of view of the supplier(s), that is a scenario in which the maximum amount of consumer surplus is captured, could be a worst case scenario for the artist if it implies a low marginal fee.

Additionally, there is evidence that the adoption of price schedules which are equivalent in total cost to the consumer despite being imposed in different ways can have a quantifiable effect on price elasticity (Holguin-Veras and Jara-Diaz, 2008). This can impact both the makeup of the pool of available consumers and the total quantity demanded.

**Figure 3 – (Oi, 1971)**



**Figure 4 – (Oi, 1971)**



Whereas Wilson’s analysis of nonlinear pricing in the energy market shows how these non-traditional price schedules can influence consumer behavior and reduce congestion, Barro and Romer published a paper on Ski-Lift pricing in 1987 that looked at the counterfactual. They surmised that since chronic long lines at the ski lift plagued most ski hills, the owners could charge a marginal ticket price for each use of the lift and increase profits while equating supply with demand. This would essentially impose a nonlinear two-tariff price scheme, as opposed to the current single tariff lump sum price. Their observation, that the long queues at ski-lifts imply an inefficient price scheme, produced an explanation for why a single tariff may be optimal under certain scenarios.

In this discussion, the authors refer to the “Two Roads Problem”, first proposed by Frank Knight (1924), which states that free entry into one of two activities equates average, rather than marginal, returns. Frank proposed that two roads to the same place, with unequal quality and attributes, would result in unequal distribution of traffic to the point where travel times were equivalent between choices. Barro and Romer extrapolate from this towards the

ski-lift problem and propose that the queues may act as implicit quantity constraints.

The “Package Deal Effect” states that someone who buys ten units of a good at \$1 each from a local merchant will be indifferent between a standard price scheme and one with a \$10 entry fee, a per-unit price of zero, and a limit of ten per customer. When skiers purchase a day pass at a hill, the constraints of the ski-lift give those skiers a “package deal”. If  $X$  total rides are available, and  $N$  people show up, the queue may act as a symmetric allocation mechanism to provide  $X/N$  rides to each person. The benefit of this is that it provides what the authors refer to as an “Ex post settling up” mechanism (p. 876). If more people than expected show up, the availability of rides is symmetrically reduced as congestion prevents usage equally among patrons. This is compared to a scenario where patrons purchase ski-lift tickets when they show up. In this scenario those that show up early and purchase tickets under an incorrect ex-ante expected demand for the day will be able to resell tickets later in the day at a higher price, creating a form of arbitrage.

The efficiency of a single lump sum in this scenario can be applied to the format of the Fringe Festivals. An unknown ex-ante demand for theatre could induce the festival to use a single lump sum tariff, such as Saskatoon’s button, as opposed to a marginal surcharge. The capacity of each theatre could then be seen as an implicit quantity constraint. In this interpretation, popular shows become more expensive to the consumer, even though ticket prices are constant. Since the patron has already paid their fee to the festival for a certain number of shows, say  $\$(5 / NS)$  for a flat “button” price of \$5 and  $NS$  number of shows, the ability to see a greater number of shows - by attending less popular shows that do not require the patron to stand in long lines - will decrease the cost per show.

Meagher and Teo, in an analysis of two-part pricing in the online gaming industry, suggested that the optimal choice of each price, the fixed fee and the linear fee, could be a reflection of the inherent asymmetric information problem of first time contracts.

They suggest that suppliers who know that they are selling a high quality product will purposefully chose a low fixed rate in order to project their quality. Low quality products will of course have higher fixed rates in order to extract more revenue upfront, whereas the higher quality suppliers will know that patrons will come back again for multiple purchases, increasing linear revenues.

The Saskatoon Fringe then, with its higher fixed fee then the Edmonton Fringe, may be projecting a lower quality of theatre. Asymmetric information might imply that Saskatoon may not trust the quality of their performances enough to believe that consumers will return for multiple purchases, instead trying to extract consumer surplus upfront. The implications of this may not be severe, since buyers in Saskatoon are generally not trying to ascertain the quality ex-anti between Saskatoon and Edmonton and travel distance would preclude most competition between the suppliers, but it is interesting nonetheless.

#### **IV. THE ECONOMICS OF THEATRE**

The characteristics of supply and demand in the lively arts, and theatre specifically, have been discussed at length in the Economic literature. As a heavily subsidized industry, especially in Europe, theatre has in many cases been the beneficiary of a public commitment to ignore the earnings gap from traditional ticket sales. This has done much to hide the fact that theatre, and especially its cousins, ballet and opera, often have trouble finding the revenues necessary from traditional tickets sales.

In her article, “The Effects of Contributions on Price and Attendance”, Touchstone discussed the implication of this earnings gap, defined as the gap between earnings and expenditures (1980, p. 33). By running a regression on attendance determinants for theatrical productions, she found that a total reduction in philanthropic and government contributions would necessitate a 70% increase in ticket prices. This ticket price increase would result in an

annual decrease in attendance of 7.6%. This clear inelasticity of demand might cause one to wonder why these companies do not merely increase their ticket prices.

These problems are analogous to those borne by the Canadian Fringe Festivals. An ability to freely impose higher ticket prices, through surcharges for example, without a substantial impact upon attendance might relax many of the budget constraints they feel. Touchstone, referencing Baumol and Bowen (1966) offers three reasons for why ticket prices might be kept low in the face of such inelasticity. First, “unlike other subsidized services, the lively arts are not viewed as necessities” (1980, p. 35). This is contrary to other services receiving subsidies, such as universities, that regularly increase their own fees. Second, competition from television and films may keep prices low. Lastly, prices may be kept low to conform to the notion of a “just” price. Because of these reasons it is possible that price increases are not institutionally possible in most cases. This may explain why other festivals, such as that in Winnipeg, have thus far avoided additional ticket charges.

Touchstone’s article is not the only one to find an inelastic demand for theatre. In fact, such a finding represents a consensus view of the literature on the subject. Seaman, in “The Handbook of Economics of Art and Culture” (2006) documented 29 separate empirical studies that found the same price-elasticity relationship. In a study of German public theatre, Marta Zieba found that “own price elasticity estimates range from -0.26 to -0.43” (2009, p. 103). Felton (1992) suggested that this phenomenon might not hold true for smaller companies and applies only to the large companies based in urban centres. His analysis of U.S. theatrical companies found a wide variance in elasticities among companies. Gapinski (1984), and Tobias (2004) also found corroborating evidence of price inelasticity.

While demand for the theatre may be price inelastic, there are certainly other factors that influence purchasing decisions. C. D. Throsby, in an article entitled “Perception of Quality in Demand for the Theatre”, proposes a method of determining “quality” from a

consumer's *Revealed Preference*. *Revealed Preference* theory tells us about a consumer's indifference curve based upon their choice of one affordable bundle over another. If two bundles were to both lie upon the consumer's budget constraint, one could infer the shape of that consumer's indifference curve based upon their choice of one bundle over another. Throsby then makes some inferences about a show's quality from these observations. He describes each show as possessing a vector of characteristics that together make up the product purchased. These characteristics, such as genre, acting standard, or production standard, are purchased as a bundle (the show) and the public's preference for one bundle over another can lead to some conclusions regarding the public's preference of one characteristic over another.

Throsby's conclusions are twofold. First, like most other researchers, he finds that theatre demand is price inelastic. However, Throsby also concludes that attendance is highly negatively correlated with new works (1990, p. 75). This has important implications for an institution, such as the Fringe Festival, that is mostly made up of new works. If these festivals are offering inferior products, such as new shows for which the public has little interest, the ability of the festival and the artistic companies to freely increase price with little concern for attendance might be impaired.

It seems relevant at this point to question just what the demographic makeup of the theatre market is. Many studies have previously found a correlation between both income and education and theatre attendance (Baumol and Bowen, 1966; Throsby and Withers, 1979). Francesca Borgonovi, in her article "Performing Arts Attendance: An Economic Approach" (2004), analyzed data from the 2002 Survey of Public Participation in the Arts. She found that participation in art education is much more important in determining attendance than any other personal characteristic, including general educational attainment. Those with a history of art education, whether musical, theatrical, or other, were much more likely to participate in the theatre market and to do so regularly.

While this may imply university students as an ideal demographic, attendance data suggests students make up only a small portion of live theatre attendees. Bonita Kolb (1997) suggested that price could be a key motivator for this demographic. Data collected from the London School of Economics found that the most common reason students gave for not attending theatre was the cost (1997, p. 143). On the other hand, it has also been pointed out that even when admission charges are not an issue, such as with free museums, the demographic profile of attendees remains consistent (O'Hagan, 1996).

To this end, many companies offer discounted prices to students. Complicated price schedules are common to the theatre market. Broadway theatres, for example, use a variety of seat prices in order to conduct price discrimination. As is common in the New York theatre market, seats are separated in price not only by quality (those being cheap seats are often situated further away) but also by date of purchase. Last minute ticket buyers are often privy to extremely cheap prices courtesy of same day sales. This is an example of second-degree price discrimination within the theatre market. Leslie's (2004) analysis of these price schedules found that uniform pricing, relative to the existing price-discrimination policy, implies lower overall attendance for the play without significantly altering the total consumer surplus.

Huntington (1993) found a similar result when analyzing data from British theatre companies. He said "it has been shown that theatres that priced seats over a range of prices would earn more than if seats were offered at a single price only" (p. 85). The optimal price scheme for a Fringe Festival may therefore involve multiple prices both linear and nonlinear.

## **V. THE DATA COLLECTED**

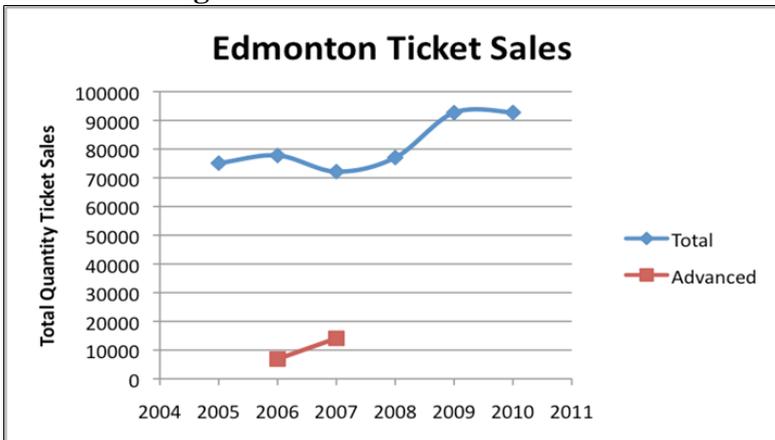
Data collection occurred from November 2010 through to March 2011. Initially, four festivals were contacted: the Edmonton,

Saskatoon, Winnipeg, and Vancouver fringe festivals. Most festivals were initially hesitant to provide specific ticket sales data, but made available overall ticket sales, separated into advance and rush, as well as ticket prices and festival attendance estimates. Vancouver was not able to provide data from years prior to 2009 and they were thusly not included in the evaluation. Data collected can be found in appendix 1.

Edmonton instituted its general surcharge in the summer of 2007. Prior to this point, tickets were priced at \$10. Advance ticket prices included a \$4 surcharge, making the total cost of an advance ticket \$14. In 2007, general ticket prices increased to \$12. As well, a general surcharge of \$2 was placed on every ticket, both advance and rush. This resulted in a total cost of \$14 for both rush and advance tickets.

As can be surmised by these events, in 2007 rush tickets increased in cost by 40%, while advance ticket prices became comparatively more affordable by remaining flat. The effects can be seen in the data collected, shown in figure 5.

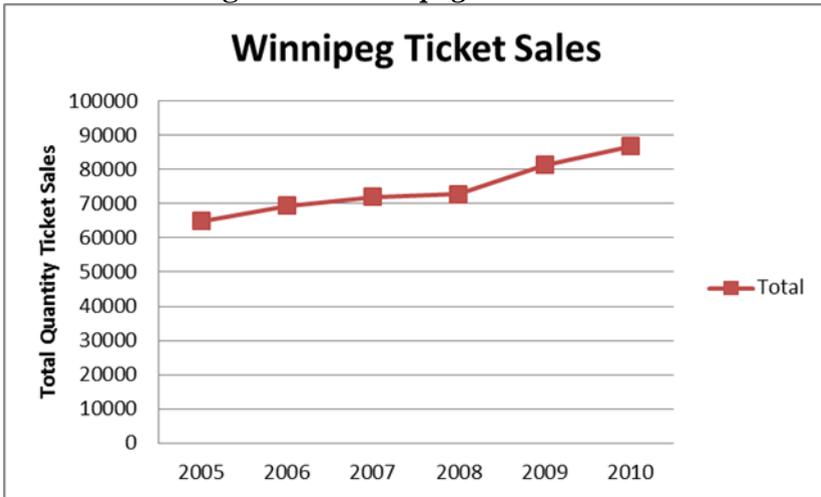
**Figure 5 – Edmonton Ticket Sales**



Between 2006 and 2007, total ticket sales decreased by 7.2%, dropping from 77770 to 72164. This was coupled with an increase in advance sales of 105%, from 6882 to 14103.

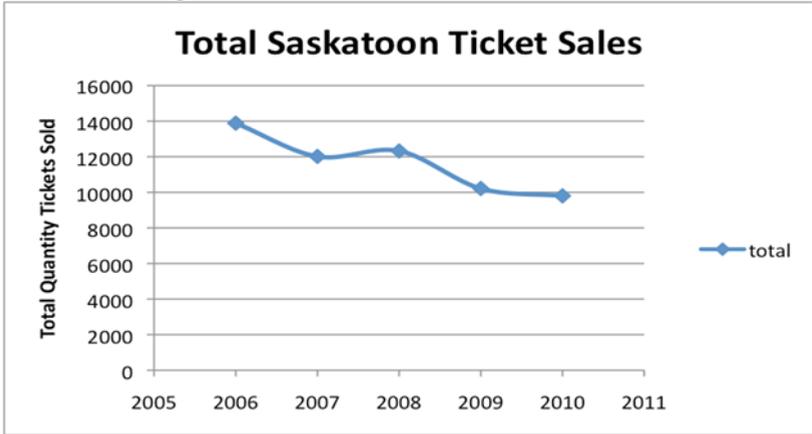
At the same time, no decrease in sales can be seen in the Winnipeg data during the same period, as shown in Figure 6.

**Figure 6 – Winnipeg Ticket Sales**

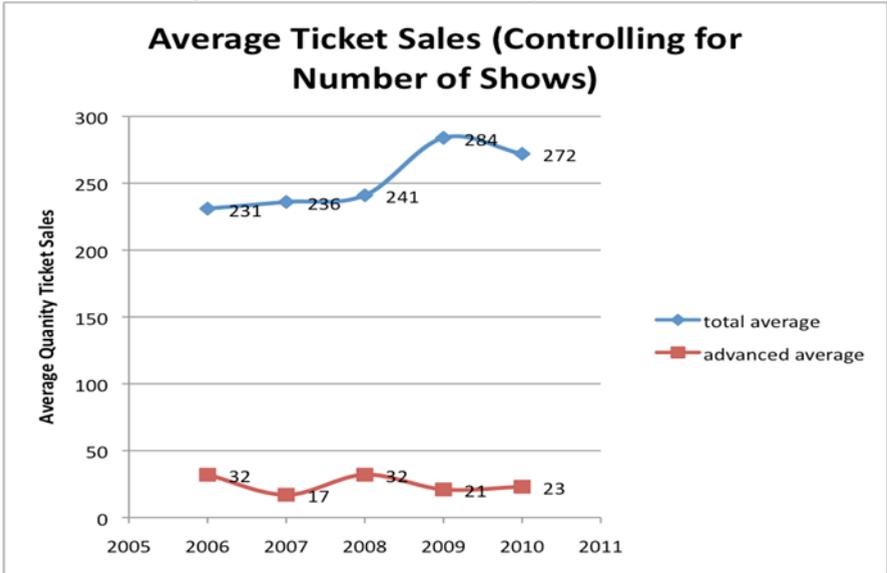


Saskatoon’s ticket sales seem, at first blush, to be an anomaly. Total tickets sales appear to decrease year over year during the analyzed period, as seen in Figure 7. However, Saskatoon drastically decreased the size of their festival in 2007 and again in 2009. Since fewer shows implies a decrease in supply, normalizing the data and adjusting for “average ticket sales per show” presents a similar growth pattern, as seen in Figure 8. This can be done since neither Edmonton nor Winnipeg substantially altered their festival size during this period.

**Figure 7 – Saskatoon Total Ticket Sales**



**Figure 8 – Saskatoon Average Ticket Sales (Controlling for Number of Shows)**



Saskatoon also altered their price regime regarding advance sales during this period. In 2007, a \$2 surcharge was placed on these

tickets (in addition to the button fixed fee). In 2008 this surcharge was removed, it was then reinstated in 2009. A quick visual analysis will show how responsive ticket sales quantity was to this price change, dropping by almost 50% from an average of 32 to 17 once a \$2 surcharge was imposed. The removal of the surcharge pushed sales back up to the original level of 32. The implication of such a drastic change in advance sales, along with the comparative elasticity of Edmonton's advance ticket sales, implies a more substantial price elasticity for advance sales than for rush sales. Of course, this could mean that regular, or rush, tickets are a substitute for advance sales, whereas no comparable substitute exists for rush tickets in general.

## VI. A POSSIBLE MODEL

The goal of the model is to predict consumer behaviour in the Fringe theatre market under both price schedules. To do so, we define scenario 1 as the Saskatoon Fringe (that being a two-tariff system with a \$5 entrance fee) and define scenario 2 as the Edmonton Fringe (that being a single price system with a \$2 surcharge). We then define the representative agent's utility function as:

$$(1) U = \frac{\theta q^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} + X$$

Where  $\theta$  is a coefficient representing artistic preference,  $q$  is the quantity of shows demanded,  $\epsilon$  is the negative price elasticity and  $X$  represents a bundle of all other goods consumed. The consumer's budget under scenario 1 (the Saskatoon Fringe) is then given as:

$$(2) y = (f + pq) + PX$$

Where  $y$  is the consumer's income,  $f$  is the fixed cost (the button),  $p$  is the price of a show and  $P$  is a vector of prices for bundle  $X$  of all other goods. Solving for the first order conditions yields the Marshallian demand function for theatre:

$$(3) \quad q = \left(\frac{p}{\theta}\right)^{-\epsilon}$$

If we make the assumption that artistic tastes are uniformly distributed (which is not necessarily true but simplifies the algebra without loss of generality) on  $[0, 1]$ , we can claim that:

$$(4) \quad n = (1 - \theta_{Cutoff})N$$

Where  $n$  is the pool of customers choosing to enter the market,  $N$  is the population of perspective customers, and  $\theta_{Cutoff}$  is the customer whose preferences dictate indifference between entering and not entering the market. That is, a customer with a preference parameter  $\theta < \theta_{Cutoff}$  will have a negative consumer surplus and will not enter the market or pay for the button. Consumer surplus is defined as:

$$(5) \quad \int_0^q p(s)ds - (f + pq) = \theta \frac{q^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - (f + pq)$$

In 2009, Saskatoon had a general festival attendance of approximately 40 000 people. In the same year they sold 12 000 tickets. Though each attendee likely purchased more than one ticket, and though the festival attendance numbers are heavily estimated, we can approximate the values for the model as  $n = 12000$  and  $N = 40000$  and make the simplifying assumption that 30% of all festival attendees choose to enter the theatre market. Inserting into equation (4) we get a  $\theta_{Cutoff}$  value of 0.7, implying only those perspective customers with a preference parameter  $\theta > 0.7$  will choose to

purchase a button and enter the market. Inserting this value into equation (5) and setting the equation equal to zero (where the consumer surplus will be zero and the customer will be indifferent), and then substituting the values of  $f = 0.5$  and  $p = 1$  (because the Saskatoon button costs \$5 and a ticket costs \$10 we can devalue the price level to find equivalent solutions since utility is homogeneous of degree zero), we solve for the unknown value of  $\epsilon$  to find an elasticity of approximately 1.98. Algebraic solutions can be found in appendix 2.

Substituting this elasticity value into the Marshallian demand functions for both scenarios, we find the average quantity demanded from each customer as:

Scenario 1

$$(6) q_{ave} = \frac{1}{0.3} \int_{0.7}^1 \frac{1^{-\epsilon}}{\theta} d\theta = 0.73$$

Scenario 2

$$(7) q_{ave} = \int_0^1 \frac{1.2^{-\epsilon}}{\theta} d\theta = 0.234$$

Multiplying these average demand function by the approximate attendance values of 12 000 and 40 000 respectively we find hypothetical ticket sales under the two scenarios to be:

Scenario 1:  $q = 0.73 * 12000 = 8\ 760$

Scenario 2:  $q = 0.234 * 40000 = 9\ 360$

This implies a greater number of ticket sales under the surcharge regime when compared to the two-tariff, button regime. However, these numbers are heavily based upon the assumptions made and are surprisingly close to one another.

## VII. CONCLUSIONS

It would be foolish to make any broad conclusions regarding the superiority of one price scheme over another. Many of the assumptions made by economists can be readily countered with alternative evidence or theory. For example, while most of the economic literature summarized for this paper pointed towards an inelastic demand for theatre, and the general ticket sales data for Edmonton anecdotally agreed, the model utilized predicted an elastic demand. The data for advance sales in Saskatoon also anecdotally suggested an elastic demand, though this may be limited to advance sales rather than sales in general.

The imposition of a two tariff price schedule, outside of elasticity assumptions, comes with some implied consequences. The literature suggests that most consumers of the lively arts are highly educated, specifically when it comes to arts education. As well, student's demand functions are suggested to be highly susceptible to ticket prices. This suggests that artistic tastes are not uniformly distributed. For example, if the makeup of  $\theta$  were to cluster around both the low and high ends, dependent upon whether the consumer has engaged in artistic education, the loss in total sales attributable to a flat fee "button" would be minimal. Under this scenario, total sales would be higher under the two-tariff schedule than with a surcharge.

As well, the literature on nonlinear pricing would suggest that a fixed entrance fee should be correlated with fixed costs, such as the ones incurred by these festivals. Since costs do not increase in a linear manner as attendance increases, a fixed fee would seem appropriate.

The model used in this paper predicted a higher overall attendance under a surcharge regime than under a two-tariff alternative. However, this conclusion is highly predicated upon the elasticity assumptions made. The literature, in fact, would suggest that a flat fee is most appropriate and different assumptions for the elasticity and  $\theta_{cutoff}$  would perhaps find similar conclusions. Further research into actual attendance ratios, such as a survey that

accurately estimates the percentage of festival attendees that choose to then see a show, could do much to illuminate these matters.

Qualitatively, it could be said that the behavior of the festival itself could change under differing scenarios. A festival that takes a surcharge on every ticket sold will have a vested interest in selling as many tickets as possible rather than making a flat fee on those choosing to enter the market. This could alter the conclusions made, since the model assumes no changes in this kind of behavior. However, this could be the most relevant scenario, since aligning the goals of both the artist and the festival would do much to allow an equilibrium price schedule to satisfy the optimum of both parties, creating a Pareto optimum outcome.

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## APPENDIX

**Table 1**

<i>Saskatoon</i>					
<i>Year</i>	<i>Advanced</i>	<i>Rush</i>	<i>Total</i>	<i>Per show</i>	<i>Shows</i>
<b>2006</b>	1922	11963	13885	231	60
<b>2007</b>	842	11173	12015	236	51
<b>2008</b>	1625	10694	12319	241	51
<b>2009</b>	756	9158	10213	284	36
<b>2010</b>	815	8985	9800	272	36
<i>Vancouver</i>					
<i>Year</i>	<i>Attendance</i>	<i>Total Tickets Sold</i>	<i>Advance Tickets</i>	<i>Ticket Price</i>	
<b>2010</b>	29,189	20,478	9,290	\$10/\$12*	
<b>2009</b>	20,380	13,974	5,201	\$10/\$12*	
<b>2008</b>	20,818	13,755	6,684	\$10/\$12*	
<b>2007</b>	20,135			\$10	
<b>2006</b>	19,549			\$10	
<b>2005</b>	26,963			\$10	
<b>2004</b>	26,883			\$10	
<b>2003</b>	30,969			\$9	
<i>Edmonton</i>					
<i>Year</i>	<i>Total</i>	<i>Advanced</i>			
<b>2005</b>	75105				
<b>2006</b>	77770	6882			
<b>2007</b>	72164	14103			

<i>2008</i>	<i>77054</i>			
<i>2009</i>	<i>92692</i>			
<i>2010</i>	<i>92745</i>			
<b><i>Winnipeg</i></b>				
<b><i>Year</i></b>	<b><i>Total</i></b>	<b><i>Ticket Price</i></b>	<b><i>Shows</i></b>	<b><i>Per-show</i></b>
<i>2005</i>	<i>64957</i>	<i>8</i>	<i>136</i>	<i>478</i>
<i>2006</i>	<i>69320</i>	<i>8</i>	<i>127</i>	<i>546</i>
<i>2007</i>	<i>71921</i>	<i>9</i>	<i>136</i>	<i>529</i>
<i>2008</i>	<i>72722</i>	<i>9</i>	<i>139</i>	<i>523</i>
<i>2009</i>	<i>81353</i>	<i>9</i>	<i>148</i>	<i>550</i>
<i>2010</i>	<i>86717</i>	<i>10</i>	<i>155</i>	<i>560</i>

# MODELING MARKET FAILURE IN FORESTRY

DEVON FRIESEN\*

## I. INTRODUCTION

Forests have been a cornerstone for all life on earth and as existence proceeds into the future their presence will only become increasingly important. Our water supply, air quality and genetic information will only persist as forests prevail. However, the need for arable land and timber has caused tension and distorted decisions regarding their nature. These private decisions tend to overlook non-market values, produce inefficiency, and result in market failure. As a result, forests are harvested prematurely and land conversion will take place before desirable to society. Thus an argument can be made for regulatory policy; however, regulation tends to create inefficiencies elsewhere.

In 2009, I was able to visit the Waipoua forest located in the Northland region of New Zealand. The Waipoua is home to *Te Matua Ngahere* (“Father of the Forest”) and *Tane Mahuta* (“Lord of the Forest”), arguably the two largest kauri trees to stand. *Te Matua Ngahere* is estimated to be 3,000 years old and attracts over 50,000 tourists each year. The Waipoua forest is recognized for its abundance of plant species and is the refuge of several endangered species including the kiwi. Further, I witnessed a Maori tribe member singing to the spirits within the “Father of the Forest” and recognized the forest’s importance both culturally and spiritually to the people of New Zealand. However, the kauri trees of the Waipoua forest had been exploited for their durability and used in the construction of ships since the early 19<sup>th</sup> century. By the mid 1900’s demand for arable land drove exploitation further. In 1952 a 9,105 hectare Waipoua Sanctuary was created and by 1987 all remaining

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kauri forests became protected by the Department of Conservation (Department of Conservation, 2012).

Essentially, my curiosity and motivation for this paper are to examine the need for such compelling regulation. For the most part, government regulation is needed when significant deviations from the ideal occur. That is, when private decisions result in market failure. Thus, the paper will utilize several models to build a basic but informative framework surrounding market failure in forestry. A brief review of policy will follow.

## II. THE MODELS

### *Introduction*

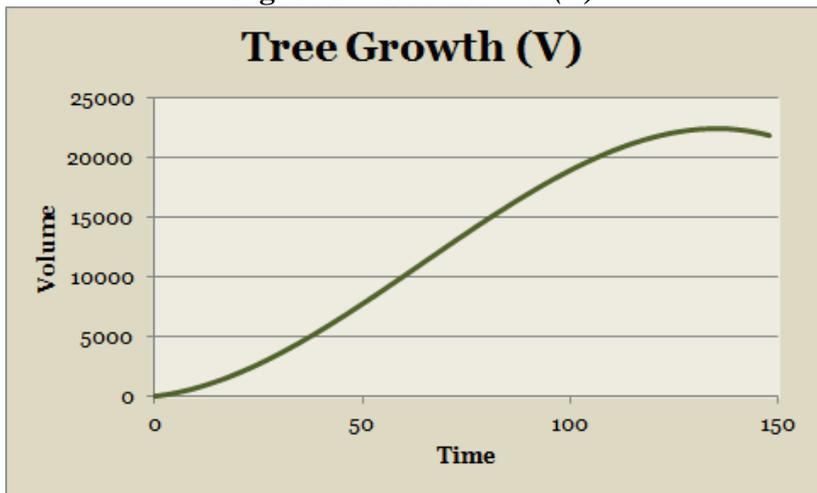
Part I combines both biological characteristics and economic variables to determine the optimal forest rotation. The rotation period is the focal point for foresters. To begin, we examine the biological rotation that is based strictly on the growth characteristics of a forest. Then we incorporate economic variables and perform a comparative static analysis. The economic rotation acquires additional attention because it provides us with a present value of the forest. In addition to the rotation period, the present value is largely of concern to foresters. Given that a private owner's objective is to maximize profit, the present value primarily determines the use of the land.

Moreover, several assumptions are employed and will be applied regularly throughout the paper. We suppose that the land devoted to forestry is initially a clear parcel that is seeded at once. This implies an even-age forest of the same species, namely Douglas fir as portrayed in Figure 1. Once the stand of Douglas fir is mature it is cut at once; this is what foresters refer to as "clear cutting." Unless stated otherwise the perspective of the models are that of a private present-value-maximizing owner. These assumptions make modeling market failure less complicated while still providing a realistic interpretation.

### ***Biological Characteristics***

Literature concerning forestry economics begins by emphasizing an importance to understanding the biological and economic fundamentals. To begin, the biological dimension of a single tree is taken into consideration. Clawson's (1977) estimated volume function referring to a stand of Douglas fir trees is utilized in Figure 1. The mathematical function represented is a third-degree polynomial of the form  $V(t)=a+bt+ct^2+dt^3$ , where ( $V$ ) is the volume and ( $t$ ) is the age of the forest. Although the equation measured relates to a single tree, Clawson argues the relationship is nearly identical when aggregating to a stand. However, the shape of Figure 1 will vary across different species as Conrad (2010) presents both exponential and cubic functional forms for timber growth.

**Figure 1 – Tree Growth ( $V$ )**



\* Marion Clawson (1977):  $V(t)=40t+3.1t^2-0.016t^3$

\* Maximum timber volume occurs at 135 years

Figure 1 demonstrates that a tree matures at a very slow rate and typically has three distinct growth phases:

- 1) Early years: the volume increases at an increasing rate
- 2) Middle years: the volume increases at a decreasing rate
- 3) Later years: the volume decreases

In the early years the growth of a tree is relatively slow in terms of volume, but the tree may gain significant height. Then the tree has a period of rapid growth. In the later years the tree reaches maximum volume and then begins to decay as it becomes victim to pests or disease. These characteristics of tree growth prove effective in conceptualizing forest problems.

### ***Biological Rotation***

This section describes the biological decision rule that was employed by early foresters. It uses a purely biological basis by exercising two well-known forestry expressions, the *mean annual increment* (MAI) and *annual increment* (AI). Conrad (2010, p. 133-135) gives an overview of the biological rotation and defines these expressions as:

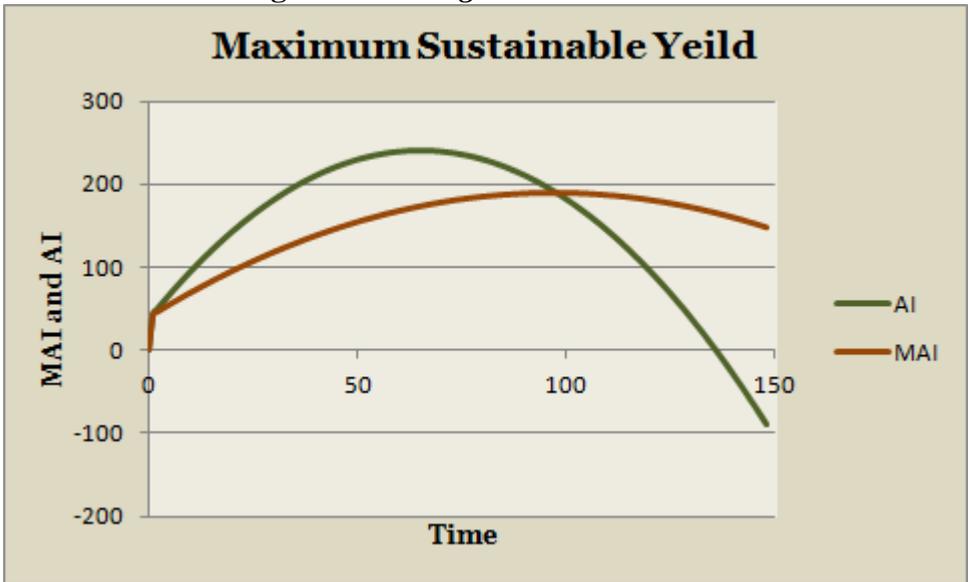
$$AI = \frac{\nabla \text{volume}}{\nabla \text{time}}$$

$$MAI = \frac{\text{volume}}{\text{time}}$$

The *AI* is the annual increase in timber volume and is similar to the *marginal product* in economics. The *MAI* is the average annual increase in timber volume and is similar to the *average product*. In the biological model the optimal rotation period will maximize the average yield (in biomass) over time from a given parcel of land. In particular, the biological decision rule seeks the year the *MAI* is maximized, known as the *maximum sustainable yield* (MSY). This maximum occurs where the *MAI* equals the *AI* as depicted in Figure

2. The optimal rotation states that the average product from waiting (MAI) must equate to the marginal product from waiting (AI). The interpretation of this concept is similar for all forest models and is repeatedly observed throughout this section.

**Figure 2 – Biological Rotation**



\*The maximum MAI occurs at 98 years

**Single Rotation**

The biological rotation serves as a useful introduction to economic forest problems but, overall, it is inefficient because it ignores the cost of harvesting, the price of timber, and the discount rate. A forest owner is obliged to include such economic variables in their decision in order to maximize present value.

Tietenberg and Lewis (2009, p. 320) describe the optimal single rotation as the harvest period that maximizes the present value of the net benefits from timber. The single rotation period

incorporates the cost of harvesting, the price of timber and the discount rate when determining the optimal harvest. The present value function is defined as:

$$(1) \quad PV = (P - C_v)V(t)e^{-rt} - C_f$$

Where,

$P$  = price per unit volume

$C_f$  = fixed cost of planting

$C_v$  = per unit cost of harvest

$r$  = discount rate

Moreover, the term  $(P - C_v)$  is referred to as the *net value constant* and  $(P - C_v)V(t)$  is what foresters call the *stumpage value*. Later on, for simplicity,  $G(t)$  will represent the stumpage value. Aside from the original assumptions, these variables are held constant for the lifetime of the forest. The planting costs consist of inputs of capital, labor and material needed to seed the clear parcel of land. These costs occur immediately and do not require discounting. In contrast to this, harvesting costs that occur in the future must be discounted to present value. The reason future values are discounted is apparent when considering the alternative of harvesting in any given year. The forest owner must choose between harvesting the stand of trees or postponing harvest till next year. If they choose to harvest, then the money obtained can be invested elsewhere earning interest. Therefore, by letting the stand grow an addition year, the forest owner is forgoing money that could otherwise be invested in an alternative. Discounting allows us to identify that opportunity cost of harvesting.

In order to find the rotation period that maximizes present value, equation (1) needs to be differentiated with respect to age (t) and set equal to zero as represented below:

$$\frac{\partial PV}{\partial t} = 0$$

By doing so,

$$(2) \quad (P - C_v) \frac{\partial V(t)}{\partial t} e^{-rt} + (P - C_v) V(t) e^{-rt} (-r) = 0$$

By rearranging,

$$(3) \quad (P - C_v) \frac{\partial V(t)}{\partial t} = (P - C_v) V(t) r$$

Interpretation of equation (3) states that the optimal harvest occurs where the marginal value of letting the stand grow another increment equals the marginal cost of letting the stand grow another increment. Equation (3) can simplify to:

$$(4) \quad \frac{\frac{\partial V(t)}{\partial t}}{V(t)} = r$$

Equation (4) states that where the rate of return from allowing the stand to grow another increment is equal to the discount rate, the present value will be maximized. However, if the value of trees is increasing faster than the value of alternative market investments then delaying harvesting will be optimal. This is represented as:

$$\frac{\frac{\partial V(t)}{\partial t}}{V(t)} > r$$

If the value of the forest is increasing slower than the value of alternative market investments then harvest should occur immediately and the money invested elsewhere. This is represented as:

$$\frac{\frac{\partial V(t)}{\partial t}}{V(t)} < r$$

### *The Value of the Land*

The single rotation above is concerned with maximizing the present value of the land in growing trees. However, a parcel of land can have numerous uses such as agriculture or rural development. It is the land owner's objective to maximize the benefits received from the land, whether the use is timber harvesting or an alternative. The value of the land ( $S$ ) is represented below:

$$S = \arg \max_t PV(t)$$

The present value in our forestry model represents the value of the land when devoted to forestry. That is to say, it is the asset value of the growing stand of timber in a single rotation period.

There are several results regarding the value of the land that are worth mentioning before moving forward. Because the land owner is interested in the use that maximizes the land value they must consider all alternatives. If we assume agriculture is the land owner's only alternative then there are two cases:

- (1)  $S_{\text{Forestry}} > S_{\text{Agriculture}}$
- (2)  $S_{\text{Forestry}} < S_{\text{Agriculture}}$

In the first case the land owner pursues planting trees, whereas in the second case the owner seeds the parcel for agriculture since its value is larger. Further, if the land value of forestry is negative then seeding will not take place and a different optimal forestry plan is required.

### *Comparative Statics*

The mathematical derivations above can become complex. A more straightforward approach to comparative statics involves using spreadsheets (Conrad, 2010). This section will apply parameter values to the single rotation model in a spreadsheet format. Analyzing harvest decisions in this framework allows variables to fluctuate while observing their different outcomes. Understanding the comparative static analysis proves valuable as the paper progresses and policy is considered.

Since modeling market failure is the objective, I am interested in the rotation period and present value. The present value has a large influence on the use of forest land. For instance, if the present value of a forest plot is less than the present value of an alternative use, then the forest owner has an incentive to switch to alternative uses. That is, if the factors of forestry yield a smaller present value than alternatives such as agriculture, the land may be converted. The idea of switching to alternative uses becomes an important component motivating discussion of market failure (see section 3).

### *Discount Rate ( $r$ )*

The discount rate is a variable with a strong influence on both the optimal rotation period and present value of the forest. A higher discount rate will cause a shorter harvesting period because less patience is shown towards the slow growth stage of the forest. Further, harvesting sooner occurs at a lesser volume, causing the present value to decrease. If the discount rate is large enough, it may generate a negative present value indicating that planting should not proceed. This scenario would occur with a planting cost that exceeds the expected present value of future profits. A lower discount rate will extend the harvesting period of the forest because more value is gained in the slow growth stage of the stand. The stand will grow

longer allowing the volume to increase, which ultimately raises the present value.

Note, if the discount rate is equal to zero the optimal harvest period becomes the point where volume is maximized. A zero discount rate implies a zero opportunity cost, so the forest owner should stay invested in the forest as long as growth is occurring. The table below was obtained from the spreadsheet analysis and confirms these results. Notice as the discount rate increases the present value and optimal rotation decrease simultaneously.

<b>r</b>	<b>Present value</b>	<b>t (years)</b>
0%	\$ 175,319	135
<b>1%</b>	<b>\$ 52,040</b>	<b>107</b>
2%	\$ 20,043	85
3%	\$ 9,201	72
4%	\$ 4,687	64
5%	\$ 2,547	59

\* The bold represents the base case

$$* PV = [(P - C_v)V(t) - C_h]e^{-rt}$$

\* Where P=\$25, C<sub>v</sub>=\$15 and C<sub>h</sub>(fixed harvest cost)=\$50,000

Both uncertainty and risk have the power to persuade present value and rotation length, and as such deserve recognition when discussing the discount rate. Often distinctions between the two are made, but such distinctions are not necessary in the context of this paper. Because costs and revenues obtained from forestry extend on predictions occurring several decades into the future, projects are often greatly uncertain. The private discount rate typically reflects uncertainty and risk. For instance, risk of fire or uncertainty of future timber prices will likely increase the private discount rate, driving the rotation period to occur sooner and at a lesser present value. Thus the more uncertain the private forest owner is about future conditions the more likely the private discount rate is larger than the social

discount rate. Ultimately, this creates a form of market failure since harvesting decisions become socially inefficient.

### ***Fixed Cost of Planting***

The planting cost is merely a one-time payment that occurs immediately when seeding takes place. This cost does not increase with age nor does it require discounting. Therefore a fixed planting cost will *not* affect the optimal rotation period, but only the present value itself. Thus an increase in the fixed planting cost will reduce the present value, whereas a decrease will raise present value. The rotation period remains unaffected regardless of the change. However, planting costs are connected to the planting decision. If planting costs exceed the discounted benefits, the present value will be negative at all ages. In this case seeding the forest is inefficient and the rotation period will not occur at all. Accordingly, seeding the land for forestry will not take place if alternative uses generate a higher present value.

### ***Fixed Cost of Harvesting ( $C_h$ )***

A fixed harvesting cost was excluded from equation (1) in an attempt to keep the math interpretation simple. However, spreadsheets allow a fixed harvesting cost to be incorporated and the results interpreted with little difficulty. Unlike planting costs, a fixed harvesting cost is incurred in the future rather than in the present meaning the cost needs to be discounted to reflect present values. This allows a large fixed cost to be delayed into the future making it smaller in present value terms. Thus the idea is to look at growth in profits. If the fixed cost of harvest is relatively large compared to the net value constant, then it may be optimal to delay the harvest to reduce its present value. By contrast, if the fixed cost of harvest is relatively smaller it may be optimal to harvest sooner because now the large benefit being received is subject to discounting. The

following table shows a consistency with the intuition just discussed. Notice a large fixed harvesting cost will decrease the present value and increase the optimal rotation length. In contrast, a small fixed harvest cost will increase the present value and decrease the rotation length.

Fixed harvest cost	Present value	t (years)
\$ 25,000	\$ 60,778	103
<b>\$ 50,000</b>	<b>\$ 52,039</b>	<b>107</b>
\$ 75,000	\$ 43,681	112

\* The bold represents the base case

$$* PV = [(P - C_v)V(t) - C_h]e^{-rt}$$

\* Where P=\$25, C<sub>v</sub>=\$15 and r=0.01

***Per Unit Cost of Harvesting (C<sub>v</sub>)***

The insight behind the variable harvesting cost is quite similar to that of a fixed harvesting cost. When considering the effect of a variable cost, it is best to think in terms of the net value constant rather than cost alone. Note that a larger variable cost will decrease the net value constant; hence the fixed cost of harvesting will be comparably larger. Thus the optimal harvest is delayed in order to decrease the present value of the relatively larger fixed harvesting cost. Further, if costs increase while holding all other variables constant the present value must decrease. Conversely, if the per unit variable cost decreases the fixed harvesting cost becomes smaller relative to the net value constant. In this case, harvesting should occur sooner and produce a larger present value. The following table demonstrates the interpretation discussed. Notice a larger (smaller) per unit variable cost decreases (increases) present value and increases (decreases) the optimal rotation period.

<b>C<sub>v</sub></b>	<b>Present value</b>	<b>t (years)</b>
\$ 20.00	\$ 17,836	116
\$ 17.50	\$ 34,820	110
<b>\$ 15.00</b>	<b>\$ 52,039</b>	<b>107</b>
\$ 12.50	\$ 69,358	106
\$ 10.00	\$ 86,730	104

\* The bold represents the bas case

$$* PV = [(P - C_v)V(t) - C_h]e^{-rt}$$

\* Where P=\$25, r=0.01 and C<sub>h</sub>=\$50,000

However if the model is considered without a fixed cost of harvesting as represented in the present value equation (equation 1) then changes in the per unit variable cost will not affect the optimal rotation period. The per unit cost is assumed to be constant in the model and is proportional with the amount of timber to be harvested. Since no large cost exists, the variable cost acts as a constant and the numerical value assigned will be irrelevant to the rotation length. Changes will merely raise or lower the present value of net benefits schedule rather than change the shape.

***Per Unit Price of Timber (P)***

Changes in the price of timber act similar to changes in the variable cost of harvesting. Like the variable cost the price must be viewed in terms of the net value constant. A rise in price will increase the constant, whereas a fall in price will decrease the constant. The table below justifies the intuition of price adjustments.

<b>P</b>	<b>Present value</b>	<b>t (years)</b>
\$ 20.00	\$ 17,836	116
\$ 22.50	\$ 34,820	110
<b>\$ 25.00</b>	<b>\$ 52,039</b>	<b>107</b>
\$ 27.50	\$ 69,358	106
\$ 30.00	\$ 86,730	104

\* The bold represent the base case

$$* PV = [(P - C_v)V(t) - C_h]e^{-rt}$$

\* Where  $r=0.01$ ,  $C_v=\$15$ , and  $C_h=\$50,000$

The price is varied in the same proportion as the per unit variable cost. Notice that the present value and the optimal rotation length have the exact same values. Thus the insight is very similar to the per unit cost of harvesting. A fall in price makes the fixed harvesting cost larger in proportion to the net value constant, which means delaying harvest is optimal. This allows the fixed harvesting cost to be gradually discounted as it is pushed into the future. However the present value of the stand will decrease because the firm is no longer receiving the higher price. The effects are similar when considering a rise in the price. Again, if the fixed harvesting cost is zero a change in the price will have no effect on the optimal rotation length.

**Remarks**

Several characteristics and comments call for acknowledgement before moving forward. Foremost, it is important to recognize that a discount rate of zero will freeze the optimal rotation period because there is no longer an opportunity cost. However the presence of a discount rate gives all variables besides the fixed planting cost the potential to influence both present value and optimal rotation length. These consequences prove to be fundamental when the objective is modeling market failure.

Additionally, if forest harvesting is conducted efficiently these variables need to accurately portray their true values. For instance, uncertainty may mistakenly represent the discount rate, creating an inefficient harvest rotation.

### ***The Faustmann Rotation***

Forest harvest decisions cannot commence without mentioning the rotation derived by the German forester Martin Faustmann in 1849 (Conrad, 2010). Often referred to as the *infinite rotation*, the Faustmann model is concerned with the land's devotion to forestry in perpetuity. For this reason it differs from the single rotation which considers harvest decisions in a one time period framework. The single rotation model is unrealistic when applied to an infinite horizon because interdependencies exist among periods. That is, a decision to delay harvest will delay all other harvest decisions and create an additional cost. Thus the gain in tree growth (and value) must cover the opportunity cost of delaying all future cycles. The idea is to maximize the present value of an infinite stream of income as opposed to an isolated payment in the single rotation.

The present value of all future streams of income of the same length ( $t$ ) is the sum of all present values received at the end of each rotation. This is represented as:

$$(5) \quad PV = [(P - C_v)V(t) - C_f]e^{-rt} + [(P - C_v)V(t) - C_f]e^{-r2t} + \dots$$

$$(6) \quad PV = [(P - C_v)V(t) - C_f]e^{-rt} [1 + e^{-rt} + e^{-r2t} + \dots]$$

From calculus an infinite series  $[1 + e^{-rt} + e^{-r2t} + \dots]$  converges to  $1/(1 - e^{-rt})$ , so the equation (6) reduces to,

$$(7) \quad PV = \frac{[(P - C_v)V(t) - C_f]e^{-rt}}{(1 - e^{-rt})}$$

By multiplying both numerator and denominator by  $1/e^{-rt}$  equation (7) becomes:

$$(8) \quad PV = \frac{(P - C_v)V(t) - C_f}{e^{-rt} - 1}$$

Or

$$(9) \quad PV = [(P - C_v)V(t) - C_f] [e^{rt} - 1]^{-1}$$

The Faustmann rotation is obtained by selecting the optimal rotation length (t) that maximizes the present value in equation (8). To maximize this equation the derivative of the objective function with respect to age (t) is set equal to zero. Thus the optimal rotation must satisfy:

$$\frac{\partial PV}{\partial t} = 0$$

To solve this problem we utilize the exponential, power, and chain rules of differentiation.

(10)

$$[(P - C_v)V(t) - C_f](-1)[e^{rt} - 1]^{-2} e^{rt} r + [(P - C_v) \frac{\partial V(t)}{\partial t}] [e^{rt} - 1]^{-1} = 0$$

Rearranging and dividing by  $(-1)[e^{rt} - 1]^{-1}$ :

$$(11) [(P - C_v)V(t) - C_f] [e^{rt} - 1]^{-1} e^{rt} r = (P - C_v) \frac{\partial V(t)}{\partial t}$$

Rearranging:

$$(12) \quad \frac{r[(P - C_v)V(t) - C_f]e^{rt}}{e^{rt} - 1} = (P - C_v) \frac{\partial V(t)}{\partial t}$$

Multiplying both sides by  $[e^{rt} - 1]$  and expanding:

$$(13) \quad r(P - C_v)V(t)e^{rt} - rC_f e^{rt} = (P - C_v) \frac{\partial V(t)}{\partial t} e^{rt} - (P - C_v) \frac{\partial V(t)}{\partial t}$$

Dividing by  $e^{-rt}$ :

$$(14) \quad r(P - C_v)V(t) - rC_f = (P - C_v) \frac{\partial V(t)}{\partial t} - (P - C_v) \frac{\partial V(t)}{\partial t} e^{-rt}$$

Rearranging:

$$(15) \quad (P - C_v) \frac{\partial V(t)}{\partial t} = r[(P - C_v)V(t) - C_f] + (P - C_v) \frac{\partial V(t)}{\partial t} e^{-rt}$$

By substituting equation (12) into the second term on the right of equation (15) it becomes:

$$(16) \quad (P - C_v) \frac{\partial V(t)}{\partial t} = r[(P - C_v)V(t) - C_f] + \frac{r[(P - C_v)V(t) - C_f]}{e^{rt} - 1}$$

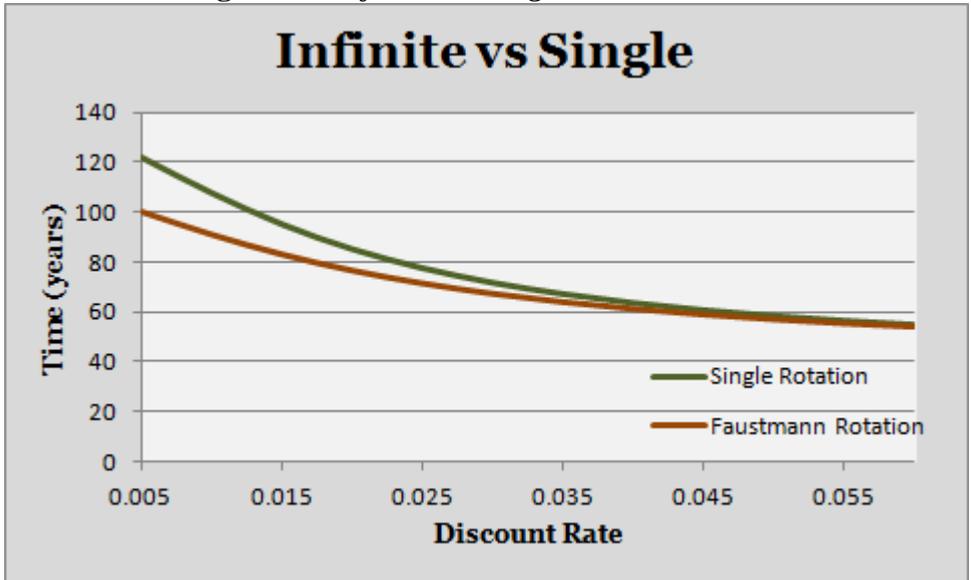
Finally, substituting equation (8) into the second term on the right of equation (16) it becomes:

$$(17) \quad (P - C_v) \frac{\partial V(t)}{\partial t} = r[(P - C_v)V(t) - C_f] + rPV$$

The interpretation of equation (17) is quite similar to the interpretation of the optimal single rotation (equation 3). The equation states that the optimal harvest occurs where the marginal

value of letting the stand grow another increment equals the marginal cost of letting the stand grow another increment. That is, the optimal harvest occurs where the benefits of waiting one more year to harvest equals the cost of waiting one more year. The left sides of both equations are identical and represent the incremental return in delaying harvest, but the right sides show slight variation amongst the two models. Similar to equation (3), the first term on the right of equation (17) denotes the interest payment if the stand is cut at that instance. This is the opportunity cost of delaying harvest. The second term on the right side is not included in the optimal single rotation and represents the cost of incrementally delaying all future stands. This term is often thought of as the interest payment on the value of the land if it were sold at that instance.

It is worthwhile to note that the present value from the Faustmann rotation will always be larger than that of the optimal single rotation. This occurs because the present value obtained from the Faustmann rotation is the sum of all future streams of income rather than just a single period's. Further, the Faustmann rotation regularly produces a shorter rotation period than the optimal single rotation because of the extra opportunity cost that it includes. Since the benefits from additional tree growth need to offset the interest payment of the stand and all future stands, shortening the harvest period becomes optimal since each period is dependent on the next. Both the Faustmann and single rotation are graphed against the discount rate in Figure 3. The two models have comparable shapes and converge as the discount rate increases.

**Figure 3 – *Infinite vs. Single Rotations***

Correspondingly, if the present values of the two models are viewed in the same way as Figure 3 the outcome is alike. That is to say, present values will converge as the discount rate increases. The additional term in the Faustmann rotation approaches zero because a higher discount rate causes the present value to move toward zero. Overall, the whole term approaches increasingly closer to zero and the Faustmann rotation draws nearer to the optimal single rotation.

Representation of a forest's economic problem commonly proceeds by exercising the Faustmann rotation. Its infinite timeframe which treats each period as dependent on the next gives the most practical method for calculating the rotation period and present value. On the other hand, Figure 3 has revealed that the Faustmann and single rotation models are analogous. In conclusion, the intuition between the Faustmann and single rotation is the same. This permits the remainder of the paper to concentrate on the simpler single rotation while still providing the same insight.

It is important to recognize that the value of the land considering an infinite timeframe is slightly different than that of a single period. Whatever the use, the land value consists of the sum of all future present values as represented below:

$$S = \arg \max \sum_t^{\infty} PV(t)$$

If the land is devoted to forestry then the value of the land is the present value obtained from the Faustmann rotation. If the land is used for agriculture its value will be the sum of each consecutive harvest into the infinite future. Under an infinite timeframe the land will be valued higher. The intuition regarding alternative uses does not change.

### **III. NON-TIMBER VALUES AND THE OPTIMAL ROTATION**

#### *Introduction*

The models introduced in Part I considered timber as the product of private forest harvest decisions. But an assortment of other products and services are produced by forests as well. These other products and services include berries, nuts, wild game, water and soil protection, biodiversity, carbon sequestration and recreation. Amenities such as these may have no observable price and would go ignored in forest harvest decisions if no market value exists for them. There are two reasons why non-market forest products go un-priced: one technical and one political (Zhang and Pearse, 2011, p.141). The technical reason refers to the difficulty to market and price such products and services. The political reason centers on public choice. Generally speaking, the public argues that by paying taxes they have the right to freely use non-market forest products such as

campgrounds and recreational areas. Although there are no technical difficulties to pricing these amenities, the public deems it would be unfair to do so considering low income individuals. However the government often charges a license fee for these amenities, but the fee is usually unrelated to the resource being consumed.

Demand for non-timber products and services is growing and the values they provide cannot be overlooked. In Canada's boreal forest, the annual estimated value of carbon sequestration, watershed services, non-timber forest products (e.g. mushrooms, berries, wild rice) and recreation are estimated to be \$1.85 billion, \$79 million, \$18 million and \$4.5 billion respectively (Anielski and Wilson, 2005). Further, the carbon storage value is estimated to be \$850 billion. These non-timber values are significant and decisions need to reflect them to ensure the wellbeing of society.

By assuming the viewpoint of society as a whole, we must take unbiased account of the variety of forest benefits whether a market exists or not. Thus decisions need to include the *total economic value* of the forest rather than timber value alone. The *total economic value* is the sum of *extractive value* and *non-extractive value* (Zhang and Pearse, 2011 p.6). Further, *extractive value* contains timber and non-timber values, whereas *non-extractive value* consists of ecosystem service and preservation values. The purpose of this section is to individually examine and categorize these forest values. Later, the paper considers how these values will affect the optimal rotation and how they might be incorporated into the models from Part I.

### ***Extraction Value***

Extraction value refers to the resources that have been physically harvested and removed from the forest for outside use (Zhang and Pearse, 2011 p. 6). Further, extraction values are divided into two categories: timber value and non-timber value.

#### ***Timber Value***

Timber value refers to the assortment of wood products that can be extracted from a forest and include timber, fuel wood and poles. Markets usually exist for timber products which allow their value to be reflected by prices. Such prices make it straightforward to include timber values into the single and infinite rotation models discussed in Part I. However, the focus of this paper is on the forest values that are ignored in timber harvest decisions rather than the ones included. Therefore, these other forest values are examined in more detail.

### *Non-timber Value*

Non-timber extractive value refers to the vast array of non-wood products contained within a forest and are often referred to as non-timber forest products. In Canada non-timber forest products include maple syrup, honey, mushrooms, berries, wild rice and wildlife. Most non-timber forest products can be converted into outputs and are reflected with prices because established markets for them exist. In 2002 the economic value of maple syrup produced in Canada was \$164 million and the total value of Saskatoon berries was \$9.1 million (Wetzel, Duchesne and Laporte 2006). Further, a single pine mushroom from Canada may retail for up to \$150. Although these products originated from forests, they usually are not harvested in their natural state but instead have been domesticated. Moreover, the economic value of non-timber forest products does not necessarily capture their social importance. The value of such products in aboriginal communities and developing counties where agriculture is limited is typically understated.

Forest based pharmaceuticals are a component of non-timber forest products as well. Wetzel, Duchesne and Laporte (2006) identify over 25 different plant species within Canadian forests that have pronounced medical uses. More notably, plant species such as *taxus brevifolia* and *podophyllum peltatum* are used in anti-cancer

agents. The worldwide market for the derived drugs exceeded \$1.6 billion in 2000 and \$100 million in 1990 respectively.

### ***Non-extractive Value***

Non-extractive value refers to indirect services that are provided from a forest network (Zhang and Pearce, 2011 p. 6). This value is further divided into ecosystems and preservation values and is discussed below.

### ***Ecosystem Value***

Forest ecosystem value denotes the benefits derived by humans (either directly or indirectly) from habitat, biological properties or processes of ecosystems (Costanza, 1997). The paper selects and defines some of the noteworthy values present in forest ecosystems.

### ***Watershed Service Value***

Pearce (2001) identifies four features provided by forests that contribute towards watershed protection. These features are soil conservation, water supply, water flow and water quality regulation. A detailed explanation of each attribute is provided by Bauhus, Van Der Meer and Kanninen (2010). To summarize, a forest offers soil conservation by controlling siltation and sedimentation. Water supply and water flow regulation is provided from the role of forests in storing and retaining water by regulating hydrological flows. Finally, forests have a characteristic that reduces soil erosion and filters pollutants from water providing nutrient flow and water quality regulation.

The Credit River Watershed located in southern Ontario illustrates how valuable these watershed services can be. The mix of forests in the Credit River Watershed are estimated to provide \$141

million in value, and the watershed ecosystem as a whole is valued at \$371 million (Kennedy and Wilson, 2009). The forested area shows significant value due to its contribution to the quality of water in Lake Ontario. It is also recognized as an important sub-component of the Great Lakes Basin and is home to 750,000 people.

### ***Carbon Storage and Sequestration Value***

The earth releases carbon dioxide naturally through rock formation, volcanic activity and the venting of gases from the earth. However the rapid increase in world population and the increasing demand to meet energy needs has caused human interference. In order to comply with human needs such as shelter, warmth and transportation we have resorted to the burning of fossil fuels. This fossil fuel burning has contributed to climate change by releasing increasing amounts carbon dioxide into the earth's atmosphere.

Carbon sequestration is the transfer and storage of atmospheric carbon dioxide into other reservoirs that would otherwise be released or remain in the atmosphere (Lorenz and Lal, 2008). Carbon dioxide in the earth's atmosphere is reduced through the process of carbon sequestration. This process occurs in forest ecosystems primarily by absorbing atmospheric carbon dioxide through tree photosynthesis and securely storing some in vegetation, detritus and soil reservoirs. Old growth forests have accumulated large amounts of carbon: the boreal forest ecosystem in particular provides the largest and most important storage of carbon (Lorenz and Lal, 2010).

The carbon sequestration rate is defined as the rate at which carbon is stored in an ecosystem. Half a tree's mass is carbon so the sequestration rate is known to resemble the same trajectory as the growth and yield curve of a stand of trees represented in Figure 1. Thus a regenerated forest sequesters carbon and stores it acting as a carbon sink. The carbon is released by combustion as the forest decays, which can take a very long time. Hence harvesting trees acts

as a stop-gap measure to storing carbon. A mature stand of trees in British Columbia has a carbon sequestration rate of zero; total carbon storage peaks as the tree reaches 175 years. This is where the forest reaches a balance between releasing and absorbing carbon (Greig and Bull, 2009). In addition, Greig and Bull state that lower impact harvesting and no harvesting have nearly the same carbon storage result over a 100 year period.

Timber harvest decisions including carbon sequestration values can contribute to reduced atmospheric carbon dioxide. Although it may not completely solve the problem, it does buy time for the development and implementation of new carbon storing techniques. Thus viewing carbon and timber together as forest commodities will increase the benefit to society.

### ***Biodiversity Value***

Ninan (2007) defines biodiversity as the variety of all animals, plants and microorganisms interacting in all kinds of environments within the planet. Biodiversity is commonly categorized into genetic, species and ecosystem diversity. Genetic diversity is the total variety of genetic material in all organisms on earth. Species diversity refers to the variety and variability of species. Ecosystem diversity is described as the different kinds of living communities and the environments in which they occur.

The value derived from biodiversity results from the ability to provide information and insurance (Pearce, 2001). The diversity present today is the result of evolutionary processes occurring over several billions of years. This has provided a stock of information to human society and will continue to be a vital source of knowledge for future generations. Biodiversity is responsible for all sorts of information surrounding plant breeding, pharmaceutical drugs and industrial processes. The search for high yielding crops, new medicines and more sophisticated practices give biodiversity significant value. In addition, biodiversity insures society with the

continual existence of species as well as ecosystem functioning and against future stress and disturbance.

Biodiversity defines a forest, as forests are the most species rich environments on the planet. The economic value of biodiversity as insurance can be observed as the insurance premium the world is willing to pay to avoid the value of forest goods and services being lost (Pearce and Pearce, 2001). This value will be large and will increase as more forest cover is lost. Seldom is the value of biodiversity measured because of its challenging nature. Instead, studies have essentially focused on valuations regarding specifics within the category. For example, in Canada's boreal forest the value of pest control services provided by birds is estimated to be \$5.4 billion (Anielski & Wilson, 2005).

### ***Preservation Value***

Wagner (2012) describes preservation value simply as the value people place on preserving forests. Existence, option and bequest values are the three types of preservation values. *Existence value* is the expressed importance to preserve the existence of a resource for the continuing benefit of future generations. *Bequest value* refers to the expressed importance to leave resources for future generations. *Option value* is the importance individuals express to retain the opportunity to consume a resource in the future. From a forest owner's perspective the preservation of the trees may be valuable merely to keep future harvest options open. From an individual's perspective the preservation of wilderness may be valuable as you might want to visit it someday. Additionally, the mere satisfaction of knowing the option exists may have value to forest owner and individuals. These values overlap and are often combined as distinction between them is subtle and sometimes unclear.

### *The Hartman Rotation*

The models from Part I included private timber value in the optimal rotation age and ignored the external values previously discussed. Efficient forest management must account for the beneficial environmental spillovers that forests contain. As a result of this, two arguments can be made. First, one can argue that the present private value is an understatement of the total value offered by forests. Second, an argument can be made for extending the rotation past the optimal Faustmann rotation. If society is to maximize welfare, the Faustmann model needs to be modified to take into account non-timber values. Hartman (1976) proposes a simple extension on the models from Part I that incorporates non-timber values. As before, the intuition between the Faustmann and single rotation models shown previously allows the Hartman rotation to be examined within a single period framework as well.

To begin, the difference between timber and non-timber values must be understood. Timber benefits occur at the end of the rotation when the stand of trees is harvested and represent a stock of value. By contrast, non-timber benefits represent a flow of value because they occur continuously as the stand grows and matures. The value of non-timber benefits flowing from a standing forest of age ( $t$ ) will be denoted as  $N(t)$  and the continuous function represent by:

$$N(t) = \int_0^t N(x)dx$$

Therefore, the new single rotation model including non-timber benefits becomes:

$$(18) \quad PV = \int_0^t e^{-rx} N(x)dx + e^{-rt} G(t)$$

Equation (18) has replaced the stumpage value of timber in a forest of age (t) with  $G(t)$  as previously indicated. Just as before, the objective function is maximized by differentiating with respect to age (t) and setting it equal to zero. Again, the optimal rotation will satisfy:

$$\frac{\partial PV}{\partial t} = 0$$

Note that by the second fundamental theorem of calculus the derivative of  $N(t)$  is,

$$\frac{\partial N(t)}{\partial t} = N(t)$$

Thus, the expression becomes:

$$(19) \quad e^{-rt} N(t) + e^{-rt} \frac{\partial G(t)}{\partial t} + e^{-rt} G(t)(-r) = 0$$

By rearranging and dividing by  $e^{-rt}$  the expression simplifies to:

$$(20) \quad N(t) + \frac{\partial G(t)}{\partial t} = rG(t)$$

This result is translated similar to the previous interpretations. The term on the right is identical to before and is the interest payment forgone by postponing harvest for another period. The left side is still the benefit received from postponing the harvest another period, but it now consists of non-timber value during the period and the values of timber growth over the period. Again, the optimality condition is where the marginal value of letting the stand grow another increment equals the marginal cost of letting the stand grow another increment. By rearranging equation (20) we obtain:

$$(21) \quad \frac{\frac{\partial G(t)}{\partial t}}{G(t)} = r - \frac{N(t)}{G(t)}$$

Therefore if non-timber values are present the forest should be harvested when the rate of growth is less than the private discount rate ( $r$ ). This will be achieved by postponing harvest. However, assuming non-timber values equal zero ( $N(t)=0$ ) equation (21) reduces to:

$$(22) \quad \frac{\frac{\partial G(t)}{\partial t}}{G(t)} = r$$

or

$$(4) \quad \frac{\frac{\partial V(t)}{\partial t}}{V(t)} = r$$

Equation (21) becomes identical to equation (4) and states the forest should be harvested when the rate of growth is equal to the discount rate. A constant non-timber value was applied to the model and both scenarios are represented by Figure 4 below.

Figure 4

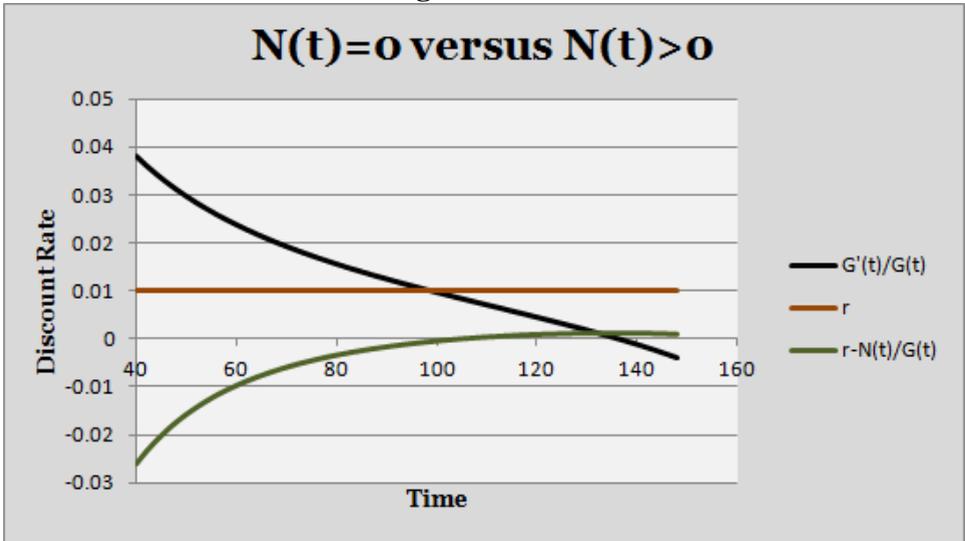


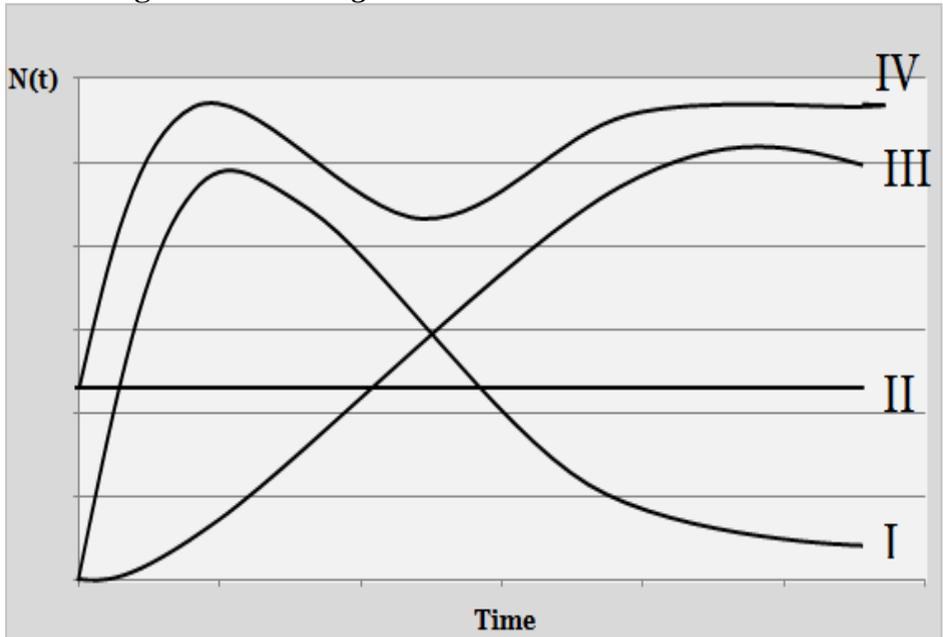
Figure 4 illustrates that if non-timber benefits are equal to zero the optimum harvest rotation occurs around 98 years. If a constant non-timber value is present and positive, the optimal rotation occurs around 130 years. Further, if non-timber values are large and the ratio of non-timber benefits to stumpage value is greater than the discount rate ( $N(t)/G(t) > r$ ) equation (21) consists of a negative value on the right side. In this case harvest will be postponed even longer and occur later than the maximum volume, if at all.

The inclusion of non-timber benefits into the optimal rotation can be extended to an infinite timeframe. The result is often referred to as the Hartman-Faustmann rotation (Van Kooten and Folmer, 2004). However if we apply the same analysis between the two models as in Part I the conclusion is equivalent. In short, the intuition between the Hartman and Hartman-Faustmann rotation will be similar.

### *Additional Remarks*

Non-timber benefits have many functional forms that vary with forest age besides the constant value used in Figure 4. Van Kooten and Folmer (2004) identify and generalize these forms along with their effect on the optimal rotation period. Examples of the relationship between forest age and non-timber values are provided in Figure 5. For instance, if non-timber value is large in a young stand its incremental growth with the forest will be negative, shortening the optimal rotation length. Examples would include certain wildlife species or grazing values. The constant non-timber value used in Figure 4 is represented by (II) in Figure 5. An example is genetic bird species that are unrelated to the forest age. However if non-timber values increase with stand age the optimal rotation length will be extended. Carbon storage, biodiversity and watershed services would fall into this category and are represented by (III).

Further, it should be acknowledged that if these values are large then a future forest harvest may not be feasible. Aggregating all the different forms of non-timber benefits would produce (IV). Even if each relationship could be identified and reliably calculated it would need to be combined with timber value to produce a single unique maximum. However by examining (IV) in Figure 5 such a task becomes very complicated given the diverse variety of non-timber value forms.

**Figure 5 – Stand age and various non-timber values**

\* Adopted from Van Kooten and Folmer 2004

#### **IV. MARKET FAILURE UNDER FAUSTMANN ROTATIONS**

##### ***Introduction***

The Hartman rotation has shown that if non-timber benefits are included into forest harvest decisions the present value and rotation period will increase. As opposed to the Faustmann rotation, the Hartman rotation is efficient provided that society values such non-timber benefits. However, forest owners are reluctant to include these values into their decision making process; this stimulates the discussion of market failure.

### ***Why and How Markets Fail in Forestry***

Markets will allocate resources efficiently if both the full marginal cost of production and the full marginal benefit of consumption reflect market and non-market values by including all components of *total economic value* (Field and Olewiler, 2011.) Part II introduced the vast array of forest uses that benefit both local and global communities. Unlike timber, these uses generally do not generate financial returns because markets for them do not exist; hence they have no observable price. Although harvest decisions should encompass the *total economic value* of the forest, having no visible financial value presents a problem. For this reason the price of timber does not accurately represent the *total economic value* of the forest, which reflects in poor harvest decisions. Economists have acknowledged various reasons why and how markets fail to reflect such non-timber values. Zhang and Pearse (2011) identify the two most important reasons for market failure in forestry as public goods and externalities.

*Ownership externalities* are defined where the producer of the external cost or benefit is not linked through a market to those who endure the result (Zhang and Pearse, 2011 p.40). Further distinction can be made between positive and negative externalities. A positive externality is where the market fails to compensate those who produce, which generally occurs when the timber remains on the stump. For instance, a forest owner incidentally improves the air quality by *not* harvesting, benefiting all surrounding communities. Market failures surface in such cases, since the forest owner cannot gain by producing a positive externality. Negative externalities arise when the market fails to penalize those who produce, usually appearing when the stand of trees is harvested. For example, a loss will likely be suffered by hunters if timber harvesting reduces the amount of wild game within the forest. Given that forest owners cannot gain by reducing negative externalities, market failure occurs. Since the market does not connect the produce with the external

benefit or cost they have no incentive to take such consequences into account when making harvest decisions. Therefore inefficiency arises because a forest owner will produce less of a positive externality and more of a negative externality, ultimately creating market failure.

Field and Olewiler (2011 p. 63) define public goods as *non-excludible* and *non-rival*. What economists call *non-exclusion* refers to when services are made available to a single person, but at the same time all other persons cannot be excluded from making use of the same services. Pricing such goods and services is impractical for the reason that no one can be excluded; thus where one person pays all other persons will benefit. Correspondingly, *non-rivalness* refers to when an individual's consumption does not diminish another person's consumption. Thus an individual's consumption imposes no cost, implying an efficient price of zero and ultimately reducing the incentive of the forest owner to provide them. In general the ecosystem values previously discussed fall into the category of public goods.

Another situation worth mentioning where market failure arises concerns the discount rate. If the private discount rate equals the social discount rate then forest decisions are socially optimal. However, private forest decisions will be inefficient if the social and private discount rates disagree (Hartwick and Olewiler, 1986). Generally speaking the private discount rate is larger since it typically reflects uncertainty and risk as mentioned in Part I.

Overall there are numerous situations where market failure emerges, but this paper is focused on those pertaining to externalities and non-timber benefits. In conclusion, market failure is present when prices and costs do not accurately portray their true social value and where private discount rates differ from social discount rates. The consequences of market failure are twofold. They generate inefficiencies in decisions regarding rotation period and land use.

### ***Market Failure and Rotation Period***

The Hartman model suggests that the rotation period should be extended past that generated under the Faustmann model. That is to say if non-timber values are included in forest decisions an argument can be made for extending the rotation. However, including non-market values in forestry decisions becomes difficult if markets fail to emerge for them, due to the reasons previously discussed. Thus a forest owner will apply a rotation period based on the Faustmann model when the correct period is that established by the Hartman model. The outcome is inefficient rotation lengths. Often, and of more direct concern, the rotation period occurs too soon when timber prices alone are used. Market failure that arises when private discount rates are larger than social discount rates will have the same consequence.

### ***Market Failure and Land Use***

The present value of the forest is understated when the forest owner takes the price of timber as an indicator opposed to the true price including ecological service values. Once again this behavior is that resulting from the failure of markets to emerge due to externalities and public goods. One can think of these different present values as those generated from the Faustmann and Hartman models. There are three scenarios regarding land use; one of which creates a market failure.

$$(1) \quad PV_{Hartman} > PV_{Faustmann} > PV_{Alternative}$$

Case (1) demonstrates that even though the value of the land is understated the outcome is still correct. Switching to an alternative use is inefficient regardless of whether the land is valued from a private or social perspective. In this case the Faustmann present value is larger than all alternative and the land is put to its best use.

From the standpoint of switching there is no market failure, however, the rotation period is still inefficient.

$$(2) \quad PV_{Alternative} > PV_{Hartman} > PV_{Faustmann}$$

In case (2) the present value of an alternative land use is greater than both the present value from the Hartman and Faustmann rotations. This represents a situation where switching uses is optimal regardless of the perspective taken. Thus even though switching occurs no market failure is present.

$$(3) \quad PV_{Hartman} > PV_{Alternative} > PV_{Faustmann}$$

It is case (3) where market failure arises from switching land uses. The present value of the forest is misinterpreted, initiating the potential to switch uses even when inefficient from a social perspective. Therefore if the present value of an alternative use falls in between the Faustmann and Hartman present values the forest owner will switch land uses. In essence, switching creates a market failure since the forest owner conducts decisions based on the Faustmann present value when the true value is that portrayed by the Hartman model.

## V. CORRECTIVE POLICY

### *Introduction*

Having concluded the argument concerning the presence of market failure in forestry, attention now turns to a brief introduction regarding the assortment of regulation options available to correct such failure. The question becomes how to influence the Faustmann rotation so that it resembles the Hartman rotation. Three types of taxes are acknowledged, which consist of a percentage rate applied

against the tax base. After the discussion on taxes other regulatory policies such as subsidies and restrictions are recognized. All proposed policies will be examined under the single rotation model unless otherwise stated. A great deal of the following discussion is a combined summary of Zhang and Pearse (2011) and van Kooten and Folmer (2004).

### *Annual Site or Land Tax*

A tax on land value is based strictly on the value of the land and not the timber on it. Typically a land tax is applied annually as a percentage rate on the site value of the bare land. The effects of a site tax in forestry are similar to an increase in the planting costs. As described in Part I an increase in planting cost have no effect on the optimal rotation and are often referred to as being neutral. However like all taxes, a land tax will decrease the present value of the forest.

A land tax may have a slightly different effect when considered in an infinite timeframe that is worth mentioning (Hartwick and Olewiler, 1986). In the single rotation model, a site tax will not be discounted since the cost occurs immediately. In the context of the Faustmann model, a land tax will not be discounted in the initial period, but will thereafter be discounted consecutively into the future. Such a tax causes the rotation interval to increase and less wood per unit of time to be harvested in perpetuity.

### *Yield Tax*

A yield tax is a tax based on the value of timber when harvested and is commonly referred to as a tax on harvest value or profit tax. Since harvest can be postponed, so can a yield tax, thus decreasing its present value. Such a tax acts in a similar way as a reduction in output prices. As Part I demonstrated, a decrease in price has the effect of extending the rotation period. For this reason a yield tax is consistent with our discussion of market failure and

should be implemented when harvest occurs too soon. However, a decrease in the price has the additional effect of decreasing the present value and could ultimately stimulate market failure from switching.

### *Ad Valorem*

An ad valorem tax is a fixed percentage applied annually on the combined value of the standing timber and land. The result is a charge equal to a fraction of the stumpage value. Thus the forest owner will incur an annual cost that increases with the stumpage value. Therefore the longer the forest is grown, the larger the accumulated tax charges will be. Because an ad valorem tax is levied as a percentage its effect is similar to that of increasing the discount rate, which provides an incentive to reduce the rotation period. Similarly, an ad valorem tax will reduce the present value of the forest.

All three forms of taxes have different effects on the rotation period but show equivalent outcomes of decreasing present value. If correcting the rotation period is the objective, the regulatory authority needs to acknowledge the contrary effect such taxes can have. For instance, if timber harvesting is occurring too soon and market failure is present, then a yield tax may appear favorable. However such a tax has potential to decrease the present value causing market failure resulting from switching uses. If the taxes pertaining to forestry are larger than the taxes applied to an alternative use then the forest owner will be more prone to switching uses. This results in a similar situation as that discussed in Part III case (3). Further, if alternative land uses are taxed more heavily the forest owner will be more reluctant in switching. A tax likely does not provide a complete solution to market failure, but may perhaps increase efficiency.

### *Subsidies and Restrictions*

Besides taxes a regulatory authority has two supplementary tools, which are now examined. To get forest owners to include non-timber values into their harvest decisions a regulatory authority can subsidize the private owner. Provided the timber remains on the stump, a subsidy equal to the value of non-timber benefits will essentially transform the Faustmann model into the Hartman model. Basically, forest owners would then receive a flow of value equal to the non-timber benefits enticing them to keep the forest intact. A forest owner will likely be subsidized when the non-timber values of a forest are significant.

Where such non-timber values are substantially important, regulatory authority may employ restrictive policies. Restrictive policy refers to the authority exercising its power to prevent timber harvest in certain zones where ecosystem values are significant. National parks, watershed protection zones and species conservation areas are just some of the familiar restrictive policies. As with taxes, the authority must recognize that correcting policy may create inefficiencies in other areas not readily observed.

## **VI. CONCLUSION**

This paper has analyzed market failure in forestry and supported the requirement of regulation within the industry. In doing so it has answered the initial question of why such influential regulation is needed within the Waipoua forest. In the case of the Waipoua the non-timber values are considerably great instigating the monetary authority to impose a restriction halting timber harvest. The conclusions of market failure derived here are well-known within the literature pertaining to timber harvesting decisions. The direction of recent literature seems to assess the valuation of non-timber values in effort of making accurate decisions. Further, many other factors are taken into consideration when harvest decisions are

made. This paper has merely assumed forest owners make their decision based strictly on present value. Interestingly, the literature also suggests that forest owners' do not always regard this as their first priority. In conclusion, externalities and public goods cause non-timber values to go unnoticed leading to decisions generated by the Faustmann model. Given that these rotations are beholden by present value the harvest decision will be inefficient in one of two ways: either the present value will be misinterpreted, influencing the potential of switching land uses, or the rotation period will occur too soon.

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# ACCESS TO EDUCATION: A REVIEW OF THE CONCLUSIONS OF THE COPENHAGEN CONSENSUS

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## I. INTRODUCTION

The last few decades have seen the growth of an increased global perspective. This has undoubtedly come hand in hand with increased global concerns. Many individuals and institutions, both governmental and non-governmental, have been making attempts to achieve a greater realization of the shared interests of humanity and the perceived benefits of greater global cooperation. The Copenhagen Consensus is an example of this more holistic forward push in thinking. The Consensus, made up of a panel of the world's leading economists, set out to identify and assess the world's greatest challenges (CCC, 2008). The focus of the Consensus was to examine a list of crisis, and within a fifty billion dollar budget, priorities the most promising opportunities for improvement. Presenting good opportunities, which create a favorable benefit is comparison to cost, was the Consensus's way of creating incentive for action. An analytical framework was constructed, using positive economics to evaluate available literature in ten problem areas, one of them being: access to education (Lomborg, 2004). The panel offered an evaluation which was undertaken by Lant Pritchett, followed by a re-evaluation by T. Paul Schultz and Lodger Wöbmann. Taking into consideration the views of both great supporters and critics, the subject of access to education, as well as the consensus as a whole, has facilitated larger discussion of many pressing global issues while presenting a concrete analysis and plans for action based on the recognition of real constraints. It is undeniable that education is of critical importance in creating inputs that foster development. In spite of this, improving access to education was not ranked as a

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practical opportunity by the Copenhagen Consensus panel. This was not because the issue was perceived as being unimportant, rather it is result of traditional methodologies failing to create significant improvements, which has made the act of spending to improve education quite ineffective.

In order to assess the success or significance of the Copenhagen Consensus's lack of ranking and overall evaluation of the global state of education, we must first understand the framework and overall goals of the project. This will allow us to discard many potential criticisms that may be constructed by those other than the perspective paper authors. The Consensus was, and continues to be, headed by Bjørn Lomborg, former head of Denmark's Environmental Assessment Institute, and a professor at the Copenhagen Business School (Lomborg, 2008). He is well known not only for his work on the Consensus but also as the author of the scientifically scrutinized book *The Skeptical Environmentalist*. In the Introduction of *Global Crisis, Global Concerns*, the published collection of challenge papers edited by Lomborg, the intentions and goals of the Consensus are outlined, as are the constraints and circumstances that helped shape them.

The consensus was developed out of a need for prioritization, which has not been carried out for a number of reasons; difficult to compare alternatives, institutional rigidities, and idealism (Lomborg, 2004). State self-interest, and as a result focuses on doing good areas, areas where solutions are viable and opportunities are present. One of the fundamental reasons for the creation of the consensus, as stated by Lomborg, was based on the idea that academic info should be brought to the general public in order to make a greater contribution to democratic decision making (Lomborg, 2004). This high regard for transparency and democracy can be further witnessed by the consensus's choice to have alternate authors read and critique the original perspective papers written on each of the ten challenges. Ludger Wobmann and T. Paul Schultz both offered commentary and some alternative perspectives to Pritchett's extensive review and

interpretation of the literature written on addressing the lack of education. These perspective papers were meant to stress differences in thinking, uncertainties in priorities, and ensure that no literature was left out of the discussion. This encouraged these additional authors to present an argument for what they felt may have been an overlooked opportunity.

Lant Pritchett, an accomplished academic and Harvard University Professor, was asked to write a challenge paper to give an overview of the dimensions of the challenge of the global lack of education. Pritchett is an expert in the field of development economics, and certainly has a broad familiarity of the challenges of creating more effective educational systems. He has worked on numerous World Bank reports on similar issues and is also co-editor of the *Journal of Development Economics* (Pritchett, 2008). He was also asked, like all other challenge paper authors, to identify practical opportunities for action. Wöbmann and Schultz are certainly authorities on education in their own rights. Wöbmann has researched and written on the role of education and development and is repeatedly cited by Pritchett in his challenge paper. Schultz, who is currently lecturing at Yale, has written dozens of papers contributing to the fields of economic growth and development (Schultz, 2007).

The topic is first introduced through a simplified overview of the article, which is followed by a careful analysis of the large scope and framework of the issue. Increased education has an immeasurable impact on both individual and societal capabilities, both directly and indirectly. The positive benefits that would be received by reaching global educational targets, such as universal primary education as outlined by the United Nations Millennium Development goals, are difficult to predict yet definitely large (UNDE, 2008). This is in terms of not only investment in future incomes but also in the sense of an immediate improvement in human capabilities, and positive decision making choices. The objectives of education, as stated by Pritchett, are “to equip individuals with the cognitive and non-cognitive competencies

necessary for integration into their society, community and the market economy” (Pritchett, 2004). The major obstacles to achieving these types of integrations are identified as being within the areas of school enrolment, attainment levels and actual learning achievements. One could make an argument that within the objective itself there may be another barrier that should be taken into account; in the developing world not all communities are actively engaged in the market economy. Such communities may perceive the returns to education as being fairly low, as the material taught in classes may have little practical application within their traditional lifestyle.

The framework of Pritchett’s analysis was built through addressing “doing good” opportunities by weighing out the costs and benefits of different demand and supply side actions (Lomborg, 2004). In order to do this he reviewed and examined an extensive amount of literature on the effectiveness of certain educational inputs and their resulting outputs across both regions and nations. The reasoning for government involvement in supply side initiatives is recognized; as is the inability of government policy to create a positive model for action and in many cases not even attempt to do so (Pritchett, 2004).

Five different classes of opportunities were identified by Pritchett: physical expansion, improved quality, expanded demand for schooling; through increased income or raising returns, reduced cost of schooling to increase demand and finally the creation of conditions for effective policy action (Pritchett, 2004). These first four opportunities have been recognized by suppliers of education in the past and continue to be taken advantage of by them. The question then to be asked is, “Why hasn’t the global situation improved already if these opportunities are in fact effective?” This is where opportunity five shows its importance. Pritchett argues that if systemic reform takes place then many of the constraints created by the current organization of the production of schooling may be addressed (Pritchett, 2004). Through the use of cost benefit analysis and the results of many independent studies, Pritchett is able to show

the uncertainty of any amount of money, fifty billion included, creating positive gains in education through the proposed opportunities. Input focused opportunities appear to be a poor approach to dealing with performance based goals. Systemic reform to adjust or correct failing or ineffective approaches cannot directly be created through the allocation of funds.

Physical expansion has and continues to be the main mechanism used to address a lack of education in developing countries. Although the creation of schools and presence of teachers and materials are undoubtedly necessary to create a formal education system, Pritchett felt that this opportunity was highly overrated. The variable costs of maintaining and running schools persist after physical expansion has taken place. The actual functioning of schools can be compromised when too much attention is focused on expansion. Even as a mere method of increasing enrollment an assumption is made about the causation between children attending schools and the availability of schools.

It was argued that the reason many children do not complete basic schooling is not because of school availability but because they are not attending available schools, dropping out too early and attaining low achievement levels (Pritchett, 2004). These three factors are examined fairly extensively based on large pool of statistical information. He is able to deduce what certain findings may be proving or masking. Neither Wöbmann nor Schultz make any critical assessments on this particular section of analysis but agree that this particular supply side initiative is of minimal use in finding general solutions.

Enrollment rates alone do not provide information on educational attainment, which is the goal of education. Many key differentiations are not made when looking at this data alone. One is the amount of children who simply never enroll vs. the amount of children who dropout. The other being the gaps in grade attainment based on categories other than gender (Pritchett, 2004). Demographic and Household Surveys (DHS) were able to fill some of these

information gaps and uncover some interesting trends across nations by linking findings on enrollment and attainment levels with socioeconomic conditions.

The three findings offer some insight into the true value of the physical expansion opportunity. First, children with educated parents, who generally have higher incomes, are more likely to be enrolled. Second, gaps in attainment between richer and poorer households are substantial in every country examined. Finally, enrollment and grade attainment aside, the actual learning achievement is unsettlingly low.

The other supply side opportunity that is examined in the Consensus is that of improving educational quality. It was proposed that this could be done through three possible strategies. These are radical expansions in budgets, expansions of specific interventions and finally experimentations with rigorous evaluation (Pritchett, 2004). Radical budget expansions of educational inputs, including those that are focused on quality, have been used by many developing countries to prove their commitment to education (Pritchett, 2004). Unfortunately, increasing spending on inputs to improve quality has proven to be ineffective. Intuition may lead us to believe that this occurrence takes place as a result of the spending being allocated through inefficient channels which are not focused on creating the incentive or motivation for the actors, in this case teachers and students, to improve performance. There is no evidence available that supports the idea that increases in spending have created any of the significant differences in educational quality that have been observed through different geographical areas over time (Pritchett, 2004). Regardless, spending is still necessary and will only help to achieve wider goals if it is focused on inputs that are already proven effective or ones that have been reformed.

This leads us to the next logical step, focusing budget expansion on specific elements that do increase learning achievement. Three different classes of inputs have been identified as showing the potential to accomplish this, they are instructional

materials, and key infrastructure and teacher training focused upon improving their subject knowledge (Pritchett, 2004). The success or failure of such a focus can only be determined on a case-by-case basis. This is because the individual incentive of those involved to actually produce improved results is the greatest factor in varied achievement levels. These are, as mentioned earlier, most significantly created by choices made parents and children. It is likely that in certain cases the reasons for low achievement is not due to a lack of incentive but possibly the lack of books, quality instruction or the absence of materials such as desks (Pritchett, 2004). If these cases can be properly identified then spending focusing on their availability would no doubt be successful. Motivating teachers to push children to achieve higher attainment through financial incentives received after proves success is another way. Finally we move to the third and final supply side tactic, experimentation with rigorous evaluations, which could aid policy makers in identifying cases where the lack of inputs are a main cause of low achievement.

Pritchett feels that this opportunity is quite promising because the funding required for research is comparatively small to the possible gains of improvement (Pritchett, 2004). This generalized solution has the potential to identify the causality of low success rates in specific situations. This could lead to a more successful allocation of funds. Evaluations of these types have been the basis for the arguments made by Pritchett in this paper and have been able to discard the conventional wisdom that has been guiding policies created to improve education. Here we run into another problem, which is that current policy continues to look at inputs and outcomes rather than causality. This is in spite of the availability of many studies which suggest current strategies produce low returns. This suggests that the opportunity to improve evaluations may not actually lead to changes in policy by donors or governments, making the returns to an investment in continued evaluation equal zero (Pritchett, 2004).

Supply side initiatives appear to have little ability to encourage attainment and competencies. A major reason for this appears to lie within the public sectors inability to create an effective model for action. The ability or inability to create such a model and the conditions necessary to begin to do so will be addressed along with opportunity five, which deals with systemic reform. For now we examine the potential of demand side opportunities.

All three authors agreed that demand side initiatives provide much more feasible opportunities for addressing the global lack of education. Raising the benefits of schooling is one way of creating incentive for children to not only attend school but to perform in school and for parents to encourage such behavior. Children that have parents that have received an education and earn higher incomes, or both, are most likely to see the value in education and have access to its benefits. The reasoning behind this phenomenon is arrived at fairly easily, however the empirical proof shows the strength of the relationships across both regions and countries.

Using DHS datasets it can be shown that both of these factors, even when examined independently of one another, are almost always statistically significant (Pritchett, 2004). It is now a commonly accepted view, based upon a wide array of studies, that the education levels of parents determine children's school enrollment to a greater degree than education policy intervention, or supply side tactics. It seems as though the ability of a government to create incentive is intrinsically linked to its economic performance. Increasing the benefits to schooling is largely created by the demand for educated workers, which is limited by the pace of development (Clemens, 2004). Economies that have low levels of growth, or are stagnating, have an equally low or stagnating demand in educated labor. This affect is the same with countries with high rates of growth. Technological shocks were pinpointed in the paper of having the ability to create increased returns to education, growth rates and incentives to attain a certain level of school achievement.

The incentive is created through perceived future private benefits, although public benefits would certainly be incurred as well. These benefits are not created through specific actions but through larger societal improvement and economic gains. Recognizing these relationships and replicating the circumstances in which they take place are unfortunately two completely different matters. Here Pritchett makes a very important point about the focus and ability to control future returns to education, that governments should always undertake policy actions that have positive economy wide impacts, such as an overall rise in GDP, if the opportunity is available (Pritchett, 2004). The creation of such opportunities is not under easy policy control; nor are any other mechanisms that increase the education of parents (Wöbmann, 2004). This goes along with what we encountered earlier in our discussion of supply side initiatives. Increasing demand by increasing supply is not an effective measure when supply cannot be easily created. All three authors agreed that raising the returns to education was an impractical opportunity.

Even in cases where demand for education exists, based on future benefits, it cannot be assumed that parents and children will be able to pay present costs. This is not because of the direct financial costs of schooling but rather the opportunity cost of having a child who would otherwise be contributing to the household, studying in the classroom. When cases such as these are present so is another opportunity to improve educational access. This is the fourth opportunity identified in the Copenhagen consensus, which is, either direct or targeted support to households that lower the costs of schooling.

Lowering the costs schooling will have on a family, in order to increase demand, can be done by either reducing fees or by creating a positive reward system either of which can be targeted at certain groups or carried out across the board (Pritchett, 2004). This opportunity was favored over all the others by Schultz in his perspective paper. He felt it not only had a greater potential to be

realized but also at a lower cost than the other suggested opportunities (Paul, 2004). Like the other opportunities in this particular challenge area it is unlikely that one effective measure can be created so that benefits can be seen in all countries. Current conditions within a country or region need to be examined in order to examine which methods will create the most cost-effective conclusions. Having enrollment rates increase based on universal cost reductions is most cost effective when the ratio of students who would have enrolled without the transfer and those who would not have is as low as possible (Pritchett, 2004).

On the surface, waiving fees appears to create enormous successes in enrollment rates. This should be viewed with caution, as it is not an effective policy measure to increase achievement. Pritchett gave a reason for this, which has, more or less, already been established during the analysis of the opportunity of physical expansion: enrollment responses do not equate to achievement responses. Two other reasons are the intrinsic value of forgone revenues, and the other, the potential, and likely effects of the forgone revenue. If budgets do not compensate for the decrease in available funds it seems unlikely that education programs could maintain their current level of quality. Wöbmann uses a cost benefit analysis and the case of Uganda to highlight the potential benefits of universal fee waivers in very low-income countries where the opportunity cost of schooling is high. His conclusion is that the predicted return per additional year of schooling, when discounted over a lifetime, has the potential for huge private returns that can be achieved by a large fraction of the population (Wöbmann, 2004). He gives these imprecise measures caution, yet still contests that even when costs are overestimated and benefits are underestimated the potential returns should create incentive for universal fee waivers, even when positive externalities are completely ignored (Wöbmann, 2004). Perhaps the constraints in realizing these outcomes are not determined by the incentive created by future benefits but of time preferences. The length of time it would take for families, individuals

and governments to realize the returns to education are substantial, and in low-income countries the income to support such a venture is scarce.

In order to avoid what for many countries, particularly those of middle income countries with large income disparities such as those in Latin America, would be a very cost ineffective policy of universal fee reduction, targeted and conditional transfers have been implemented. A poverty reduction program carried out by the Mexican government called PROGRESA has been distributing such transfers to improve not only education but health and nutrition since 1997 (IFPRI, 2002). The program targets its transfers towards those who are most marginalized, the rural poor. Transfers are given to mothers of poor families under the conditions that they take part in educational health workshops, the children in their household are attending school on a regular basis, and finally that all family members make regular health center visits (Green, 2005). The extended reach and success in raising levels of human well-being have allowed for initiatives like PROGRESA's to spread throughout other parts of Latin America. Pritchett is critical of programs such as these, because from an economic point of view they are not the most cost effective ways to improve schooling. He points out that the total public sector cost of implementing education initiatives through PROGRESA was double the current average cost per student beforehand (Pritchett, 2004). This criticism certainly overlooks the goals of development and the externalities outside of education which the program creates. If the goal of the Copenhagen Consensus is to find solutions to global problems that compromise the welfare of human beings, then increasing education is merely a means to the types of ends that transfer initiatives like those of PROGRESA are trying to create. This is not to make the generalization that conditional transfers are an effective way of increasing education across the board. PROGRESA's own impact reports suggest that the program increases the number of children who enroll in school but does not show a significant impact on the time children spend in

school or on the time they spend after school on homework (IFPRI, 2002).

The final opportunity proposed within the Consensus was systemic reform. This was the solution that Pritchett believed would trump all of the other opportunities if it could be properly executed. Pritchett called for clear objectives, autonomy to manage results, sustained adequate financing and accountability as the measures needed to make an education system work (Pritchett, 2004). Schultz was highly critical of this being a legitimate solution and suggested that perhaps the focus should go towards what the necessary conditions for reform would be (Paul, 2004). He also noted that there was no cost benefit analysis mentioning the cost effectiveness of this approach, which more or less ignores the platform of the Consensus. Schultz also points out the barrier of vested interest. This is certainly a huge problem anytime any type of systemic reform is proposed. Another problem with creating systematic reform is rule based rigidity, which is present within all bureaucracies. The incentive systems that exist within governments and organizations are not easily manipulated.

## II. CONCLUSION

The Copenhagen Consensus was successful in pointing out that the challenge of education, much like all development challenges, are much more complex than was initially assumed by project planners and policy makers. It was also successful in pointing out what should be taken into account in specific situations before planning for improvement should begin to take place. Unfortunately, many of these solutions are in the hands of governments and organizations that already have incentive systems in place that are not easily altered. Instead of approaching these issues from the top down they can be approached from the bottom up. The challenge of increasing education certainly has its complexities but varying complexities exist within countries and regions as well. Every

situation will require multiple assessments before what might work can be established. Pritchett's challenge paper and the reflections by Wöbmann and Schultz can certainly provide a good starting point.

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# SASKATCHEWAN'S URANIUM ROYALTY AND IMPLICATONS OF CHANGE

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## I. INTRODUCTION

Politically, uranium is an explosive topic. Yet the industry remains an important one for Saskatchewan – and following Prime Minister Harper's February 2012 agreement to increase uranium exports to China, its usefulness as an asset continues to grow. But is the province positioned to get the most that it can from this resource? The Saskatchewan NDP claim this is not the case – and made it a central tenet of their 2011 election platform. In their policy report *A Rooted and Growing Vision* and subsequent television ads, the NDP argues that the government should “charge more royalties” on the extraction of uranium. In an industry as capital-intensive as mining, such decisions can have profound implications for both firms and the province. Accordingly, it is in the public interest to clarify the precise nature of the royalty as it is, and to explore the implications of the NDP's proposal. Little in the way of academic literature on Saskatchewan's uranium royalty exists from recent years, though it received a great deal of attention in the early 1980s. At the time, a general consensus came about that the two goals of mineral royalty policy should be tax neutrality and the assurance of a minimum return on extraction. In order to accommodate NDP political philosophy, we discuss the party's proposal in light of a third objective, that of maximising government revenues. To begin, let us examine the uranium tax scheme as it exists.

## II. OVERVIEW OF THE SASAKATCHEWAN ROYALTY SYSTEM

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The Saskatchewan uranium royalty has two components: a basic and a tiered royalty. The basic royalty is a traditional *ad valorem* tax of 5% on gross sales minus a 1% resource credit for a net of 4%. The net basic royalty is not a credit against tiered royalties. Tiered royalties increase in a progressive scheme as follows:

<b>Table 1</b>	
Tiered Royalty Rates for Uranium (U <sub>3</sub> O <sub>8</sub> )	
Average Price/kg U <sub>3</sub> O <sub>8</sub> (indexed annually from 1999 values)	Royalty as a % of Revenues within the bracket
Less than \$30	0%
\$30 - \$45	6%
\$45 - \$60	10%
Greater than \$60	15%

Revenues falling within each tier exclude revenues subject to other royalty rates. The revenues eligible for tiered royalties are discounted by withdrawals from a 'capital recovery bank' intended to allow for full recovery of capital investments. The balance of this account is not determined by actual expenditures, but on 'standard allowances' for particular investments as follows:

<b>Table 2</b>
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Capital Recovery Bank Allowances (indexed annually from 1999 values)	
Open Pit Mine Development	\$45 / kg of annual capacity
Underground Mine Development	\$60/ kg of annual capacity
Mill Construction	\$80/kg of annual capacity
Mill Expansion (minimum 25% expansion)	\$50/kg of expanded capacity

The capital recovery bank is adjusted for inflation, where the balance of the CRB is multiplied by the ratio of the price index for the previous royalty year over the price index for 1998, when the figures were set.

Of the nine types of rent taxes identified by Garnaut and Clunies Ross (1983), the Saskatchewan system is best characterised as a modified resource rent tax (RRT). An RRT deducts expenditures against revenues in the year which the expenditure was incurred, focusing on net cash flows. If expenditures exceed revenues and cash flows are negative, as they are likely to be in years of heavy investment, the negative cash flows are carried forward at a rate reflecting the return on capital required by a firm when making an investment (Garnaut 2010). However, Saskatchewan diverges from a classic RRT in significant ways. For one, the CRB, the mechanism reflecting deductions based on negative cash flows, is carried over at a rate unlikely to compensate for the opportunity cost of investment. The CRB balance is adjusted only for price-indexed inflation, rather than at a typical ‘threshold rate’ which incorporates a normal return. Secondly, net cash flows are fully estimated. The CRB is credited based on standard allowances rather than actual costs, while tiered royalty payments are based on revenue

expectations associated with average prices of uranium. The existence of a graduated royalty is a divergence from classic RRT in itself. An RRT is usually modeled with a constant tax rate, and graduated systems classified differently as progressive profit tax schemes (Garnaut and Clunies Ross, 1983). Yet, the most substantial deviation is the basic royalty. As it is applied to gross sales and not profit, it is thus at odds with the RRT principle that taxes are paid only in years of positive cash flow; this will have substantial implications for the neutrality of the tax.

### III. GOVERNMENT REVENUE MAXIMISATION

With the NDP's claim that the government must "charge more royalties" on uranium extraction so the province "can invest more in hospitals, schools, and families," it is clear that the party's primary concern is not necessarily to maximise social welfare, but particularly to maximise government revenues. This assumption is consistent with the historical approach of the NDP-CCF, which gained a reputation for pursuing mineral rent appropriation in the 1970s (Anderson and Barnett, 1983). When a government acts with the purpose of maximising revenue from the sale of its resources, it behaves as a firm in the marketplace. Royalty taxes represent the price of the product. Buyers, which are mining firms, determine their desired amount of investment based on the price. Higher taxes decrease the profitability of projects by increasing their cost, and therefore deter investment in ventures of low profitability or high risk. Therefore, the orthodox condition for maximising total revenue is that taxes be set such that the price elasticity of investment demand is exactly one.

However, Garnaut and Clunies Ross dismiss the simple trade-off between "heavy taxation, which discourages mining, and light taxation, which yields little in the way of revenue" (1983:1). They place particular emphasis on neutral taxation, an attempt to collect economic rent without distorting the investment decisions of a profit-

maximising firm (Kwon, 1983). The crux of their argument is that social welfare is best served by avoiding deadweight losses. As they write, “a more efficient allocation of resources within the government’s jurisdiction implies a higher real income in that economy at large, and this on the whole means more taxable capacity” (Garnaut and Clunies Ross, 1983:87). For this reason, Garnaut asserts that tax neutrality is “an accepted ideal in any system” and is the key to governments seeking to maximise welfare (2010).

### *Tax Neutrality*

Typically, RRT are thought to be nearly neutral on mine development and expansion, as the revenue it collects is likely to be concentrated on income in excess of the investor’s minimum return requirement (Garnaut, 2010). To the extent that the majority of taxes are applied on an assumption of operating profit, and that capital expenses are assumed to be recovered, Saskatchewan’s uranium royalty scheme is expected to be largely neutral. However, this evaluation rests on a number of assumptions, not the least of which is the assumption that estimated cash flows are accurate interpretations of their real counterparts.

The 4% net basic royalty is clearly not a neutral tax, and will reduce the quantity of investment undertaken in the province. As it can be regarded as an addition to unit cost, it may result in areas of the ore deposit being neglected, as higher-cost portions will become uneconomical on the margin (Campbell and Wrean, 1984). Kwon (1983) notes this effect will be particularly significant in times of falling uranium prices, and may result in portions being abandoned forever, as it may not be possible to restart production in the future once a project is ended.

On the other hand, the tiered royalty has the capability to be neutral. Garnaut clarifies that “the quest for neutrality in taxation reduces itself to finding ways of extracting no more and no less than

what is called the economic rent . . . [for] the economic rent can be extracted by the owner of the resource or taxation authority without affecting the amount of investment” (2010). Saskatchewan’s standard allowance system assumes a certain level of economic profit based on average prices of uranium (Table 2). To the extent that these allowances are a correct representation, the tiered royalties will focus on economic profit, and therefore be neutral. In addition, standard allowances encourage good business practice, and significantly limit government revenue vulnerability to suboptimal operations. Allowances are therefore an improvement over an RRT tied to operating profits, although there exists a danger that firms may cut costs by increasing externalities, including environmental harms. Unfortunately, without experimentation, it is difficult to determine the ideal values for each bracket.

This uncertainty is exacerbated further by complications in remunerating capital for the purpose of neutrality. The condition underlying neutral taxation is that all costs incurred in undertaking a project can be deducted against taxable income (Campbell and Wrean, 1984). In order to be consistent with tax neutrality, these costs should be obtained by accumulating annual investment expenses compounded by the threshold interest rate (Kwon, 1983). However, as discussed earlier, the balance of the CRB is carried over at a rate only sufficient to cover inflation, and therefore does not ensure a normal return on capital. The consequence of this policy is that normal returns on investment must come from the profitability of the venture itself. It is a rather inaccurate way of ensuring an adequate or desirable return on capital. Doing so increases the risk to investors, as they are unsure of receiving their required minimum (threshold) return, which deters overall investment in the province.

The implicit requirement that operating profits cover the return to capital makes it difficult to distinguish what portion of total profit is economic profit, and what an investor can rightfully expect as a return on their investment. This leads to possibilities that (a) government tax levels are too low and allow for an unnecessarily

high return to capital; or (b) that tax levels are too high and, by subjecting normal returns to taxes meant to capture economic profit, will punish investors. If either of these situations exist, it will affect the production function. An unproportionally high return on capital will result in a substitution of labour for capital, while the opposite situation in (b) will result in a substitution towards labour and away from capital.

In the royalty regime enacted by Allan Blakeney in 1976, outstanding expenditure claims were grossed up by multiplying them by an interest rate factor which is that year's average prime rate, plus 10% of the prime rate – in other words, 110% of the prime rate (Holland and Kemp, 1978:236). This type of valuation is more typical in RRT systems. Reinstating this form of compensation would ensure investors receive a fair return, thus leaving governments free to tax profits without the worry that doing so will affect investment decisions. For the purpose of neutrality, it would be preferable to increase the CRB multiplier and tiered royalty rates rather than to continue with the current balance.

Alternatively, this problem can be simplified if one assumes the initial CRB credit includes a margin for normal return. Approaching the problem thus, a government need only be sure the given figures accurately reflect the actual and opportunity costs of investment. If not, similar substitution problems will emerge and firms will begin substituting between capital and labour. At the same time, reliance on a fixed-figure solution will magnify the implications of such a system. Most importantly, fixed-figures encourage firms to cut capital investment costs, as their CRB balance is credited in at a uniform rate based on output regardless of the specific nature of the investment. This leads firms to choose the cheapest capital available, which may be the least environmentally friendly. It may also be to the disadvantage of the province in the long-run, as firms do not have the same incentive to purchase the new technology as they do when credits are based on actual costs. However, these problems will exist so long as the province relies on

fixed figures at all. On the whole, the easiest way to achieve tax neutrality is to ensure that the standard allowances are an accurate representation of all costs of investment, including the opportunity cost.

Without empirical analysis, it is challenging to determine the overall effect that the NDP's proposal to "charge more royalties" would have on government revenues and total welfare. Increasing the rate of the basic royalty would make the taxation system less neutral, and would decrease total investment in the province. Its effect on government revenue maximisation depends on the price elasticity of investment demand. If demand is relatively elastic, total revenue will fall; if inelastic, total revenue will increase. These conclusions are impacted by the existence of the CRB and the tiered royalties. Reducing CRB allowances for investment will cause producers to invest less and substitute capital for labour, but net government revenues may be unaffected if the savings may offset the loss in investment quantity. Raising tiered rates will have the least effect on the neutrality of the tax regime, so long as an assurance is made that investors will recover a normal profit from their capital investment, because payments are dependent upon the assumption of profitability.

### ***A Minimum Return***

The second objective associated with mineral royalties is that of guaranteeing a minimum return on extraction to the Crown. Anderson and Barnett (1983) understand this as a political rather than economic objective, and explain that it allows a government "never to be seen giving away society's nonrenewable resource base." Kwon (1984) goes further and characterises the desire for a minimum return as a constraint on the goal of tax neutrality, as governments seek to avoid the possibility that firms will depart when capital costs are recovered, thus providing no tax income to the province. The basic royalty achieves the objective of a minimum

return at the expense of neutrality, though the NDP may still believe this minimum to be too low based on its political leanings. As previously discussed, raising the basic royalty rate may increase or decrease total government revenues. To offset the effect of an increased basic royalty, the NDP might make this basic royalty payment deductible from graduated royalty payments, so as to avoid double taxation. Politically, this may also be easier to sell to fiscal moderates.

#### IV. CONCLUSION

The Saskatchewan uranium royalty is a modified RRT. It differs in that (a) CRB balances are not increased at a threshold interest rate, and thus do not cover the opportunity cost of investment, though this cost may in fact be covered by the allowance itself; (b) cash flows are estimated and not based on actual figures; (c) a graduated royalty exists to capture economic rent; tax rates increase with the average price of uranium, assuming increased economic profits (d) a basic royalty is required on all sales, including in years of negative cash flow. The system as a whole is likely to be largely neutral, so long as these approximations are accurate representations of cash flows. The existence of the net basic royalty is not neutral, but guarantees the province a minimum return for the extraction of its uranium. While there is room to improve the tax scheme, it is uncertain if the NDP's proposals will have their intended effect – to maximise government revenues from the extraction of uranium. Violating the principle of tax neutrality may not only deter investment with sufficient effect as to reduce total government revenues, it may also reduce the social welfare of the province and create deadweight losses. The overall desirability of incurring these losses is therefore normative, and may be more acceptable to a socialist government than to others.

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# A CRITICAL LOOK AT THE ISSUES IN ENVIRONMENTAL POLICY DEBATE

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## I. INTRODUCTION

The body of literature encompassing the debate regarding economic approaches to the climate change problem spans, at most, twenty years. Throughout the twentieth century, environmental activism never deigned itself to be of a single cause. From the repercussions of agrarian chemical use in the sixties, to alarm over the shrinking ozone in the eighties, not long after one ecological disaster in the making was addressed would another pop up, like a dangerous carnival game. The rise of global climate change as a primary concern for ecological sustainability in the 1990's brought with it applied interest in the repercussions of legislative solutions to the problem. Various policy instruments have been debated just as rigorously throughout the economic literature as in the House of Commons. Now, some twenty years after this conversation began, though legislative impasse in North America has made it clear that political consensus is still a long ways off, the Economic community has seem to come to a, though admittedly imperfect, partial agreement.

In order to discuss the development of the Economic literature it is necessary to understand that climate changed remained a point of science outside the zeitgeist prior to the early 1990's, which contributes to why it remains outside the "beltway" to the day in Washington, and why it remains anathema to many special interests and a pariah to political debate.

Research into the potential existence of human-induced climate change began as early as the late 1800s, but findings indicating a potential danger associated with human emissions were

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not only debated but largely ignored during the early twentieth century (Weart, 2008). It is apparent that the historically sparse body of economic research on the subject of climate change is attributable to the lack of incentive. The previously inconclusive scientific research had insured that the phenomenon was a non-issue in the political world and rendered economic analysis unnecessary and infeasible. However, recent years have brought increased scientific certainty, and with it popular opinion. Since the 1990's there has been growing concern about the potential consequences of climate change that has become majority opinion in many countries of the western world. To illustrate current consensus, or lack of consensus, Giddens (2008) outlines three primary positions on climate change. The position of the skeptics is that climate change may not be a real issue, and that evidence of the phenomenon is inconclusive. On the other hand, the radical view holds that sudden changes in the climate could possibly or even probably occur in the future, having potentially disastrous consequences. Lastly, the mainstream view could be characterized as that of the Intergovernmental Panel on Climate Change (IPCC), that it exists, it is manmade, and the consequences, though unknown, could possibly be great (2007). This is the most prominent view in both the public and the scientific community.

The acceptance of the existence of a problem does not necessarily resolve what to do about it. The sheer magnitude of undertaking a global solution implies immense social costs that may outweigh any future gains. The literature under review in this article spans the development of proposed solutions, the costs and benefits of each, and the eventual politicization of each approach into dogmatic camps. Where the natural sciences have promoted the costs of inaction, or the status quo, upon the environment and the earth, the Economists and social scientists have concerned themselves with the costs of addressing, or not addressing, the problem in social concerns; studiously avoiding any normative declarations.

## II. THE DISCOUNT RATE AND THE DANGERS OF DOGMATIC DISCOURSE

Goulder and Pizer, in their article “The Economics of Climate Change”, divided the negative consequences of climate change into two primary categories (2006). Non-market damages embody the first category and, as the name would suggest, these damages do not take on a market value but instead represent welfare losses attributable to a decrease in some non-monetary resource such as environmental beauty. Because the presence and severity of these damages is usually subjective, they are exceedingly difficult to quantify even with the use of qualitative approaches. Market damages, on the other hand, can be quantified and result from changes in the price and quantity of commodities as a consequence of climate change. Unlike non-market damages, they can be easily measured and are thusly better suited to the quantitative nature of economic research. Moreover, market damages represent the type of problem that is central to the discipline of economics, while non-market damages seem better suited to other social science disciplines.

In the field of economics, quantifying the negative effects of climate change is exceedingly difficult due to the numerous elements of uncertainty surrounding the phenomenon, and thus it is difficult for researchers to reach a consensus on what social discount rate should be used. Weitzman (1998) has argued that the substantial uncertainty surrounding the “distant future” phenomenon of global warming dictates that the relevant discount rate should be below that used for “near future” discounting. Since the probability distribution of any event approaches zero as they become more distant, only the most extreme minimum limit of the discounted interest rate becomes stochastically relevant.

The Stern Review on the Economics of Climate Change, presented by the British government in 2006, expanded upon this and coined climate change as representing “the biggest example of

market failure ever" (HM Treasury, 2006). As one would expect from such a strongly worded statement, the discount rates used in the study were near-zero. Critically, Nordhaus (2007) argues the low discount rates used in the Stern Report were the underlying reason for the strong results about the severity of climate change. He explains that when discount rates are used which are more representative of near future, traditional discount rates, the results of the study change dramatically. As will become clear throughout this exploration, the lack of unanimity on the validity of key assumptions is the source of most argumentative discourse in the field. Indeed, the Stern Review concluded that extreme measures were necessary to combat climate change, while one of the most agreed upon findings of economic research in the area is quite to the contrary: the most efficient economic policies to combat climate change are those that take place gradually over an extended period of time and whose imposed reductions increase in future periods (Nordhaus, 2007).

From the perspective of classical growth theory, Nordhaus' claim - that the market rate of return should be considered when calculating the discount rate - does not hold the same merit. Michl (2010) argues that the focus should not be on adopting capitalist preferences (that of discounting future generations) and that it is not reasonable to base assumptions on current economic data, as Nordhaus proposed. Michl advocates that the findings of the Stern Review could indeed not only be relevant but also accurate in its assumptions.

Despite this seemingly endless debate, the discount rate represents one of the smaller issues in the economics of environmental policy. Another, more substantial, area of study is that of the policy mechanisms that might be adopted as a solution to the problem.

### **III. POTENTIAL POLICY INSTRUMENTS FOR CLIMATE CHANGE**

The increasing public and scientific interest of recent decades in the issue of climate change has resulted in an abundance of research regarding potential methods for reducing emissions. The most obvious of these is strict regulation in which emissions are controlled with restrictions. However, as early as Pigou (1932), it has been shown that regulation is a suboptimal instrument for the control of negative externalities.

With regulation being an unappealing option, two potential categories of market based instruments for emissions reduction remain: Price based mechanisms, such as a carbon tax, and quantity based mechanisms, such as a tradable emissions scheme. In a paper arguing for more consideration of politically feasible mechanisms, Pezzey and Park (1998) outlined four main types of non-mutually exclusive market based instruments for emission control. These four categories of mechanisms were tax-reducing, zero-revenue, hybrid, and environment-subsidizing. In the tax-reducing case, the revenue obtained from the market-based instrument would be recycled by way of reduction in some distortionary tax in the tax system. Conversely, in the zero-revenue case, tax-free allowances or freely allocated permits would be given out, with no revenue resulting from such a policy. A hybrid instrument would be some combination of these two scenarios. Lastly, an environment-subsidizing MBI would be any type of tax with which the revenue raised is then put towards additional environmentally beneficial activity, either directly through funding or indirectly by making available some sort of subsidization as an incentive to further promote changes such as more efficient production technology in firms.

Notably, three of these four types of market-based instruments can be implemented as either a price mechanism or a quantity mechanism, with environment-subsidizing instruments being the exception (implementable as a price mechanism only). Beyond this, there are further modifications to quantity-based mechanisms that can be made. One of these suboptimal variations of cap and trade mechanisms is a safety valve instrument in which a

soft emissions cap is set and permits are allocated as usual, with the exception that when the permit price exceeds a maximum price, predetermined by policymakers, unlimited permits are then made available for auction at the maximum price. In this case, when demand reaches a certain threshold the cap and trade system essentially becomes a price mechanism. Another potential variation of cap and trade is the adoption of an indexed cap in which permit allocation is based upon on some quantifiable aspect of the economy (such as GDP) rather than on predetermined emissions limits (Webster, Wing, and Jakobovits, 2010).

The evaluation of the many potential policy choices reveals that the relevant question is not just to what degree to impose a cost on the negative externality (carbon emissions, in this case) but also in which way to impose it. The costs and benefits of price and quantity mechanisms are not simply one-dimensional; they range from more qualitative aspects such as potentials for misrepresentation and gaming to more clear-cut ones such as relative welfare effects. Weitzman (1974) determined that an advantage of using one mechanism over another would occur only in the presence of uncertainty (in a second best situation) and that in this case, the ideal choice of instrument would depend on the slope of the marginal cost and marginal benefit curves. The results of the study are summarized in Table 1.

**Table 1 - Comparative Advantages of Instruments under uncertainty (based on the findings of Weitzman, 1974)**

<b>Marginal Cost curve linear or near linear</b>	Small miscalculations have large effects, resulting in potentially disastrous consequences (price mechanism)
<b>Marginal Benefit curve sharply curved</b>	Small miscalculations have large effects, resulting in potentially disastrous consequences (price mechanism)
<b>Marginal Benefit curve linear or near linear</b>	Marginal social benefit near constant (price more attractive)
<b>Cost function sharply curved</b>	No significant economic difference between mechanisms

In situations where there is a large potential for error or inconsistency in emissions control with a particular instrument, opting for the less risky mechanism would appear to be the logical choice and one might think for this reason that a quantity based mechanism would be adopted in most situations. However, because climate change is such a long-term phenomenon, it makes sense intuitively that the instruments implemented to reduce climate change will not have immediate benefits, and indeed it has been found that the marginal benefit curve of this reduction is fairly flat (see Kolstad, 1996).

This assumption of flatter marginal benefit curves is generally accepted and adopted in the majority of research, and for this reason most research concerned primarily with economic cost-benefit analysis of market based instruments for emissions control will favour a price mechanism over a quantity mechanism. However,

recall the radical view on climate change as outlined by Giddens (2008) that sudden changes in climate could possibly or even probably take place in the future. In this hypothetical scenario, the marginal benefit curve of emissions reduction would prove to be steeply curved, and thus a quantity mechanism would likely be favoured. From this it is evident that the primary assumptions underlying economic analysis have a substantial impact on the results.

Nevertheless, as previously mentioned, the factors affecting the choice between instrument types are not limited to those that can be easily calculated. Despite the relative efficiency of price mechanisms, the certainty surrounding the overall level of emissions is an appealing aspect of quantity mechanisms and it is for this reason quantity mechanisms are preferred by many environmentalists (Goulder and Pizer, 2006). Intuitively, however, this set emissions cap could result in large fluctuations in energy prices during business cycles due to the fact that emissions cannot be temporarily raised to adjust to increasing demand. The aforementioned adaptations to quantity based mechanisms such as safety valves and banking and borrowing can be added to avoid extreme volatility in energy prices, but this introduces new issues. If the hard cap on a cap and trade policy is essentially removed, then the appeal of a set limit on emissions no longer exists. Furthermore, if banking and borrowing is implemented it could provide incentive for polluters to borrow against future years in order to emit more in earlier years when the technological changes that would need to be implemented in order to reduce emissions in the future would not, or could not, be planned for. The prevention of this type of gaming is an example of one of the potential policy challenges that could be expected in this scenario.

The allocation of de facto pollution rights (grandfathered tradable emissions permits, or a tax deduction, as discussed above) could also present a problem depending on how these rights are administered. Granting these rights (or a percentage of them) based

on emissions prior to the policy could be viewed as an incentive for firms to pollute excessively in the time period prior to policy implementation in order to be granted more property rights. In this case, firms would essentially be rewarded for higher emissions and, depending on the severity of this problem, the overall effectiveness of the policy could suffer.

Another issue with the free allocation of permits is the resulting implications for firm profits. In a study focusing on the U.S. economy, Goulder, Hafstead, and Dworsky (2010) utilized a general equilibrium model in order to assess the implications of various allowance allocations in a cap and trade system. Specifically, they focused on the most energy intensive production industries of the U.S. Surprisingly, it was shown that freely allocating as little as 15% of available emissions permits to these particularly vulnerable production industries was sufficient to prevent losses in these industries. Accordingly, freely allocating the majority (or all) of the available permits resulted in unusually high firm profits, which evidently is not the goal of implementing such a policy. Despite this, even when firm profits are artificially inflated by such a policy there is nevertheless an incentive to reduce emissions in order to further increase profits, so one cannot assume that a policy being inefficient also renders it ineffective. Consistent with the literature, it was also found that the benefits associated with the auctioning of permits in order to reduce distortionary taxes (a revenue-neutral auction) were not present when revenues were instead redistributed in a lump sum fashion, a concept which will be revisited in relation to the double dividend hypothesis.

With the multiple flaws associated with most quantity based mechanisms, the economic efficiency of a carbon tax is appealing, especially when welfare could potentially be increased by using the revenue from the tax to finance a reduction in some other distortionary tax. This is the idea behind the double dividend hypothesis, which became hugely popular during the 1990s as the subject of economic research. However, for reasons that will later

become evident, in the last decade there has been a marked shift of interest cap and trade policies which are often touted as being more politically attractive. Despite this, many economists still advocate a carbon tax as the most effective strategy to control climate change.\*\*

#### IV. THE DOUBLE DIVIDEND HYPOTHESIS

With economic theory clearly indicating the efficiency of price-based mechanisms for emissions control, under standard assumptions, the concept of environmental taxation was widely examined in recent decades. Despite the relative efficiency of taxation, however, the welfare costs resulting from the implementation of such a tax remained. Because the solution of a traditional Pigovian tax, where the tax rate is representative of the marginal social damage of an externality, is obtained only in a first-best setting, a slightly different approach is required for a second-best scenario in which tax interaction effects are present. Nevertheless, with a second-best optimization model it can be shown that a modified form of Pigovian taxation can hold even in a situation where distortionary taxes are present (Sandmo, 1975).

In time, a theory emerged of a potential “double dividend” effect in certain cases of revenue-neutral taxation. This effect would occur in the hypothetical case where a tax on carbon emissions is implemented and the resulting revenue is used to finance a reduction in some existing distortionary tax. The intuition behind this double dividend hypothesis is that the first dividend constitutes the increased environmental sustainability resulting from the reduction in carbon emissions due to the increased cost of producing the negative externality, while the second dividend is the increased in social welfare resulting from the reduction in distortionary taxes (Goulder, 1995).

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\*\* See, for example, Nordhaus, 2010.

From simple observation, it is intuitive that the first dividend will hold. Because it is a general assumption that a reduction in carbon emissions will benefit the environment, the only thing left to prove is that a tax on carbon emissions will induce polluters to change their behaviour and utilize less carbon. This follows from economic theory since such a tax will effectively increase the cost of all activities requiring carbon as an input, causing economic agents to find a new, and lower, optimum level of carbon consumption. Although one could argue that in substituting away from carbon, producers might employ other environmentally damaging inputs in production, this is not an argument that is generally accepted. Indeed, a sizeable portion of double dividend literature considers the potential substitution towards a more labour-intensive production optimum as a benefit of carbon taxation, especially when the research is predominately concerned with areas with high unemployment.<sup>††</sup>

Evidently, if the first dividend generally holds without exception, any debate regarding the validity of the double dividend hypothesis must center on the magnitude (or existence) of the second dividend, and naturally this is the case. The second dividend can be classified, as Goulder (1995) does, into three different forms. The weak form claim is simply that by recycling the revenue from a carbon tax in order to reduce some other distortionary tax, the resulting savings are roughly equivalent to those that would be obtained had this revenue been redistributed in a lump-sum fashion. As Goulder emphasizes, the weak form holds logically because it essentially follows directly from the definition of a distortionary tax, and this weak form is therefore neither controversial nor particularly interesting. Rather, the subject of interest is whether the revenue recycling as discussed above could result in a negative or nonexistent overall cost of the environmental tax. The intermediate form claim is

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<sup>††</sup> See, for example, Koskela, Schöb, and Sinn (1999), where the environmental tax reform is proposed as a possible option to help combat Europe's high unemployment rate and decreased international competitiveness.

that this would be the case for at least one distortionary cost in existence, and the strong form claim is that this would be the general case. The appeal of the double dividend hypothesis is that if the strong form were found to hold true, the magnitude of the difficult-to-quantify environmental benefits associated with the first dividend would not need to be proven in order to justify the implementation of a carbon tax because the tax would itself be costless.

As one would expect, most double dividend literature is centered on determining whether the strong form of the second dividend can exist, and, if so, under which circumstances. The majority of researchers have used static general equilibrium models in order to meet this objective; a model used by Bovenberg (1999) is representative of those utilized by most researchers. This model, based on Bovenberg and de Mooij (1994), assumes that the labour market is the only market in which distortion is present, and that labour is the only factor of production. The output produced in the goods market can be utilized either for public consumption (represented by  $G$ ) or for consumption by households in the form of either a clean good ( $C$ , which produces no negative externality) or a dirty good ( $D$ , which produces a negative externality). This, equilibrium in the goods market can be defined as:

$$(1) \quad NL = G + NC + ND$$

Where  $L$  is per-capita employment and Where  $N$  is the number of representative households, whose utility function is represented by  $u = u(M(Q(C,D), I-L), G, E)$ , where  $E$  indicates environmental quality, which declines with the consumption of the dirty good. These households face the following budget constraint with  $tD$  as a tax on the dirty consumption good, and  $tL$  as a distortionary tax on labour supplied. These taxes are used to finance government spending.

$$(2) \quad C + (1 + tD)D = (1 - tL)L$$

Government revenue can be represented by:

$$(3) \quad G = tDND + tLNL$$

One key assumption of this model is that households disregard environmental externalities and therefore show no preference for the clean good. Naturally, this is a questionable assumption although it is not treated as such. Solving the household optimization problem will result in the following conditions:

$$(4) \quad uc = \lambda$$

$$(5) \quad uD = \lambda(1 + tD)$$

$$(6) \quad u1-L = \lambda (1 - tL )$$

Additionally, the total differential of utility  $U(C, D, 1-L, G, e(ND))$  shows the effect on overall welfare from the introduction of a revenue-neutral tax, where the revenue is used to reduce the tax rate of some other tax.

$$(7) \quad du = uCdC + uDdD - u1-LdL + NuE eNDdD$$

By substituting the first order conditions from the household optimization problem into this expression and then eliminating  $dC$  and rearranging, it is possible to obtain the following equation, which represents the resulting economic changes from a change in taxes in a second-best setting:

$$(8) \quad \frac{du}{uc} = -\frac{uE}{uc} [N(-e_{ND}dD) + [t_L dL + t_D dD]$$

At this point it is helpful to introduce some definitions. The tax interaction effect is defined as the increase in the cost of the tax

being implemented that occurs as a result of interaction between the new tax and the existing distortionary tax (or taxes, if more than one distortionary tax is present in the economy). The revenue-recycling effect embodies the increase in welfare that occurs due to the decrease in distortionary taxation that accompanies the implementation of the revenue-neutral tax. (Goulder, 1995). In equation (8), the left hand term inside brackets in the solution represents the net of these two effects. The term to the right represents change in welfare that occur as a result of the change in environmental quality, which as previously discussed is difficult to quantify and is not the primary concern of the research. This general procedure is similar to that used in a large body of research and exemplifies the underlying effects that are analyzed in general equilibrium models.

Using the results of this derivation, Bovenberg analyzes the effects of the revenue-neutral tax on employment, which is essentially the analysis of the revenue-neutral tax's effect on the first term of (8), and finds that there is no overall effect on employment from the introduction of a revenue-neutral carbon tax which finances a reduction in labour taxation. Furthermore, he finds that if initial environmental taxes are positive rather than nonexistent, an increase in this tax rate will actually decrease labour supply due to the change in their real after-tax wage. This finding represents one of the primary reasons why the strong double dividend claim fails in the majority of the literature.

At the margin, distortions in favour of leisure will consistently result in a reduction of overall welfare, and by increasing the cost of goods the environmental tax is essentially an implicit tax on labour, resulting in said distortion (Pezzey and Park, 1998). Clearly, though, this finding depends on the assumption that the labour supply is elastic, otherwise an implicit tax on labour would not necessarily function as a significant disincentive to labour. However, it is likely that this is not a reasonable assumption, as studies have shown that the labour supply is in fact inelastic in many

situations. Furthermore, even in the case that such an elastic labour supply exists, there is no evidence to prove that the average worker would view the situation in the way that economic research seems to suggest. While a reduction in labour taxation will be directly associated with labour and hence serve as motivation to participate in the labour force, given the present assumptions regarding elasticity, the corresponding increase in the price of the dirty good is not as readily considered in decisions concerning labour participation. Intuitively, even if this price increase is a consideration, it could not possibly have as great an effect as the corresponding direct reduction in labour taxation. Bovenberg states that because the higher price level of the dirty good serves as a disincentive for its consumption, government revenues decrease, causing the labour tax reduction to decrease as well. He claims that "the associated adverse implications for public revenues imply that the government is not able to reduce the tax rate on labour sufficiently in order to offset the adverse effect of a higher pollution levy on the real after-tax wage. The resulting lower income from an additional unit of work reduces labour supply and thus employment." (1999, p. 427) However, if the difference in human perception between a direct change in a labour tax and an indirect change in the price level could be quantified, the definition of what would be "sufficient" to offset the aforementioned adverse effects would surely change. From this it is easy to see why the double dividend debate eventually became unpopular; the assumptions that ultimately underlie the less promising results are difficult to change even if they may be flawed.

Additionally, in a prominent paper on the subject, Bovenberg and de Mooij (1994) imply that because the optimal environmental tax falls short of the Pigouvian level (the level of marginal damages), the overall effect will be damaging to the environment. However, Metcalf (2000) argues that the focus of most of the literature is misguided, and that instead of focusing on the tax system, research should instead be concerned with the actual changes in emissions that result from such policies. He proposes that changes in

environmental quality result from the net of two effects: an output effect (substitution towards leisure) and a substitution effect (substitution between clean and dirty goods). He constructs a model to show that for most realistic parameter values, the former effect dominates and the resulting increase in required tax revenues is actually likely to promote a cleaner environment. <sup>‡‡</sup>

Several other researchers have attempted to explore the double dividend hypothesis with different initial assumptions or from different perspectives. One major flaw in much of the earlier research is the exclusion of factors of production other than labour. Analysis with two factors of production, labour and capital, does yield some interesting results (Bovenberg and Goulder, 1997). What is especially interesting in this case is the variation between the optimal and suboptimal tax systems in a general equilibrium analysis. In an optimal tax system, any taxes on capital are absent due to the fact that capital taxation results in the distortion of multiple markets, and as one would expect, the imposition of a revenue-neutral environmental tax results in a negative second dividend, much like that obtained by Bovenberg and de Mooij. However, in the case of a suboptimal tax system capital is obviously the factor that is overtaxed. Thus, by introducing an environmental tax with the revenue obtained then financing a reduction in capital taxes, the tax burden is redistributed to some extent from capital (the overtaxed factor of production) to labour and as a result the efficiency of the tax system increases overall. The key finding in this case is that if two factors of production are considered, an increase in welfare could only result if the tax burden is at least partially shifted to the undertaxed factor of production. Using the environmental tax revenue to subsidize the less productive factor would have the opposite result and would serve only to worsen the already existing inefficiencies, and indeed this calls into question whether reductions

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<sup>‡‡</sup> One can refer to Sandmo (1975) for the intuition behind this result. Metcalf finds that as the need for revenue increases, so does the Ramsey component of the environmental tax.

in labour taxation are a realistic goal in the case where capital is also being taxed. §§ Though these findings appear to lend some support to the validity of the double dividend hypothesis, the researchers conclude from the numerical model included in the study that this beneficial shifting of the tax burden is never large enough to result in a positive double dividend, even under a multitude of various assumptions.

Despite the evidence suggesting that reduction in taxes other than those applying to labour might result in higher welfare gains, most double dividend research nevertheless focuses on the labour aspect, or even go as far as to examine the effects of environmental taxes on international competitiveness. While the prominent earlier research does not allow for involuntary employment, other researchers have incorporated this and obtained drastically different results. For example, in a study specifically focused on Europe, Koskela, Schöb, and Sinn (1999) formed their economic model of an open economy with a non-clearing labour market with involuntary employment as a result of an exogenous shock to the country's economy. They found that the introduction of a revenue-neutral environmental tax would actually serve as a second-best solution to the continent's decreased international competitiveness. While these results may seem surprising, it is helpful to note that there was no "dirty" good used in this model but rather a "dirty" factor of production. It is easy to see how this assumption, when coupled with the existence of involuntary employment, could increase overall welfare. Increasing the cost of the "dirty" factor of production would provide an incentive for firms to substitute in more labour as a factor of production, which would in turn alleviate involuntary employment. The results of this study also hinge on the high tax rates

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§§ These particular findings rely uniquely on Bovenberg and Goulder's assumption of a perfectly elastic capital supply, which is arguably not applicable in a real-world scenario. If this assumption is violated, these results do not hold. See for example McKittrick (1997) where a fixed capital structure is used and a cut in payroll taxes is therefore favoured over a cut in capital taxes.

of labour and low tax rates on energy during the period of study. This can be understood by examining the aforementioned findings of Bovenberg and Goulder (1997). In this case, labour is the overtaxed factor of production while energy is the undertaxed factor, and the introduction of an environmental tax therefore increases the efficiency of the tax system by shifting the burden of taxation from the undertaxed to the overtaxed factor. Note the stark contrast between these assumptions and those of earlier researchers in which labour supply is assumed to be inelastic and involuntary employment nonexistent.

Double dividend research has by no means been limited by strict focus on European countries. Recently, Glomm, Kawaguchi, and Sepulveda (2008) used a dynamic equilibrium model of the United States economy to evaluate the potential effects of an increase in gasoline taxes. This abstracts from the issue of carbon taxes in that gasoline taxes would be notably easier to implement from a political standpoint, however this does not detract from the generalizability of the results as most double dividend literature does not consider the political feasibility of the tax reforms in question. Here, health of the representative agent is incorporated as a stock variable in the utility function and varies with the amount of pollution present. This assumption corrects what could be interpreted as a major shortcoming in previous research. Recall that in the household utility function defined in Bovenberg (1999), households disregard environmental externalities and as a result show no preference for the clean good. Similarly to Bovenberg and Goulder (1997), they find that due to the fact that the largest tax distortions lie on capital income, the reduction of these tax distortions will likely be the best use of revenue from the environmental tax. Additionally, they find that both dividends result from the tax, although they find the actual environmental dividend to be relatively small based on the information currently available about the value of a cleaner environment. Being that in the past researchers have often emphasized the need to focus on the more quantitative value of a

cleaner environment, this finding may indicate that the environmental dividend may not be as large in magnitude as was previously assumed.

Although it may seem surprising given the relatively weak evidence supporting the existence of the strong double dividend, carbon taxation is still supported by many economists. This is due to the previously discussed notion that price mechanisms are generally more efficient than quantitative mechanisms given realistic assumptions about the economy. If some sort of market based instrument is to be adopted, then it makes sense that a carbon tax would receive the most support from an economic point of view. Nordhaus even goes as far as to propose that "there is no better fiscal instrument to employ at this time, in this country, and given the fiscal constraints faced by the U.S." (2010, P. 1)

To evaluate the countless findings published on the subject of the double dividend, numerous quantitative assessments have been done. As one would expect from the economic models and results discussed above, it has been found that various factors such as the assumptions underlying the economic model and the exact definitions of the dividends in the research have an effect on the ultimate outcomes of the research (Patuelli, Nijkamp, and Pels, 2005). Below the results of 61 double dividend studies are shown. Interestingly, contrary to the findings of Glomm, Kawaguchi, and Sepulveda (2008) discussed above, the environmental dividend appears to outweigh the other effects.

**Table 2 - Results from 61 studies (186 simulations) -  
obtained from Patuelli, Nijkamp, and Pels, 2005, p. 568**

Average results in percentages

	CO <sub>2</sub> emissions	Employment	GDP	Firm investments	Consumer prices
Average variation	-9.70	0.44	-0.05	-0.23	1.18
Europe	-9.40	0.71	-0.07	-0.14	1.42
Rest of the world	-12.86	0.31	0.24	0.95	n.a.
Mediterranean countries	-2.85	0.30	0.15	-0.58	2.70
Nordic countries	-11.03	1.07	-0.03	-0.02	1.23
Short-medium period	-6.02	0.44	0.06	-0.42	1.23
Long period	-13.08	0.97	-0.05	0.48	1.17
EC tax	-6.39	0.33	0.01	-0.85	1.69
Other taxes	-11.22	0.85	-0.07	0.38	0.97
SSC recycling	-7.99	1.04	0.15	0.24	1.20
Other recycling	-12.10	0.05	-0.17	-0.16	1.72
Macroeconomic model	-7.57	0.46	-0.12	-0.86	1.51
General equilibrium model	-12.89	1.06	0.26	0.73	0.38
Journal/book papers	-11.85	0.79	0.22	0.37	1.33
Non-published papers	-7.40	0.48	-0.06	-0.51	1.20

## V. POLITICAL AND ECONOMIC CHALLENGES IN THE RESEARCH AND IMPLEMENTATION OF ENVIROMENTAL POLICY

With the abundance of emissions control literature and the rise and fall of the double dividend hypothesis, there has been much focus on the theoretical aspects of market-based instruments. One could argue, as Park and Pezzey (1998) have, that this focus is misguided in that it fails to consider the political feasibility of the implementation of emissions control policies from a realistic perspective. While the hypothetical existence of a double dividend would render a carbon tax costless, this condition would surely not be sufficient to ensure the implementation of such a tax. Perhaps more importantly, the vast majority of economic research completely lacks political considerations. There are several potential explanations for this, one of which is that in order to make assumptions about political or public opinion, it would be necessary to examine the political climate of the region in question. Naturally,

this would require an analysis of current circumstances and political ideals, which in most cases are not only unique to the region in question but are also subject to frequent change. Clearly then, an increased focus on the elements that influence the implementation of policy could substantially limit the theoretical breadth and popular appeal of economic research. Despite this, several researchers do attempt the discussion (see, for example, Goulder, Hafstead, and Dworsky, 2010), but this tends to be in regard to quantity rather than price mechanisms.

An additional, and arguably more problematic, issue with the incorporation of situational factors in economic research is the nature of politics and public opinion. As will be discussed, many of the numerous barriers to policy implementation are not dependent on objective aggregate welfare costs or benefits but rather on factors such as current events, political gaming, and human psychology. If the benefits resulting from the first dividend (the reduction of non-market damages) are not worth addressing in economic analysis because they are too difficult to quantify, then it follows logically that the same could likely be said about political considerations.

One example of the political gaming that must take place during the policy implementation is the observation that governments tend to experience a "honeymoon period" shortly after election in which they have greater flexibility in terms of the implementations of policies which change the structure of the tax system (Peters, 1991). This would mean that the introduction of quantity or price mechanisms for environmental sustainability could be possible only during the period immediately following an election, or that the political costs of the implementation of such policies could increase with time. This is just one example of the windows of opportunity that may exist for such policy implementation. Many other factors, such as international events and national economic strength, could present similar constraints on policymakers.

If action is to be taken against climate change by policymakers, there are many issues beyond that of simply acting at the opportune time. Giddens, (2008) outlines several of the political challenges that must be overcome in order to effectively introduce climate change policy. Political risk management must be a goal in that public opinion must be weighted alongside the objectives of any political agenda in order to maintain consistent and realistic goals. In addition, political interest groups would be expected to oppose many climate change initiatives, and this is a major reason why quantity based mechanisms may be adopted rather than price based mechanisms which tend to result in a larger reduction in firm profits (Park and Pezzey, 1998). It also seems that a return to long-term government planning would be required to adopt climate change policy, and a focus on these long-term goals would need to be communicated to and agreed upon by the public. This presents a difficult objective, since these policies result in permanent price increases in energy and goods, which would likely be the most pronounced in the short term prior to the substitution to other goods and factors of production. It is easy to imagine the difficulty a government could have when attempting to convince the public to bear short-term costs in order to reach long-term goals, and in addition to this policymakers must also attempt to ensure fairness and social justice by ensuring that lower income households are not unduly penalized by the introduction of new policies.

This issue of fairness is not limited to low income households but also extends to less economically developed countries when the goal at hand is international climate change policy. An important issue of debate is whether industrialized countries bear the greater burden of market based climate change policies or if the costs should be more evenly divided between countries (Aldy and Pizer, 2009). While international climate change policy seems appealing, especially due to the decreased costs that accompany a broader policy coverage base, this type of policy is wrought with challenges. For example, the Kyoto Protocol has been criticized on many

grounds, including its stringent emissions targets and its lack of emission caps on certain countries. Additionally, it is an example of the regulatory challenge of such a feat; despite the fact that the emission caps are legally binding, there is evidently no way to truly enforce these limits as international laws do not allow for this. It is helpful to keep in mind these political challenges when examining other climate change policies enacted during recent years.

## **VI. CURRENT PROGRESS IN ENVIRONMENTAL POLICY**

In the past few years, many countries have endeavored to adopt policies to reduce climate change. Some, such as Denmark, Sweden, Finland, and Norway, have used price mechanisms, while others, such as Iceland, have favoured quantity mechanisms (Aldy and Pizer, 2009). While these cases are interesting, to obtain an up-to-date perspective it is helpful to examine more recent happenings in this area. Here, three recent developments in three different countries will be briefly discussed: the carbon taxes recently adopted in British Columbia and Australia, along with the push for a Cap and Trade program in the United States.

In 2008, British Columbia introduced a revenue-neutral carbon tax on consumption. The revenue from the tax was designated to be used to finance reductions in both personal and corporate income tax rates, with these cuts increasing over time. Additionally, a tax credit for low-income households was introduced to help offset the increased cost of living that resulted from the tax (See: BC Ministry of Small Business and Revenue). Certain aspects of the introduction of this tax, such as the progressive increases in taxation and low income tax credit, are examples of introducing the tax in such a way as to minimize public backlash and increase the acceptability of such a policy, and these measures seem to be working. In a poll released by Environics in 2009 almost half of British Columbia residents responded that they at least somewhat

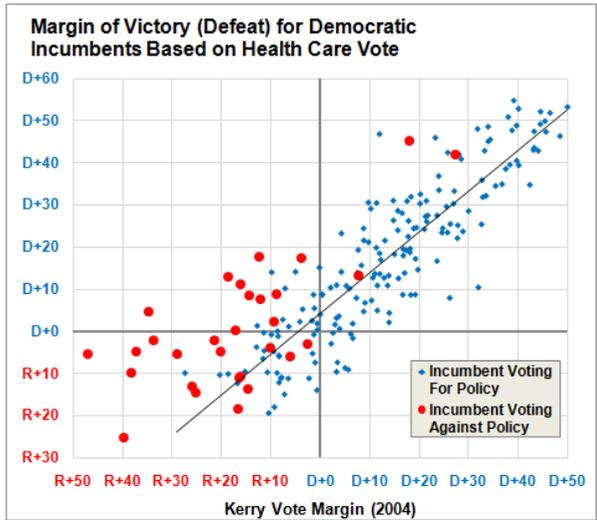
supported the tax on carbon, an 8% increase in support from the prior year (EnviroNics Research Group, 2009).

On another front, the Labor party that was recently elected to power in Australia has announced the introduction of a fixed carbon price beginning in 2012. Around 2015, this policy is planned to transition to an emissions trading scheme (The Australian, 2011). This approach is an unusual one as it sets out to gradually cap emissions in the long term, while simply increasing the cost of carbon consumption in the short term. In contrast to the British Columbia carbon tax, that which is being introduced in Australia has been surrounded by hefty debate. This comes largely due to the fact that Julia Gillard, the current Prime Minister, vowed prior to being elected that there would be no carbon tax implemented if she were to be voted into power. She has stated repeatedly that her intention was to only implement an emissions trading scheme, but that this was not feasible given the minority government, and support needed from the Green party, that resulted from the election (Australian Associated Press, 2011).

In the United States, a recent push to implement a cap-and-trade policy fell short of the required support in congress. The Democratic Party, and current President Barack Obama, managed to push a bill designed to implement cap-and-trade in the United States through the lower chamber, though just barely and with ample controversy. Unfortunately, political support dried up in the Senate where the bill never received a vote and died at the end of the 111th congress. The 2010 midterm elections that elected a Republican controlled House effectively ended all legislative efforts involving climate change for the time being. Even more damaging for the prospects of political legislation on the subject, public opinion has been moving in the opposite direction in recent years. A recent Gallup poll found that a decreasing number of Americans were concerned about global warming (2011), perhaps as a reflection of more pressing problems in the American psyche pushing global warming out of the limelight. While economic proposals emanating

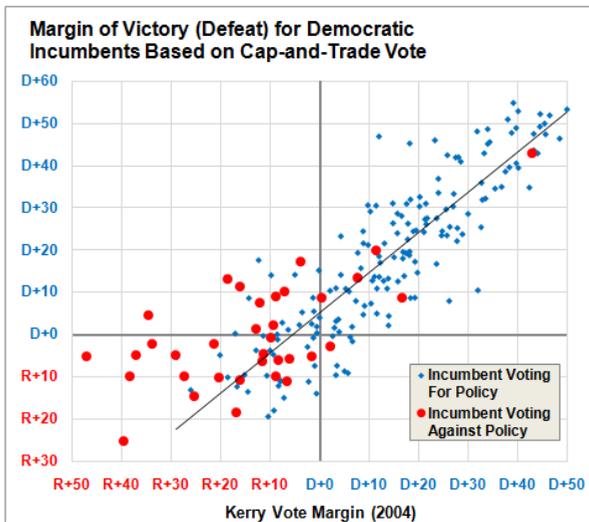
from the academic community are sure to continue within the United States, these proposals are almost universally “dead in the water” for the time being.

**Figure 1 - Margin of Victory (Defeat) for Democratic Incumbents Based on Health Care**\*\*\*



\*\*\* Silver (2010), “Health Care and Bailout Votes May Have Hurt Democrats” (<http://fivethirtyeight.blogs.nytimes.com/2010/11/16/health-care-bailout-votes-may-have-hurt-democrats/>)

**Figure 2 - Margin of Victory (Defeat) for Democratic Incumbents Based on Cap-and-Trade Vote<sup>†††</sup>**



Proponents of these efforts may take solace in a recent finding by Nate Silver. In the above figures, graphing the 2010 election results against the baseline of John Kerry’s vote margin in 2004, he shows that although legislation targeting climate change may remain controversial, it may not be as politically risky as it may seem. Analyzing the correlation between major votes of the 111<sup>th</sup> Congress and the 2010 election results, Silver found that a representative’s affirmative vote on either the ACA health care legislation, or the TARP “bank bailouts” of 2008 had a statistically significant negative effect on his or her re-election, while the same could not be said for a vote for the cap-and-trade bill. Perhaps then the next “legislative window” may result in signed legislation. When

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<sup>†††</sup> *Ibid.*

that happens, the Economic community should be ready with a consensus view on just what that legislation might look like.

Overall, it seems that political debate and action regarding climate change is still alive and well. Current events seem to show that the absence of a strong second dividend or ideal emissions control policy does not rule out the implementation of either quantity or price based mechanisms, and only time will tell to what extent the assumptions made in prior research carry over to the real world. One thing seems clear from this: Perhaps the objective shouldn't be to find a golden key in the form of some costless environmental policy, but rather simply to find one that is reasonable given the political and economic constraints at hand.

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