WORKING PAPER
2004-09

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Demand for Wildlife Hunting in British Columbia

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Abstract

We present estimates of the demand for hunting licenses by residents and non residents in British Columbia for the period 1971–2000. We obtain estimates of both short-run and long- run price elasticities and discuss their revenue implications for future fee increases. We find the demand by non residents to be strongly correlated with U.S. income variation over the business cycle, but find no such role for cyclical income variation for resident hunters. The ability of the government to increase revenues from resident hunters turns out to be limited, particularly in the long run, while greater opportunities exist to raise revenues from U.S. hunters as short- and long-run price elasticities of demand are quite inelastic. We argue that conservation surcharges on foreign hunters are one way to capture more of the resource rent.

Key Words: recreation demand; resource revenues and rent capture; conservation surcharges

JEL Categories: Q21, Q26, Q28

Acknowledgements: The authors wish to thank British Columbia's Ministry of Land, Water and Air Protection for research support, and Patrick Anglin and Roger Reid of the Ministry for suggesting this topic, making available hunting data, and providing helpful insights into the Province's hunting institutions. However, this study does not reflect their views or that of the Ministry. Any errors are the responsibility solely of the authors.

Demand for Wildlife Hunting in British Columbia

I. Introduction

Wildlife game resources constitute an important source of economic well being in many jurisdictions, providing both use and non-use benefits to citizens. To prevent open access exploitation and potential extirpation of wildlife game resources, governments allocate take, and monitor and enforce hunting regulations. To do so, governments generally establish a system of hunting licenses. Often these consist of a general license and some form of species license that limits the potential harvest of a particular species, usually larger game. In many instances, these species licenses are sold on a "first-come, first-served" basis. In some cases, licenses to hunt prominent species, such as bighorn sheep or grizzly bears, are auctioned off so that the government collects the resource rent accruing to these animals. With the exception of auctions, hunting fees are generally not designed to capture the resource rents, but they often fail even to cover the operating costs of hunting programs.

The problem of generating revenue for wildlife management is not unique to any jurisdiction. Numerous State fish and wildlife management agencies in the United States have previously experienced severe financial problems. While costs of providing wildlife management services had gone up for a variety of reasons, including greater demands by the public for protection of non-use values, revenues from user fees had fallen as a result of inflation and the failure of State legislators to increase fees (Reiling et al. 1980; LaPage 1981; Anderson et al. 1985). Many fish and wildlife agencies resolved their fiscal problems by lobbying State legislatures to increase license fees, using demand analysis to demonstrate that fee increases would be beneficial all around. Similar efforts are only now beginning to appear in Canada, even though funding challenges have been the same, except that, unlike in the United States, hunting by foreigners is an important component of revenues in Canada.

In this paper, hunting data for the Province of British Columbia are used to examine the demand for hunting by both residents and non residents. Our objective is to find empirical specifications of the demand relationships suitable for assessing the revenue implications of variations in domestic and foreign hunting license fees. For purposes of wildlife management and revenue generation, we are also interested in the importance of income variation, particularly the sensitivity of non resident demand to fluctuations in income. Finally, since BC charges hunters a wildlife conservation fee, it is of interest to gauge the response of resident and non-resident hunters to this surcharge. Although in principle it acts simply to increase the hunting license fee, as a designated environmental surcharge it is possible that hunters may respond differently – and our results suggest this may be the case. If so, this has direct implications concerning rent capture.

Our focus is on the analysis of hunting demand. The analysis is partial equilibrium in the sense that we do not take into account how hunting might impact non-use or non-consumptive use benefits, or its impact on the economy more generally. For example, by increasing hunting fees, resource rents may increase, but reduced activity elsewhere in the economy from less tourism (hunters) might reduce tax revenue in ways not taken into account in this study. Nonetheless, we illustrate the importance of demand analysis as a component of policy making.

We begin in the next section by examining hunting licenses and fees in British Columbia over the past three decades, using this information to specify models of demand for hunting. The econometric results for several models are provided in Section 3. An important component of the analysis is the separation of resident and non-resident demands for hunting. In section 4, key results of the analysis are discussed and placed in a broader policy context.

2. Modeling Demand for Hunting Licenses in British Columbia

All hunters in British Columbia require a Basic hunting license, which by itself only permits small game hunting.[1] For large game, individual Species licenses are also required. The fees for the Basic hunting licenses and Species licenses vary depending upon the age of the hunter (juniors, adults and seniors), the residence of the hunter and, for the Species licenses, the type of animal involved. There are three categories of residence: BC Resident, Canadian Non-BC Resident, and Non Canadian Resident. While in principle one could investigate quite narrow markets (e.g., demand for grizzly bear licenses by BC Resident juniors), our analysis considers two broadly defined markets, both of which are important sources of revenue for the British Columbia government. The first is the market for basic hunting licenses for adult BC Residents and the second is that for basic hunting licenses for adult Non Canadian Residents. For simplicity, we refer to these markets as Residents and Non Residents. Further, our best information concerning Non Residents is that they are primarily from the United States, which is how we treat this group in what follows.

Table 1 provides a summary of the fees and quantities of licenses for these two categories of residence for the year 2000. A couple of points are worth noting. First, many more Resident hunting licenses are sold than Non Resident, but the latter is also significantly more expensive. Second, more Species licenses are sold than Basic licenses; on average a Resident hunter in 2000 purchased a basic license and two species licenses (most likely one of which was a Mule or Whitetail Deer species license). This pattern is consistent with previous years and highlights an

[1] Information in this section is based on discussions with the Ministry of Land, Air and Water Protection.

important consideration when modeling the demand for basic hunting licenses, specifically, that species licenses are an important complementary good.

Figures 1 and 2 present the historical development of basic hunting license fees, both in real and nominal terms, and the numbers of such licenses sold for Residents and Non Residents.[2] An immediate conclusion from these figures is that hunting fees in British Columbia have not kept up with inflation, especially fees charged Non Resident hunters. For Non Residents, the depreciation of the Canadian dollar over the 1990s has contributed to the fall in real fees. The other interesting feature is the contrasting behaviour of the quantity of licenses purchased by Residents and Non Residents. For Residents, the number of basic hunting licenses has trended downwards over time – from over 150,000 hunters in the early 1970s to some 80,000 today. This has been noted in other studies of hunting demand and is generally attributed to changing attitudes toward hunting (see, e.g., Reiling et al. 1980). For Non Residents, there is no evidence of a secular decline in hunting. Although the number of licenses purchased falls during the 1970s, with a very large decline coincident with the large price increase of 1973–74, it has trended steadily upwards since 1982.

It is also of some interest to consider how government revenues from licenses have fared over this period; Figure 3 presents estimated total revenue from hunting fees across all categories and species (including animal royalties as discussed below). In 1974, as a result of a dramatic fee increase imposed on Non Residents (Figure 2) and a smaller increase on Residents (Figure 1), real and nominal revenues increased substantially. Since then, real revenues have remained relatively constant, declining somewhat during the late 1990s (after 1994), while nominal

[2] The Resident fees are deflated by the Canadian CPI and those for Non Residents are deflated by the US CPI. Note that the Non Resident fees are set in Canadian dollars; values in Figure 2 have been converted to US dollars.

revenues generally increased only to decline slightly after 1995. During the three decades from 1971 to 2000, nominal revenues increased by an average 8.3% per year, while real revenues increased by only 3.0% annually.

There are two other types of fees hunters face in British Columbia. First, as already noted, a conservation surcharge is levied on all hunters in British Columbia purchasing a basic hunting license (see Table 1). The revenue is dedicated to the conservation of wildlife through the Habitat Conservation Trust Fund. The surcharge was first introduced in the 1984/85 fiscal year at $C3 for Residents and Non Residents alike. It was increased in 1989-90 to $C5 for Residents and $C30 for Non Residents. Since then, these surcharges have remained unchanged so that in real terms they have eroded over time. Second, Non Resident hunters are required to employ a guide outfitter.[3] Guides are legally liable to pay royalties for animals taken by Non Resident hunters, but the royalties are typically passed on to the guided hunter. Royalties were introduced in 1982 and are imposed on ten major mammal species; the royalties in force in 2000 are presented in Table 1. In principle, these royalties act as an additional expected cost to hunting these species and should, when increased, reduce the demand for hunting licenses.

2.1 Demand and Supply of Hunting Licenses

We focus in this paper exclusively on the demand for basic licenses, either by residents or non residents. In general terms, we can specify the demand for basic hunting licenses as:

(1) $h_t = h(fb_t, \boldsymbol{f}_t, m_t, h_{t-1}, \boldsymbol{z}_t, t)$,

where h_t is the quantity of basic licenses purchased in year t, fb_t is the basic license fee (own price), $\boldsymbol{f}_t$ is a vector of license fees or surcharges that affect the purchase of a basic license

[3] With the exception of Non Resident hunters accompanied by a blood relative who is a BC Resident.

(complementary prices), m_t is a measure of income, z_t is a vector of other factors (e.g., age, gender, other costs associated with hunting, price and availability of other leisure activities), and t is a time trend that takes into account long-term secular trends that may influence hunting activity. We also include a lagged dependent variable, h_{t-1}, for two possible (related) reasons. First, like many consumption goods, there is likely to be a degree of persistence in the purchase of hunting licenses from year to year – behavior is influenced in part by habit. It might also capture factors related to the positive or negative experience from hunting in the previous period. Imagine one year is particularly good for hunting, say due to weather conditions, and this motivates high current demand. In the following year, because of the good conditions previously, hunting demand is again higher than otherwise. Alternatively, since hunting activities require specific capital, short-run price responses are likely greater than long-run responses.

According to the Ministry responsible for setting all fees for hunting licenses, the supply of licenses is perfectly elastic in any one year at the fees set by the Ministry. There are no restrictions on the quantity of licenses sold once the fee has been established. Over time, license fees are adjusted; however, there is no evidence that the pricing decisions are influenced in any way by possible determinants of demand. Our best understanding is that fees have been set on the basis of political and budget considerations, with little or no reference to the market for hunting licenses. On this basis, we are confident that we can treat the license fees as exogenous variables in our model and estimate the demand for licenses directly using equation (1).

A number of other estimation issues arise. First, hunting is only one of many activities and is therefore affected by prices of other consumer goods. We address this by specifying all fees in real terms deflated by the consumer price index. For the Resident models, we use the Canadian CPI. For the Non Resident models, we use the US CPI after first converting the fees to

US dollar values. (We do not explicitly identify the exchange rate adjustment in the formulas below.) As long as these other prices have tended to rise more or less with the CPI, this is a reasonable first approximation. Similarly, we have no information on other costs associated with hunting, such as fixed costs of equipment (vehicles, rifles, tents, special clothing, etc.) and variable costs of travel, ammunition and so on.[4] A second and somewhat related concern is the lack of data concerning individual characteristics that might affect demand, such as gender and socio-economic characteristics of hunters. This information is not collected and maintained by the BC government so it is not included in our analysis.

The next issue to address is the measurement of fees. For Resident hunters, the demand for a basic hunting license will depend upon the basic license fee, fb_t. Demand also depends upon species license fees, denoted fs_{it} for species i, as basic and species licenses are complementary goods. Because there are a number of species licenses and because species license fees are co-linear as they are typically adjusted all together, it is not possible to include these individually in our empirical models. Instead, we construct a weighted geometric index over the N categories of species defined as follows:

$$(2) \qquad fs_t = \prod_i \left(\frac{fs_{it}}{p_t} \right)^{\gamma_{it}} ,$$

where p_t is the consumer price index and γ_{it} is the share of species i licenses in year t out of all species licenses sold in that year.

Finally, the conservation surcharge, denoted cs_t, is an additional cost to purchasing a basic hunting license. (It too is deflated by the CPI.) While it would be natural simply to add this

[4] Ward and Beal (2000) for example introduce travel costs in their modeling of demand for recreation, which is a useful direction for further research, particularly for Non Resident demand.

to the license fee, which we do consider, it is of interest to consider whether demand responds differently to the surcharge. If hunters truly believe that the surcharge will be used to fund wildlife conservation, their response to variation in this surcharge may differ relative to their response to general fee increases. There are two possible related explanations for this. First, habitat conservation may be viewed as an alternative public good for which there is a willingness to pay, irrespective of current and future expected use. A second, somewhat more sophisticated argument is that hunters treat these types of charges as an option price related to the option value of the hunting experience available in the future, given that future availability of the hunting experience (supply of adequate wildlife game animals) is uncertain (Graham-Tomasi 1995). Our data do not allow us to discriminate between these two explanations, but we are able to examine whether the response to an increase in the surcharge is the same as to general fee increases. Whether this is the case is of some relevance for environmental policy more generally.

Identical considerations apply to the model for Non Resident licenses with one additional aspect. Non Residents must pay royalties, either directly or indirectly, on large game taken. As with the species licenses, it is necessary to construct an index of these royalties, defined as:

(3) $$fr_t = \prod_i \left(\frac{fr_{it}}{p_t} \right)^{\gamma_{it}},$$

where fr_{it} is the royalty fee for species i and γ_{it} is the share of species i out of all species licenses purchased in year t, as before. As with the species licenses, this is a price index for a good complementary to the basic license. It is dependent, however, on a successful hunt. If the subjective probability of a successful hunt varies substantially over time, it is not possible to identify a price response to variation in royalty costs.

To summarize, we consider the following fees associated with the demand for basic hunting licenses. For both Residents and Non Residents, we have the basic license fee, fb_t; a principal objective is to determine the own price elasticity for basic licenses with respect to this fee. As well, we have additional fees that we treat, at least initially, as the price of complementary goods: the conservation surcharge, the species fee index, and, for Non Residents, the royalty fee index.

The other variables included in the model are de-trended per capita disposable incomes, measured in real terms and denoted y_t, and a linear trend. Per capita disposable income is de-trended using the band pass filter described in Baxter and King (1999). This filter is designed to extract the business cycle frequency component of economic time series. Following Baxter and King, we define the business cycle frequency to be between two and eight years. Details of the construction of this series are provided in the data appendix.

We expect that hunting is positively related to individuals' disposable income.[5] Over the sample period 1971-2000, this can manifest itself in two ways. First, over the sample there has been a secular increase in the per capita disposable income of both Residents and Non Residents. This may well contribute to a secular increase in the demand for hunting; as individuals become wealthier they are likely to increase their consumption of leisure activities such as hunting. Confounding this, however, is a possible secular move away from hunting as a leisure activity over our sample period. The linear trend in the model in principle captures the net effect of both these contributions to hunting license demand.

The second way in which income may contribute to hunting license demand is through cyclical fluctuations. It seems very likely that during periods of strong economic growth –

[5] This is a testable hypothesis. Alternatively, hunting might be an inferior good, particularly for Residents where hunting to supplement a family's meat consumption might be important.

periods when per capita income is above trend – demand for hunting may be relatively high. Conversely, during periods of unusually low economic growth, demand for hunting may be relatively low.[6] For this reason, we include a measure of the cyclical variation of per capita income. An alternative and more common strategy would be to include the level of per capita disposable income directly into the regression (assuming a log linear demand specification). With a linear trend in such a model, this is equivalent to including linearly de-trended income. We chose not to do this, however, because this is often a poor way of obtaining business cycle fluctuations of aggregate income data. In our case, it works particularly badly for British Columbia income. The de-trended income series is presented in Figure 4.

2.2 Empirical Model

We consider two possible functional forms, linear and logarithmic, for the demand function in equation (1). For the two markets, the linear models are:

(4) $$h_t^R = \alpha_0 + \alpha_1 h_{t-1}^R + \alpha_2 fb_t^R + \alpha_3 fs_t^R + \alpha_4 cs_t^R + \alpha_5 y_t^R + \alpha_6 t + u_t^R$$

(5) $$h_t^{NR} = \beta_0 + \beta_1 h_{t-1}^{NR} + \beta_2 fb_t^{NR} + \beta_3 fs_t^{NR} + \beta_4 fr_t^{NR} + \beta_5 cs_t^{NR} + \beta_6 y_t^{NR} + \beta_7 t + u_t^{NR}$$

The two logarithm models are:

(6) $$\ln h_t^R = \alpha_0 + \alpha_1 \ln h_{t-1}^R + \alpha_2 \ln fb_t^R + \alpha_3 \ln fs_t^R + \alpha_4 cs_t^R + \alpha_5 \ln y_t^R + \alpha_6 t + u_t^R$$

(7) $$\ln h_t^{NR} = \beta_0 + \beta_1 \ln h_{t-1}^{NR} + \beta_2 \ln fb_t^{NR} + \beta_3 \ln fs_t^{NR} + \beta_4 fr_t^{NR} + \beta_5 cs_t^{NR} + \beta_6 \ln y_t^{NR} + \beta_7 t + u_t^{NR}$$

We have introduced the superscript notation R and NR to discriminate between Resident and

[6] This is not the only reasonable conjecture, particularly for Residents where hunting costs may be relatively low (e.g., no significant travel). It is possible that during recessionary periods, the opportunity cost of leisure may be low, increasing the demand for hunting. Similarly, during expansionary periods, the opportunity cost of leisure may be quite high causing hunters to forgo recreational activity.

Non Resident variables. In the equations, u_t^R and u_t^{NR} are assumed to be mean zero innovations that we would like these to be independently and identically distributed. However, since this does not appear to be the case, we use the Newey and West (1987) heteroskedasticity and autocorrelation robust covariance estimator for inference.[7] Note that for the logarithmic models (6) and (7), two fee variables do not enter the equation in logarithms but in levels, because they are set at zero for part of the sample – the conservation surcharge was introduced in 1984, while species royalties were introduced in 1982.

Because the conservation surcharge applies to all purchases of a basic license, we also consider a combined fee, defined as $fb_t + cs_t$, for both Residents and Non Residents. Of course, for the linear model this is a directly testable restriction, which we evaluate below. For the model in logarithms, the combined fee is $\ln(fb_t + cs_t)$; in contrast to the linear model, this is not a simple linear restriction of models (6) and (7) and, in this case, we use non-nested tests to see if we can discriminate between the different specifications. As discussed previously, this restriction (however tested) is of some interest since it considers whether hunters treat the conservation fee as simply an additional charge to the basic license or as the fee for a separate complementary good.

3. Empirical Results

We estimate equations (4)–(7) over the sample 1971–2000. Data sources and construction are provided in the Appendix. The results are reported in Tables 2 and 3. Models that use the unrestricted fee structure are identified as RU, NU (levels) and RU-L, NU-L (logs) for Resident

[7] We cannot reject the hypothesis of serial correlation of order two in many of our models. While modeling this directly is desirable, we chose not to do so because of our limited sample.

and Non Resident, respectively. Models that use combined fee are identified as RC, NC (levels) and RC-L, NC-L (logs).

3.1 Resident Results

Results for the Resident models are reported in Table 2: Table 2a reports the ordinary least squares regression results, while Table 2b provides various elasticity measures and hypothesis tests. A number of results common across all regression models are worth highlighting. First, in all cases the lagged dependent variable is positive, quite large and statistically significant. We interpret this as evidence of habit in consumption behaviour that is, perhaps, related to previous investment in hunting gear.[8] Second, as we might expect from Figure 1, we observe a negative and statistically significant coefficient on the trend term, consistent with a secular movement away from hunting. Third, in all cases the coefficient on cyclical disposable income is statistically insignificant indicating a zero income (cyclical) elasticity of demand for hunting licenses by BC Residents. Finally, all of the models reported in Table 2a have very high adjusted R-squared values. This should not, however, be taken as strong evidence in favour of these models; much of the fit is determined by the linear trend term and the strongly significant lagged dependent variable term.

Turning to the fee variables, we again observe some consistent patterns across the models. First, the basic license fee is negative and statistically significant while the conservation surcharge is statistically insignificant (models RU and RU-L). There is, however, evidence that the basic license fee and the conservation surcharge can be combined. For the model in levels

[8] An obvious explanation for the results in Table 2a is that Resident hunting license demand is well described by a unit root with drift in contrast to our implicit assumption that it is trend stationary. We did experiment with models in first differences but were unable to obtain any useful relationship between quantity and price for hunting licenses. The difficulty of discriminating between first difference and trend stationarity in small samples is well known.

(RU), a test of the hypothesis that the coefficient on the two variables are equal cannot be rejected (the marginal significance level for the associated F statistic is 0.446). For the model in logarithms, we perform Davidson and Mackinnon's *J*-test for non-nested hypotheses.

Consider first the model RU-L. We re-estimate this model including the predicted dependent variable from the estimation of RC-L. A test that the RC-L predicted values have a zero coefficient is a test of RU-L against a composite null of RU-L and RC-L. Rejection of the zero coefficient is evidence against RU-L in favour of RC-L. In a similar way, we can test RC-L against the composite null. In Table 2a, we report marginal significance levels for F-statistics that test if the predicted values are zero. For RU-L, we reject the null hypothesis that the RC-L predicted values have a zero coefficient (the p-value is 0.002), evidence against an unrestricted structure, RU-L. For RC-L, we cannot reject the null hypothesis that the RU-L predicted values have a zero coefficient (the p-value is 0.360), evidence in favour of a combined fee structure, RC-L. So, as with the model in levels, we find evidence in favour of combining the basic license fee and the conservation surcharge when modeling the own price response of the basic license fee demand.

The final fee variable to consider is the species index. In both RU and RC, the index is negative and statistically significant. In RU-L and RC-L, it is negative but only statistically significant in RC-L where the basic license fee and conservation surcharge are combined. If we focus on RC and RC-L, with the combined fees, we find the models in levels and in logarithms give very similar information. We can, however, use a standard Likelihood Ratio test to discriminate between the two functional forms as both models are special cases of a general Box-Cox transformed model. The row denoted Specification LR reports the marginal significance levels for the LR test of the restricted models against the more general Box-Cox model. From the table, we reject the logarithm models but do not reject the model in levels.

We put forward model RC as our preferred model for BC resident hunters, because of the specification test for functional form and because we find in favour of the combined fee. Now consider the elasticities from this model in more detail (reported in Table 2b). While we focus on RC, for completeness we also report measures associated with the other models. The great deal of consistency across different models suggests that our conclusions are reasonably robust.

The combined fee short-run elasticity, evaluated at the means of the combined fee and numbers of basic licenses, is -0.21 and statistically different from zero (as noted previously).[9] The species price index has a short-run elasticity of -0.15, slightly less than that of the basic license fee itself; however, the two elasticity estimates are not statistically different at standard significance levels (the F-statistic under the null hypothesis that the two elasticities are equal is 0.77 with a p-value of 0.39). Very similar elasticities (slightly smaller) are reported for model RC-L. Finally, as noted previously, the cyclical short-run income elasticity is small and statistically insignificant from zero.

As the model has a lagged dependent variable, the long-run effect of fee changes will differ from that predicted by the short-run elasticity. Table 2b also reports long-run elasticities that capture the effect of fee changes over time. As expected, these values are larger (in absolute value); for the combined fee the elasticity measure is -0.59, while for the species index it is -0.42 Again we cannot reject the hypothesis that the two elasticities are equal (the F-statistic is 0.82 with p-value 0.37). We report two hypothesis tests for the long-run elasticities: The first is a null of zero, which is strongly rejected for both the basic fee and the species fee. The second is for a

[9] When performing hypothesis tests on the elasticities constructed using mean levels of the data, we do not take account of any sample variation in the estimated means.

null of -1, which is also strongly rejected for both fees. Thus for our preferred model for Resident basic licenses, short- and long-run demand is inelastic with respect to its own price and with respect to the species license fee. In addition, both the short- and long-run elasticity measures for cyclical income are insignificantly different from zero.

We can use the estimated model to provide some information about the effect on revenue from basic license fees if the basic license fee is increased from current levels (strictly speaking 2000 levels). For this, we focus on the long-run elasticity as it captures the full effect of any change in fees. We should also calculate the elasticity at the end of sample values for fee and quantity, rather than at the mean fee and quantity as reported in Table 2b. In this case, the long-run elasticity is -0.86 and not statistically different from -1 (the p-value for the F-statistic with null hypothesis of -1 is 0.43). This suggests that a basic license fee increase from 2000 levels will have little or no effect on government revenue from basic license fees in the short and long run. Notice that this conclusion is also consistent with the long-run elasticity estimates from model RU.

For completeness and as a check as to whether certain observations are influential to the estimation of the Resident demand curve, particularly with regard to the fee elasticity coefficient, it is useful consider a plot of the (short-run) demand curve of model RC (our preferred specification). To do so, we first obtain the residuals from two regressions: (1) the basic license quantity variable against all regressors excluding the basic license fee variable, and (2) the basic license fee variable against all remaining regressors. This strips out all other variation and captures only the variation between fees and quantities, thus providing the demand curve for these licenses. These residuals are plotted in Figure 5, along with the regression line for these two variables (with slope -0.11, by construction, identical to that reported in Table 2). A visual inspection of the estimated demand curve suggests that the model is doing a reasonable job; partial R^2=0.45, giving a sense of how much of the variation in the quantity of licenses can be attributed to variation in the license fee alone.

3.2 Non Resident Results

Table 3 reports a similar modeling exercise for Non Resident basic licenses. As before, we consider models with the basic license fee and the conservation surcharge separate and with the two fees combined; we also consider the model in levels and in logarithms, though again in the latter the conservation surcharge and the royalty index are in levels because of their zero values over part of the sample. An additional issue arises, however, with the Non Resident models, which alters our modeling strategy. When we compare the basic license fee for Non Residents with the species price index we construct, we find the two series are highly correlated.[10] As a consequence, when we include both the basic license fee and the species license index in the regression models, either in levels or logs, we do not get meaningful results; there is not enough information to identify separate quantity effects from these two fee variables.

One way to proceed is to accept the limited information in our data and focus on the theoretically more important of the two fee variables for modeling basic license demand, the basic license fee. This strategy makes it difficult to assess the effect of license fee increases, however, since it leaves out a potentially important variable. Indeed, the problem is worse when one considers that the BC government has invariably altered both the basic license fee and the species license fees simultaneously (hence the co-linearity), so by excluding species license fees

[10] In levels, the correlation between the two series is 0.94. As the series are possibly non-stationary, we might properly wish to consider the correlation between the de-trended series, which is in effect how we are treating these variables in the regressions. After de-trending, the correlation between the two series is 0.95. In contrast, the same calculation for the respective Resident series is 0.69.

we potentially miss an important part of the story. For these reasons, we consider an alternative strategy that constructs an aggregate price index based upon the basic license fee and the species license fee index.[11] The index, which we refer to as the composite license fee (*clf*), is constructed as follows:

$$clf_t = (fb_t)^{0.3} \times (fs_t)^{0.7},$$

where recall *fb* is the basic fee and *fs* is the species fee index (equation 2). The weights we use reflect the relative number of basic licenses and total number of species licenses purchased in one year. On average over our sample, the number of basic licenses is approximately 30% of the total of purchased basic and species licenses.

It is important to bear in mind that we are treating this index as the "price" of purchasing a basic hunting license; the quantity variable for our demand model is unchanged (the quantity of basic hunting licenses, not the aggregate of basic and species licenses). Such a model makes sense if we assume that all Non Resident hunters only purchase a basic license to hunt licensed species, and so the demand for the basic license depends upon this composite fee. The advantage of this model is that we can reasonably consider the effect of an increase in the basic license fee or generic increases in species license fees.

The disadvantage is that we do not have any direct statistical evidence to support the use of such an index, or a simple (unweighted) linear combination of the two fees ($= fb + fs$). If we estimate the model in levels, including both the basic and species license fees separately, we can ask whether the coefficients are the same, which would then allow us to aggregate the two fees and so circumvent the co-linearity issue. But this restriction is rejected by the data. Alternatively, if we estimate the model in logs, then the geometric index we construct is a linear restriction of a

[11] More detail on these and any other results reported in the paper are available upon request.

more general model where the basic license fee and the species fee index enter separately in logs. Again this restriction is rejected by the data. Despite these concerns, we proceed with the index as constructed for two reasons: its behaviour captures very well the behaviour of the basic license and the species fee licenses, and the estimated model provides sensible results.

Table 3a reports the regression results for Non Resident demand using the composite fee. Models NU and NC are in levels, while NU-L and NC-L are in logarithms. The combined fee is now constructed as $(clf_t + cs_t)$ for NU and NC and $\ln(clf_t + cs_t)$) for NU-L and NC-L, where cs is the conservation surcharge. As with the Resident models, we observe a positive and significant coefficient on the lagged dependent variable across all specifications indicating a fair degree of persistence in the demand for basic licenses by Non Residents. In contrast to the Resident model, however, we get quite different results for trend and cyclical per capita disposable income. Generally speaking, the trend coefficient is positive and, except for NC-L, statistically insignificant. So unlike Resident demand, there is no evidence of a secular trend away from hunting. For cyclical income, we observe a strong positive and statistically significant coefficient across all models. Evidently, there is a strong cyclical component to hunting demand by Non Residents.

Prior to discussing the various effects of the different fees, it is useful to narrow the discussion. Both the levels and the logarithm specifications are restricted versions of a more general Box-Cox specification. Based on the LR tests reported in Table 3a, we have evidence against the level specification (rejected with p-values of 0.00 for both NU and NC) and no evidence against the logarithm specification (p-values of 0.70 and 0.38 for NU-L and NC-L). Thus, we focus the remaining discussion on the log models NU-L and NC-L. We are unable, however, to discriminate further between the logarithm model that treats the conservation surcharge as a separate fee, NU-L, and the one that combines the surcharge with the composite fee (*clf*), NC-L, on the basis of the non-nested tests. Fortunately, the conclusions from the two models are very similar so the distinction appears not to matter.

The composite license fee, whether individually or combined with the surcharge, is negative, statistically significant and of similar magnitude across the two models. In model NU-L, the surcharge itself is statistically insignificant so, if it is appropriate to treat the surcharge differently from other fees, it appears to have a zero elasticity with respect to basic license demand by Non Residents (perhaps not too surprising given the relative magnitude of the surcharge compared to other hunting costs). The royalty index, while correctly signed in both models, is statistically insignificant at conventional levels, though the p-values for the two sided t-tests are just over 0.20.

Table 3b provides the short- and long-run elasticity estimates for our models; again we focus discussion on models NU-L and NC-L. Whether measured as a component of the composite fee alone or as a component of the combined fee, the demand for basic licenses is clearly inelastic in the short and long run. In the short run, the elasticity is just under -0.2 (absolute value), while in the long run it is roughly -0.3. For the long run, a test that the elasticity measure is -1 is strongly rejected (as it is for the short-run elasticity, though this is not reported in the table). On this basis, we conclude that an increase in either the basic license fee or species license fee will have a relatively small effect on the quantity of basic licenses purchased by Non Residents. For the Royalty index, both the short- and long-run elasticity measures (recall the index is entered in the regression in levels so the regression coefficient is not an elasticity estimate) are not statistically different from zero based on the tests reported in the table. Finally, the cyclical income elasticities are large and statistically different from zero in both the short and long run.

Inspection of Figure 2 suggests a natural experiment would be to check the elasticity estimates from Table 2. Between 1973 and 1974, basic license fees rose by approximately 175 percent while the quantity of licenses fell by approximately 43 percent, giving an elasticity at this point of approximately -0.24, very similar to those from models NU-L and NC-L. Of course, this ignores changes in the other determinants and information from the rest of the sample, but it is encouraging that the large swing in price and quantity in 1974 is consistent with our model. An obvious concern, however, is that this observation is very influential.

As with Resident demand, we can plot the relationship between fees and quantities implied by the regression (i.e., the residuals after fees and quantities have been projected onto the other regressors). This relationship for model NC-L is reported in Figure 6. Clearly, the 1972 and 1974 observations are influential, as suspected. If we remove these observations, the slope coefficient is considerably smaller, approximately -0.09; moreover, the partial R^2 measure drops considerably, indicating these two observations are important determinants of the overall fit. To the extent that the fee rise in 1974 is valuable information, it doesn't seem sensible to exclude these observations from our analysis; however, the importance of this and other influential observations should be borne in mind.

4. Discussion

A number of interesting points merit further discussion. First, for both the Resident and Non Resident models, we use a measure of cyclical variation in per capita disposable income as a determinant of hunting license demand. This is designed to capture the influence of short-run fluctuations in income in contrast to the general increase in real per capita disposable income occurring over time. The latter is difficult to identify because of the other trend influences on hunting, particularly the recognized movement away from hunting as a leisure activity. Interestingly, we obtain very different results for Residents versus Non Residents and, moreover, these results are not too difficult to explain. Non Resident hunting demand is strongly pro-cyclical, making it similar to other tourism activities.[12] Non Residents are likely to incur significant fixed travel costs to hunt in BC; moreover, as Non Residents are likely to have other less expensive hunting alternatives, they are more likely to travel to BC to hunt large game, which is relatively expensive. In contrast, hunting demand by BC residents is not cyclical. As the costs of hunting (fees plus fixed travel costs) are much smaller for Residents, it seems reasonable that the general demand for basic hunting licenses is less likely to depend upon transitory fluctuations in disposable income. We might conjecture that the margin affected by cyclical income variation for Residents is the demand for more expensive game, an issue we leave for future research.

The second point of interest concerns the elasticity results and the implications for revenues. If demand is inelastic then an increase in price will raise revenues. Similarly, if demand is elastic, revenue will decrease with an increase in price, while, with unit elasticity, revenue is unaffected by changes in prices. Our results suggest that raising Resident fees may raise revenues in the short run, but is likely to be revenue neutral in the longer run. In contrast, it appears possible to increase government revenues from the sale of Non Resident licenses by raising the basic license fee. This is likely to be particularly appealing to the BC government

[11] Empirical studies of tourism generally include an income component, as would seem reasonable. In a recent study for Australia, Lim and McAleer (2001) use cointegration to model tourism demand. In addition to finding a long-run relationship between tourism and income, for one of the countries they identify significant dynamic effects that can be loosely interpreted as similar to our cyclical variation.

since these hunters have no direct political constituency, although the effect on guides and outfitters must be borne in mind. Perhaps more importantly, the results are potentially useful for wildlife management because, if reduced hunting is warranted for wildlife conservation purposes, higher fees can be imposed to reduce hunting without detrimental effects on license revenue since demand is inelastic. Of course, it is necessary to be careful about such statements. While the functional specifications we use may be reasonable local approximations, they may not be so in all instances, particularly if significant fee increases are being considered. As well, higher fees may also affect compliance, leading to more instances of unlicensed hunting and unreported kills (loss of royalty revenues).

Finally, we consider the response of hunting demand to the introduction and subsequent increases in a conservation surcharge, the proceeds from which are dedicated to the conservation of wildlife through the Habitat Conservation Trust Fund. For Resident demand, our results suggest that the surcharge is treated as an additional fee eliciting a similar response for hunting demand as increases in the basic license fee. For Non Resident hunters the results are less clear. We do not have conclusive evidence one way or the other as to how best to treat the surcharge, as either a separate charge or as one component of the overall basic license fee. Whatever the case, our results do suggest that further increases in the surcharge will have little effect on demand for basic hunting licenses by Non Residents, indicating that there is further room to raise resources for habitat conservation in this manner.

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Data Appendix

Hunting Licenses and Fees

All of the hunting fee and licenses purchased data are provided by the British Columbia Ministry of Land, Water and Air Protection. The data are proprietary although the authors may be able to make some of the data available upon request.

Consumer Price Indices

Residents: Canada Consumer Price Index (CPI), 1996 Basket, Monthly. CANSIM II Series V735319. Monthly data are averaged to obtain annual series.

Non Residents: US Consumer Prices Monthly. International Financial Statistics [11164…ZF…]. Monthly data are averaged to obtain annual series.

Exchange Rate

Canada US Dollar Exchange rate. CANSIM II Series V37426. Monthly data are averaged to obtain annual series.

Per Capita Disposable Personal Income

Non Resident series are constructed using aggregate measures of personal disposable income divided by total population. Both Resident and Non Resident series are then deflated using the CPI indices.

Residents:

(i) BC Per Capita Personal Disposable Income is constructed from two annual series: (1) CANSIM II Series V508975 (1926–1991) and (2) CANSIM II Series V691726 (1981–2002). The two series are spliced using the CANSIM II Series V508975 until 1980.

Non Residents:

(i) United States; Disposable Personal Income: CANSIM II Series V122016. Data are seasonally adjusted quarterly data at annual rates. Annual series is constructed by averaging quarterly data.

(ii) Population data are from the International Financial Statistics [11199Z..ZF...].

Construction of Cyclical Income Measures

The per capita real disposable income series for both Residents and Non Residents are filtered using the approximation to the Band Pass filter described in Baxter and King (1999). The moving average length is set to two. The business cycle frequency is defined to be 2–8 years, which is standard in the macroeconomics literature. The income series are constructed over the period 1948 to 2002 and it is these series that are filtered. In constructing the filtered data, we lose the first and last two observations, but the remaining series are defined over 1950–2000.

Table 1: BC Hunting Licenses and Fees, Year 2000[a]

	Residents		Non Resident Aliens		
	Quantity	Fee ($)	Quantity	Fee ($)	Royalty ($)
Basic License	80 554	16.00	5 293	115.00	
Conservation Surcharge		5.00		30.00	
Individual Species					
Black Bear	15 409	20.00[b]	3 266	130.00[b]	50.00
Caribou	1 517	20.00	559	150.00	75.00
Cougar	1 035	30.00	227	150.00	75.00
Mule & White Tail Deer	95 154	15.00	1 492	75.00	38.00
Elk	10 812	25.00	839	150.00	75.00
Grizzly Bear	776	80.00[b]	339	530.00[b]	250.00
Moose	33 842	25.00	2 563	150.00	75.00
Mountain Goat	1 999	30.00	863	200.00	100.00
Mountain Sheep	1 913	50.00	388	400.00	200.00
Wolf	–	–	2 561	25.00	25.00
Bobcat/Lynx/Wolverine	668	8.00	320	25.00	–
Upland Game Bird	–	–	569	25.00	–
Bison	101	70.00	7	450.00	–
Total Species Licenses	163 226		13 993		

[a] Data provided by BC Ministry of Land, Air and Water Protection
[b] Includes $5 conservation surcharge on black bears and grizzly bears for Residents and $30 for Non Residents.

Table 2a: Resident Level and Logarithm Models: Estimation Results

Dependent Variable: Quantity of Basic Licenses (levels)			Dependent Variable: Quantity of Basic Licenses (logarithm)		
Explanatory variables (levels)	RU	RC	Explanatory Variables (logs unless indicated)	RU-L	RC-L
Constant	13.1534	11.7991	Constant	1.4122	1.4214
	7.1787	6.5922		0.2939	0.3129
Lag dependent variable	0.6692	0.6433	Lag dependent variable	0.7671	0.7257
	0.0814	0.0547		0.0842	0.0724
Basic license fee	-0.1391	—	Basic license fee	-0.2282	—
	0.0391			0.0838	
Conservation surcharge	-0.0567	—	Conservation surcharge (level)	0.0024	—
	0.0785			0.0056	
Combined fee	—	-0.1097	Combined fee	—	-0.1522
		0.0256			0.0580
Species price index	-0.0902	-0.1107	Species price index	-0.0591	-0.0970
	0.0394	0.0298		0.0556	0.0425
Cyclical income	-4.6346	-3.0496	Cyclical income	-0.6035	-0.3867
	6.7519	5.9264		0.5365	0.4882
Trend	-0.0796	-0.0626	Trend	-0.0074	-0.0046
	0.0301	0.0143		0.0028	0.0016
$\overline{R}^2$	0.972	0.973	$\overline{R}^2$	0.968	0.969
Separate vs. Combined fees	0.446		Non-Nested Test	0.002	0.360
Specification LR Test	0.490	0.793	Specification LR Test	0.046	0.061

Notes:

Coefficients are estimated by OLS. The sample is 1971-2000, 29 observations. The quantity of licenses is scaled by 1.0×e-4. Numbers below coefficient estimates are Newey and West (1987) standard errors calculated using a lag truncation parameter of two. Separate vs. Combined fees reports the marginal significance levels for an F-test that the coefficients on the Basic License Fee and the Conservation Surcharge in the levels regression RU are equal. Non-Nested Test reports the marginal significance level for an F-test for the coefficient from the predicted value for the alternative general specification (RU-L vs. RC-L and RC-L vs. RU-L) is equal to zero. Specification LR Test reports the marginal significance levels for a Box-Cox based LR test of the levels specification against the log specification.

Table 2b: Resident Level and Logarithm Models: Elasticities

Dependent Variable: Quantity of Basic Licenses (levels)			Dependent Variable: Quantity of Basic Licenses (logarithm)		
Short-run Elasticities	RU	RC	*Short-run Elasticities*	RU-L	RC-L
Basic license fee	-0.2319 [0.0018]	—	Basic license fee	-0.2282 [0.0125]	—
Cons. Surcharge	-0.0146 [0.4775]	—	Cons. surcharge (level)	0.0075 [0.6761]	—
Combined fee	—	-0.2110 [0.0003]	Combined fee	—	-0.1522 [0.0152]
Species price index	-0.1230 [0.0319]	-0.1510 [0.0012]	Species price index	-0.0591 [0.2994]	-0.0970 [0.0318]
Cyclical income	-0.3761 [0.4996]	-0.2475 [0.6118]	Cyclical income	-0.6035 [0.2727]	-0.3867 [0.4363]
Long-run Elasticities			*Long-run Elasticities*		
Basic license fee	-0.7011 [0.0297] (0.3323)	—	Basic license fee	-0.9800 [0.0913] (0.9716)	—
Cons. Surcharge	-0.0441 [0.4193] (0.0000)	—	Cons. surcharge (level)	0.0323 [0.7037] (0.0000)	—
Combined fee	—	-0.5917 [0.0000] (0.0018)	Combined fee	—	-0.5550 [0.0065] (0.0250)
Species price index	-0.3719 [0.0120] (0.0001)	-0.4234 [0.0024] (0.0001)	Species price index	-0.2539 [0.2587] (0.0025)	-0.3538 [0.0610] (0.0015)
Cyclical income	-1.1370 [0.5165]	-0.6938 (0.6087)	Cyclical income	-2.5918 [0.3000]	-1.4100 [0.4232]

Notes:
Elasticity measures are calculated from regression estimates; for the level regressions, elasticities are calculated at the mean levels of fee and quantity. For the logarithm regressions, the conservation surcharge elasticity is calculated at the mean surcharge. Numbers in square brackets [] are marginal significance levels for an F-test with null hypothesis that the elasticity is zero. Numbers in parentheses () are marginal significance levels for an F-test with null hypothesis that the elasticity is -1.

Table 3a: Non-Resident Level and Logarithm Composite Fee Models: Regression Results

Dependent Variable: Quantity of Basic Licenses (levels)			Dependent Variable: Quantity of Basic Licenses (logarithm)		
Explanatory Variables (levels)	NU	NC	Explanatory Variables (logs unless indicated)	NU-L	NC-L
Constant	-1.4242	-1.4220	Constant	0.3711	0.3901
	0.5113	0.5357		0.1003	0.1168
Lag dependent variable	0.5134	0.5474	Lag dependent variable	0.4229	0.4586
	0.1151	0.1106		0.0921	0.0929
Composite license fee	-0.0007	—	Composite license fee	-0.1746	—
	0.0002			0.0236	
Conservation surcharge	0.0003	—	Conservation surcharge (level)	0.0002	—
	0.0007			0.0012	
Combined fee	—	-0.0006	Combined fee	—	-0.1679
		0.0002			0.0280
Royalty index	-0.0002	-0.0004	Royalty index (level)	-0.0016	-0.0017
	0.0005	0.0006		0.0013	0.0013
Cyclical income	1.7277	1.7208	Cyclical income	3.4554	3.5472
	0.4915	0.5126		0.9288	0.9822
Trend	-0.0025	-0.0007	Trend	0.0014	0.0043
	0.0023	0.0015		0.0031	0.0029
$\overline{R}^2$	0.882	0.880	$\overline{R}^2$	0.903	0.902
Separate vs. Combined fees	0.205		Non-Nested Test	0.700	0.327
Specification LR Test	0.000	0.000	Specification LR Test	0.704	0.380

Notes: Coefficients are estimated by OLS. The sample is 1971-2000, 29 observations. The quantity of licenses is scaled by 1.0×e-4. Numbers below coefficient estimates are Newey and West (1987) standard errors calculated using a lag truncation parameter of two. Combined fee is the sum of the Composite License Fee and the Conservation Surcharge. Separate vs. Combined fees reports the marginal significance levels for an F-test that the coefficients on the Combined License Fee and the Conservation Surcharge in the levels regression NU are equal. Non-Nested Test reports the marginal significance level for an F-test for the coefficient from the predicted value for the alternative general specification (NU-L vs. NC-L and NC-L vs. NU-L) is equal to zero. Specification LR Test reports the marginal significance levels for a Box-Cox based LR test of the levels specification against the log specification.

Table 3b: Non-Resident Level and Logarithm Composite Fee Models: Elasticities

Dependent Variable: Quantity of Basic Licenses (levels)			Dependent Variable: Quantity of Basic Licenses (log)		
Short-run Elasticities	NU	NC	*Short-run Elasticities*	NU-L	NC-L
Composite license fee	-0.2039 [0.0003]	—	Composite license fee	-0.1746 [0.0000]	—
Conservation surcharge	0.0072 [0.6948]	—	Cons. surcharge (level)	0.0027 [0.8545]	—
Combined fee	—	-0.2124 [0.0009]	Combined fee	—	-0.1679 [0.0000]
Royalty index	-0.0071 [0.7588]	-0.0158 [0.5013]	Royalty index	-0.0305 [0.2300]	-0.0317 [0.2192]
Cyclical income	3.8744 [0.0020]	3.8590 [0.0027]	Cyclical income	3.4554 [0.0012]	3.5472 [0.0015]
Long-run Elasticities			*Long-run Elasticities*		
Composite license fee	-0.4191 [0.0014] (0.0000)	—	Composite license fee	-0.3025 [0.0000] (0.0000)	—
Cons. Surcharge	0.0148 [0.6796] (0.0000)	—	Cons. surcharge (level)	0.0047 [0.8529] (0.0000)	—
Combined fee	—	-0.4692 [0.0030] (0.0010)	Combined fee	—	-0.3102 [0.0000] (0.0000)
Royalty index	-0.0146 [0.7650] (0.0000)	-0.0350 [0.5161] (0.0000)	Royalty index	-0.0528 [0.2373] (0.0000)	-0.0585 [0.2282] (0.0000)
Cyclical income	7.9626 [0.0136]	8.5263 [0.0165]	Cyclical income	5.9876 [0.0077]	6.5524 [0.0111]

Notes: Elasticity measures are calculated from regression estimates; for the level regressions, elasticities are calculated at the means of the fees and licenses. For the logarithm regressions, the conservation surcharge elasticity is calculated at the mean surcharge. Numbers in brackets [] are marginal significance levels for an F-test of the null hypothesis that the elasticity is zero, while those in parentheses () are marginal significance levels for an F-test of the null hypothesis that the elasticity is -1.

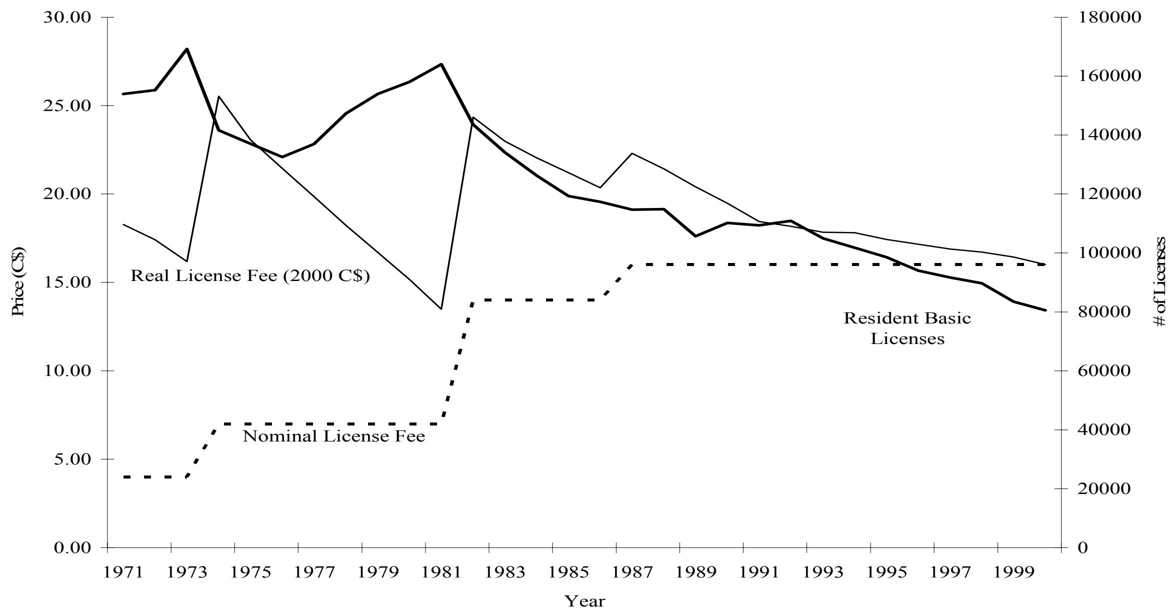

Figure 1: Basic Licenses for Residents

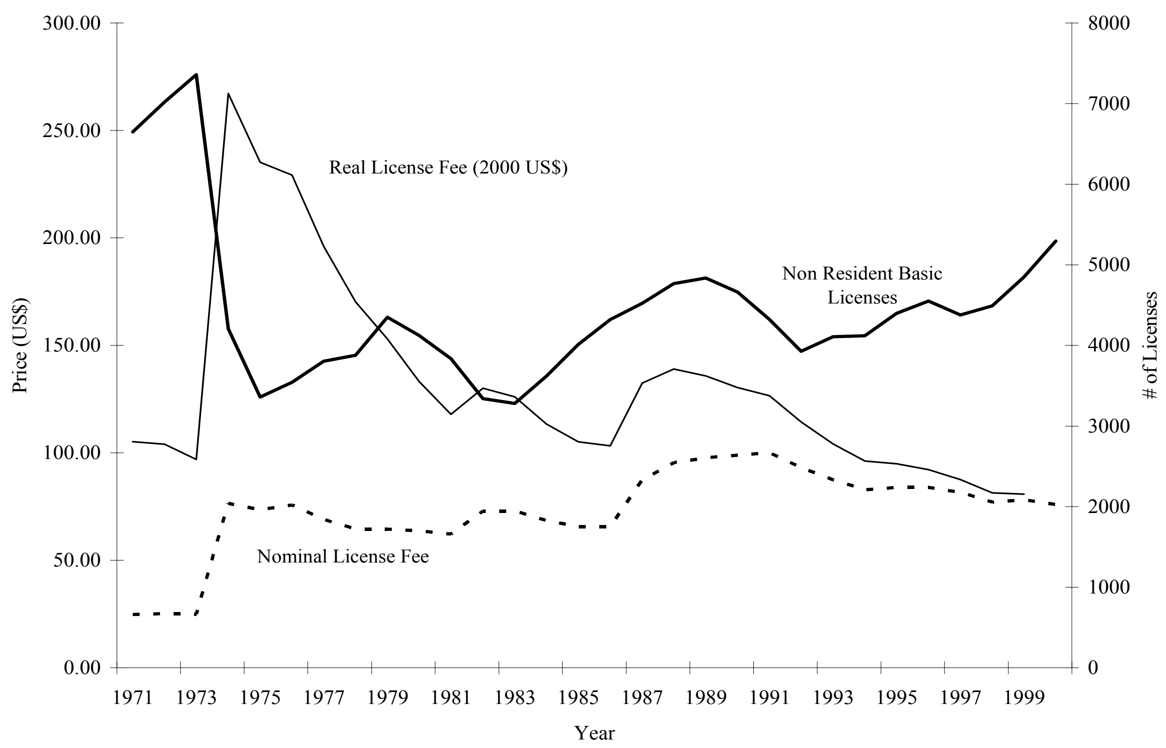

Figure 2: Basic Licenses for Non Residents

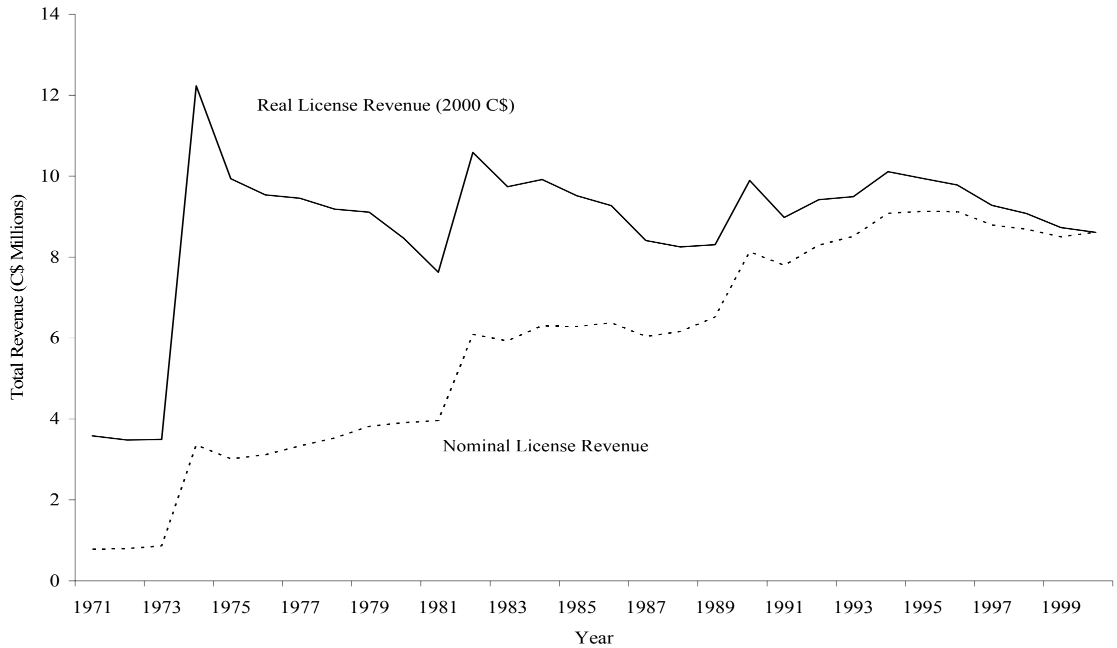

Figure 3: Revenues from Hunting Licenses

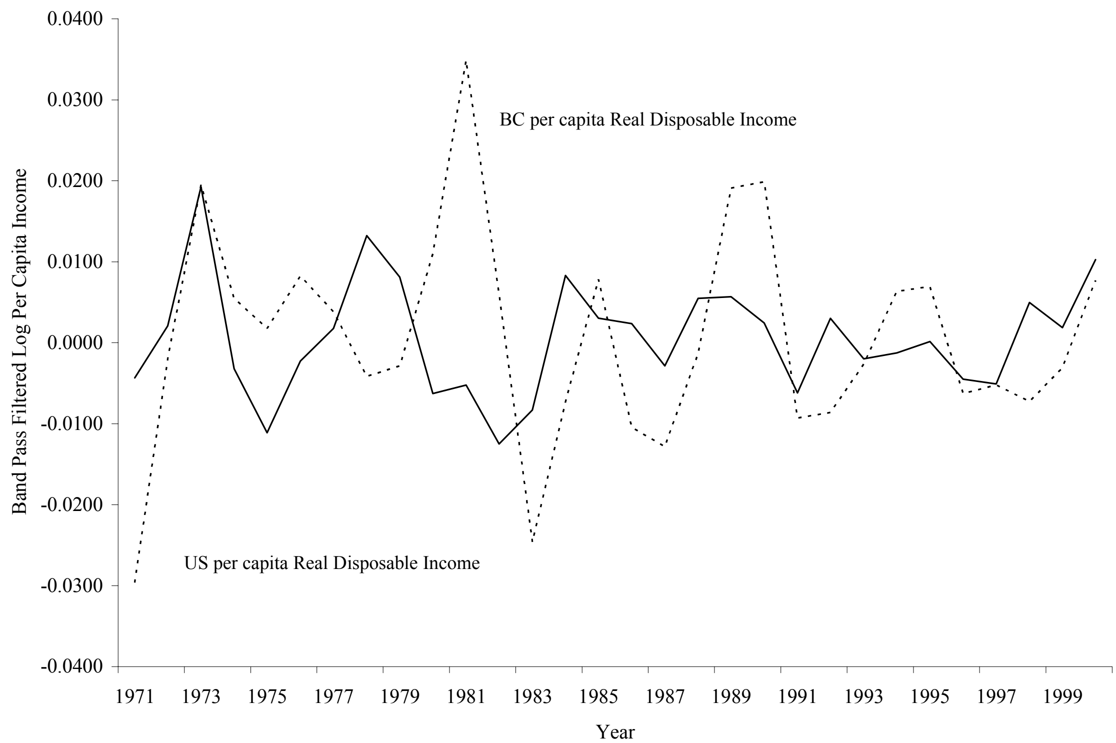

Figure 4: Cyclically-Adjusted Real Personal Disposable Income

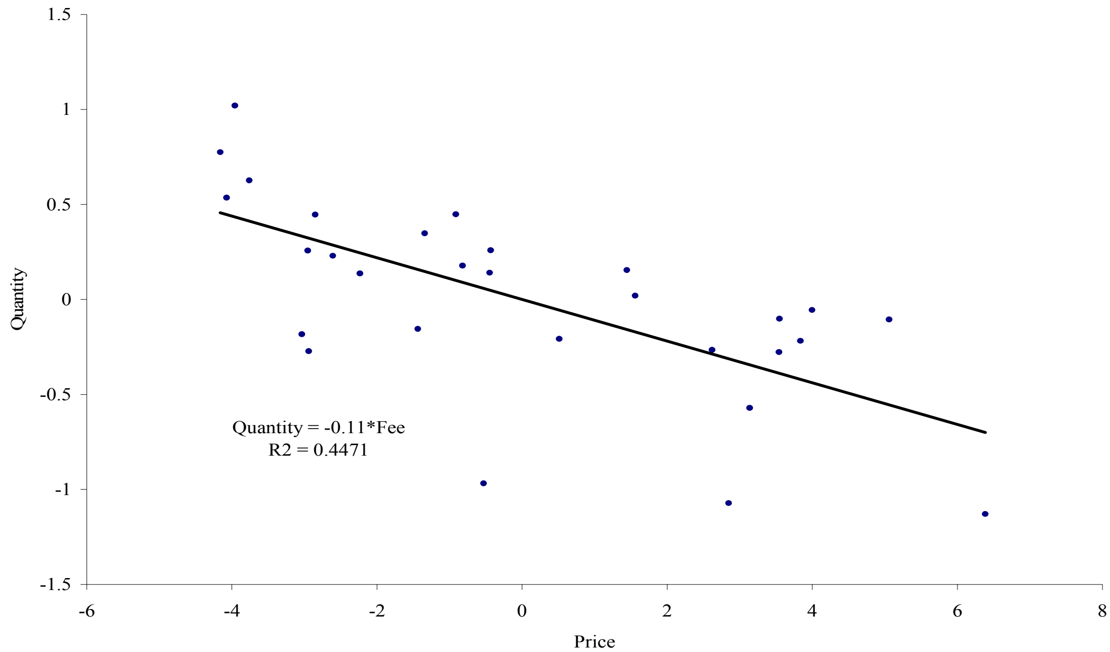

Figure 5: Estimated Residential Demand using Combined Fee

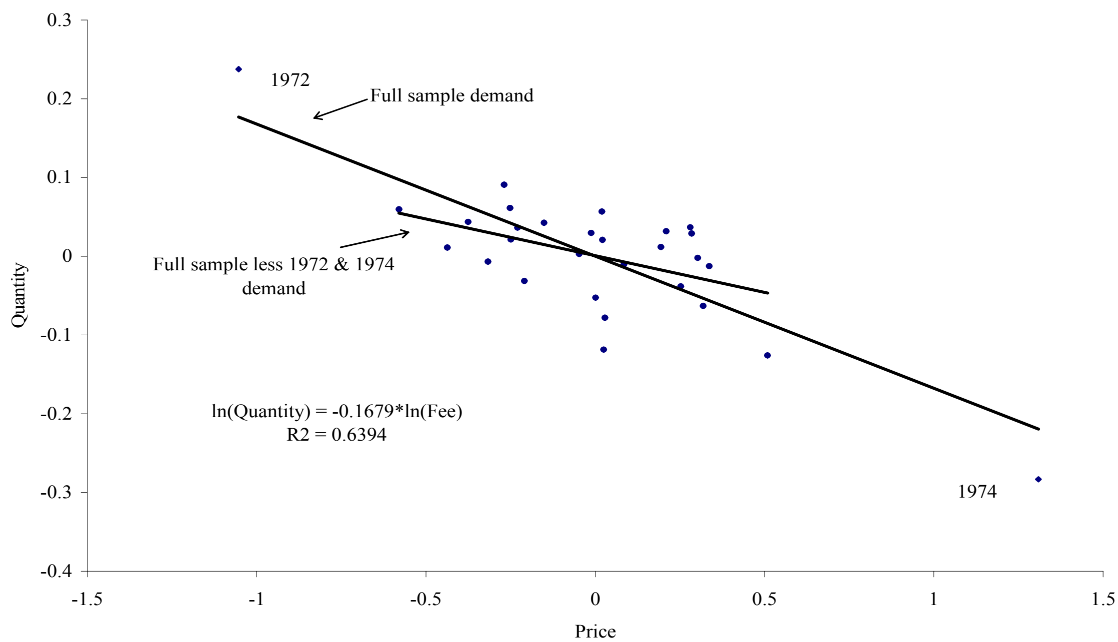

Figure 6: Estimated Non-Residential Demand using Combined Fee and Logarithmic Functional Form