Residential Energy Demand in Canada

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EXECUTIVE SUMMARY

Energy markets have experienced many changes in the past few years. There has been increasing pressure on energy supplies and increased volatility of energy prices, while environmental concerns about energy consumption have increased in importance, so that energy utilization and measures that might be used to affect it have become key issues. Although energy markets have been extensively analyzed, most of this work predates the recent increases in energy prices and attention to environmental concerns. Since many of the mechanisms being considered to address environmental concerns involve affecting the price of energy in order to influence the way that it is used, any assessment of how successful such policies are likely to be depends on the responsiveness of energy users to changes in energy costs. Of course this responsiveness is likely to differ in different sectors and in different regions. The purpose of this report is to provide information on price and income responsiveness of energy use in the residential sector in Canada.

Specifically, the analysis in this report focuses on estimates of energy demand responses to changes in energy prices, and income, as well as how these responses have evolved over time, particularly as real energy prices have changed. Provincial energy consumption and price changes pertaining to electricity, natural gas, and oil consumption are examined for a period spanning more than 40 years, from 1960 to 2007. Price elasticities and income elasticities are estimated using a linearized version of an Almost Ideal Demand System. Energy consumption patterns and responses to energy price changes are found to diverge noticeably between provinces and for different types of energy. Demand responses were generally stable overall through most of the period, but become more volatile when high price variations arose. This suggests that there may be some difficulty in predicting future energy consumption behaviour if prices continue to experience large fluctuations and rapid increases as in the past few years.

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1 Introduction

Energy markets have experienced many changes in the past few years. There has been increasing pressure on energy supplies as well as increased volatility of energy prices, with global energy demand rising due to the rapid economic development of several countries such as China, India, and Brazil. As the wealth and living standards of the large populations of these countries has improved, their use of and demand for energy has increased. At the same time, a number of forecasters have predicted energy scarcity within the coming decades, so that uncertainty about sufficient availability of energy supply in the future and its affordability is growing. In addition, environmental concerns about energy consumption continue to increase in importance, so that energy utilization and measures that might be used to affect it have become key issues. Although energy markets have been the object of close attention and extensive analysis, most of this work predates the recent increases in energy prices and attention to environmental concerns. While there are many ways that these environmental concerns have been and continue to be addressed, many of the mechanisms being considered involve affecting the price of energy in order to affect the way that it is used. However, any assessment of how successful such policies are likely to be depends on the responsiveness of energy users to changes in energy costs. The purpose of this report is to provide information on price and income responsiveness of energy use in the residential sector in Canada. Specifically, we focus on estimates of energy demand responses to changes in energy prices, and income, as well as how these responses have evolved over time, particularly as real energy prices have changed.

Canada is a large producer of energy, with sizeable reserves of natural gas and oil in the Prairies and a strong capacity for hydro-electricity production in most provinces, particularly in Quebec. As a result, most energy consumed in Canada is produced in Canada itself. However, with energy markets being integrated globally, prices are subject to the influence of factors external to Canada. This situation has been highlighted in the past few years when energy prices were very volatile and increased sharply. It is likely that due to these factors, energy price responsiveness in particular has changed over time, and might be expected to be quite different in recent years from the levels that were experienced previously.

Energy in the residential sector is mainly used for heating or cooling dwellings, lighting, and appliance use. The amount of energy used for these purposes depends on both the behavior of households and the characteristics of dwellings. However, the focus in this report is on aggregate consumption of energy and its response to changes in price, at the national and provincial level. Some other aggregate factors expected to influence the consumption of energy are included in the analysis, such as weather characteristics and the availability of particular sources of energy, especially natural gas.

The analysis reported here is based on data pertaining to consumption (quantities), prices and other factors for different sources of energy that have been assembled from a variety of sources. Due to data considerations, the analysis here is limited to the main sources of energy used in the residential sector: electricity, natural gas and light fuel oil. In order to describe the evolution of demand response to changes in price, the analysis uses data from 1960 until 2006. These data are available separately for the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec, as well as aggregated for the region comprising the Atlantic Provinces – New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador.

The remainder of this report is structured as follows. Section 2, which contains a description of the data, including an examination of the different variables and how they have evolved over time, provides an overview of energy markets in various Canadian regions for each source of energy. Section 3 presents the econometric model used to obtain estimates of the price and income responses of energy demand. Results concerning price responsiveness are discussed in Section 4, while Section 5 focuses on income elasticities. A brief summary and conclusion are provided in Section 6.

2 Evolution of energy prices and demand in Canada

2.1 Description of the data

The key series required for analysis of energy demand responsiveness are prices and quantities of the various energy sources used in the residential sector in each province. Unfortunately, there is no single source that provides all these data, especially for the extended period that is needed to analyze the extent to which such responsiveness has changed over time. Consequently, in order to conduct such analysis it is necessary to assemble data from a number of different sources, as is described in more detail below. The dataset used in the research reported here is part of a larger, though still incomplete, dataset that has been assembled by CBEEDAC researchers and covers the period 1960 to 2007. This larger dataset contains information on consumption (quantities) and prices for electricity, natural gas, light fuel oil, heavy fuel oil, wood, and kerosene in the residential sector. However, due to very low levels of heavy fuel oil and kerosene consumption, the analysis reported here focuses on the three main sources of energy for the residential sector – electricity, natural gas, and light fuel oil – although some descriptive information about wood consumption is also provided.

Residential consumption data pertaining to various energy sources for each province are obtained directly from Statistics Canada's electronic database, CANSIM II, and are measured in Terajoules. For the residential sector alone, these data are only available from 1978 to 2007, but data series that combine consumption for both the residential and agricultural sectors extend back to 1962. Using the combined residential-agricultural data in the analysis allows an examination of the effects of events taking place prior to 1978 in the energy sector. In any event, the share of the residential sector in this combined residential and agricultural data is considerably larger than the share of the agricultural sector, so that analysis based on the combined data will still predominantly reflect behaviour in the residential sector. Average prices for each energy source are computed at the provincial level by dividing energy sales revenue by quantities sold, and then applying appropriate provincial and federal tax rates to the resulting values. Price data cover the years 1964 to 2006 for electricity, and 1961 to 2007 for natural gas

and light fuel oil. In addition to average prices, which are needed to calculate expenditure on the various energy sources, the relevant variable for determining price responsiveness is the marginal electricity price. Marginal prices were assembled for the period 1961 to 2006 for electricity, and from 1961 to 2007 for natural gas. These marginal rates are computed using the monthly energy rates charged by utility companies, in addition to various variable charges, such as distribution, transmission, or service access, with appropriate provincial and federal tax rates again applied to the resulting series.

In addition to prices and quantities, there are various other variables that are relevant when assessing energy demand responsiveness. For natural gas, a variable that indicates the length of distribution pipelines is included to the analysis in order to reflect the availability of this type of energy in each province. Unfortunately, at the time this analysis was conducted, data for this variable could only be assembled from 1960 to 2001. Weather characteristics are captured by the calculation of heating degree days (hdd) and cooling degree days (cdd) for each province, annually from 1962 to 2007. Heating degree days are calculated from the monthly sum of the number of degrees between the daily average and 18°C every day, if the average is less than 18°C. The sum of monthly hdd is then used to obtain annual heating degree days. A similar procedure is used to compute cooling degree days, except that this calculation uses the number of degrees between the daily average and 18°C, when the daily average is above 18°C. The data are collected at a weather-station level and then aggregated to the provincial level using population weights.

In order to understand the response of energy demand to energy price changes, it is important to know how energy consumption and energy prices have evolved over the sample period. Figure 1 depicts energy consumption in Canada by source of energy from 1960 to 2007, while Figure 2 depicts various energy prices over the same period.

As can be seen from Figure 1, consumption of both electricity and natural gas in the combined residential and agricultural sectors has been increasing relatively steadily in Canada from 1960 to 2007, although natural gas consumption has experienced larger fluctuations since 1995. Consumption of light fuel oil increased until the early 1970's but subsequently decreased quite

rapidly. Data on wood consumption, which extend only until 2001, show relatively stable consumption levels overall, although there is a steady but slight decrease until 1978 and an increase in subsequent years.

Figure 1: Energy Demand in Canada

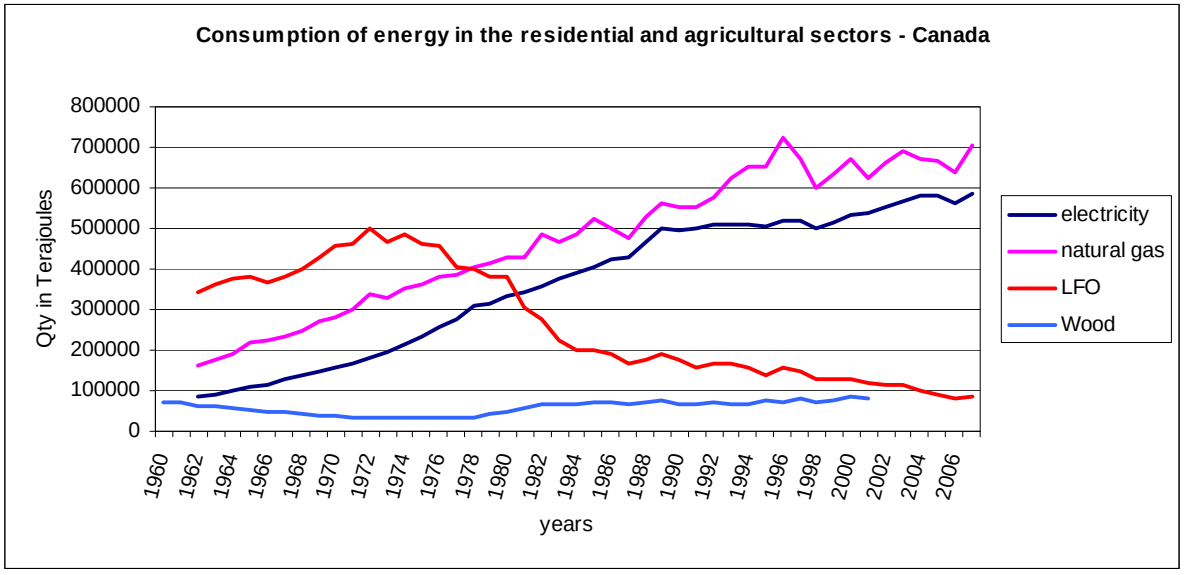
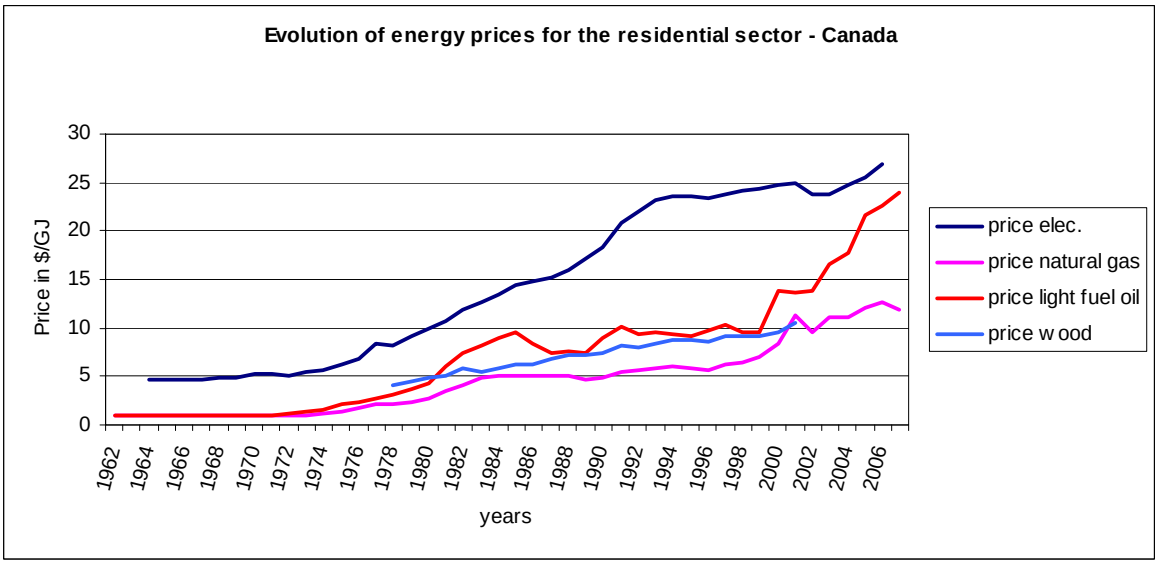


Figure 2: Energy Prices in Canada



Comparatively, the evolution of the energy prices in Canada, as shown in Figure 2, reveals increases over almost the entire period, with some short periods of decreases. Light fuel oil

prices fluctuate more than other prices, while wood prices, for which only limited data are available, appear to follow a less volatile path than the other energy prices. Excluding wood, natural gas prices have the smallest increase over the entire period. They remained relatively stable during the period 1984 to 1997, and then increased rapidly in the early 2000's.

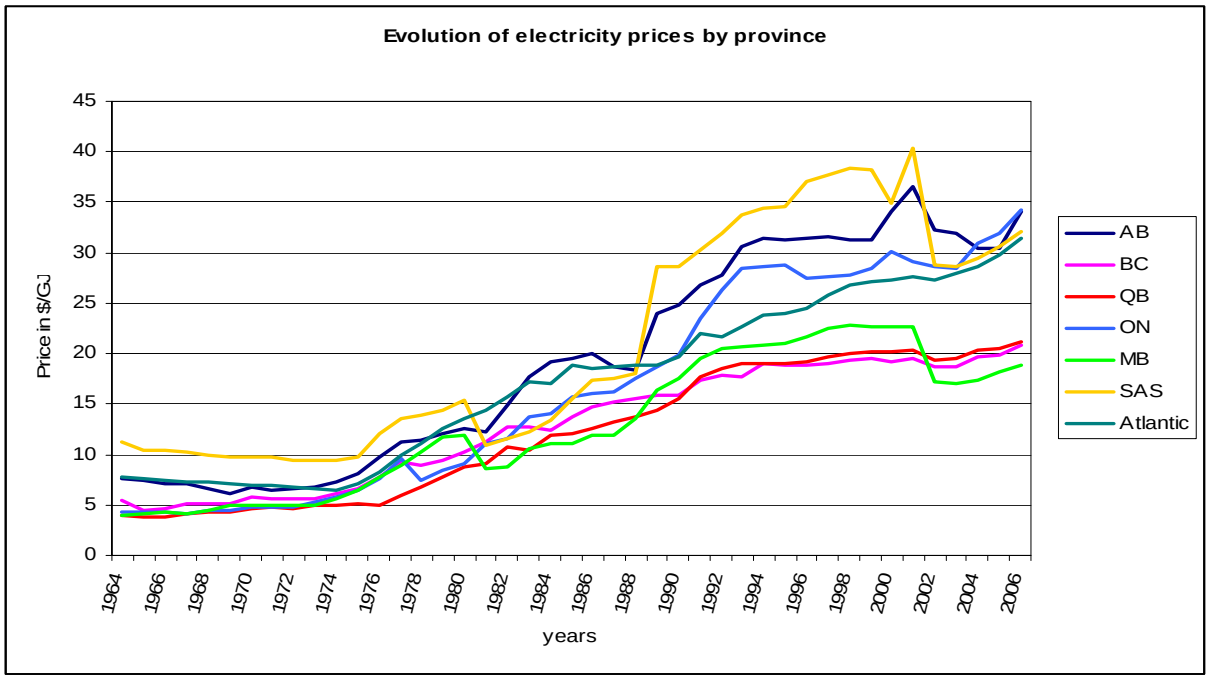
These observations for Canada as a whole often hide some dissimilarity between provinces. Reflecting their larger populations, Quebec, Ontario, and then British Columbia, have the largest consumption of energy, and tend to experience larger fluctuations in energy demands. Energy consumption in most provinces follows the Canadian trend, with an increase in electricity and natural gas use over the sample period and an increase followed by a decrease for light fuel oil. However, there are different patterns of consumption across provinces. Quebec does not consume much natural gas, consumption of light fuel oil in British Columbia and the Atlantic Provinces is higher than in all other provinces, and the Prairies are the largest consumers of natural gas. In view of the large dissimilarities in population size between provinces, in subsequent analysis comparisons across different provinces of consumption of the three energy sources are made on a per-capita basis.

2.2 Evolution of the electricity market

Figure 3 depicts average electricity prices in each province during the sample period. As this figure shows, there are some distinct differences in the evolution of these prices in different provinces. Ontario experienced the largest increase in average electricity prices, its price going from one of the lowest in Canada in the 1960's to one of the highest in 2006, along with Saskatchewan, Alberta and the Atlantic provinces. Prices in the Atlantic Provinces also increased over the sample period, but at a steadier pace, while Saskatchewan and Alberta experienced large fluctuations. British Columbia and Quebec have a very smooth evolution of their electricity prices, which have been relatively stable and low since the early 1990's. Finally, the price of electricity in Manitoba fell noticeably around 2001 and has remained low since then. This long sample period can be divided into a number of sub periods in order to better facilitate the analysis of energy demand response to changes in price. From 1964 to 1974, electricity prices were relatively stable and similar in every province. During the following 20 years, until

1994, prices generally increased, with much more fluctuation than previously, and with different patterns of evolution in different provinces. In particular, from 1994 to 2006, the price slowly increased in some provinces, while other provinces faced large fluctuations, with a peak in 2001.

Figure 3: Average Electricity Prices



For the same period, Figure 4 shows that Quebec, Manitoba and the Atlantic Provinces experienced large increases in consumption of electricity per person, so that increases in their population size did not account for all the observed increase in provincial electricity consumption. In Alberta, Saskatchewan, and British Columbia, per-capita consumption slightly increased over the entire period, while consumption per person in Ontario decreased after 1990.

The marginal prices of electricity, displayed in Figure 5, also show some disparities among provinces, although to a lesser extent than for the average prices. The same pattern applies to all provinces, with the exception of the 2001 peak in Alberta (corresponding to retail market restructuring and a greater use of natural gas for electricity generation), but Ontario seems to face more instability than the other provinces. Marginal prices were generally stable during the period 1960 to 1974, before increasing continuously until the end of the sample period.

Figure 4: Electricity Consumption Per Capita

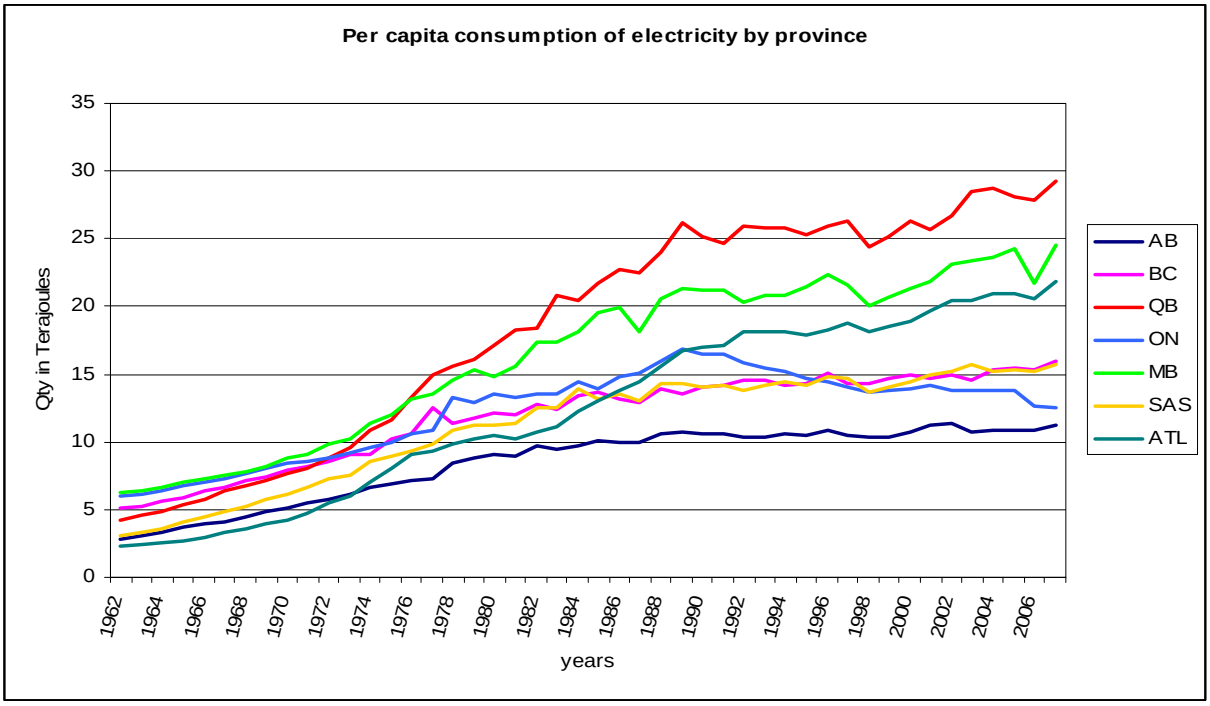
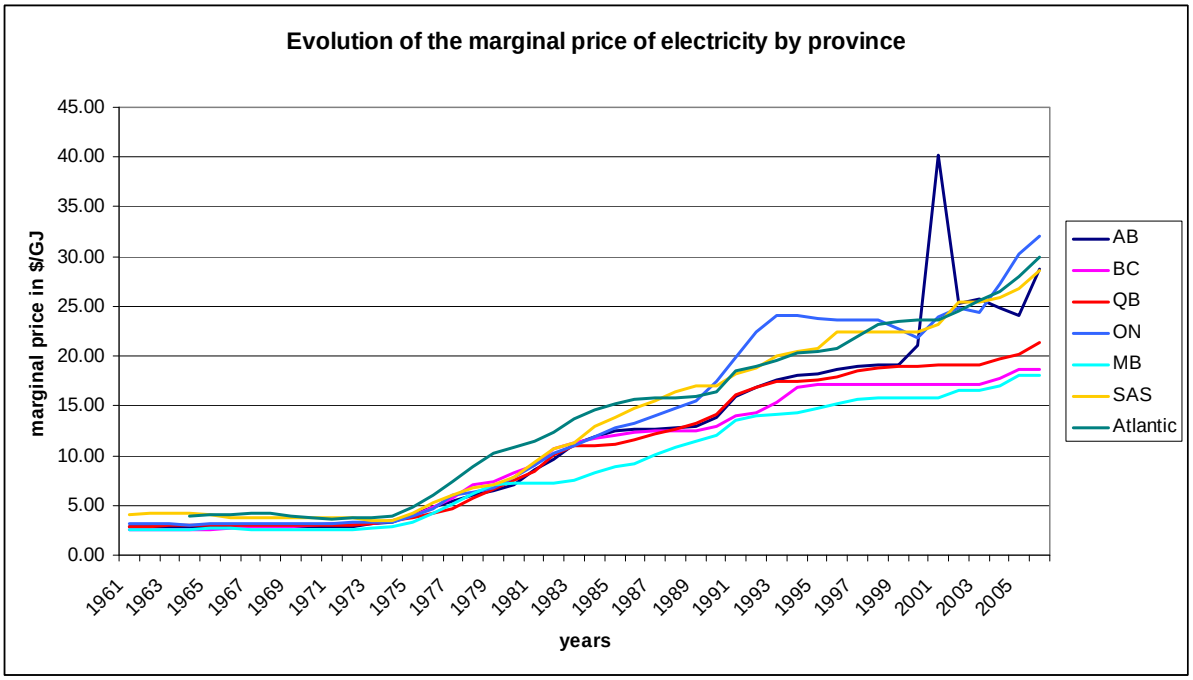


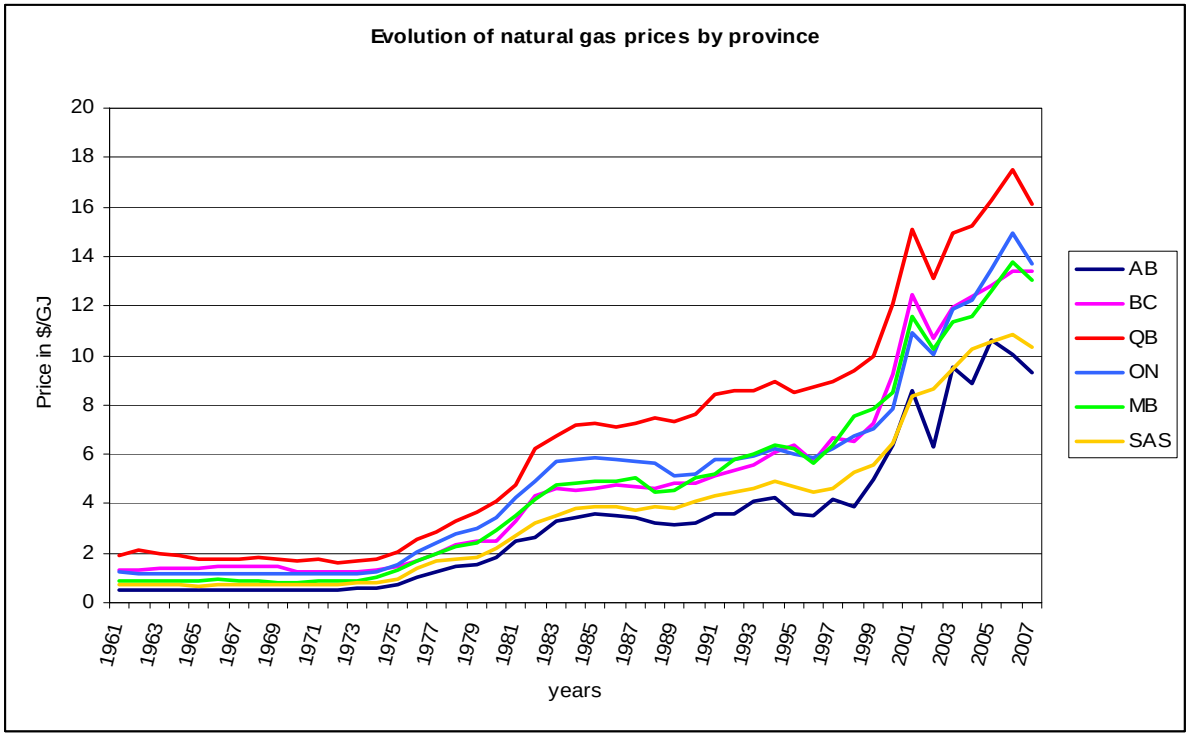
Figure 5: Marginal Prices of Electricity



2.3 Evolution of the natural gas market

Figure 6 shows that the evolution of average natural gas prices is more similar between provinces than is the evolution of electricity prices.

Figure 6: Natural Gas Prices

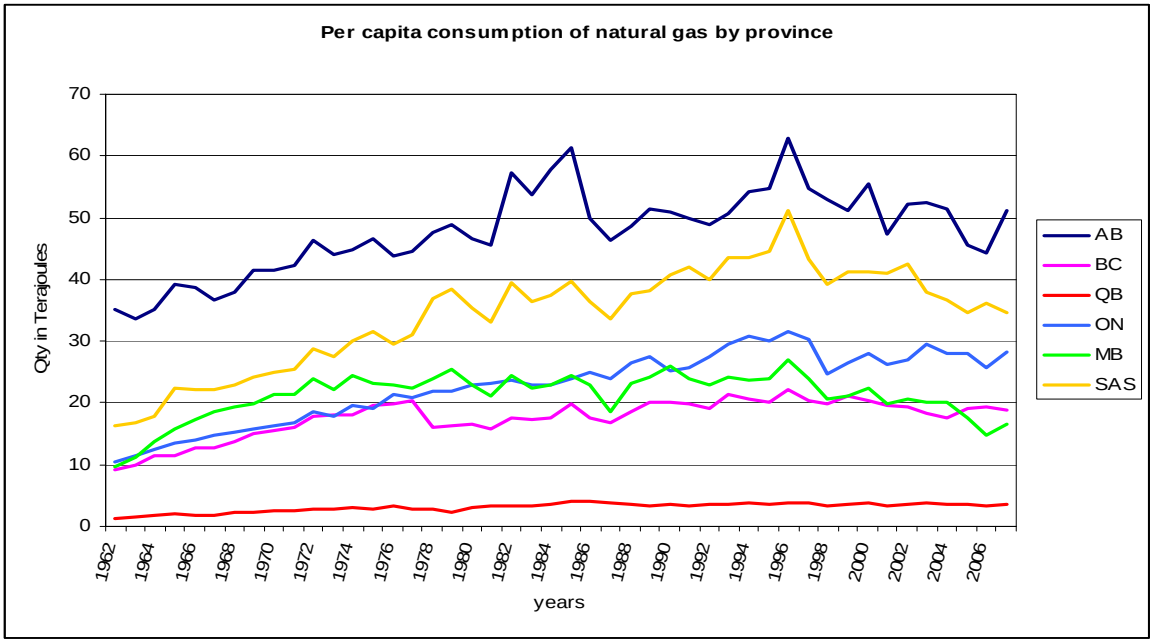


In general, natural gas prices are higher in Quebec and lower in Alberta and Saskatchewan. Except for Saskatchewan, where prices generally continued steadily upwards, natural gas provinces peaked in each province in 2001 and again in 2006. Note that the natural gas price for the Atlantic Provinces is not included due to the lack of availability of this energy source in this region for most of the sample period. In terms of analyzing consumer responses to changes in energy prices, four periods of price evolution can be distinguished. From 1960 to 1974, prices were very stable and very similar between provinces. For the decade following 1974, natural gas prices increased at a relatively regular rate. From 1984 to 2000, the difference between natural gas prices in different provinces generally widened; prices oscillated more but overall they

increased at a slower rate. Since 2000, average natural gas prices have increased sharply and have experienced more fluctuations, while the difference between natural gas prices in different provinces has further widened.

According to Figure 7, which shows the evolution of per-capita natural gas consumption, there are large differences between provinces, but the evolution of this series is similar in most provinces. There are large and frequent fluctuations in the consumption of natural gas, more than is observed in the consumption of electricity.

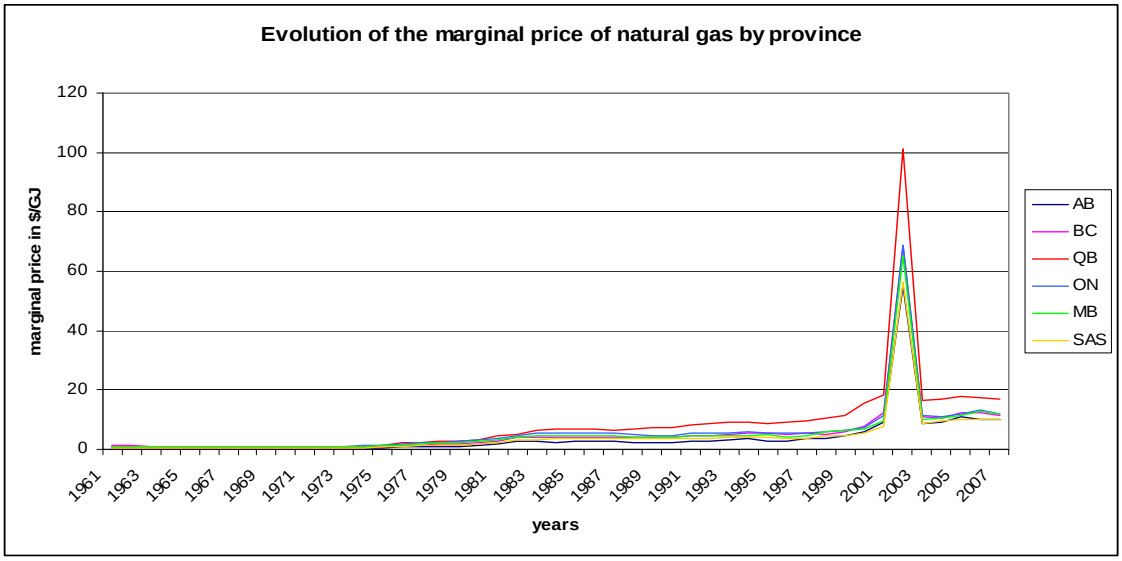
Figure 7: Natural Gas Consumption Per Capita



All provinces experience a peak of per-capita natural gas consumption in 1996, as well as from 1981 to 1987 for Alberta and Saskatchewan, which have the highest consumption per head. Quebec consumers use a very low per-capita quantity of natural gas, which is offset by their high consumption of electricity.

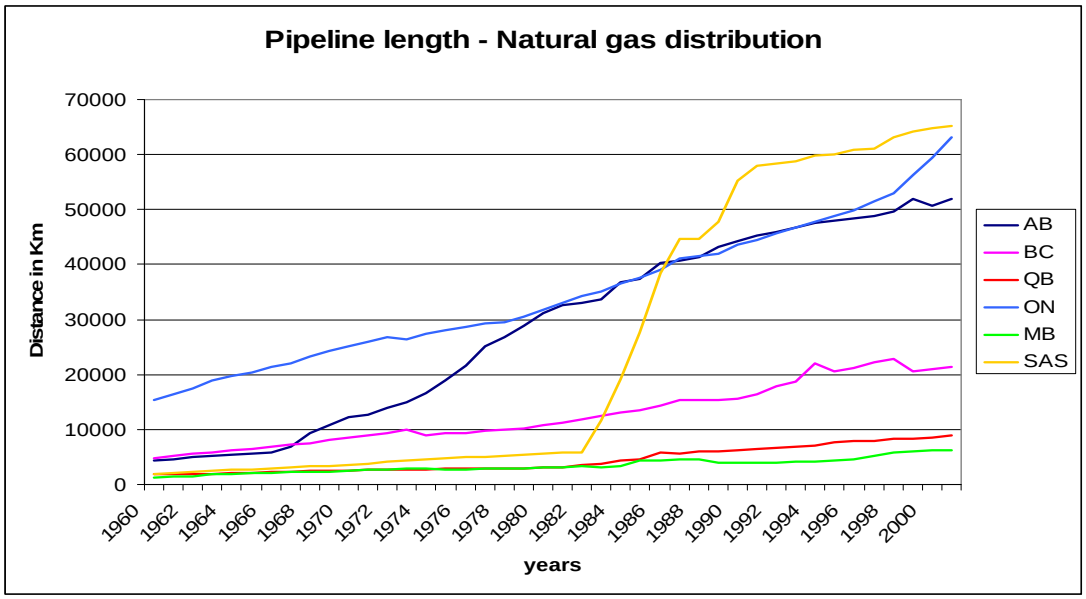
The marginal prices of natural gas, displayed in Figure 8, are very similar in each province. The prices are stable throughout the period, except during an enormous peak in 2002. Quebec has a higher price than all other provinces over the sample period.

Figure 8: Marginal Prices of Natural Gas



The consumption of natural gas is also greatly dependent on the availability of natural gas in the region, represented here by the length of distribution pipelines. Figure 9 shows the evolution of pipeline length in every province. This is mostly an important factor for Saskatchewan, Alberta and Ontario, which have seen their distribution network significantly extended over the sample period.

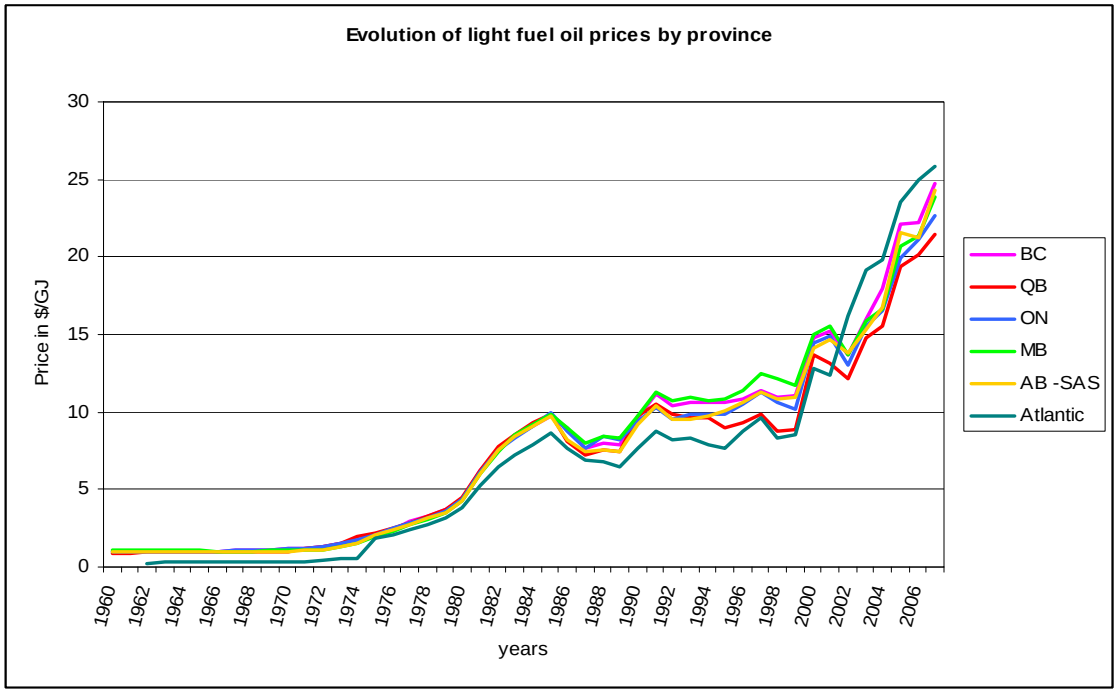
Figure 9: Pipeline Length



2.4 Evolution of the oil market

Figure 10 shows that, as for natural gas, the price of light fuel oil follows a similar pattern in every province; moreover, here there are almost no differences in the price level between provinces. The evolution of this series largely mimics the behaviour of natural gas prices. From 1960 to 1974, the prices are stable; during the following decade, they increase at a regular pace; while from 1984 to 2000, more fluctuations appear, as well as a widening gap between provinces. Finally, since 2000, prices have increased sharply and experienced larger fluctuations. The Atlantic Provinces have experienced the largest recent increase in these prices.

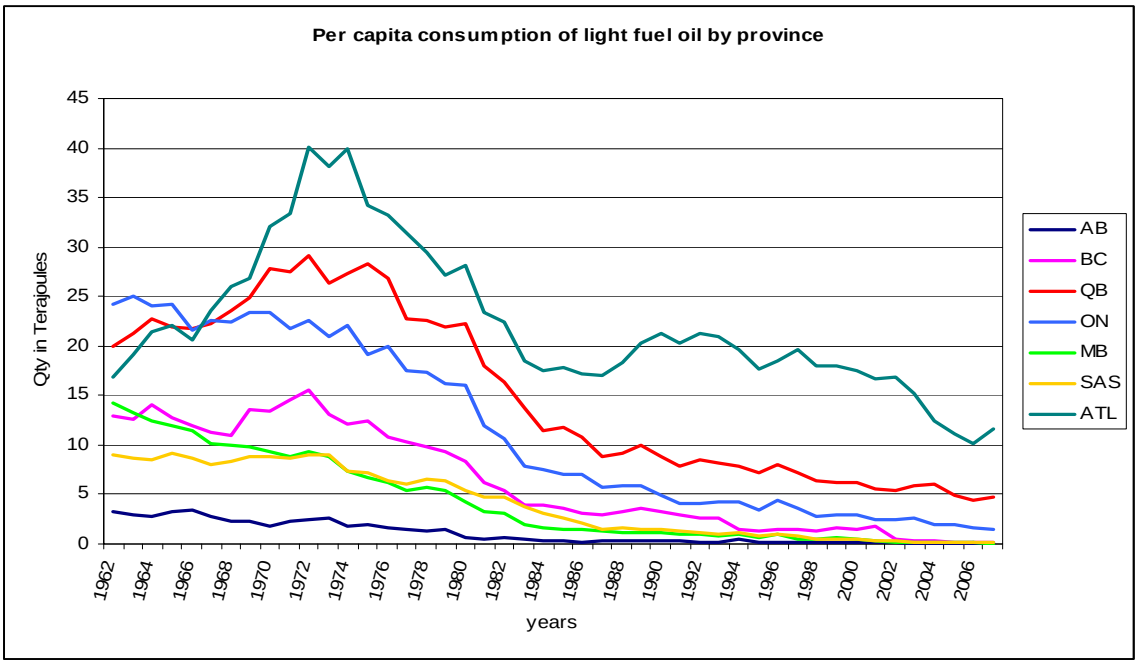
Figure 10: Light Fuel Oil Prices



Unlike the prices of natural gas, differences between provinces in oil prices are very small. However, per-capita light fuel oil consumption exhibits large dissimilarities between provinces, as shown in Figure 11. As mentioned earlier, the inhabitants of the Atlantic Provinces consume much more light fuel oil per capita than anywhere else in Canada, likely reflecting the lack of availability of natural gas in this region. Quebec has the next highest per-capita consumption of this energy source, while Albertans, who consume more natural gas, use considerably less oil.

While most of the provinces seem to follow a pattern of constant decrease in their consumption, this pattern shows some fluctuations. This is particularly apparent for the Atlantic Provinces, where per-capita oil consumption increased quickly until the mid 1970's, and then subsequently decreased just as fast, although there was a further short period of increases during the late 1980's.

Figure 11: Light Fuel Oil Consumption Per Capita

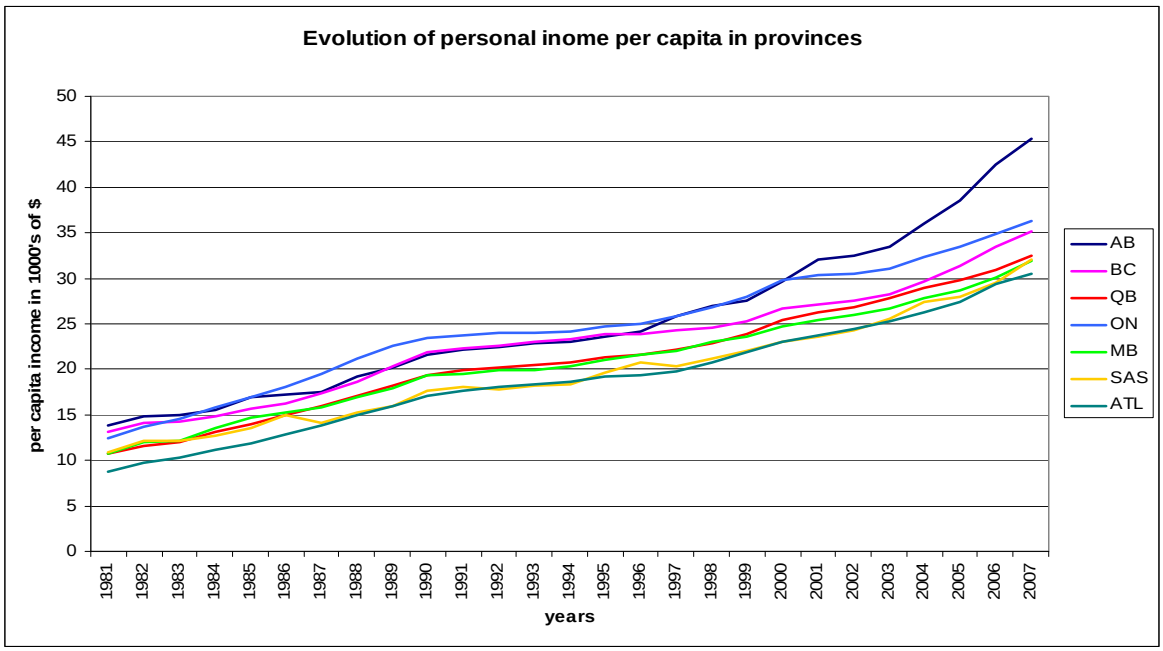


2.5 Other factors

Among other factors that influence energy consumption, weather plays an important role through its effect on heating or cooling needs. Heating needs are mainly reflected in the consumption of energy for heating a dwelling, with British Columbia and Ontario having the lowest heating degree days and Manitoba and Saskatchewan having the highest. The presence of cooling degree days is mainly reflected in energy consumed for air conditioning. Ontario and Quebec have the highest number of cooling degree days, while British Columbia, Alberta and the Atlantic provinces have the lowest number.

Some measure of personal income is also expected to influence energy consumption. Figure 12 shows the evolution of personal income per person in the different provinces. These series increase steadily for all provinces, with Alberta and Ontario having the highest per-capita income while the Atlantic Provinces and Saskatchewan have the lowest.

Figure 12: Personal Income



Z

2.6 Summary

The observations in the preceding sections illustrate that energy consumption patterns vary across provinces and over time, and that these variations over time are not the same for all provinces. Although the evolution of energy demand generally seems to follow the same pattern in most provinces, there are differences between provinces in scale and timing. The evolution of demand for the various energy sources is never smooth and from the preceding analysis it is not apparent that these demands respond directly to changes in prices, or that any such responses have been constant over time. It appears that for natural gas and light fuel oil, differences in the evolution of provincial energy demands, on a per-capita basis, are larger than the differences in the evolution of provincial energy prices. This suggests that for relatively similar changes in

prices in each province, the energy consumption patterns differ quite substantially. For electricity, there are wide differences between provinces in both the evolution of the prices and the quantities consumed. There is also much more instability in the consumption of natural gas than in the consumption of electricity, and some provinces experience more fluctuations for some particular sources of energy than do other provinces.

In summary, provincial factors appear to influence the way consumers demand energy and respond to various changes. These provincial divergences can be explained by two factors. First, variables influencing the demand for energy, such as energy prices, personal income, weather, etc., vary across provinces. Second, even accounting for these factors, energy demands and energy demand responses of households in different provinces might still differ simply because these households have different preferences. To allow for all these effects, empirical analysis of the demand for various energy sources and determination of price and income responsiveness will be conducted separately for each province and will incorporate the effects of various other factors, such as weather.

3 Modelling and Estimation of Residential Energy Demands

As noted earlier, in view of the available data our analysis for the residential sector focuses on three energy sources, natural gas, electricity, and oil products. As data sources are further developed, the analysis can be readily extended to include other energy sources, such as wood. The period of estimation is from 1962 to 2006, the end-point being limited by the availability of electricity prices. Since the data from 1962 to 1977 are only available for the combined residential and agricultural sectors, in the estimations undertaken here we focus on the combined data for the entire period. Very little change in the results occurs if the data after 1977 are limited to the residential sector alone, since the shares of total energy expenditure allocated to each energy source are not noticeably different in the residential sector in the combined agriculture and residential sector. Also, due to data limitations with calculated marginal energy prices, all the price variables used in the subsequent empirical analysis refer to average prices for the various energy sources.

To estimate demand responses we make use of the Linearized version of the Almost Ideal Demand System (LAIDS). Focusing on consumer expenditures on the three energy sources, the system of energy share equations that are estimated has the following form:

$$s_{it} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} \ln p_{jt} + \beta_i \ln(E_t / P_t) + c_i \ln hdd_t + d_i \ln cdd_t + \delta s_{i,t-1} + e_{it}$$

where:

s_{it} is the share of energy expenditures allocated to the i^{th} energy source in period (year) t, where i = 1,2,3 refers to natural gas, electricity, and oil, respectively;

E_t is total expenditure on the three energy sources;

p_{it} is the price of the ith energy source;

hdd_t refers to heating degree days in period t;

cdd_t refers to cooling degree days in period t;

$s_{i,t-1}$ refers to the value of s_{it} in the previous period, that is the lagged share;

P_t is the Stone price index, calculated as $P_t = \sum_{j=1}^{3} s_{jt} \ln p_{jt}$;

e_{it} is the error term for the i^{th} energy source in period t; and

$\alpha_i, \gamma_{ij}, \beta_i, c_i, d_i,$ and δ are parameters to be estimated, where i, j = 1,2,3.

Since the shares sum to one, and due to the linear homogeneity of energy expenditures in prices and total expenditure (doubling all prices and total expenditure on energy does not affect the quantities purchased of each energy source), there are certain conditions that the parameters must satisfy. These are as follows:

$$\sum_{i=1}^{3}\alpha_i + \delta = 1;\ \sum_{i=1}^{3}\beta_i = \sum_{i=1}^{3}c_i = \sum_{i=1}^{3}d_i = 0;\ \sum_{i=1}^{3}\gamma_{ij} = \sum_{j=1}^{3}\gamma_{ji} = 0;\ \ \gamma_{ij} = \gamma_{ji}\ \ i, j = 1,2,3.$$

The lagged shares, $s_{i,t-1}$, are included in the specification to allow for the possibility that consumer responses to price and income changes may not be immediate. For example, if the price of a particular energy source increases and the consumer wants to switch to a different energy source, it is typically necessary to make changes to the installed capital, such as the furnace or water heater, and this can often not be achieved instantaneously. Since these lagged shares also sum to one, it is necessary that they have the same coefficient (δ) in each equation.

Although all three energy sources are available throughout the sample period except in the Atlantic region, natural gas is only available to residential consumers if there are distribution pipelines. Therefore, it was desired to include the length of natural gas distribution pipelines as an additional explanatory variable in the share equations to control for this effect. Unfortunately, data on this variable could not be obtained for the later years of the sample period. Rather than limit the analysis to exclude the most recent years when this pipeline information is not available, this variable was omitted from the model. Efforts to obtain up to date data for this variable are continuing, and it is anticipated that it will be included in revised estimates at a later date.

Since the shares sum to one, as do the expressions (other than the error terms) on the right-hand side, it is necessary that the errors sum to zero. As a result, only two of the three equations are estimated, with the parameters of the other equation being retrieved using the conditions specified above. Since the same results are obtained regardless of which equation is omitted, this choice is arbitrary and we omit the share equation for electricity. Finally, since error terms in different time periods may be correlated, we allow for the possibility of a first-order autocorrelation process in the system of share equations, that is: $e_{it} = \rho e_{i,t-1} + \varepsilon_{it}$, where ρ is the

first-order autocorrelation coefficient, and ε_{it} is an error term. Since the errors sum to zero, the autocorrelation coefficient must be the same in all three equations.

The estimated coefficients of the system of share equations have little direct interpretation, so we focus our attention on the price and income responses. Specifically, we calculate the elasticity of each type of energy demand with respect to its own price (η_{ii}) as well as with respect to the prices of other energy sources (η_{ij}), as well as "income" elasticities which are the elasticity of energy demand with respect a change in total expenditure on energy (η_{iE}). For the LAIDS model specified above, these elasticities are obtained as follows:

$$\eta_{ij} = (\gamma_{ij} - \beta_i s_j)/s_i, \qquad i, j = 1,2,3;\ i \neq j$$

$$\eta_{ii} = (\gamma_{ii} - \beta_i s_i)/s_i - 1 \qquad i = 1,2,3;$$

$$\eta_{iE} = \beta_i / s_i + 1 \qquad i = 1,2,3;$$

These elasticities are evaluated using the estimated parameters and the estimated shares that result when the estimated parameters are used in the share equations of the LAIDS model as specified above. Since these estimated shares differ in each time period, the elasticities will also differ in each time period. Therefore, in the analysis of results below we use graphical representations of the elasticities so that it can be seen how they evolved over the sample period. Since the elasticities involve estimated parameters, they are themselves stochastic. Thus, rather than just considering the elasticity estimate in any time period, we also examine a 95% confidence interval for these elasticities, formed by adding and subtracting 1.96 estimated standard errors of the elasticities to and from each elasticity estimate. By determining whether this confidence interval includes zero for any particular year, the statistical significance of the elasticity can be readily assessed. Estimated price elasticities for the different energy sources are discussed in the following section, while estimated total energy expenditure elasticities (sometimes referred to as income elasticities) are considered in Section 5.

4 Price elasticities of energy demand

Figures depicting the three own-price elasticities as well as the six cross-price elasticities are assembled in the Appendix. In this section, the information concerning price elasticities that is contained in these figures is discussed for each energy source, and for each of the provinces or regions. This is followed by an overall summary for the three energy sources as well as a discussion of how recent price responses compare to those observed previously.

4.1 Electricity

In most provinces, the price elasticity of electricity is negative, between 0 and –1, and relatively stable before 2000. The negative elasticity signifies that an increase in the price will reduce consumption, but the consumption reduction will be proportionately smaller than the change in price.

In British Columbia (Figures A1-A3), the own-price elasticity of electricity is very stable but decreases in magnitude during the sample period from –0.7 to –0.6, meaning that demand has become less elastic over time. The elasticity with respect to the price of natural gas is small (-0.15) but increases in size a little during the period. The elasticity with respect to the price of oil is approximately –0.08, and very stable.

In Alberta (Figures A4-A6), the own-price elasticity varies between –0.6 and –0.7. Since 2000 it has been reduced in size to between –0.5 and –0.6, but with more variation. Electricity became a little less elastic after 2000, when the price suddenly increased substantially and then subsequently decreased, while at the same time consumption of electricity in Alberta did not fluctuate greatly. The elasticity of electricity with respect to the price of natural gas is also negative at around –0.4, but has increased in size to –0.7 since 2000, when the prices of natural gas increased. The elasticity of electricity demand with respect to the price of oil is more stable than is the elasticity with respect to the price of other energy sources. Although it fluctuated after 2000, it remained very small throughout the period (–0.025), and has not been significantly

different from zero since the late 1970s, indicating that the evolution of the oil price does not greatly affect the consumption of electricity in Alberta.

In Saskatchewan and Manitoba (Figures A7-A12), the elasticities of electricity consumption with respect to its own price, the price of natural gas and the price of oil are remarkably stable throughout the period, even though the prices themselves fluctuate considerably. The demand is relatively own-price elastic (–0.9 for Saskatchewan and –0.7 for Manitoba) but is very stable throughout the period. The price elasticity with respect to the natural gas price is relatively small (–0.1), but is generally significant and in Saskatchewan, varies more than the own-price elasticity. As in Alberta the price elasticity of electricity with respect to oil is negative but relatively small. It is insignificant in Saskatchewan, although significant in Manitoba, and in Manitoba it is larger in Manitoba (–0.07) and tends to increase during the sample period.

In Quebec (Figures A13-A15), the own-price elasticity of electricity fairly large at –0.9. As electricity is the main energy source in Quebec, the elasticities of electricity with respect to the prices of natural gas and oil are very small (–0.03 and –0.02, respectively), and although the elasticity with respect to the price of natural gas declined from –0.04 at the beginning of the period to less than –0.02 at the end, this elasticity remains significantly different from zero, unlike the elasticity with respect to the oil price.

Similarly in Ontario (Figures A16-A18), which also consumes large amounts of electricity, the own-price electricity elasticity is large (–0.8) but stable, while the elasticity with respect to the price of natural gas and oil is very small and generally not significantly different from zero – except for the elasticity with respect to the price of natural gas prior to 1978.

Finally, in the Atlantic Provinces (Figures A19-A20), the elasticity of electricity follows the same trend as in the previous provinces. It is stable around –0.9 with respect to its own price and around –0.05 for the price of light fuel oil, although this latter elasticity is never significant. Thus, the relatively larger consumption of light fuel oil in this region and the large variation in prices do not seem to affect the consumption of electricity any more than in the other provinces.

Since the consumption of natural gas in the Atlantic Provinces is zero throughout most of the sample period, elasticities with respect to the price of natural gas are not determined.

4.2 Natural gas

In British Columbia (Figures B1-B3), the own-price elasticity of natural gas varies around –0.5. Between 1960 and 2000, the elasticity of natural gas with respect to the price of electricity decreases from –0.2 to –0.3. However, apart from 1983 to 1987, this elasticity was not significant. After 2000, consumption of natural gas became less elastic with respect to the electricity price, almost returning to its original level, and was significantly different from zero. At the beginning of the period, natural gas consumption was relatively more elastic with respect to the price of oil (–0.1) in British Columbia compared to other western provinces, and remained so for a long time, but decreased recently. However, throughout the sample period this elasticity was not significant.

In Alberta (Figures B4-B6), which has the largest per-capita natural gas consumption in Canada, the own-price elasticity of natural gas is very uneven over time, following the large variation in natural gas consumption identified earlier in this report. Over the entire period this elasticity increases in size from –0.3 to –0.5. The elasticity of natural gas with respect to the price of electricity also experiences large fluctuations, but it decreases in size from –0.6 to –0.4 over the entire period. This relatively high number at least partially reflects the large changes in both the price of electricity and natural gas consumption. Due to very low consumption of light fuel oil and high consumption of natural gas in Alberta, the elasticity of natural gas to the price of oil is close to zero and never significant.

In Saskatchewan (Figures B7-B9), the own-price elasticity of natural gas is larger than in Alberta, but it is also increasing in size, ranging from –0.55 in 1960 to –0.8 at the end of the period, and experiencing large fluctuations. However, the elasticity of natural gas with respect to the price of electricity is smaller, but also decreasing in size from –0.3 to –0.1, and following the same pattern as in Alberta. The elasticity with respect to the price of oil follows a similar

pattern. Both these elasticities fluctuate considerably, but both remain significant throughout the sample period.

In Manitoba (Figures B10-B12), the own-price elasticity of natural gas follows the same pattern as in Alberta and Saskatchewan, but with larger fluctuations than in the other provinces, ranging from –0.3 to –0.7. Also, this elasticity was insignificant for some years near the start of the sample period, but has remained significant since that time. The elasticity of natural gas with respect to the price of electricity also experiences similar fluctuations as in Alberta and Saskatchewan, but it is larger than in these provinces, ranging from –1.3 to –0.5. As in Alberta, the elasticity with respect to the price of oil is near zero and insignificant. Generally, throughout the Prairie Provinces, consumption of natural gas has become more elastic with respect to its price, but less elastics with respect to the price of electricity. For the most part the own-price elasticities have similar magnitudes in the three western provinces.

In Quebec (Figures B13-B15), the own-price elasticity of natural gas is fairly large at –0.8, but remains around the same level over time, probably due to its high price variation but low and stable consumption. As for the provinces considered previously, its elasticity with respect to the price of electricity decreased over time, from –0.2 to –0.1, but includes large variations and has been insignificant since the late 9180s. The elasticity of natural gas with respect to the price of oil is insignificant throughout the sample period.

In Ontario (Figures B16-B18), the own-price elasticity follows the same pattern as for the other provinces, increasing in size over time from –0.7 to –0.9, but fluctuations are less than in the large natural gas consuming provinces such as in the Prairies. The elasticity of natural gas with respect to the price of electricity decreases from –0.4 to –0.2 and follows the same pattern as elsewhere. The natural gas elasticity with respect to the price of oil is quite large at the beginning of the period (–0.25) compared to other provinces, but it has decreased over time and is only significantly different from zero right at the start of the sample period.

4.3 Oil

In British Columbia (Figures C1-C3), the own-price elasticity of oil is significantly negative and increasing in size, ranging from –1.2 to –1.4. The elasticity of oil with respect to the price of electricity and of natural gas is positive, significant, and increasing. This is probably correlated with the higher consumption of oil in BC than in the Prairie Provinces.

In Alberta (Figures C4-C6), the elasticity of oil with respect to its own price was slightly negative and significant until 1978. Since that time it has been insignificant, while the point estimates of this elasticity have been positive (since 1985), and have fluctuated wildly in recent years. A similar pattern is observed for the elasticities of oil with respect to electricity prices and natural gas prices, although in these cases, the elasticities have always been positive and insignificant.

In Saskatchewan (Figures C7-C9), the behaviour of the own-price elasticity is similar to Alberta, except that the elasticity is significantly negative until 1987. The cross-price elasticities are insignificant throughout except for some years late in the sample period (1992 to 2001) where the elasticity of oil with respect to the price of natural gas is negative and just statistically significant. In Manitoba (Figures C10-C12), which has a similarly low consumption pattern of oil as in Saskatchewan, the own-price elasticity of oil varies from –1.2 to –1.6 over time and is significant throughout the sample period. The elasticity of oil with respect to the electricity price and natural gas price are both positive (around 0.4 and 0.2 respectively) and increasing, but generally insignificant.

In Quebec (Figures C13-C15), the own-price elasticity of oil is extremely stable at –1 during the entire period, as the increases in price proportionately match the decrease in the consumption. The elasticity of oil with respect to the electricity price and with respect to the natural gas price are both insignificant throughout the sample period. The consumption of oil is therefore only elastic with respect to its own price in Quebec. This might be related to high oil consumption in the province.

In Ontario (Figures C16-C18), which is also a large consumer of oil per head, the own-price elasticity of oil was around –1 at the beginning of the period but then steadily decreased to reach –0.5 by the end of the period. From 2000, the elasticity was more irregular. The elasticity of oil with respect to the price of electricity follows a similar pattern as in the Prairies (positive and increasing) but to a smaller extent, between 0 and 0.5. The elasticity to the price of natural gas is negative and increasing, but never exceeds –0.2. Neither of these two cross-price elasticities is significant at any time.

In the Atlantic Provinces (Figures C19-C20), a major consumer of oil per capita, the own-price elasticity of oil is high but stable at around –0.9. Over the entire period, as the prices increased, consumption decreased. The elasticity of oil with respect to the price of electricity varied from -0.18 in the 1960's to –0.06 in the mid 1970's and back to around –0.15 in the most recent years, and has remained positive throughout.

4.4 Summary

Electricity

Of the three energy sources, the own-price and cross-price electricity elasticities are the most stable over the entire sample period. This means that for the most part, the response of the demand for electricity to changes in prices does not depend of the level of the prices (which have changed over this period), so that consumer behaviour is generally the same whatever the level of the price. The average own-price elasticity for electricity is around –0.8. Demand is usually more elastic for Quebec, Ontario, and the Atlantic Provinces, who are larger consumers of electricity than provinces in western Canada, although Saskatchewan also has a relatively large own-price elasticity. The elasticity of electricity demand with respect to the price of natural gas is relatively low, at around –0.1. It is larger for Alberta and smaller for Quebec, possibly due to differences in their consumption of natural gas. It seems that the demand for electricity is less affected by changes in the prices of other energy sources when the consumption of electricity is large. In Manitoba and British Columbia, the cross-price elasticity of electricity with respect to

oil is very small, being less than –0.01. In all other provinces and regions this elasticity is insignificant. Overall, electricity demand is relatively elastic to its own price but relatively inelastic to changes in the prices of other energy sources.

Natural gas

The elasticity of natural gas to its own price and to electricity prices is very unstable and changes over time. This means that when the level of the prices change, the consumer's response is modified. As discussed below, with the sharp increase of natural gas prices after 2000, the demand for natural gas became more inelastic. Overall, the price elasticity of natural gas to its own price is around –0.5. This is smaller than that of electricity; as natural gas is the main source of heating in Canada, the demand is less elastic. There are, however, variations between provinces: Alberta, which is the main consumer of natural gas on a per-capita basis, has a very inelastic demand, ranging from –0.2 to –0.5. Conversely, the demands for natural gas in Quebec and Ontario, where per-capita consumption of natural gas is smaller, are more elastic at around –0.8. The elasticity of natural gas with respect to the price of electricity is generally smaller. Here, the cross price elasticity is around –0.2, except in Alberta where it is between –0.6 and -0.4. The cross price elasticity with oil is insignificant except in Saskatchewan, where it ranges between –0.25 and –0.1. Overall, the demand for natural gas is relatively elastic to its own price, slightly elastic to the price of electricity but generally unaffected by changes in the price of oil.

Oil

The price elasticity of oil is very disparate across the provinces of Canada. In some provinces it fluctuates strongly over time, but for other provinces it does not. This means that provinces are affected differently by changes in the oil price. To some extent there appear to be greater variations in the own-price elasticity over time in western Canada, although even this is not consistent. The own-price elasticity is not significant in Alberta or Saskatchewan since the mid 1980s, or in Ontario since the late 1990s. Elsewhere the own-price elasticity is significant and larger than the own-price elasticities of electricity or natural gas. The elasticity of oil with

respect to the price of natural gas is positive and significant in British Columbia elsewhere. The elasticity of oil with respect to the price of electricity is also positive and significant in British Columbia but generally insignificant elsewhere, except in the Atlantic Provinces where it is small but negative. Thus, oil consumption is very elastic to its own price in many provinces, but not very responsive to other energy prices.

Interestingly, there does not seem to be an obvious relationship between the price elasticity of demand for any particular source of energy and the level of consumption of that energy source. In some cases demand is more own-price elastic for the provinces that are large consumers of a particular energy source, while in other cases demand is more elastic when the province is a small consumer. As well there does not appear to be a particular province where demand is always more or always less own-price elastic than elsewhere. The demand for light fuel oil is usually more own-price elastic, but this elasticity tends to vary more over time than the other own-price elasticities.

After 2000

In the period since 2000, large changes have occurred in energy prices. Prices of electricity, natural gas and oil have all displayed high volatility and rapid increases. Consumers of these three sources of energy reacted differently to these changes, leading to a variety of modifications to the previously determined values of the price elasticities. The changes in electricity prices were smoother than the changes in the prices of natural gas and electricity, but were more disparate across provinces. These changes did not have much effect on the own-price elasticity of electricity consumption, although in British Columbia, Alberta, and Saskatchewan the own-price responsiveness did decrease marginally, and in Alberta it became more variable. Overall though households appeared to adjust their consumption to the new prices the same way they did prior to 2000. However, it is apparent that following the rise in electricity prices, the elasticity of natural gas with respect to the price of electricity became slightly smaller in size (less elastic), while the elasticity of oil with respect to the price of electricity was largely unchanged except for Manitoba where its positive value increased slightly.

The change in natural gas prices after 2000 was more rapid than for electricity prices. It also led to more uniform consequences. The response of electricity demand to natural gas price changes became slightly larger in size except in Quebec and Ontario where there was little change. A similar result occurred for the own-price natural gas elasticity, although here the increases in size were generally larger. There was little effect on the elasticity of oil with respect to the natural gas price.

The price of oil was also more unstable and increasing after 2000. However, in view of the insignificance of most elasticities with respect to the price of oil by the second half of the sample period, these later oil price changes had little effect on consumer responsiveness. The most noticeable effects, which were generally small, occurred in British Columbia and Manitoba, where the responsiveness of electricity demand and oil demand to oil price changes increased.

5 Energy expenditure elasticities

Since the relevant income variable in the estimated share equations is total expenditure on the three energy sources, the income effects that are calculated really refer to the effects of changes in total expenditure on the three energy sources. Thus the elasticities that are calculated should be referred to as total energy expenditure elasticities, since they represent the percentage effect on consumption of a particular energy source of a percentage change in total expenditure on the three energy sources. However, for convenience, and in common with typical practice, we refer to these measures as income elasticities.

As for other western provinces, the income elasticity of electricity in British Columbia (Figures D1-D3) is around 0.9 and does not change over the period. The demand for natural gas is similarly relatively income elastic, although it experiences small fluctuations over the period. The sudden and sharp increase in natural gas prices after 2000 made natural gas demand slightly more income elastic. The income elasticity of the demand for oil decreases from 0.7 in 1964 to 0.2 in 2006.

Alberta (Figures D4-D6) has experienced the largest increase in its income per head over the period and in recent years has reached the highest level in Canada. Generally, it is found that the income elasticity for any energy is a lot larger and generally tends to exhibit less variability over time than the price elasticities. The income elasticity of electricity in Alberta is positive and just below 1.2 throughout the sample period. Small variations appear after 2000, at which time the demand for electricity became a little more income elastic. As the major source of energy used in Alberta, the demand for natural gas is a little less income elastic than electricity, with values around 0.9 during the entire period. In contrast to electricity, there are no major fluctuations that appear after 2000, although natural gas demand became a little more elastic in this later period. The income elasticity of oil differs from the other energy sources, displaying considerable variation, especially in later years. While the income elasticity of oil was insignificant in the early years of the sample, beyond 1980 it is significant but negative, indicating that an increase in income would cause a decrease in oil consumption. The high volatility of this elasticity mostly occurs in the last decade following the large instability and increases in oil prices.

However, due to the very small amounts of oil consumed in Alberta by the end of the sample period, this observation would appear to have little relevance.

In Saskatchewan (Figures D7-D9), the income elasticity of all three types of energy is similar to those of Alberta, but exhibits less variation. The income elasticity of electricity is close to 1 throughout the sample period, including after 2000. Demand for natural gas is a little more income elastic (1.1) than in Alberta, while the income elasticity of oil becomes negative after 1998, but is not significant after 1987.

In Manitoba (Figures D10-D12), the income elasticity of electricity is very stable around 0.9 during the period. The evolution of the energy market after 2000 does not affect the behaviour of Manitoba consumers in this regard. The demand for natural gas is more income elastic (1.4 on average) than is the demand for electricity. It is also less stable during the period, with more fluctuations appearing and the elasticity tending to decrease over time. The income elasticity of the demand of oil is very stable around 0.9.

In Quebec (Figures D13-D15), the high consumption of electricity does not seem to affect the income elasticity, as this has a similar value as in other provinces (+1) and is remarkably stable. The income elasticity of natural gas also has a similar value as in other provinces of 0.9, although with some variability. The response of oil demand to changes in income is also more stable than in other provinces, remaining at +1 during the entire sample period.

In Ontario (Figures D16-D18), the demand of electricity responds to changes in income in much the same way as in the other provinces. The demand for natural gas is more income elastic (1.3 on average) than in the other provinces, although it becomes less elastic over time, fluctuating between 1.4 in 1964 and 1.2 by 2006. The income elasticity of oil follows a similar pattern as in several other provinces, beginning around 1 in 1964, then decreasing and becoming insignificant by 1990.

In the Atlantic Provinces (Figures D19-D20), the income elasticities for both electricity and oil are positive and close to +1 throughout the sample period.

Overall, the income elasticity of electricity is similar and stable in each province. The demand for natural gas is often more income elastic than the demand for electricity. However, there are larger fluctuations over time in the income elasticity for natural gas, and the values and small differences appear between provinces. This makes the effect on consumption of natural gas less predictable when changes in income (total energy expenditure) occur. The demand of oil is generally less income elastic than the other energy sources. After 2000 there are large fluctuations in this elasticity in the provinces that do not consume much oil, but the demand responses of provinces that are large oil consumers to changes in income is especially stable over time. Demands for energy are therefore more elastic to changes in income than to changes in their own price or the price of other energy sources. However, in contrast to price responses, income responses in different provinces are quite similar.

6 Conclusion

In this report, the evolution of energy demand and energy demand price and income responsiveness is examined for the residential sector in Canada. Using detailed data for each province, extending from the early 1960's to 2007, the evolution of demand for and prices of electricity, natural gas and oil are characterized. Subsequently these data series are used with information on weather-related variables to estimate a LAIDS model of energy expenditure share equations for the residential sector in each province and region. The estimated parameters from this model are used to obtain estimates of own-price and cross-price elasticities as well as total energy expenditure, or income, elasticities for each energy type in each province.

The main findings concern large disparities among provinces and among energy types. Consumers respond differently to changes in the price they face according to the province where they are located and to the type of energy considered. This means that energy demand does not have the same elasticity in each province or for each different energy source. Moreover, it is not the same provinces that have always the highest/lowest elasticity. It is found that generally, the demands for electricity, natural gas and oil have negative own-price elasticities and cross-price elasticities with respect to the prices of other energy sources, but have positive elasticities with respect to changes in income. The income elasticity is always larger than price elasticity, and is also more stable over time. In many, but not all, provinces, the income elasticity for oil decreases over time and becomes insignificant in the later part of the sample period. The income elasticity of electricity is more even across provinces, while electricity is more responsive to changes in its own price rather than to changes in the prices of other energy sources. The demand for natural gas is usually less elastic to changes in its own price than is the demand for electricity or oil, although its cross-price elasticities are usually higher than those for electricity or oil. This means that oil and electricity prices have a greater effect on the consumption of natural gas than the prices of natural gas and oil have on the consumption of electricity.

There does not appear to be an obvious relationship between the level of consumption of a particular energy source in a province and the demand elasticities for that province. For example, the Prairies are the largest consumers per capita of natural gas and they exhibit the

most inelastic demand for natural gas in Canada. However, Quebec has the highest consumption per head of electricity and exhibits the most elastic demand for electricity in Canada. Of course this does not mean that the demand for energy in the Prairies is always the most price inelastic in Canada (or that Quebec always has the most price elastic demand in Canada), as these rankings differ for different energy sources and at different times. In general, the effect of price changes on energy consumption became less predictable after 2000, as high price volatility was correlated with high elasticity volatility. If prices continue to exhibit large variation, and to increase sharply as was the case in the recent past, the effect on the energy consumption might be more difficult to predict as this may induce further changes in the elasticities. This suggests that when consumers see high volatility in the energy prices, they tend to change the extent to which they adjust their behavior to changes in prices. However, this tendency does not appear to extend to other factors such as income, as income elasticities were not greatly affected by the different price behaviour in the period after 2000.

Finally, while it is difficult to succinctly summarize the large amount of information that has been presented in this report, there are perhaps four main messages that are evident. First, it is inappropriate to view Canada as a homogeneous whole when considering energy demand responses to price or income changes. Effects differ across different provinces, in different ways for different energy sources, and in different ways at different times. Thus, detailed analysis needs to be conducted at the provincial level rather than for Canada as a whole. Second, price and income elasticities are not constant over time, so that model specifications that impose such a restriction are inappropriate and are likely to yield misleading inferences. This also suggests that a common practice in models that don't impose such a restriction, of just evaluating elasticities at the sample means, for example, is likely to mask much information about how these demand responses vary across time. Third, although some elasticities exhibit increased volatility in recent years, in many cases (especially with respect to oil) these elasticities are not significantly different from zero, so that there is no informational content in this observed volatility. This highlights the need to look beyond the point estimates of elasticities, and to also calculate their significance. Finally, taken as a whole, the results obtained here suggest the need for relatively frequent re-estimation of these price and income responses as new data become available. Otherwise, assessments of how successful various policies or mechanisms that are

being considered to address environmental concerns are likely to be, especially those that affect the price of energy in order to influence the way that it is used, may be completely mistaken.

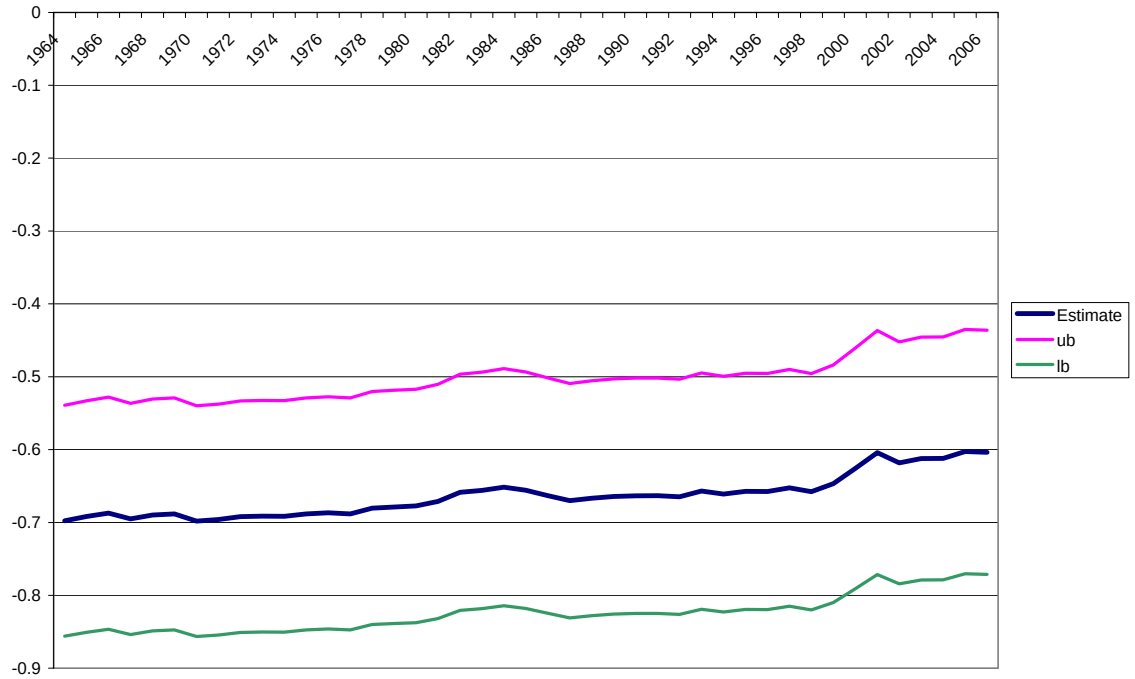
APPENDIX: ESTIMATED ELASTICITIES

This appendix contains figures that depict the estimated elasticities calculated from the estimates of the parameters of the LAIDS model, as described in Section 3. As well as the elasticities themselves, 95% confidence intervals for these elasticities are also computed. These are indicated on the figures by the lines labeled “ub” for Upper Bound, and “lb” for Lower Bound. At any point where this interval includes zero, the estimated elasticity is not significantly different from zero, and its sign at those points is irrelevant.

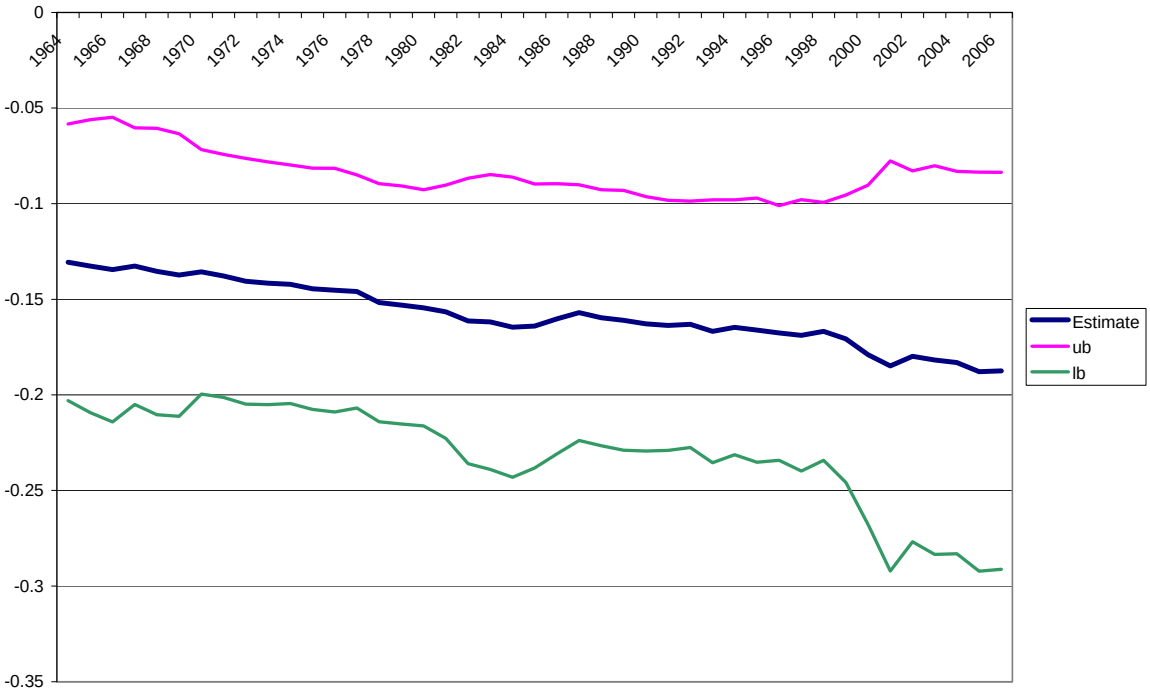
The first set of figures (Figures A1 to A20) pertains to elasticities of electricity demand with respect to the various energy prices for each province or region. This is followed by price elasticities of natural gas demand (Figures B1 to B18), and of oil demand (Figures C1 to C20), again for each province or region. The final set of figures (Figures D1 to D20) refers to income elasticities of demand for each energy source for each of the provinces or regions.

Appendix A: Own-Price and Cross-Price Elasticities for Electricity

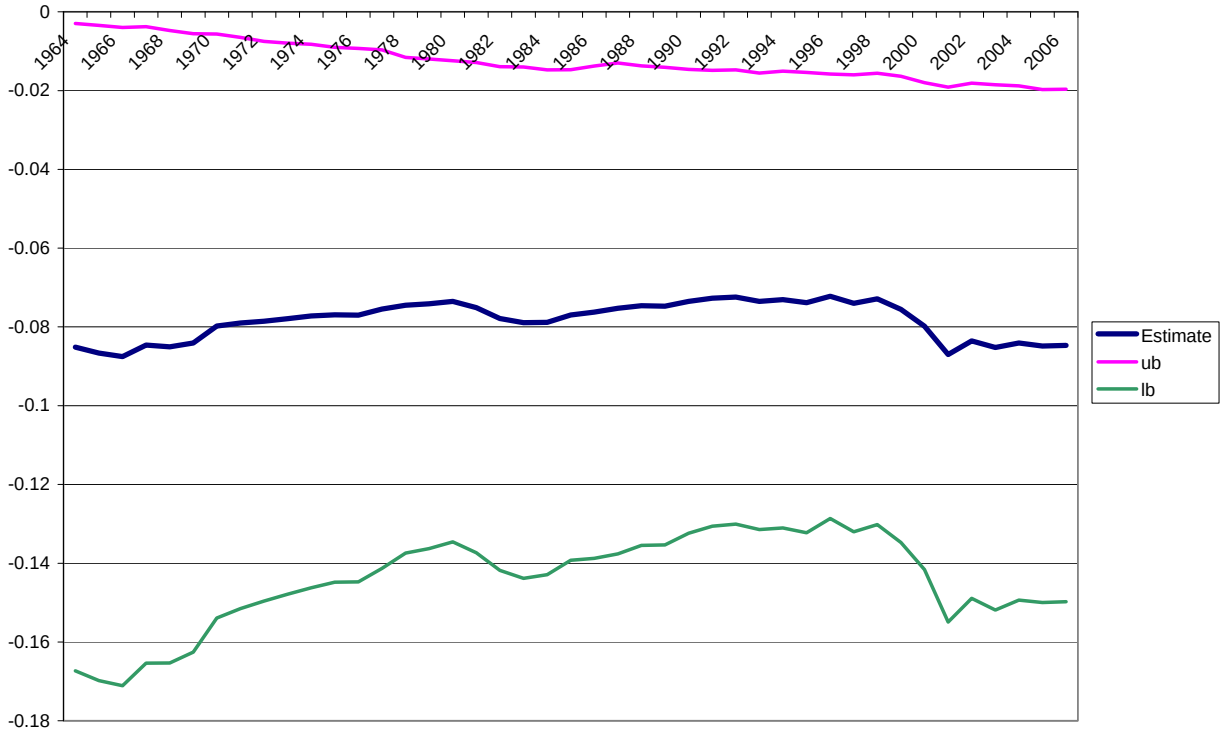
A1: Elasticity of electricity to its own price



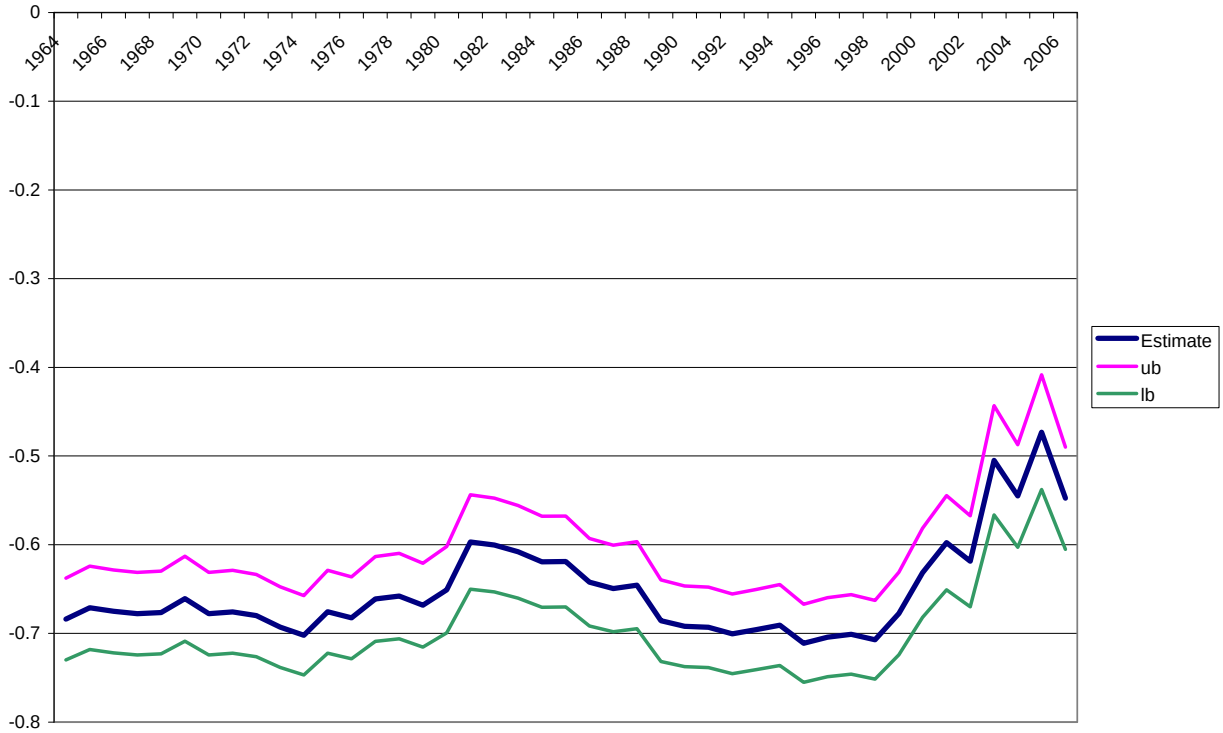
A2: Elasticity of electricity to the price of natural gas - British Columbia



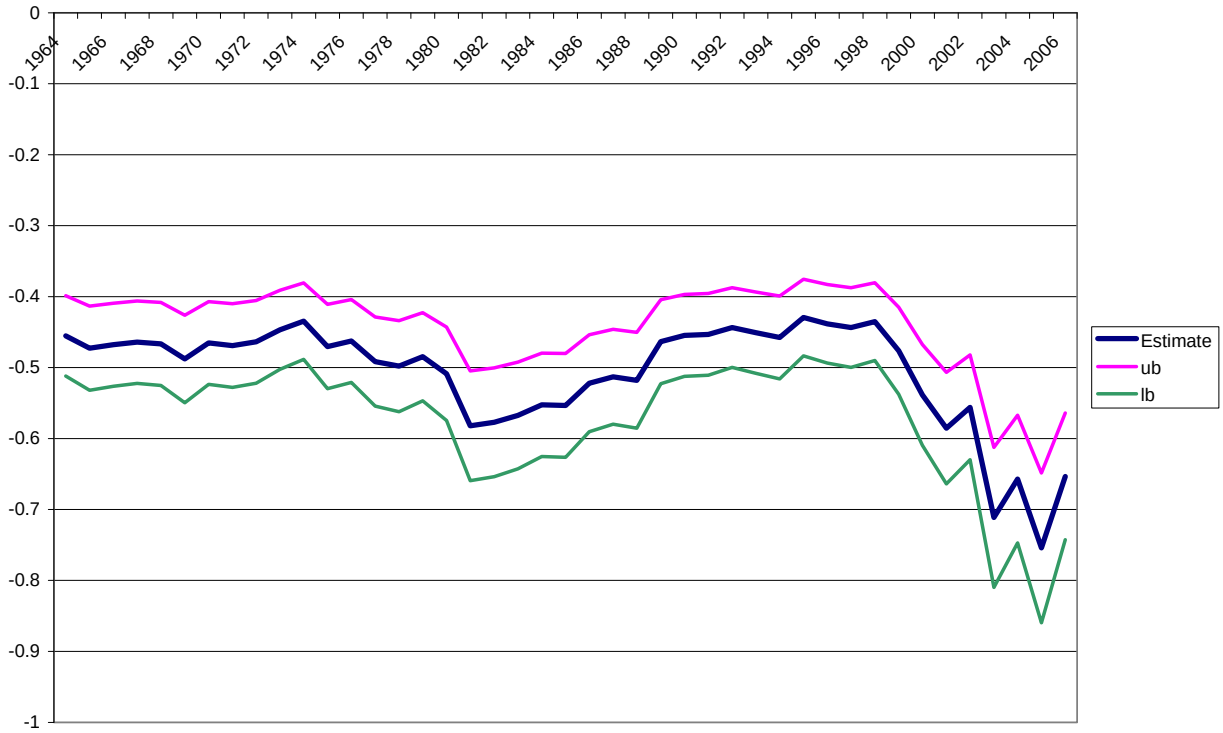
A3: Elasticity of electricity to the price of oil - British Columbia



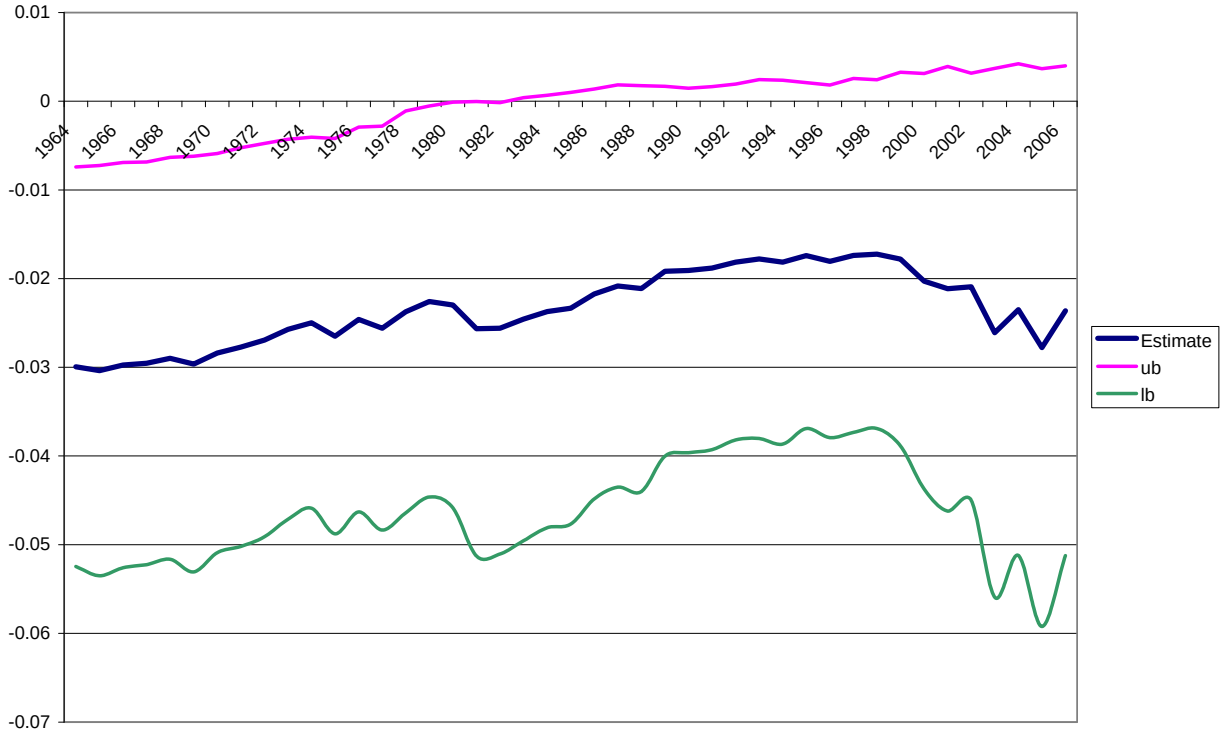
A4: Elasticity of electricity to its own price - Alberta



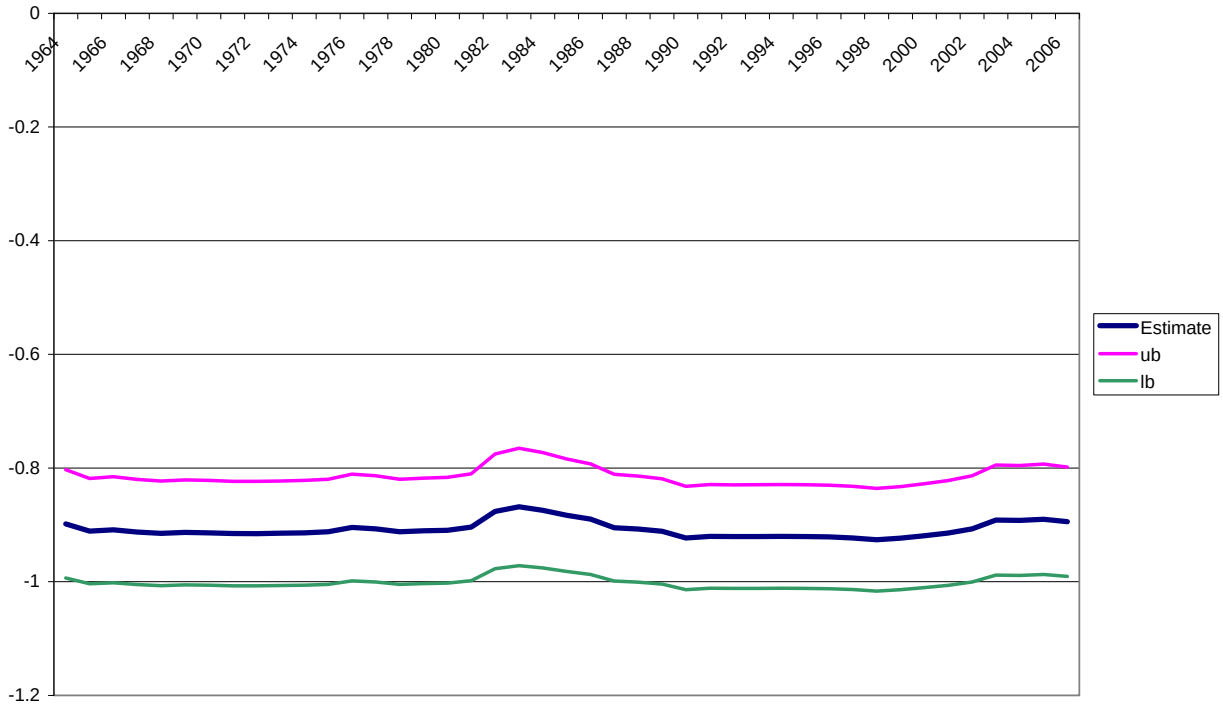
A5: Elasticity of electricity to the price of natural gas - Alberta



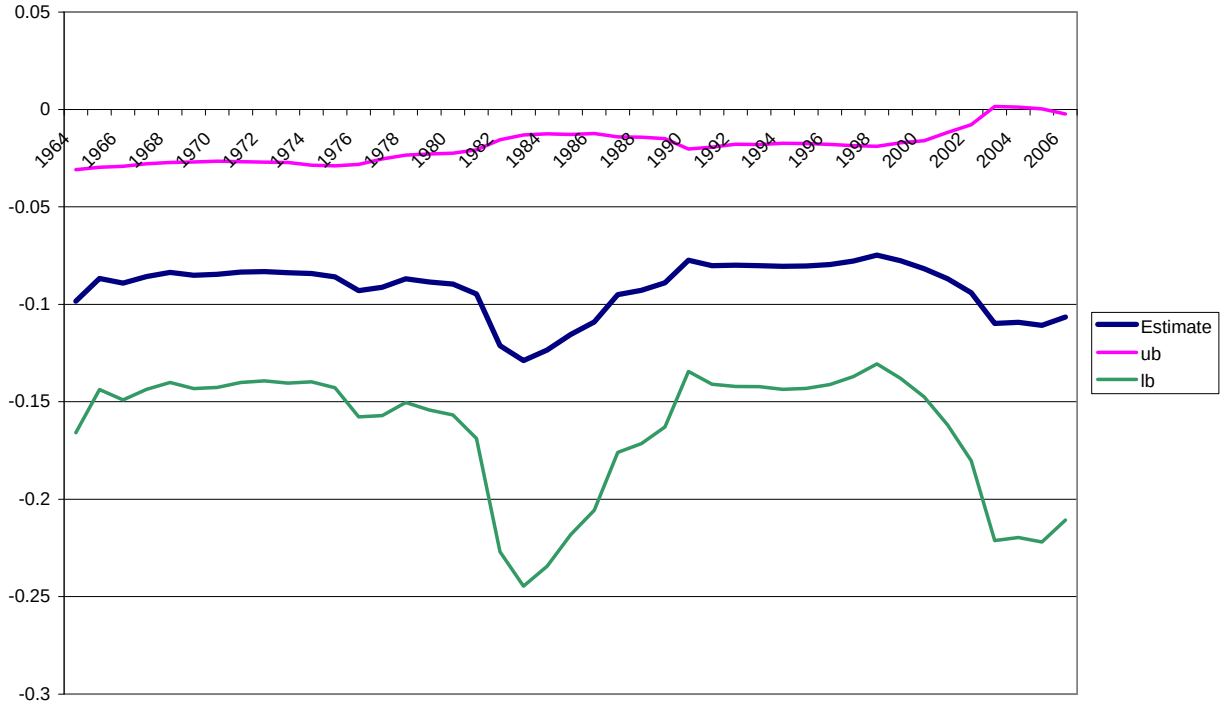
A6: Elasticity of electricity to the price of oil - Alberta



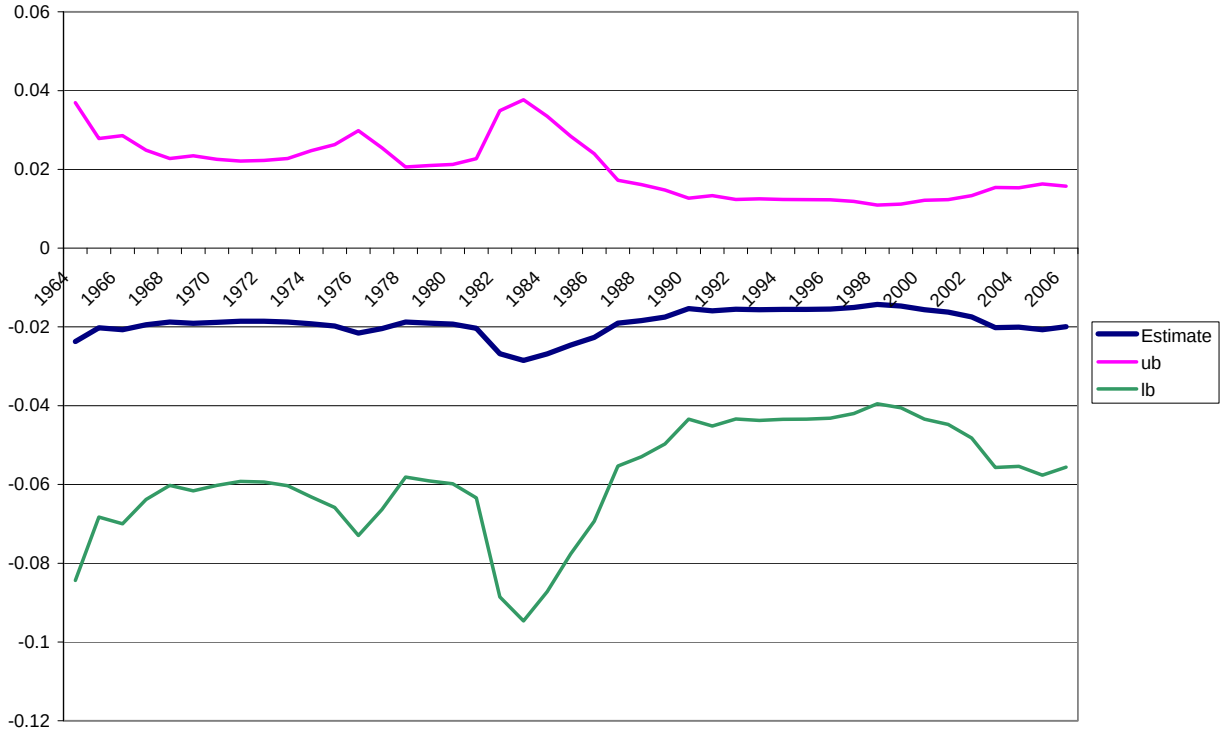
A7: Elasticity of electricity to its own price - Saskatchewan



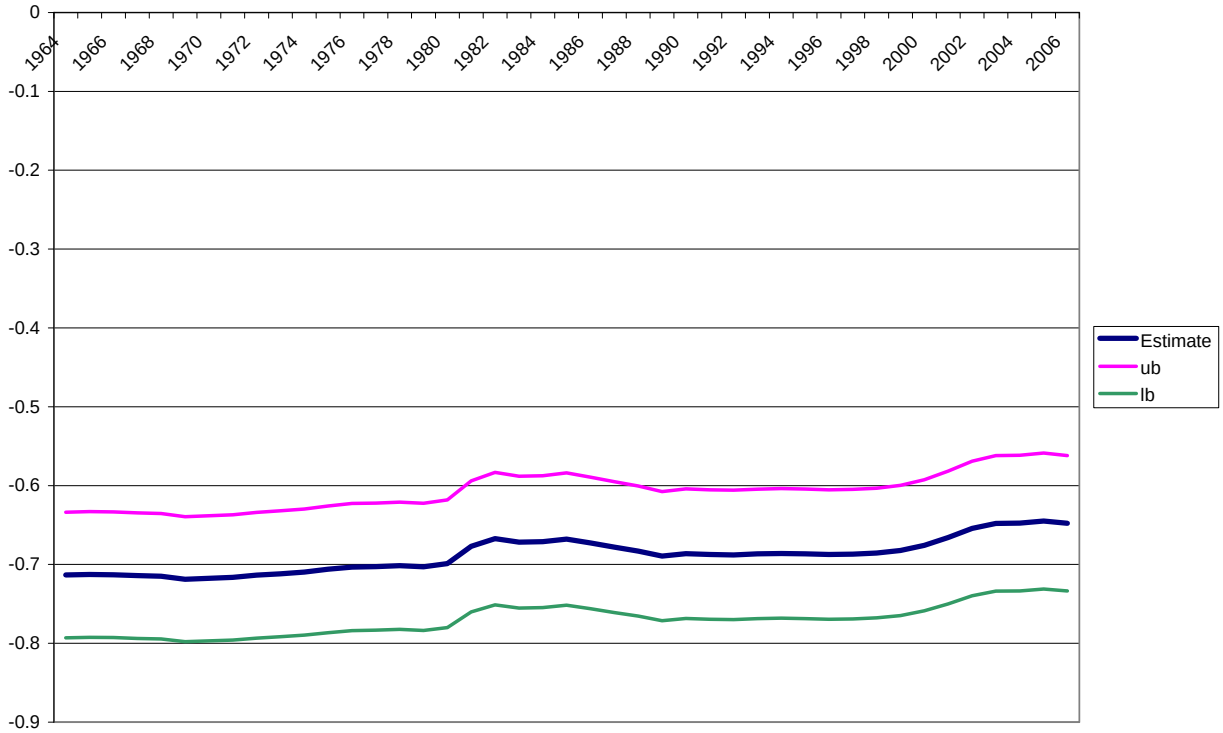
A8: Elasticity of electricity to the price of natural gas - Saskatchewan



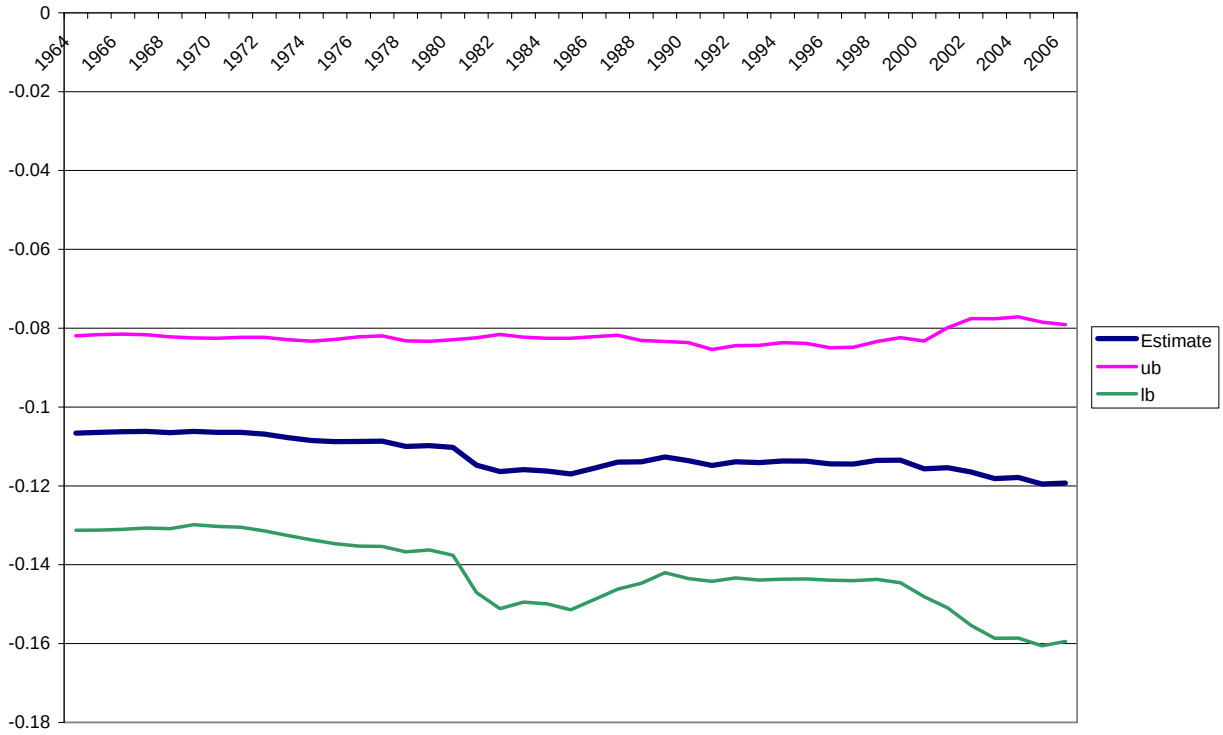
A9: Elasticity of electricity to the price of oil - Saskatchewan



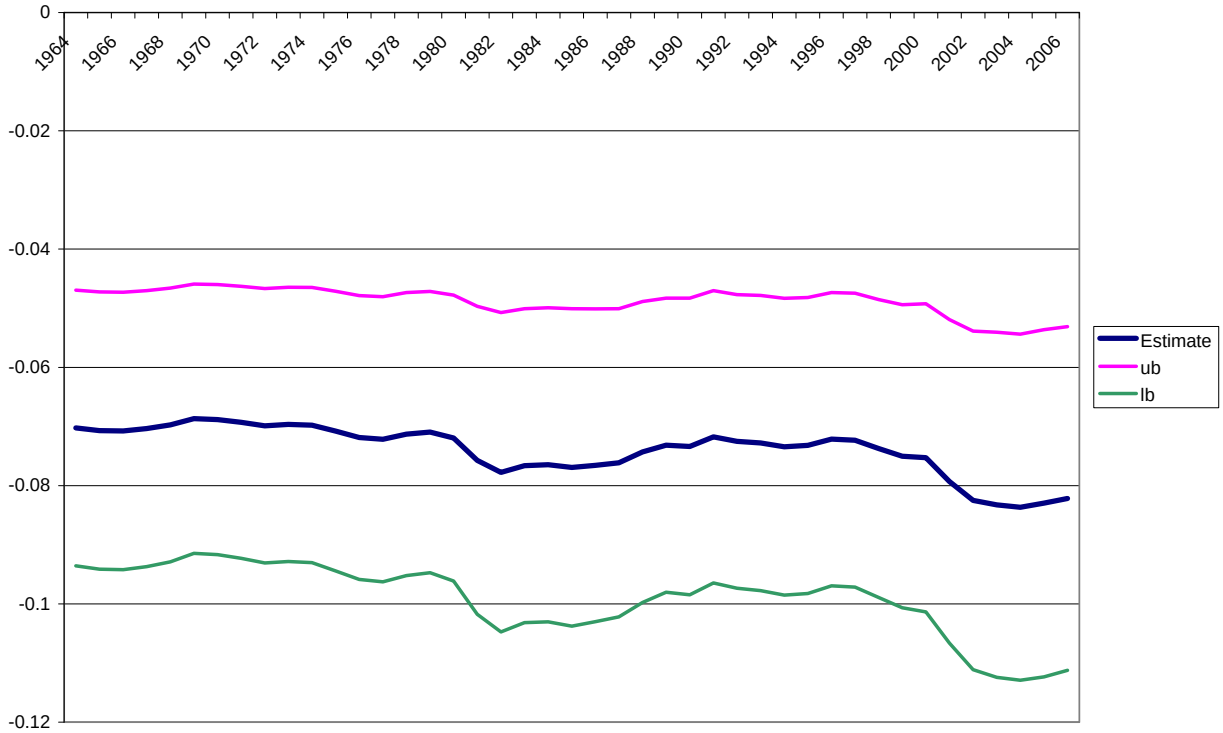
A10: Elasticity of electricity to its own price - Manitoba



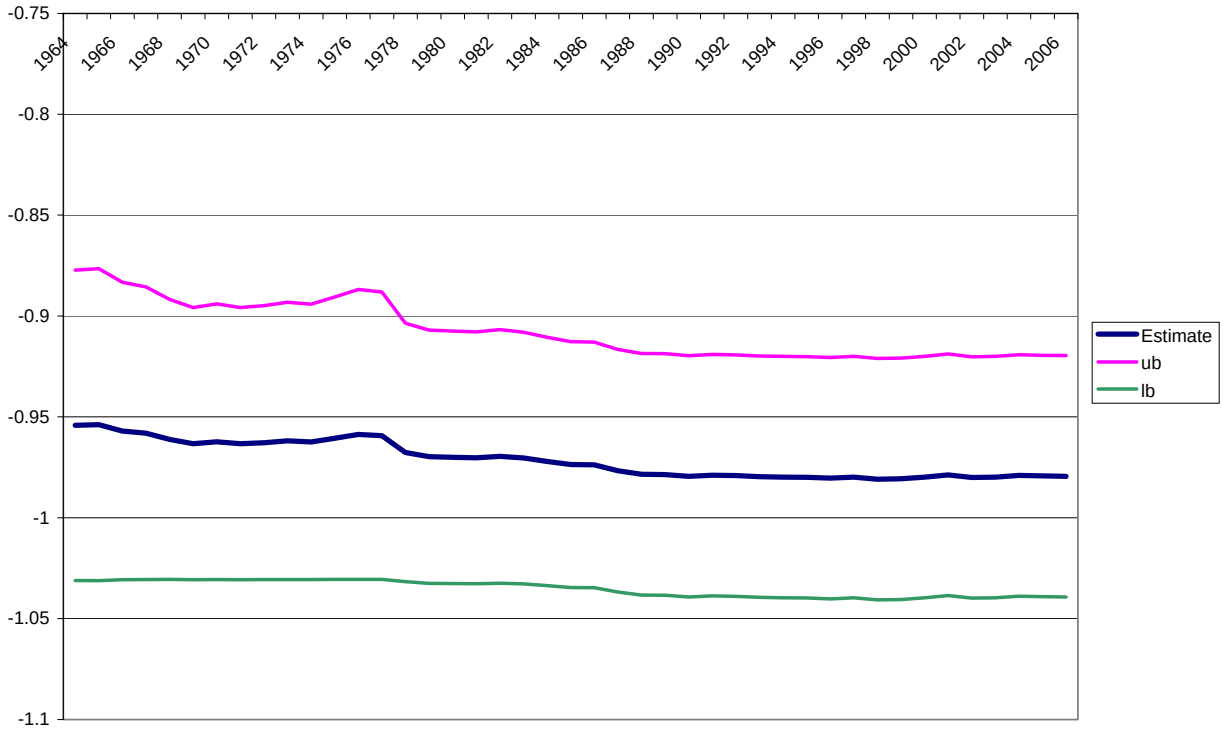
A11: Elasticity of electricity to the price of natural gas - Manitoba



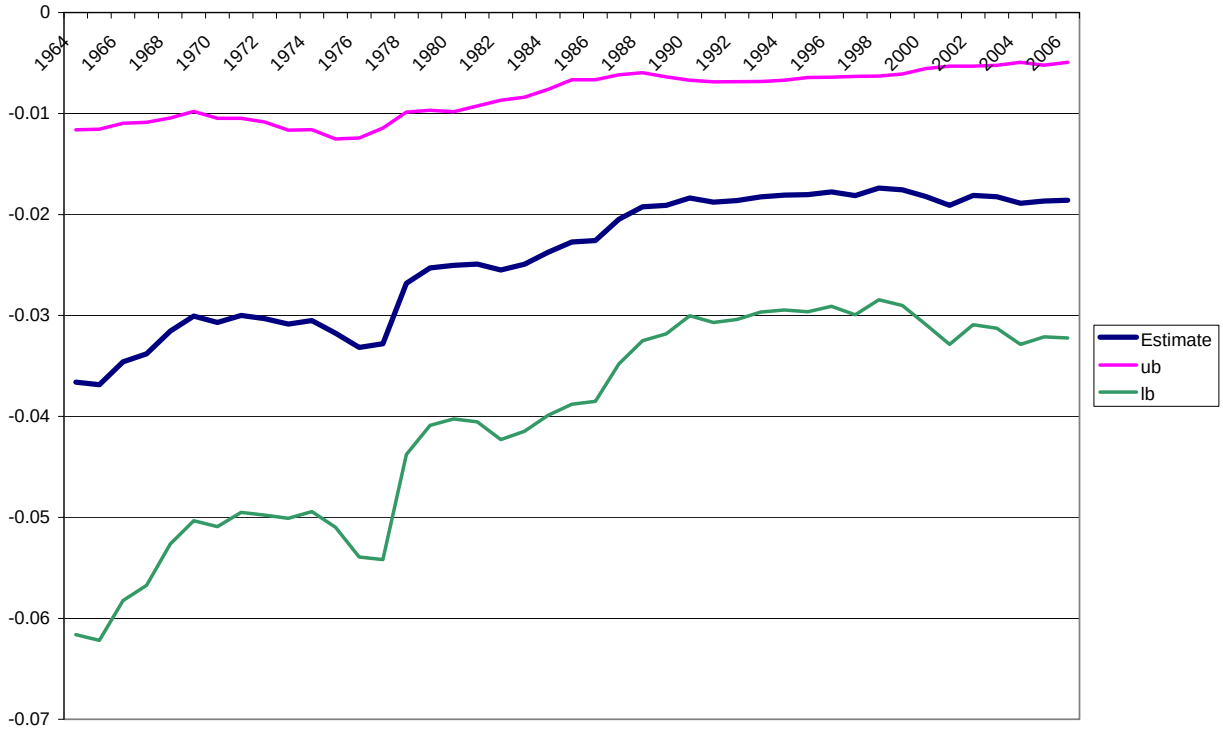
A12: Elasticity of electricity to the price of oil - Manitoba



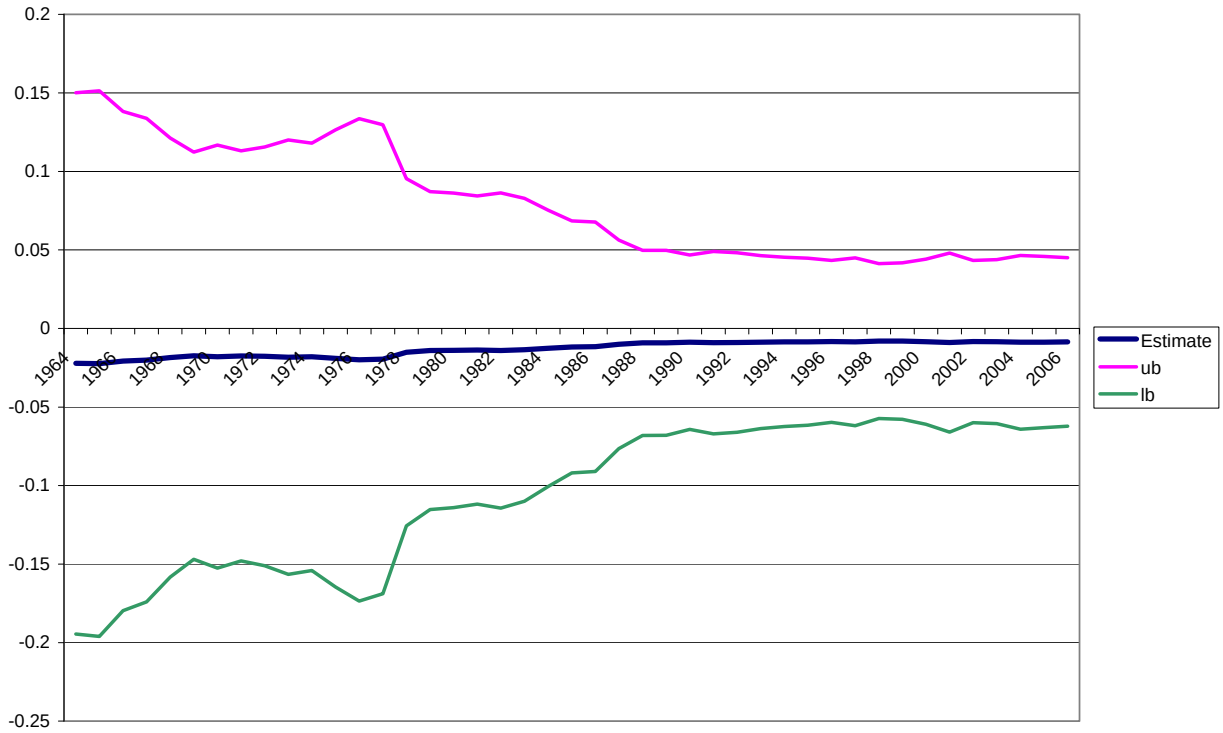
A13: Elasticity of electricity to its own price - Quebec



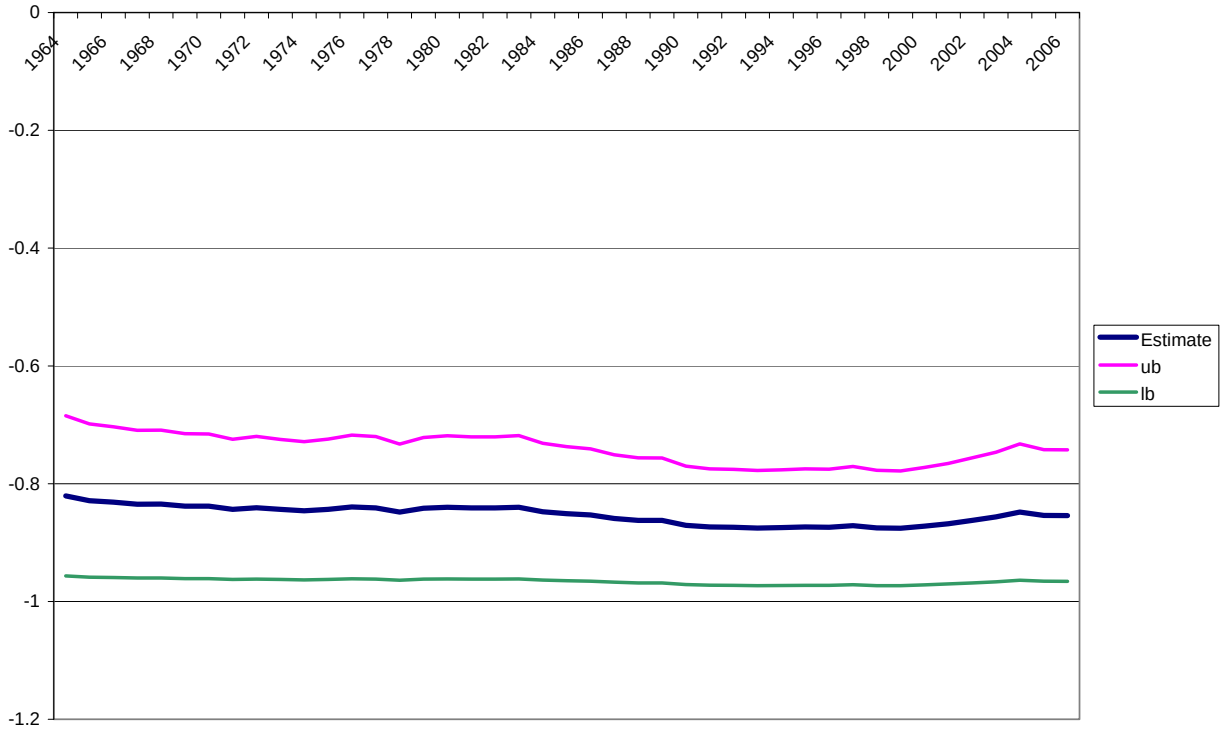
A14: Elasticity of electricity to the price of natural gas - Quebec



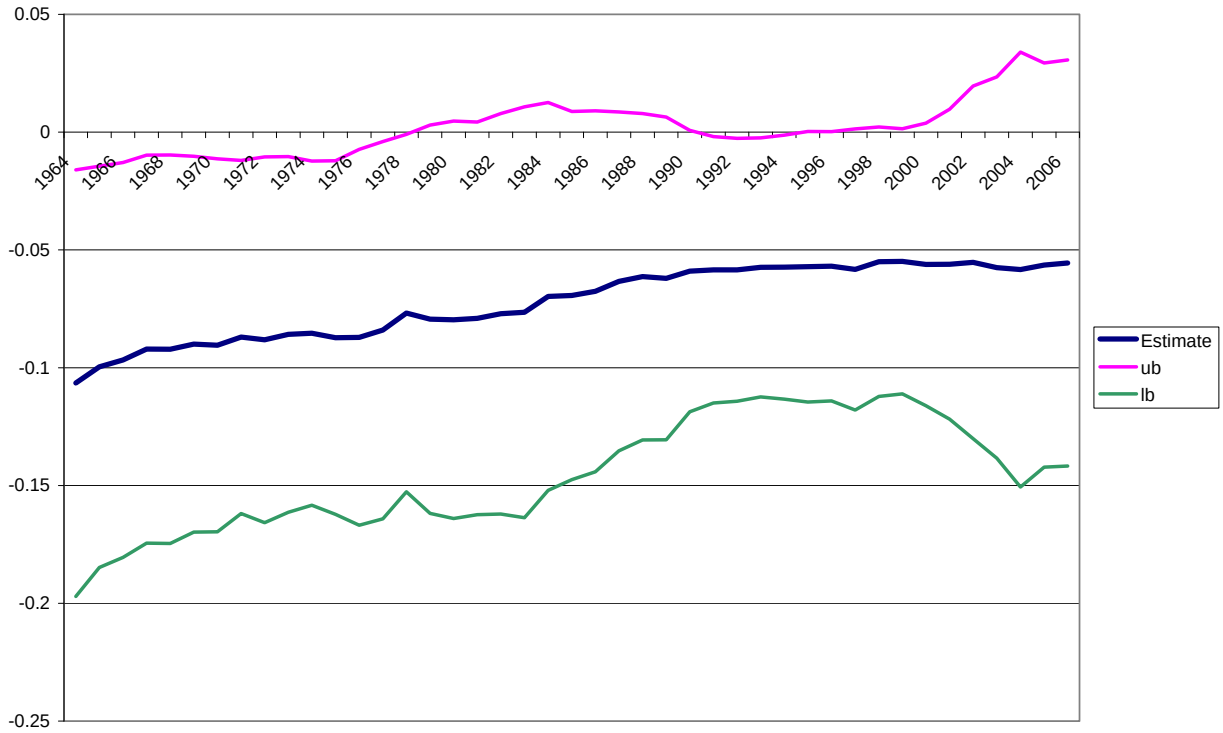
A15: Elasticity of electricity to the price of oil - Quebec



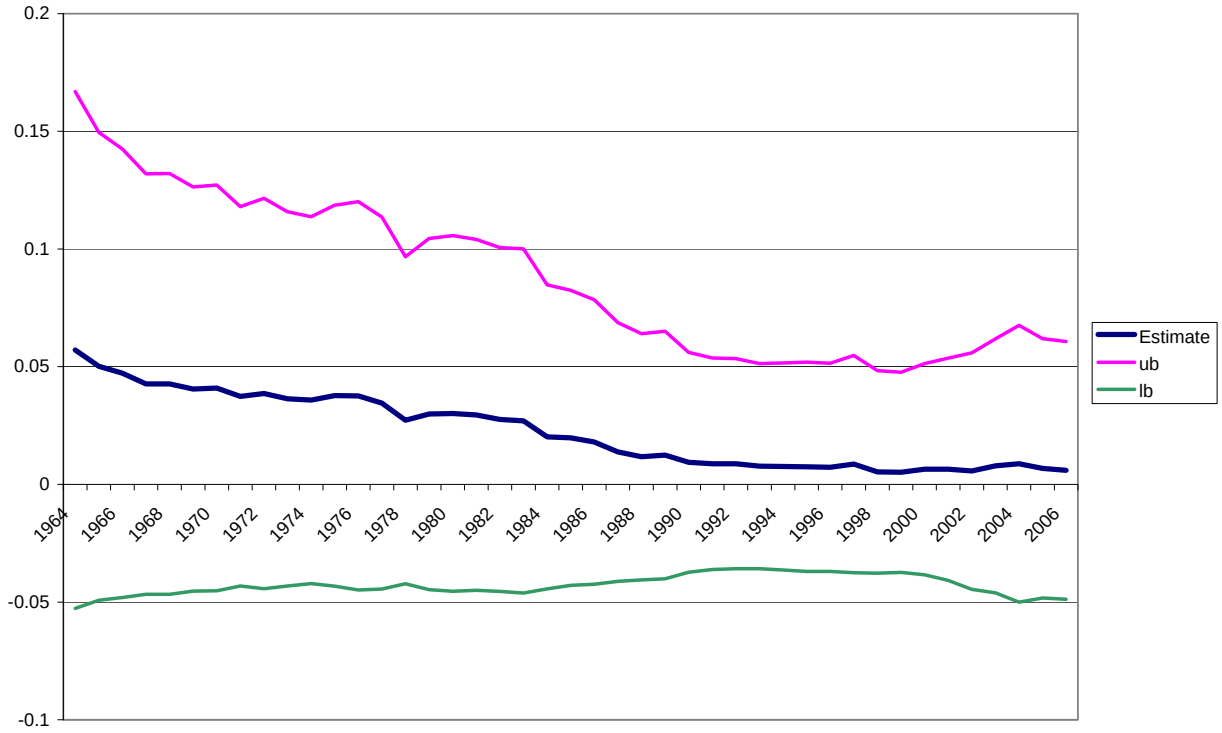
A16: Elasticity of electricity to its price - Ontario



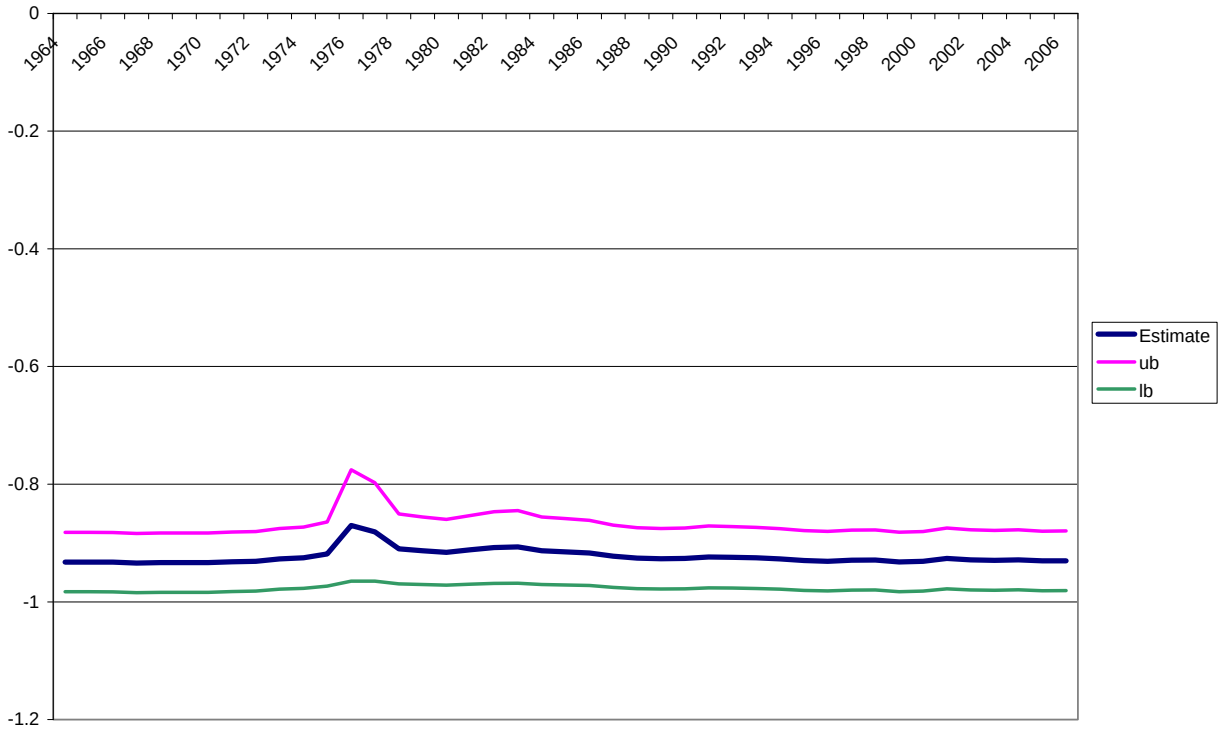
A17: Elasticity of electricity to the price of natural gas - Ontario



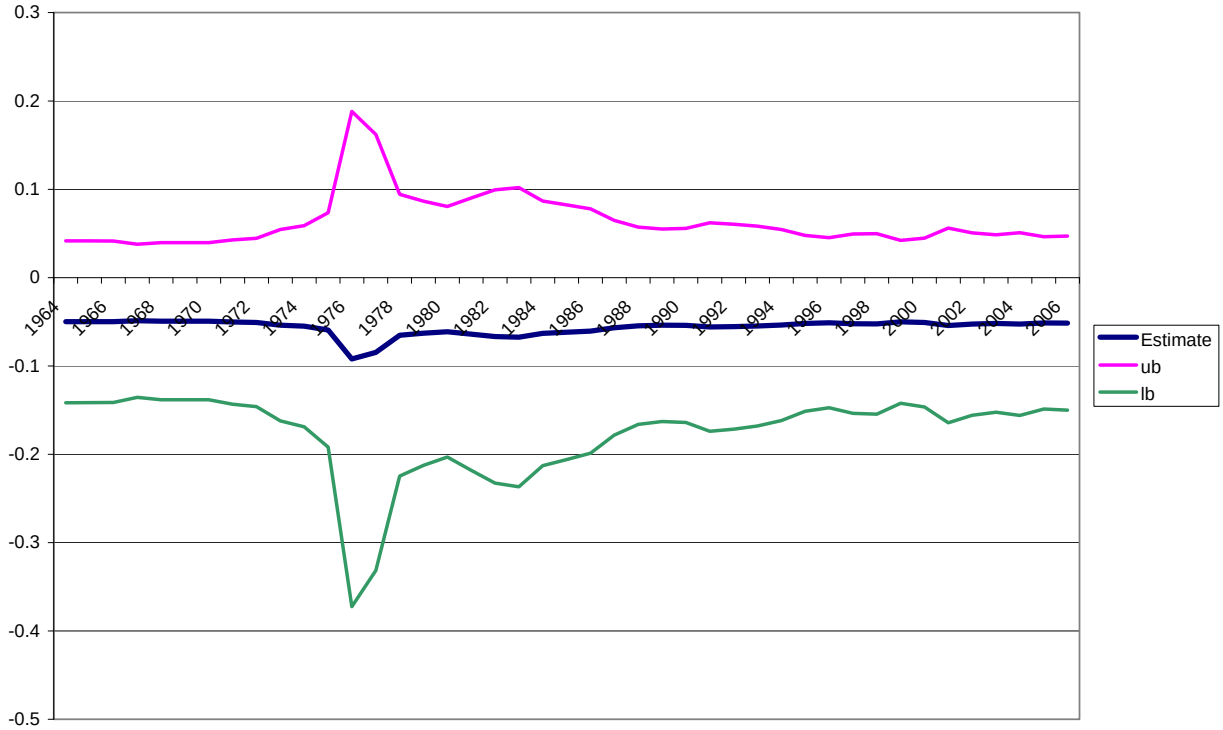
A18: Elasticity of electricity to the price of oil - Ontario



A19: Elasticity of electricity to its own price - Atlantic Provinces

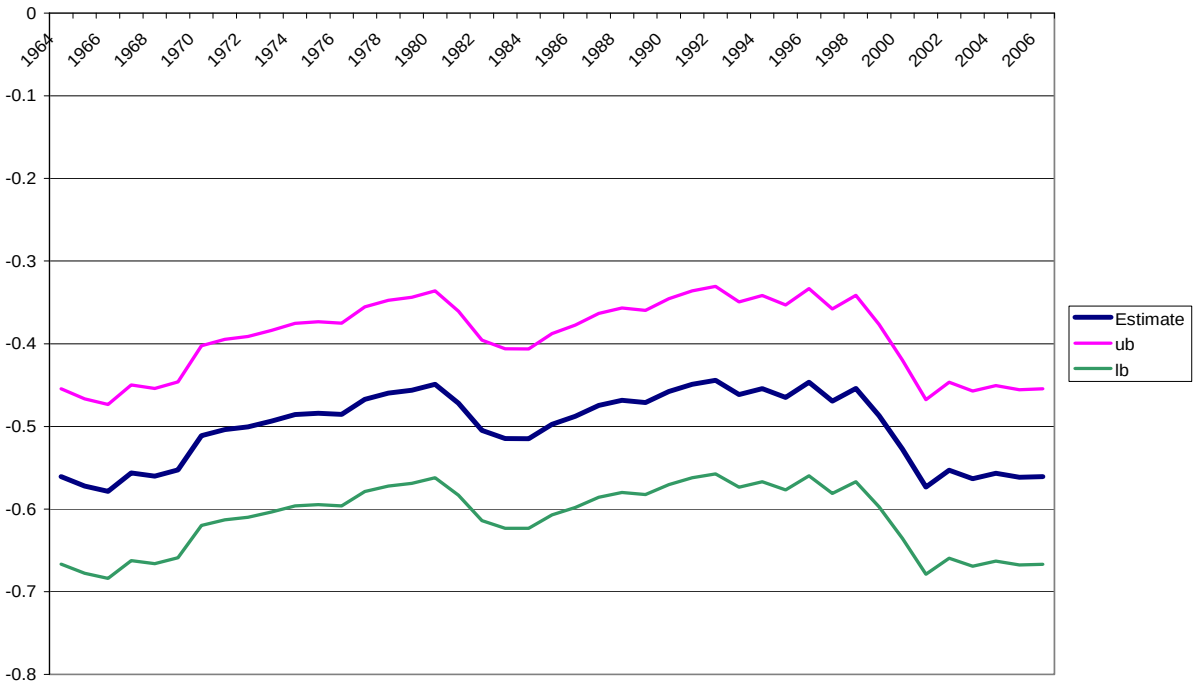


A20: Elasticity of electricity to the price of oil - Atlantic Provinces

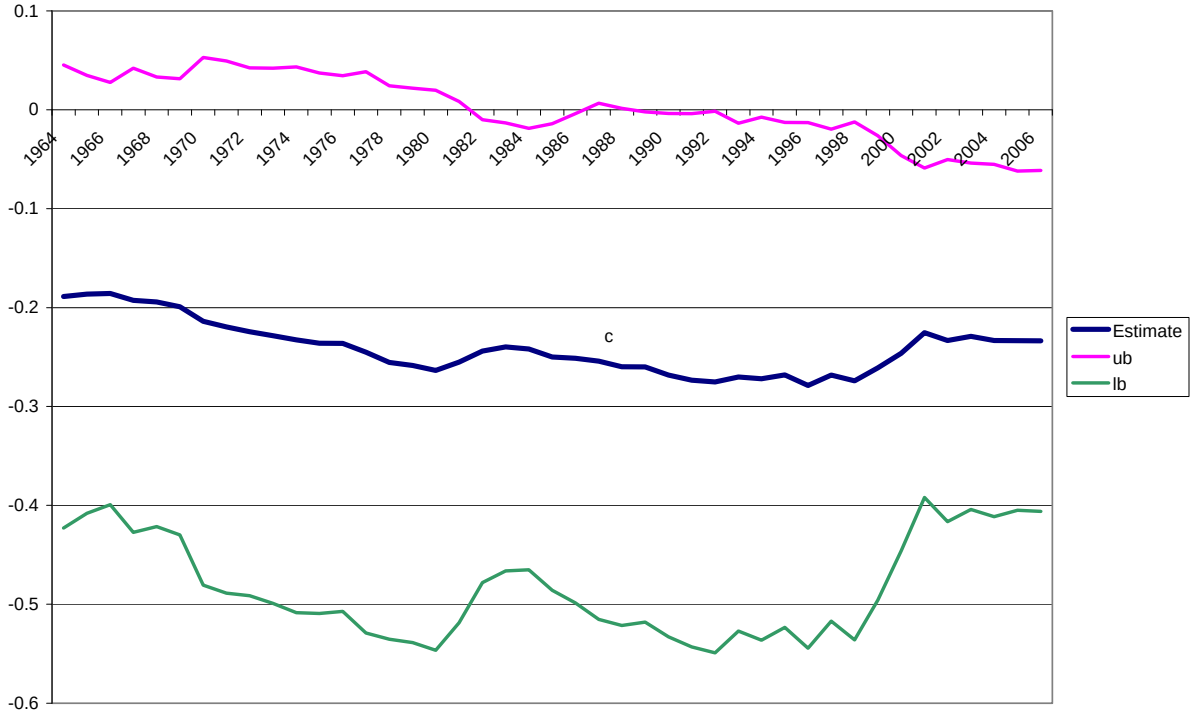


Appendix B: Own-Price and Cross-Price Elasticities for Natural Gas

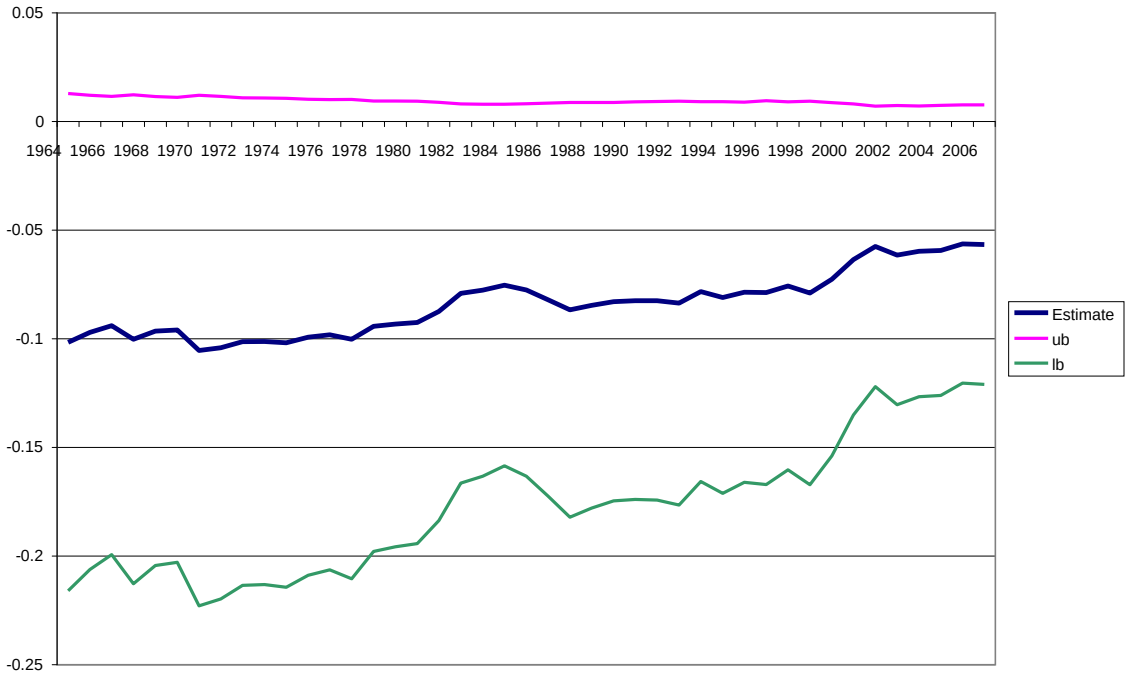
B1: Elasticity of natural gas to its own price - British Columbia



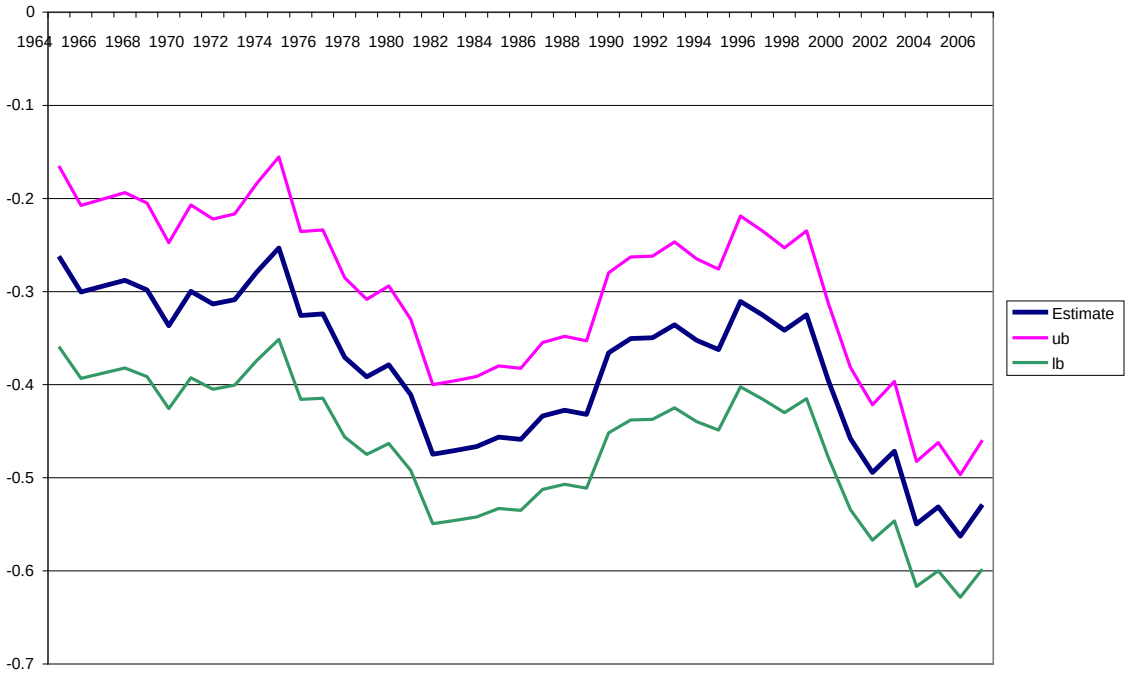
B2: Elasticity of natural gas to the price of electricity - British Columbia



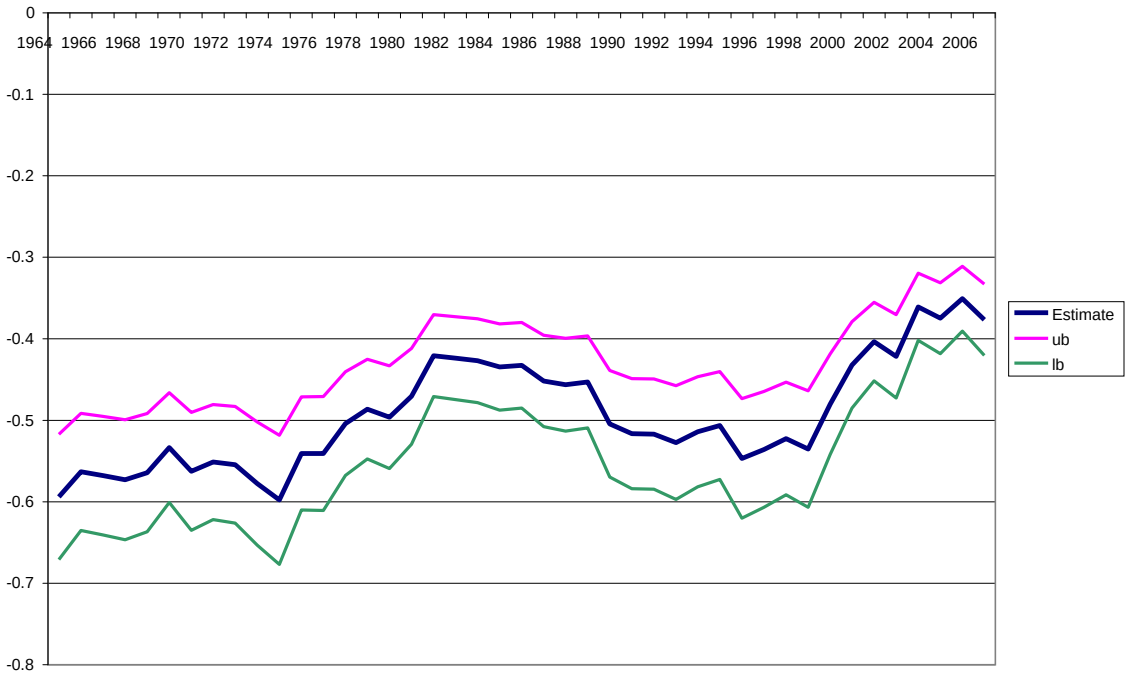
B3: Elasticity of natural gas to the price of oil - British Columbia



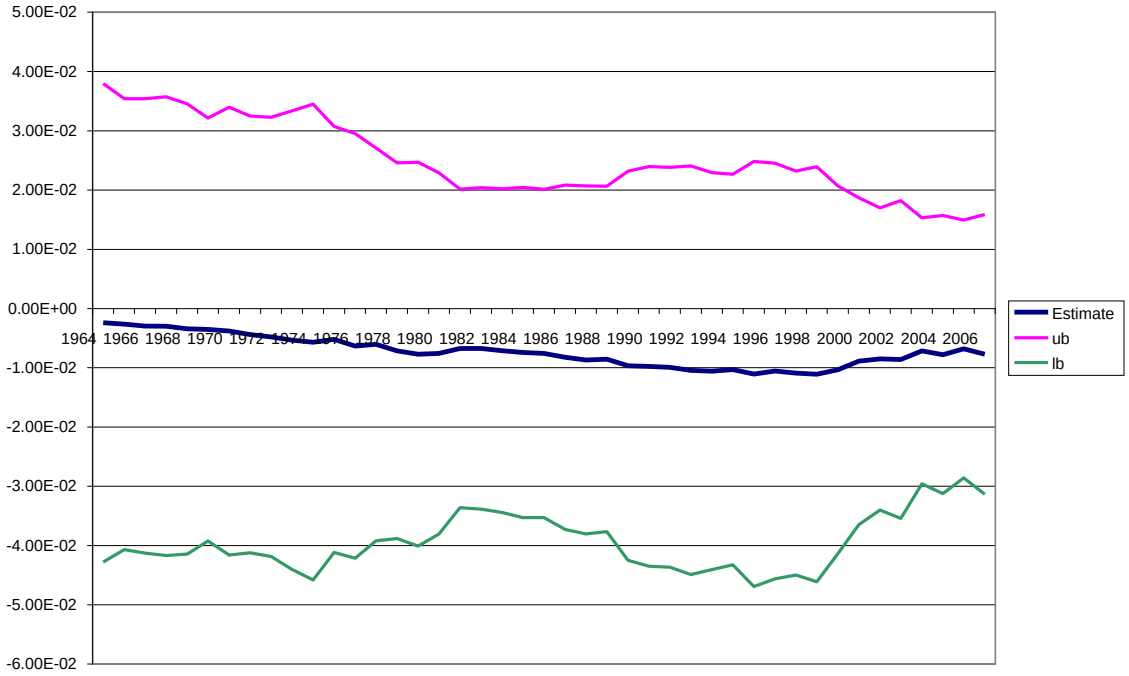
B4: Elasticity of natural gas to its own price - Alberta



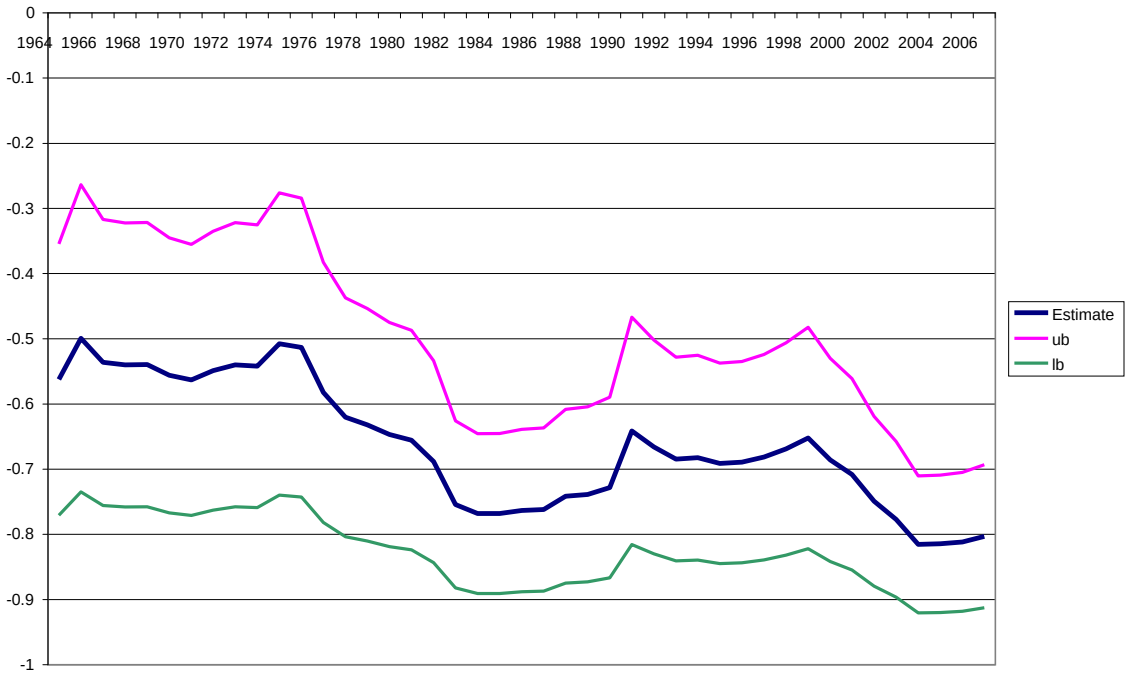
B5: Elasticity of natural gas to the price of electricity- Alberta



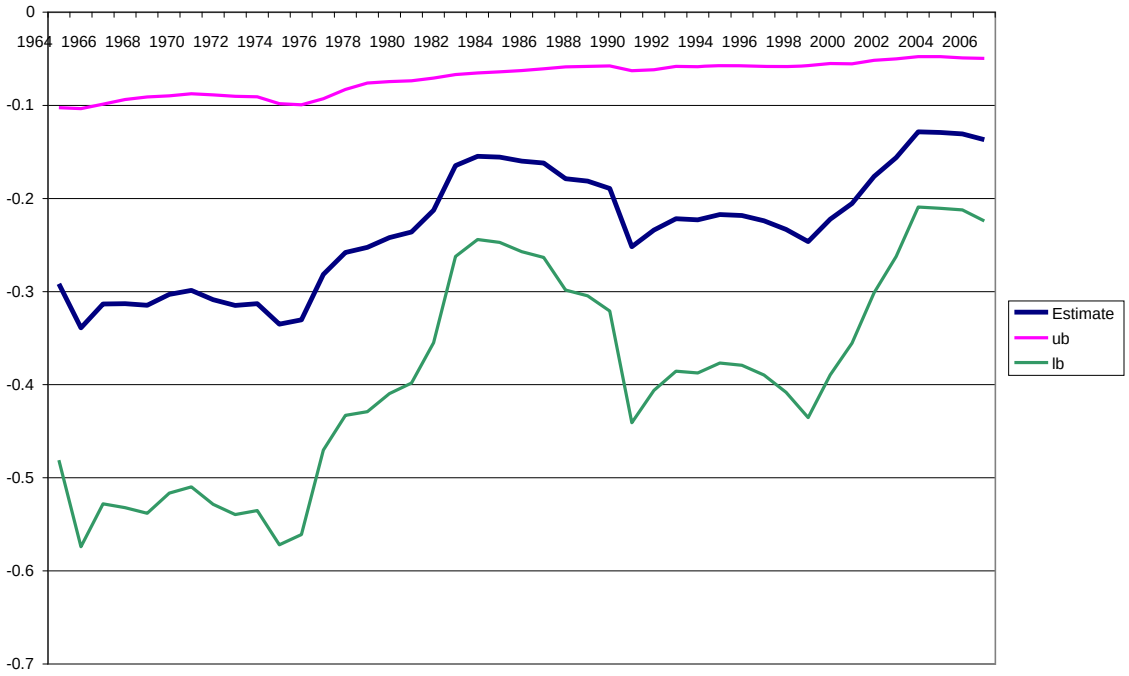
B6: Elasticity of natural gas to the price of oil Alberta



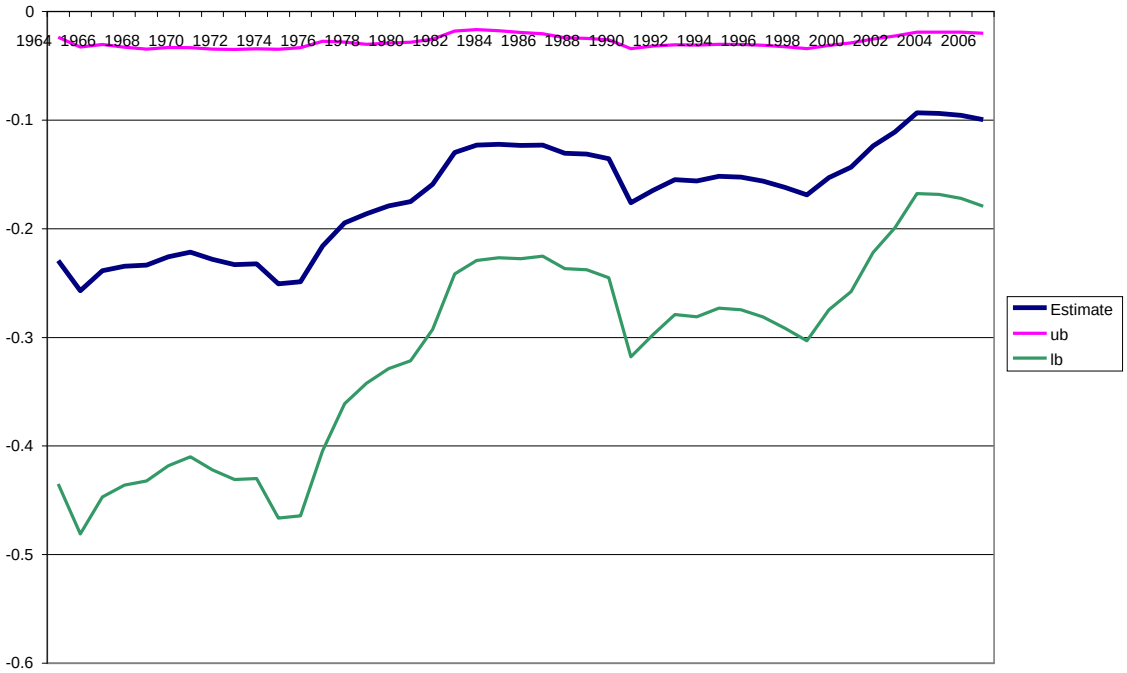
B7: Elasticity of natural gas to its own price - Saskatchewan



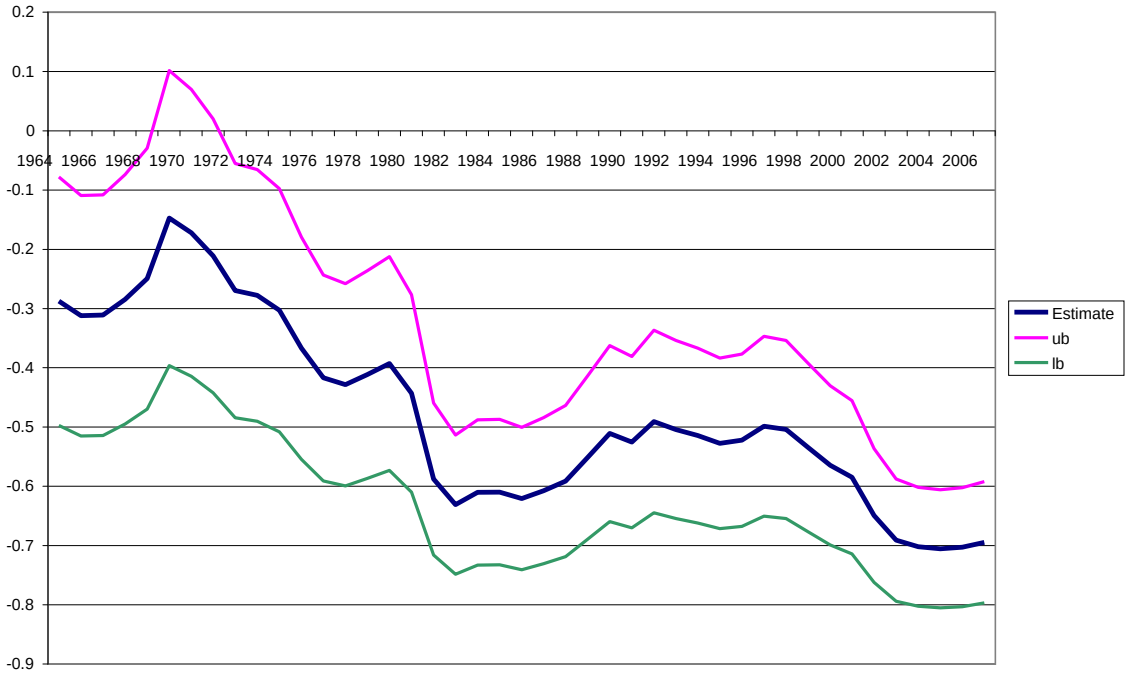
B8: Elasticity of natural gas to the price of electricity - Saskatchewan



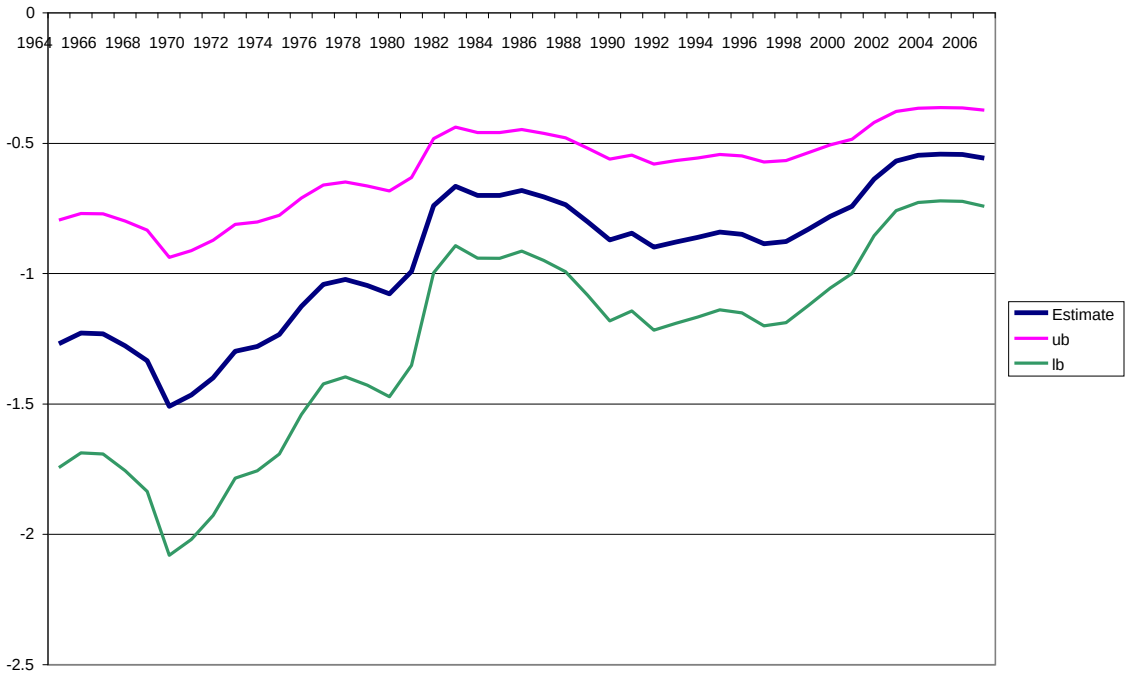
B9: Elasticity of natural gas to the price of oil - Saskatchewan



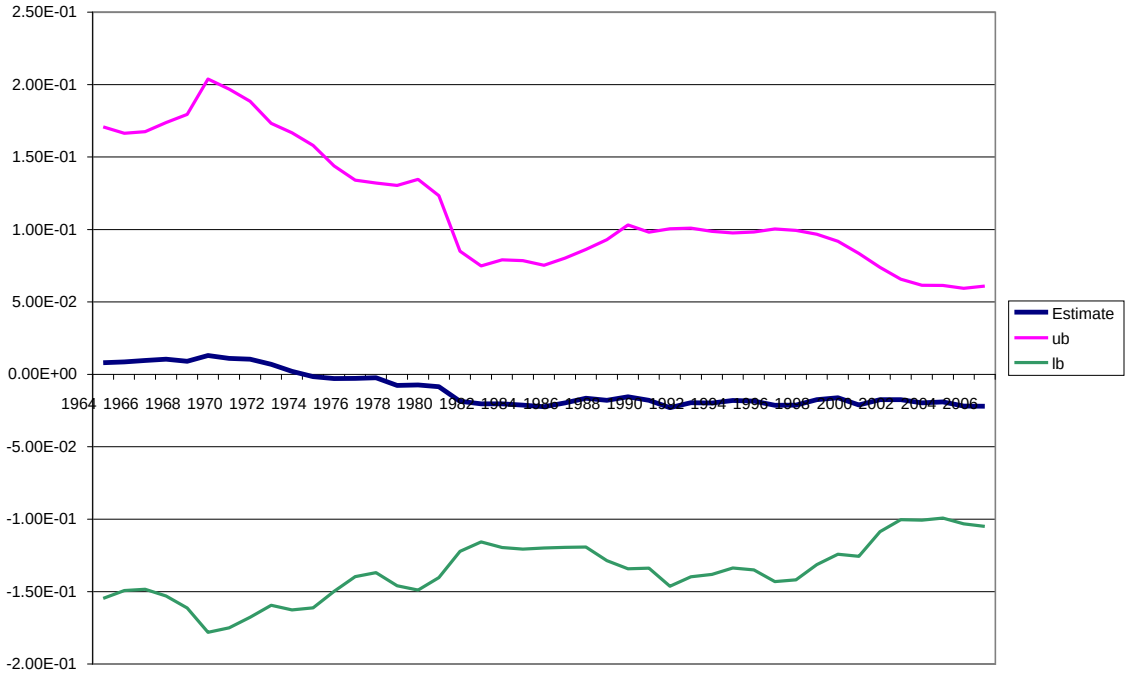
B10: Elasticity of natural gas to its own price - Manitoba



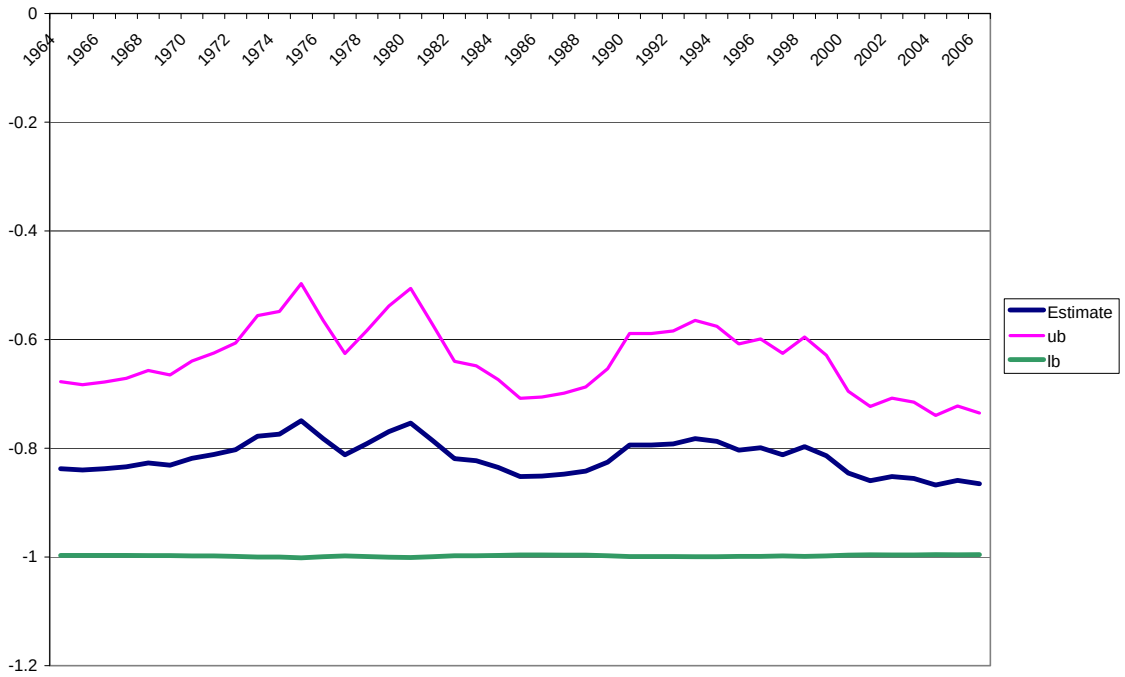
B11: Elasticity of natural gas to the price of electricity - Manitoba



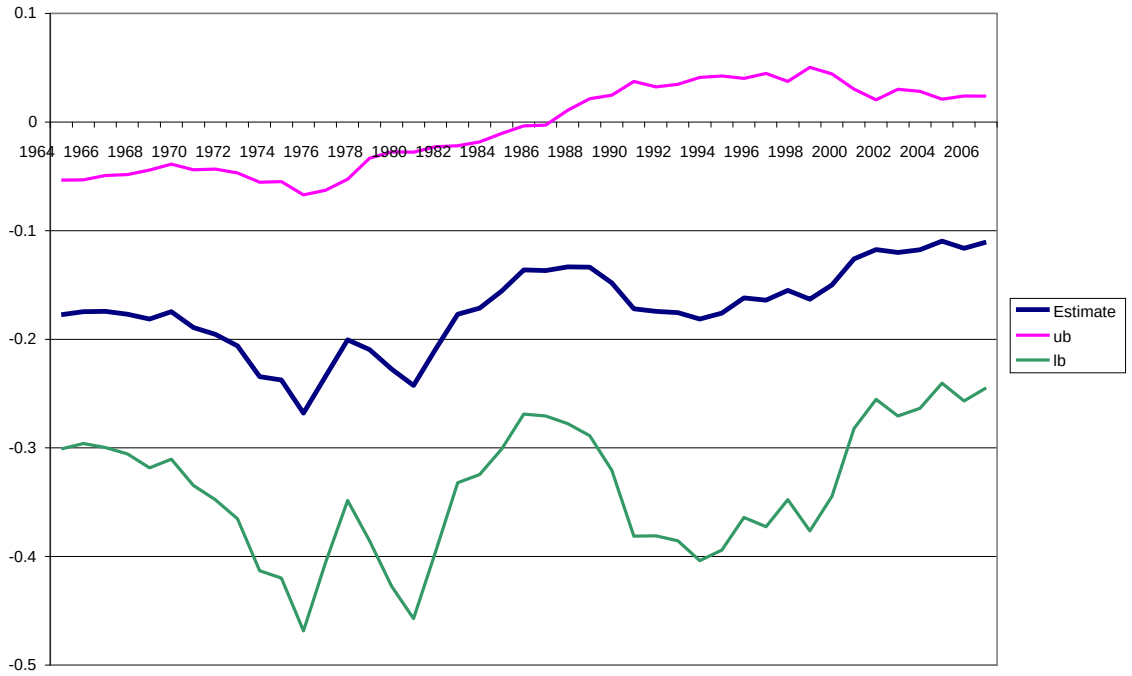
B12: Elasticity of natural gas to the price of oil - Manitoba



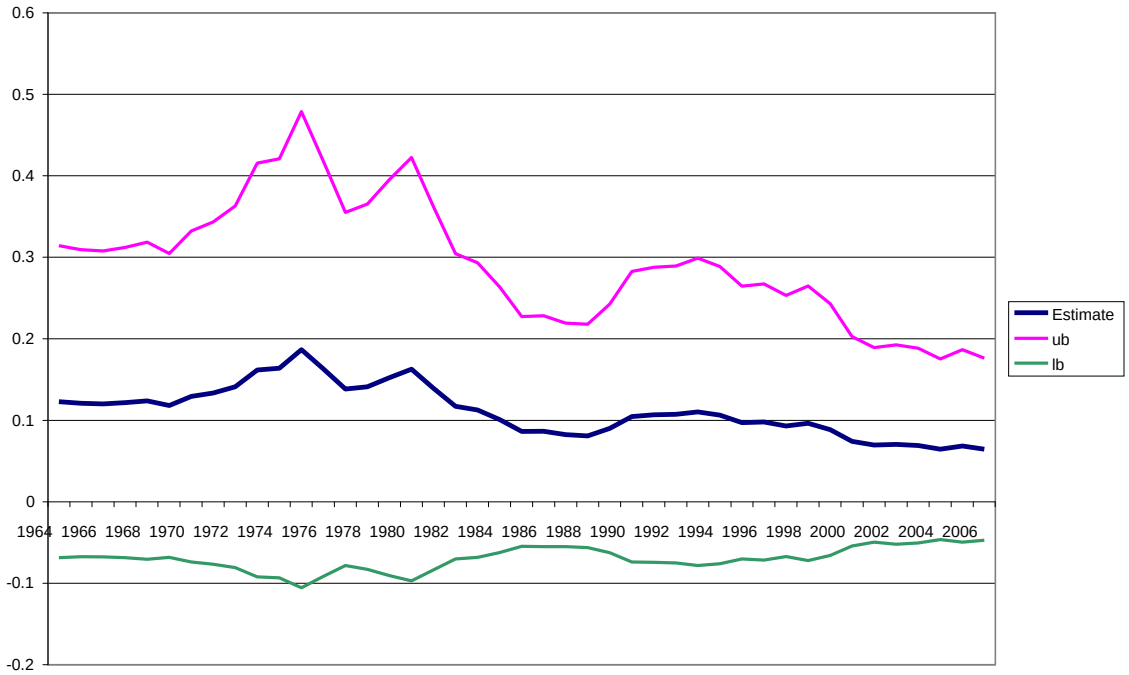
B13: price elasticity of natural gas to its own price - Quebec



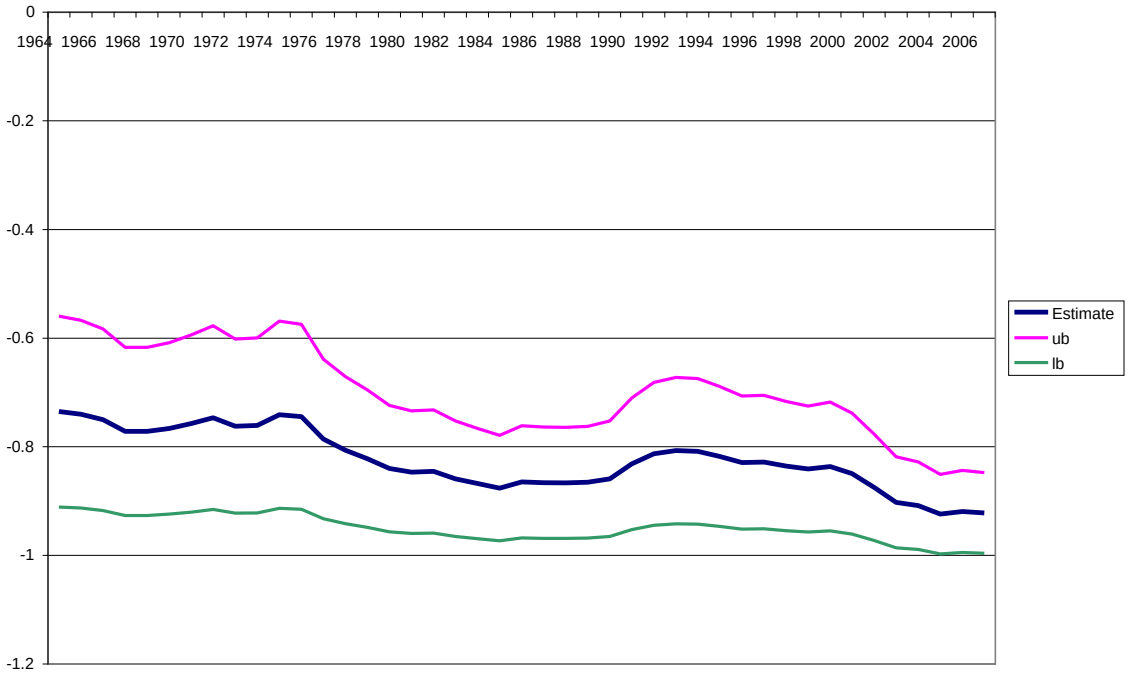
B14: Elasticity of natural gas to the price of electricity - Quebec



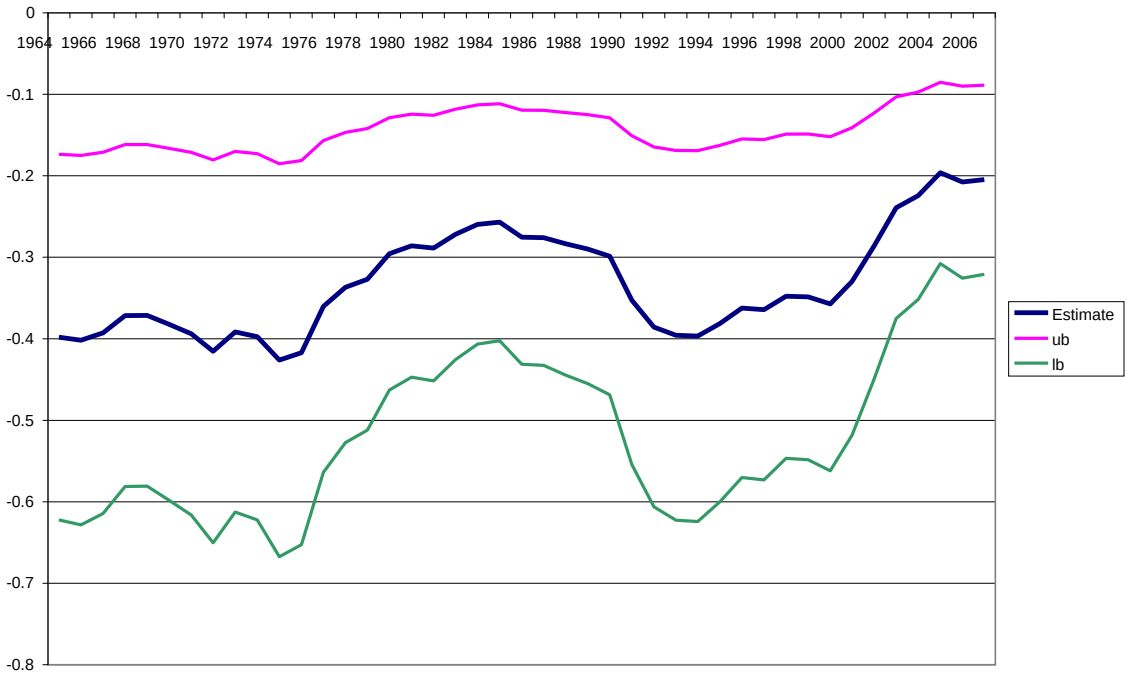
B15: Elasticity of natural gas to the price of oil - Quebec



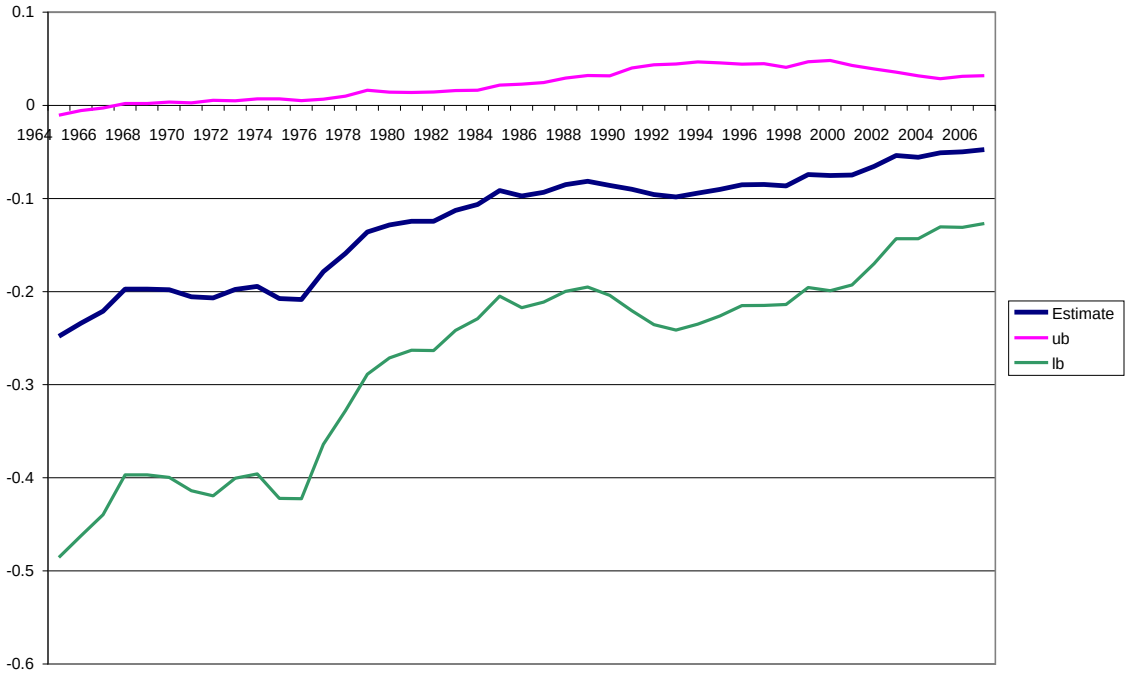
B16: Elasticity of natural gas to its own price - Ontario



B17: Elasticity of natural gas to the price of electricity - Ontario

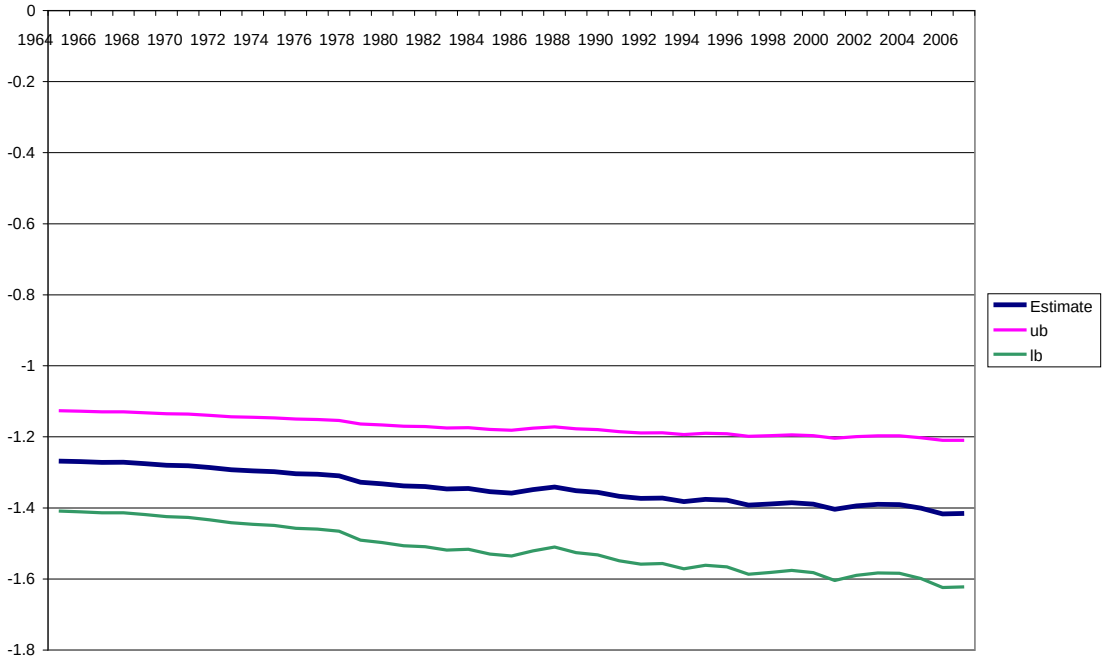


B18: Elasticity of natural gas to the price of oil - Ontario

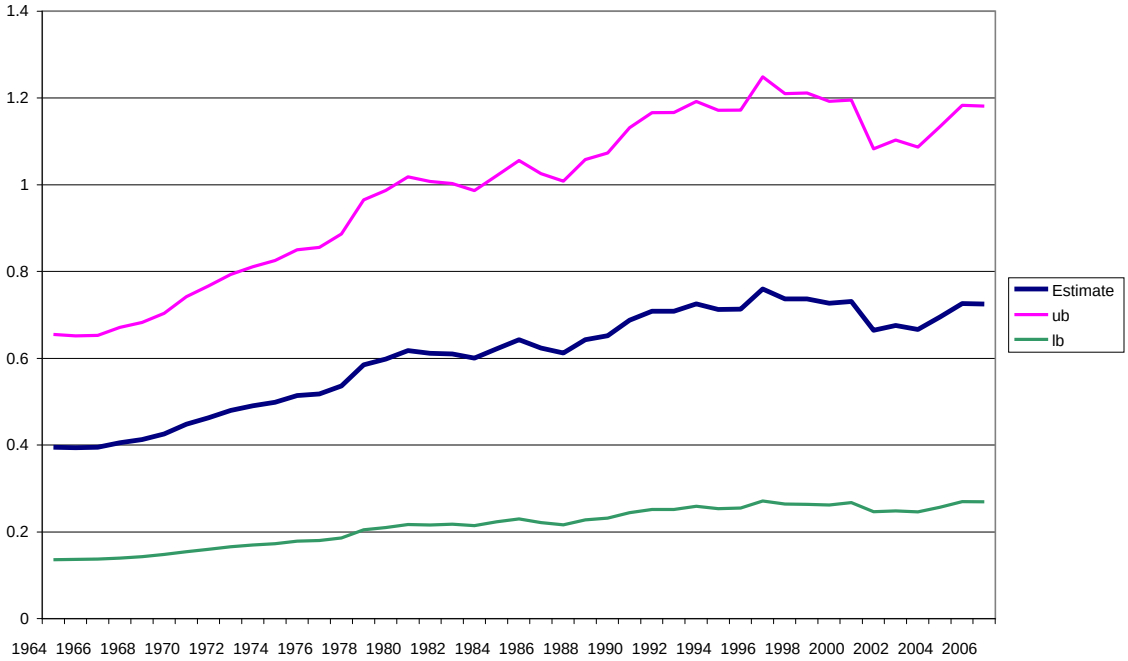


Appendix C: Own-Price and Cross-Price Elasticities for Oil

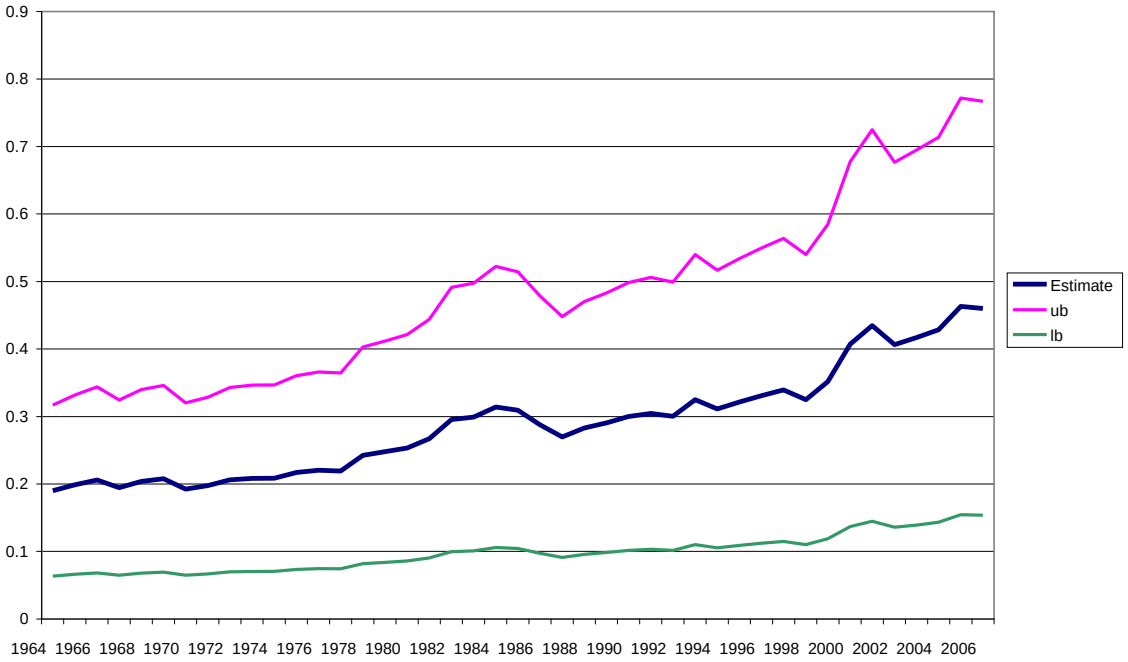
C1: Elasticity of oil to its own price - British Columbia



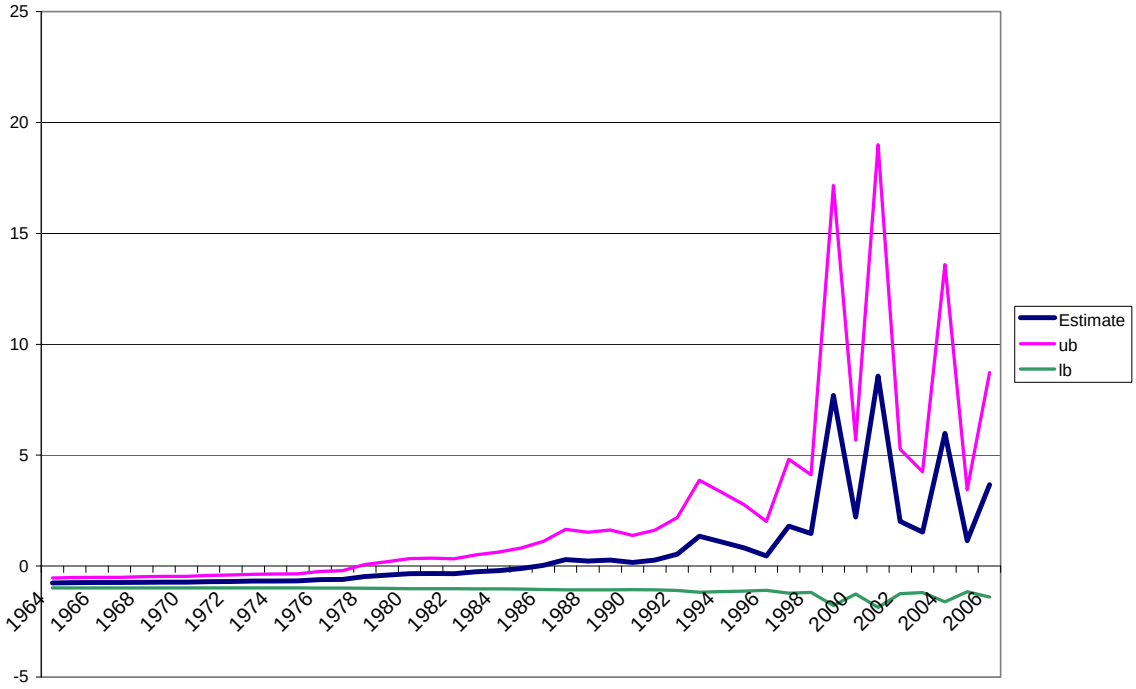
C2: Elasticity of oil to the price of electricity - British Columbia



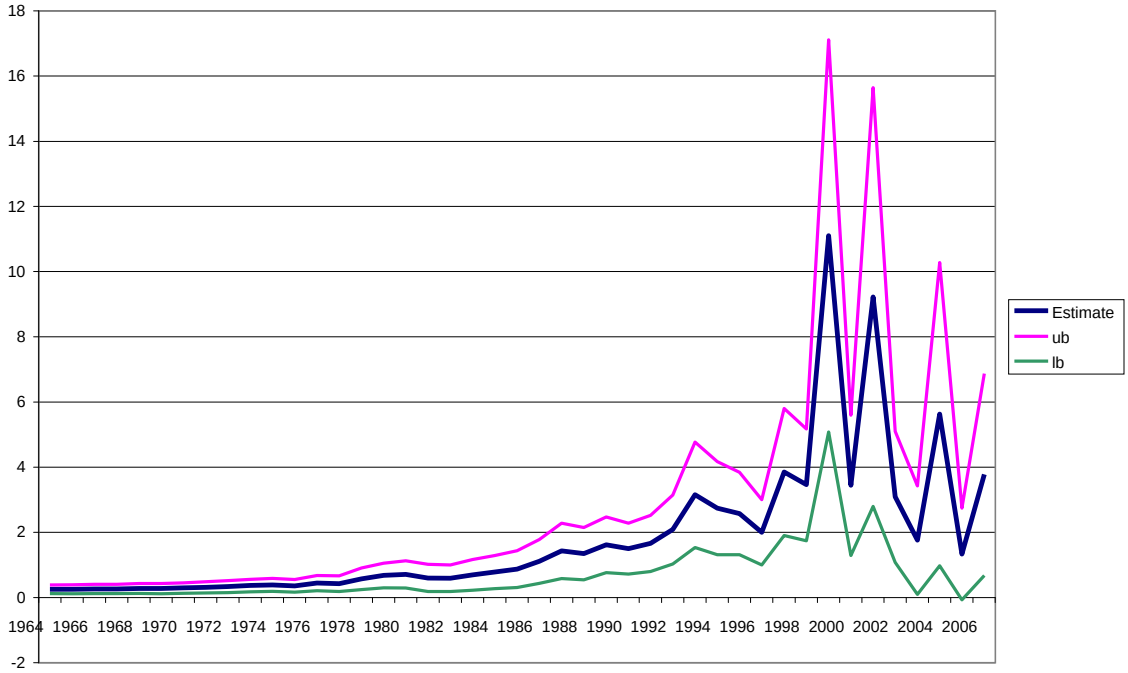
C3: Elasticity of oil to the price of natural gas - British Columbia



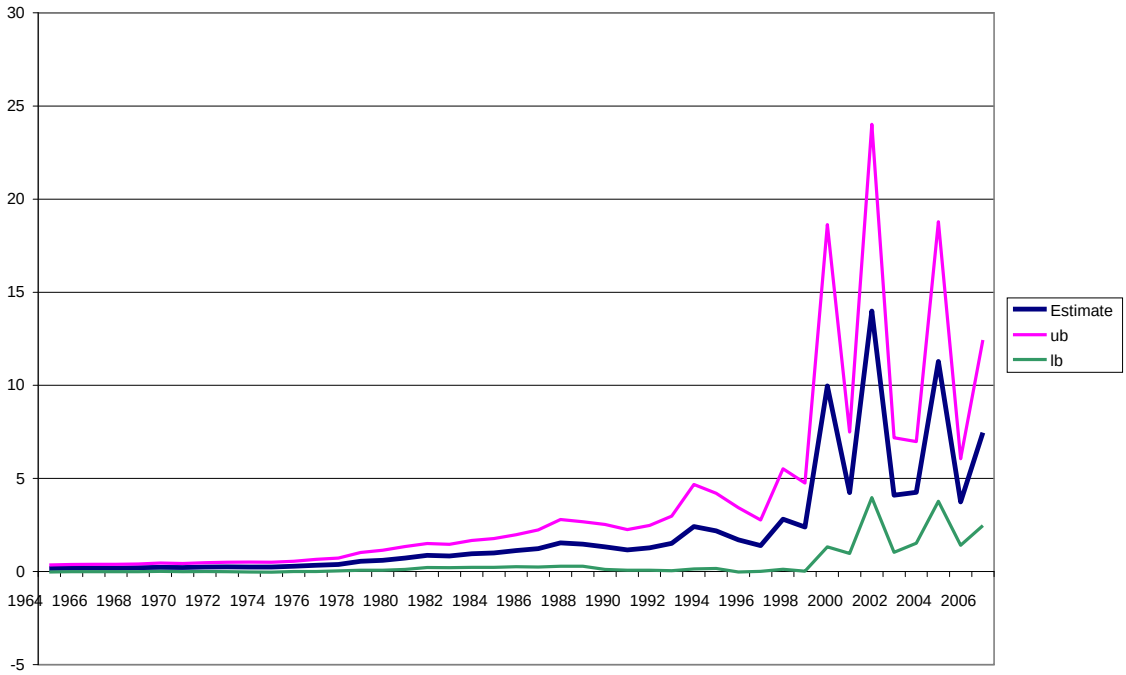
C4: Price elasticity of oil to its own price - Alberta



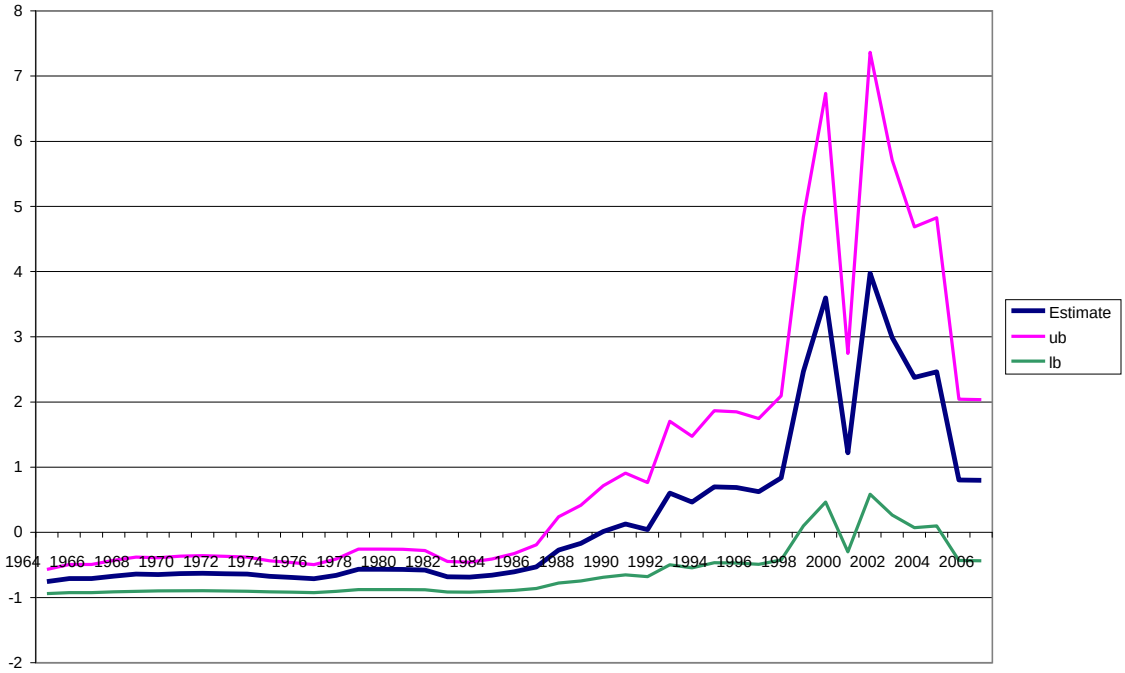
C5: Elasticity of oil to the price of electricity - Alberta



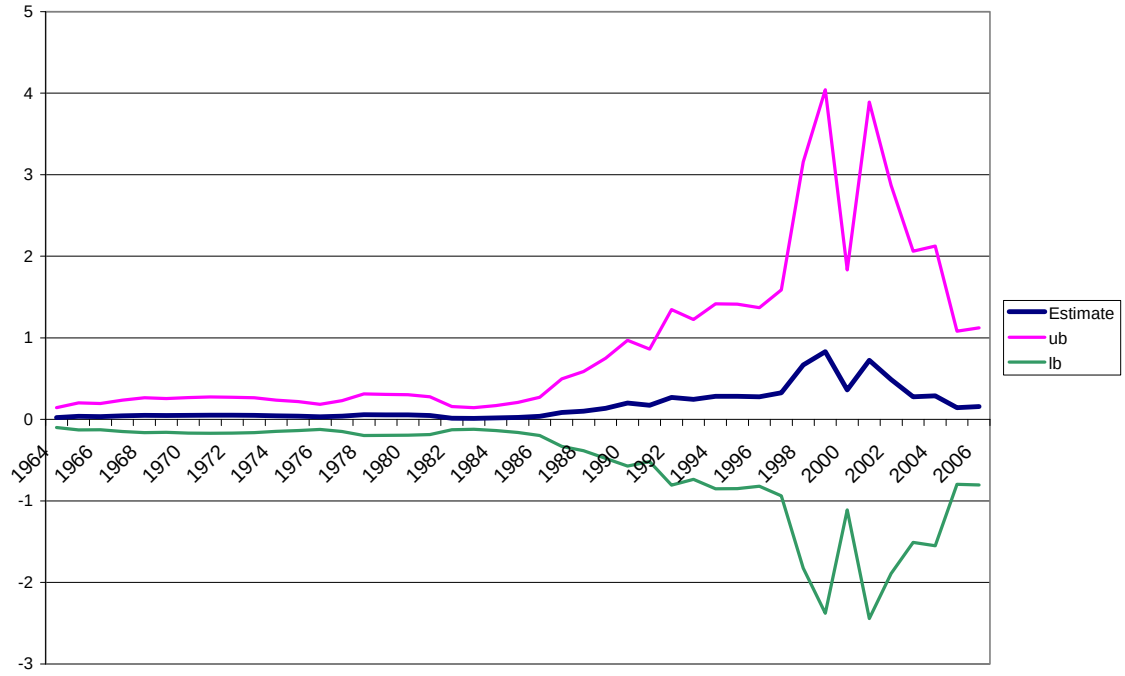
C6: Elasticity of oil to the price of natural gas - Alberta



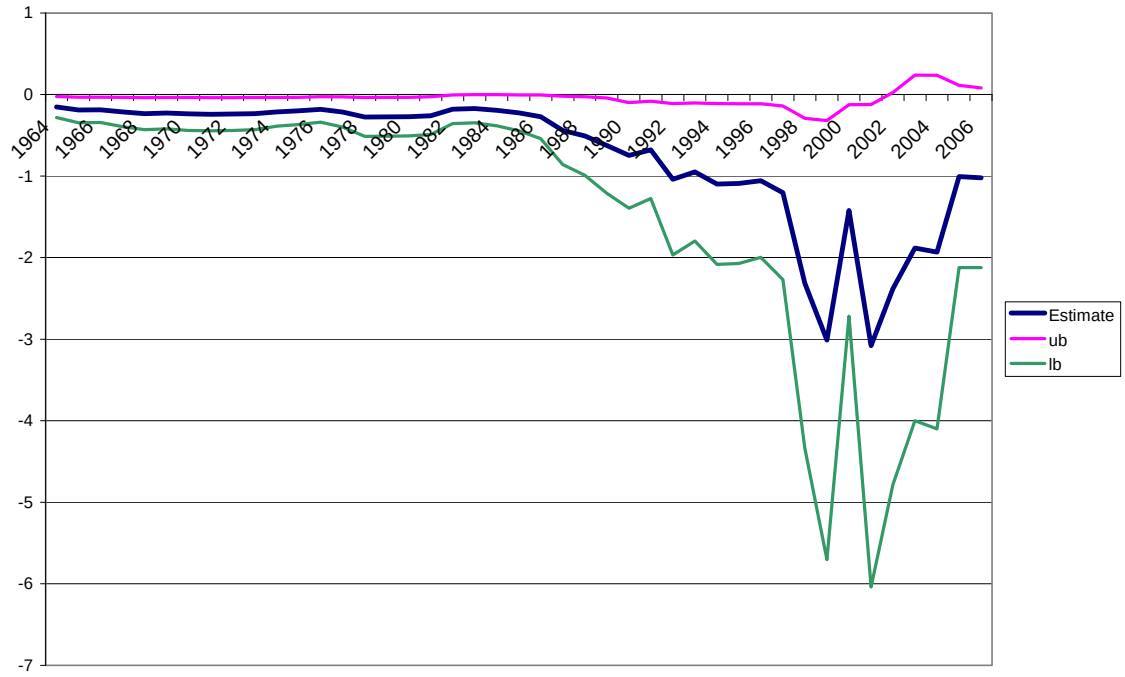
C7: Elasticity of oil to its own price - Saskatchewan



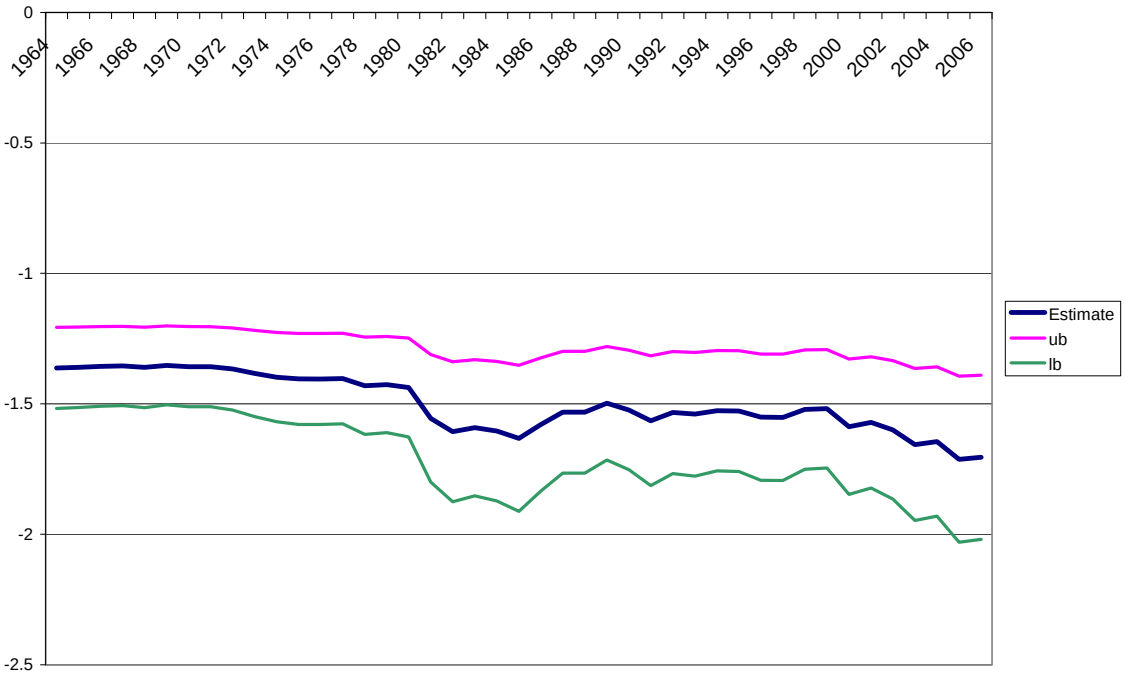
C8: Price elasticity of oil to the price of electricity - Saskatchewan



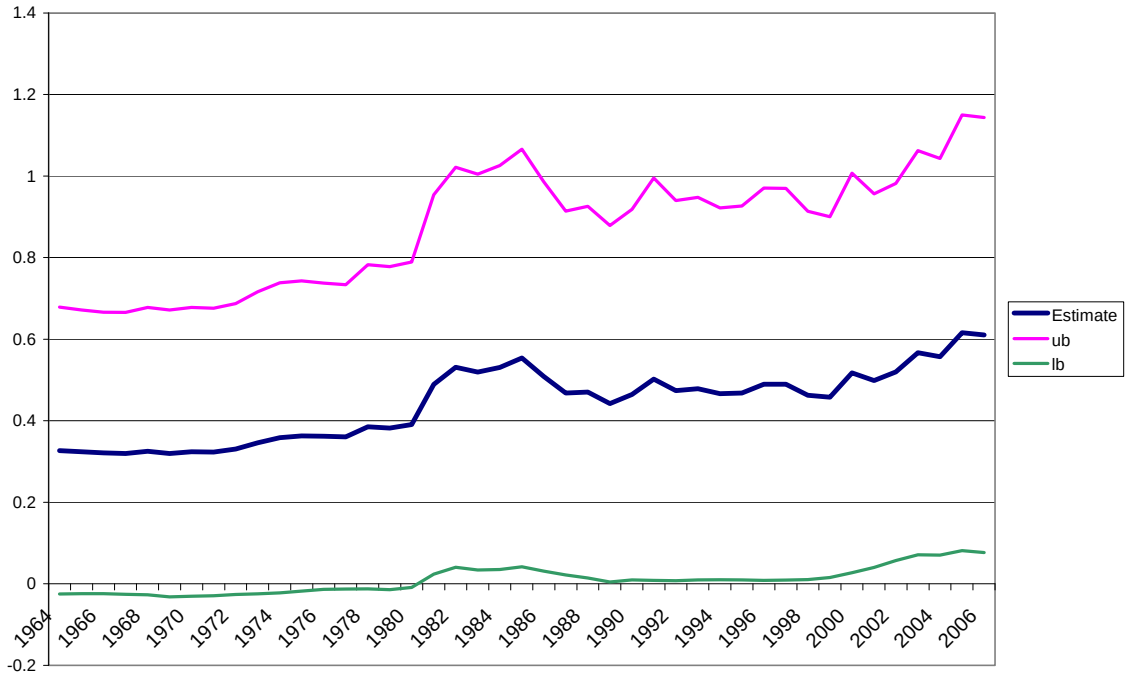
C9: Price elasticity of oil to the price of natural gas - Saskatchewan



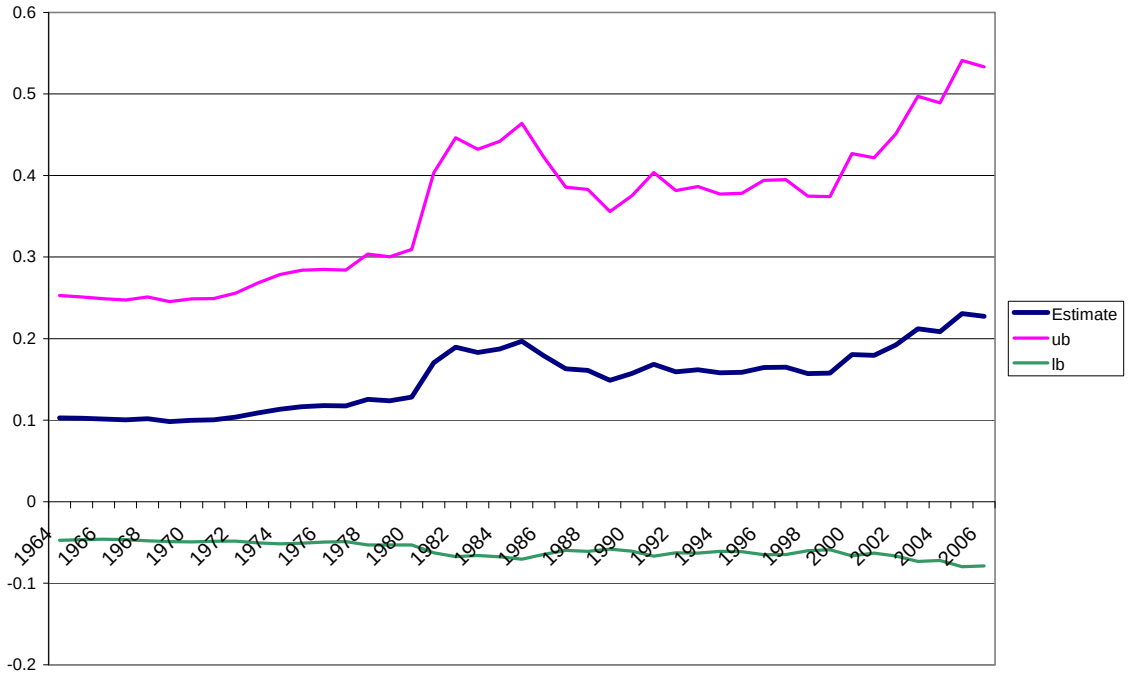
C10: Price elasticity of oil to its own price - Manitoba



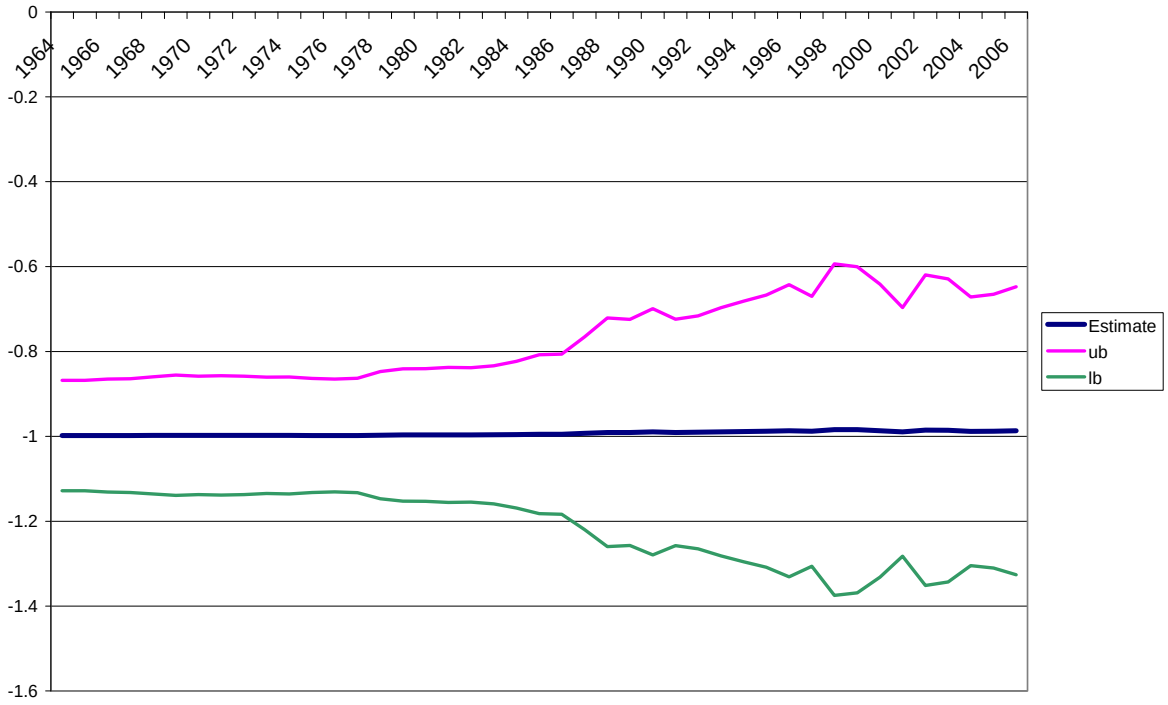
C11: Elasticity of oil to the price of electricity - Manitoba



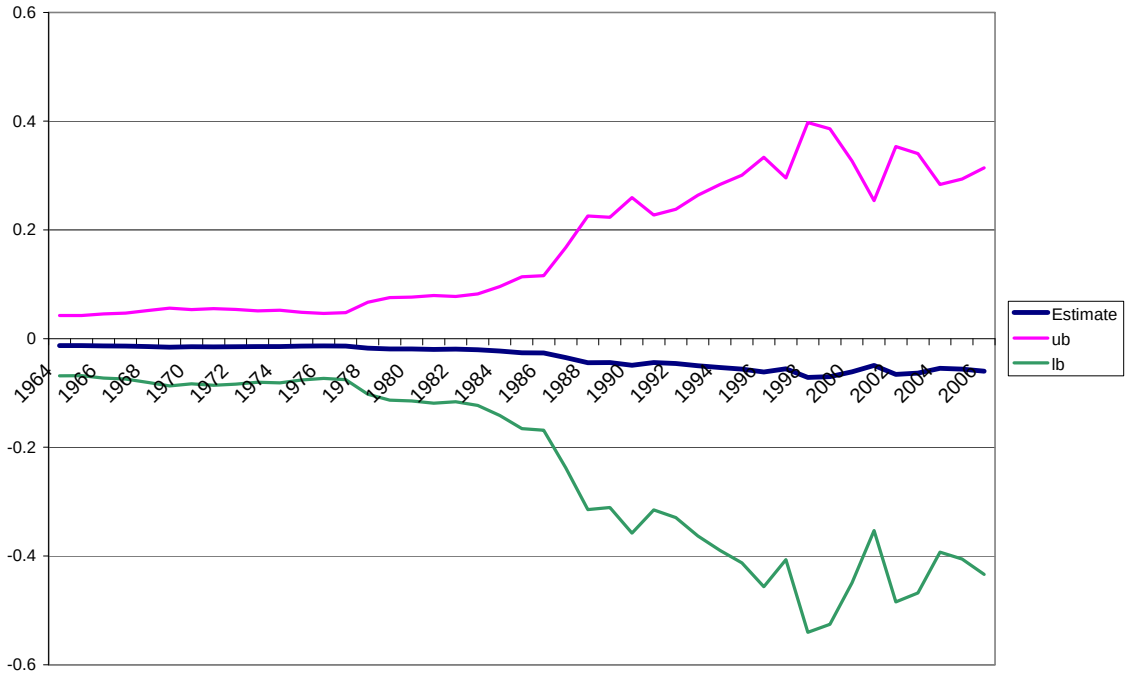
C12: Elasticity of oil to the price of natural gas - Manitoba



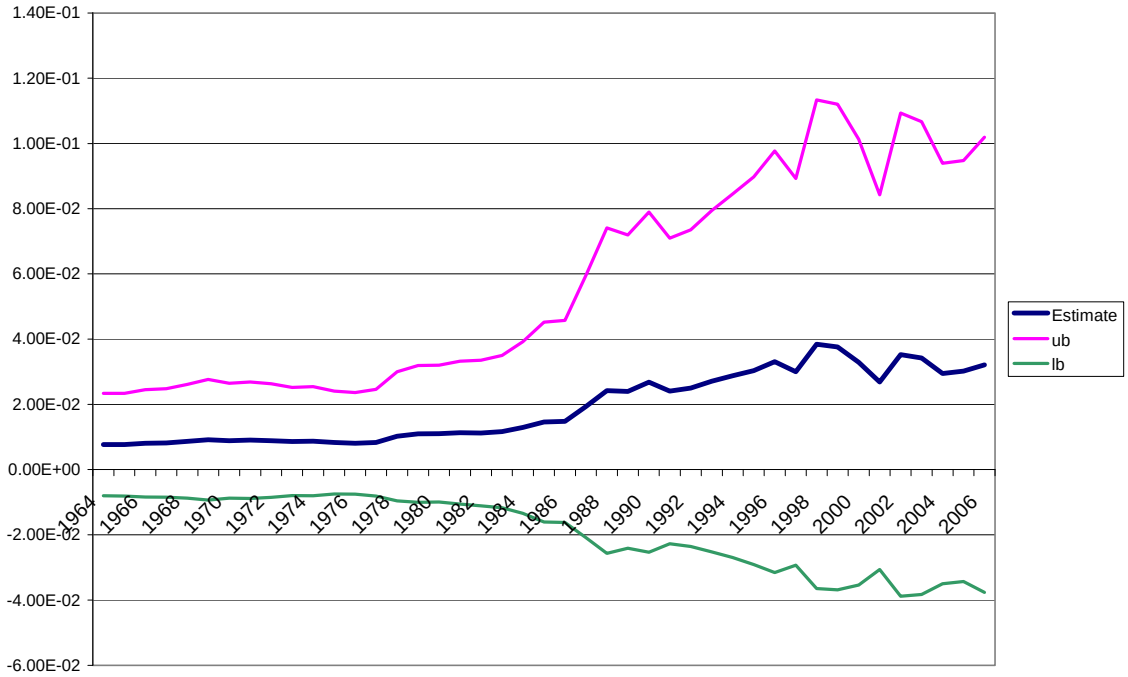
C13: Elasticity of oil to its own price - Quebec



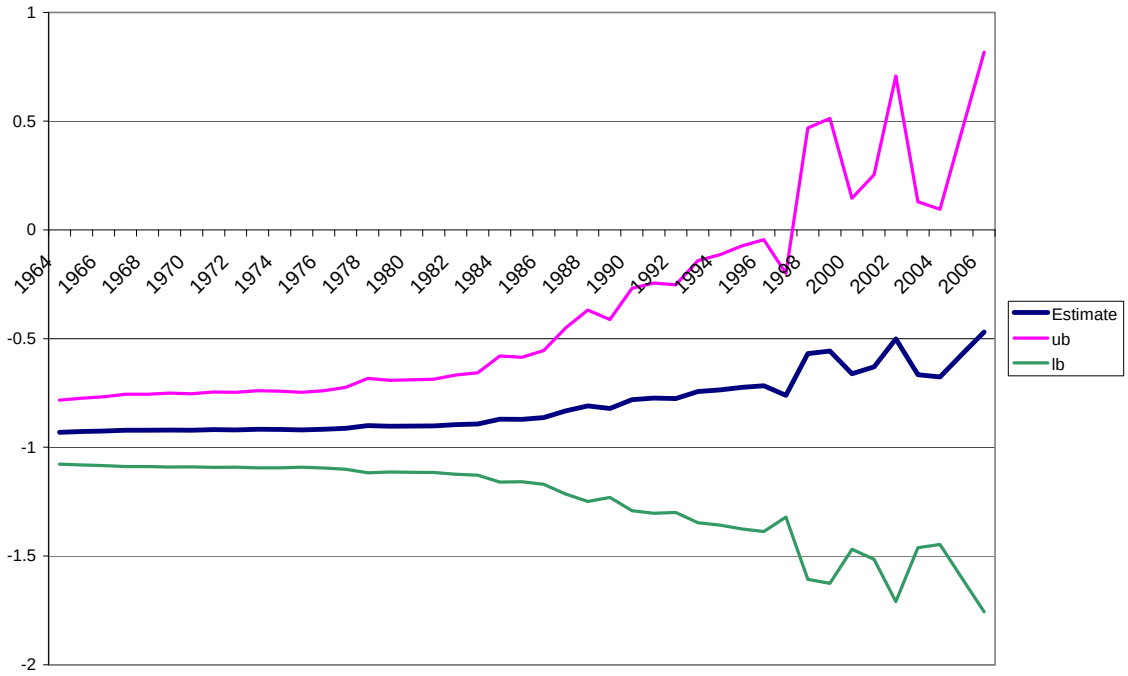
C14: Elasticity of oil to the price of electricity - Quebec



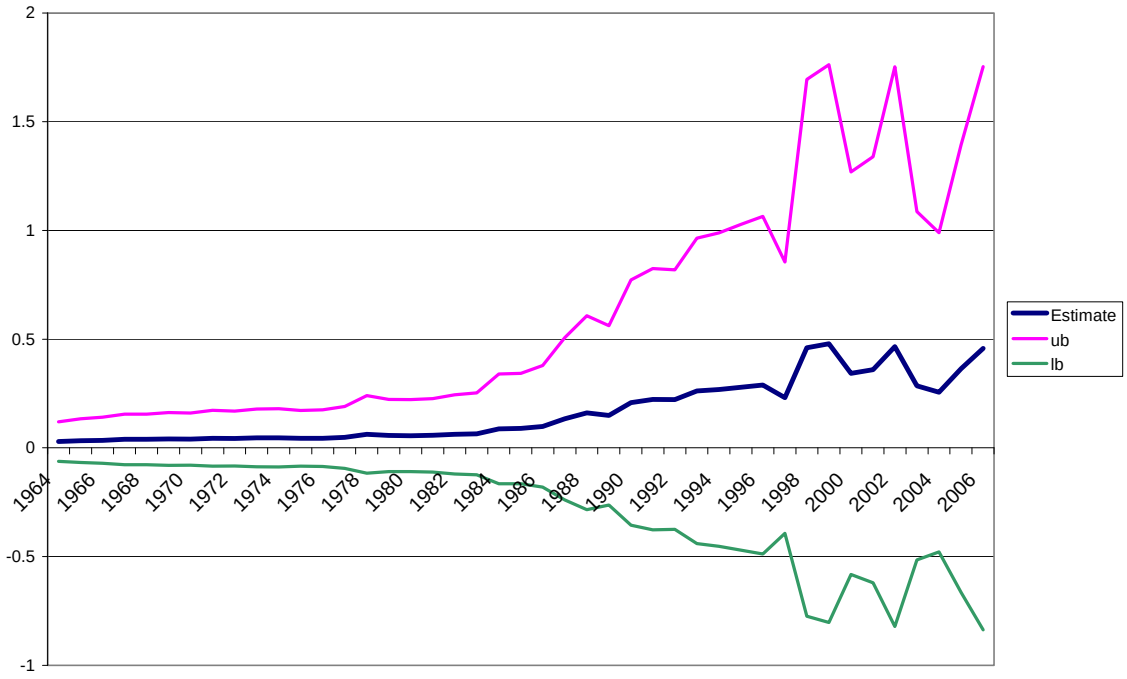
C15: Elasticity of oil to the price of natural gas - Quebec



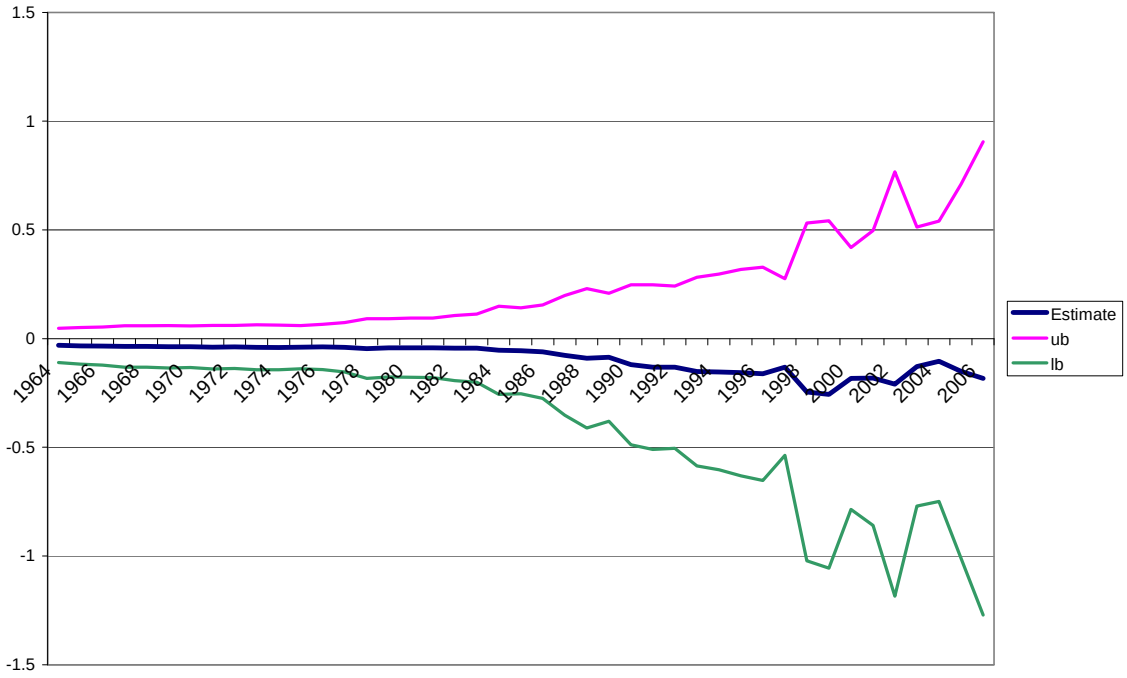
C16: Elasticity of oil to its own price - Ontario



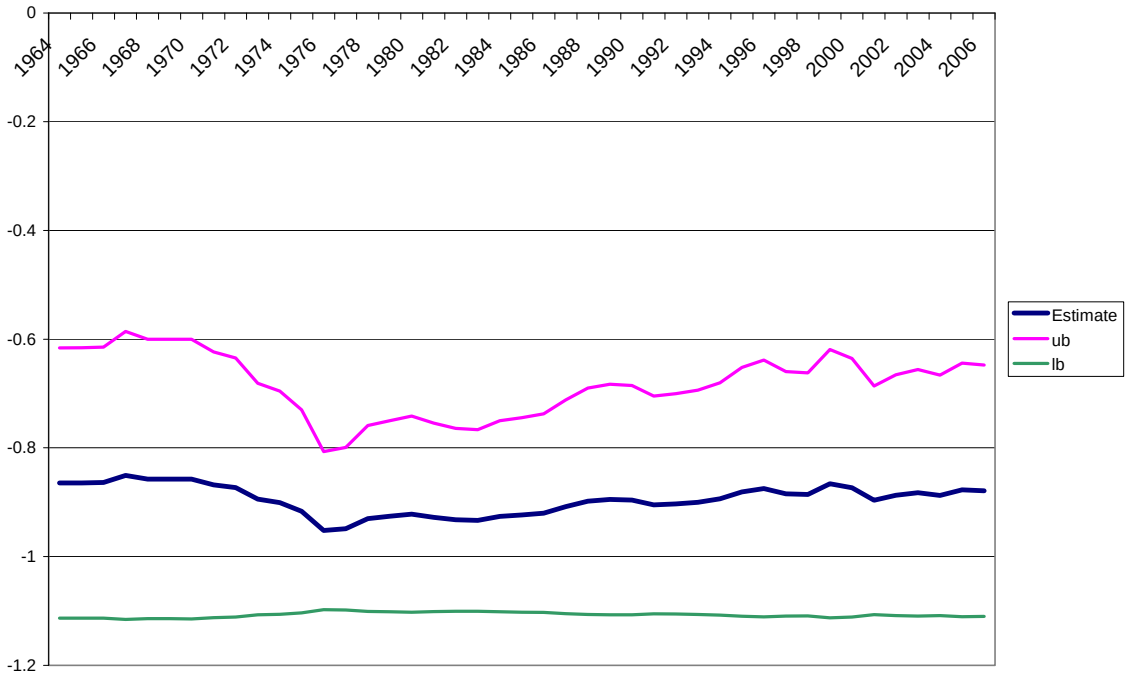
C17: Elasticity of oil to the price of electricity - Ontario



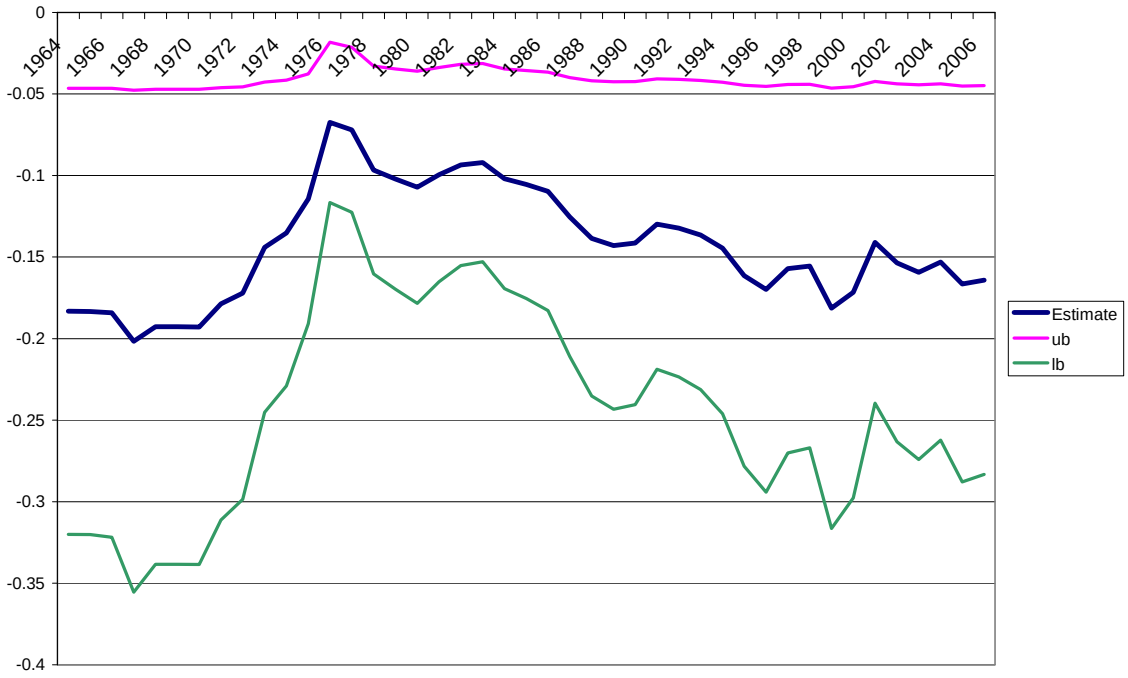
C18: Elasticity of oil to the price of natural gas - Ontario



C19: Elasticity of oil to its own price - Atlantic Provinces

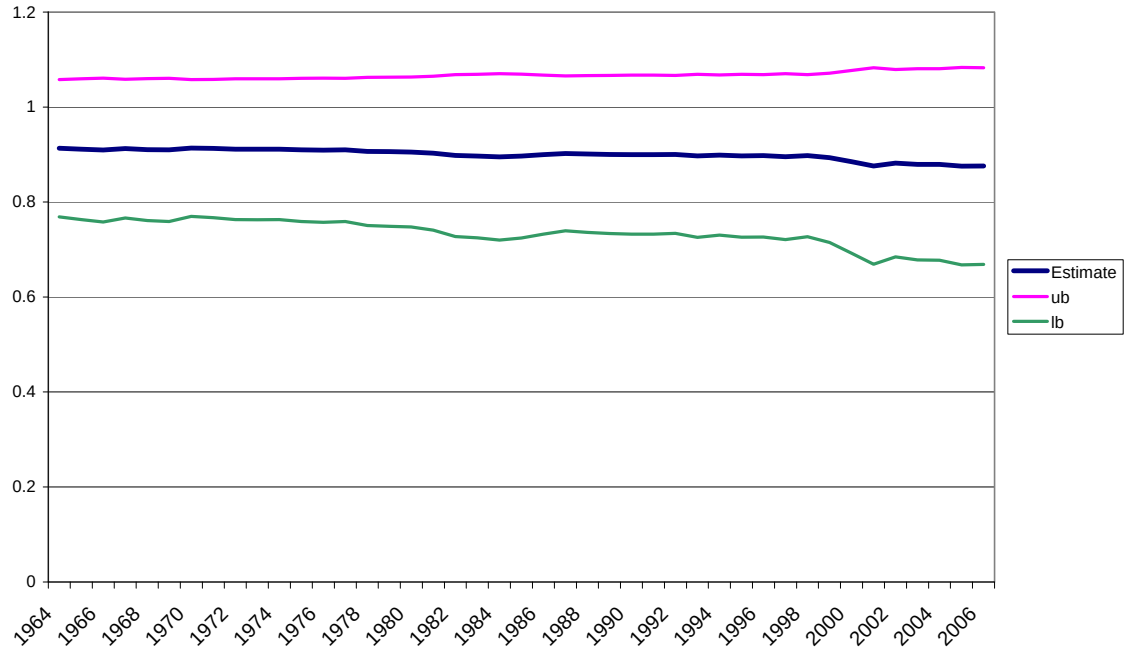


C20: Elasticity of oil to the price of electricity - Atlantic Provinces

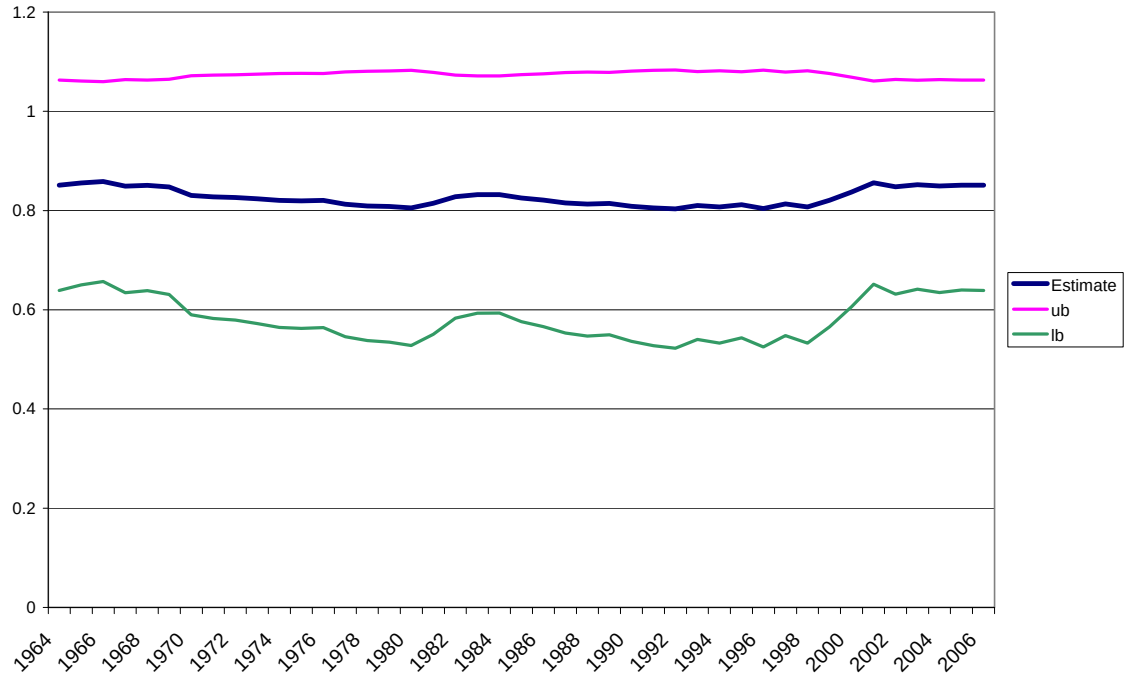


Appendix D: Income elasticities

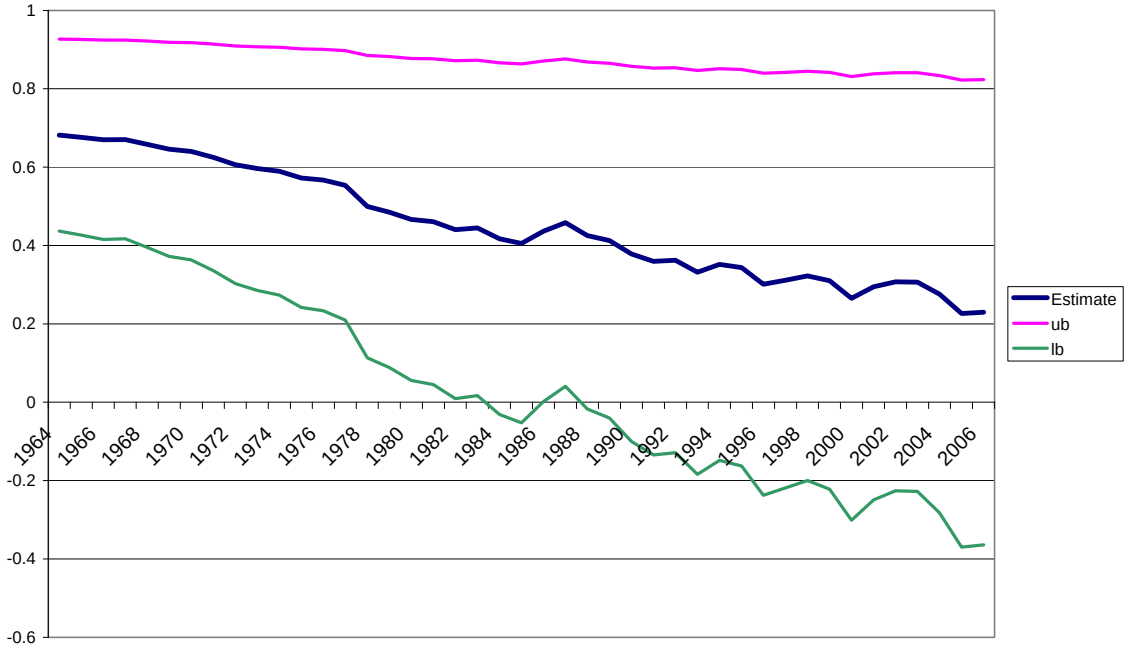
D1: Income elasticity of electricity - British Columbia



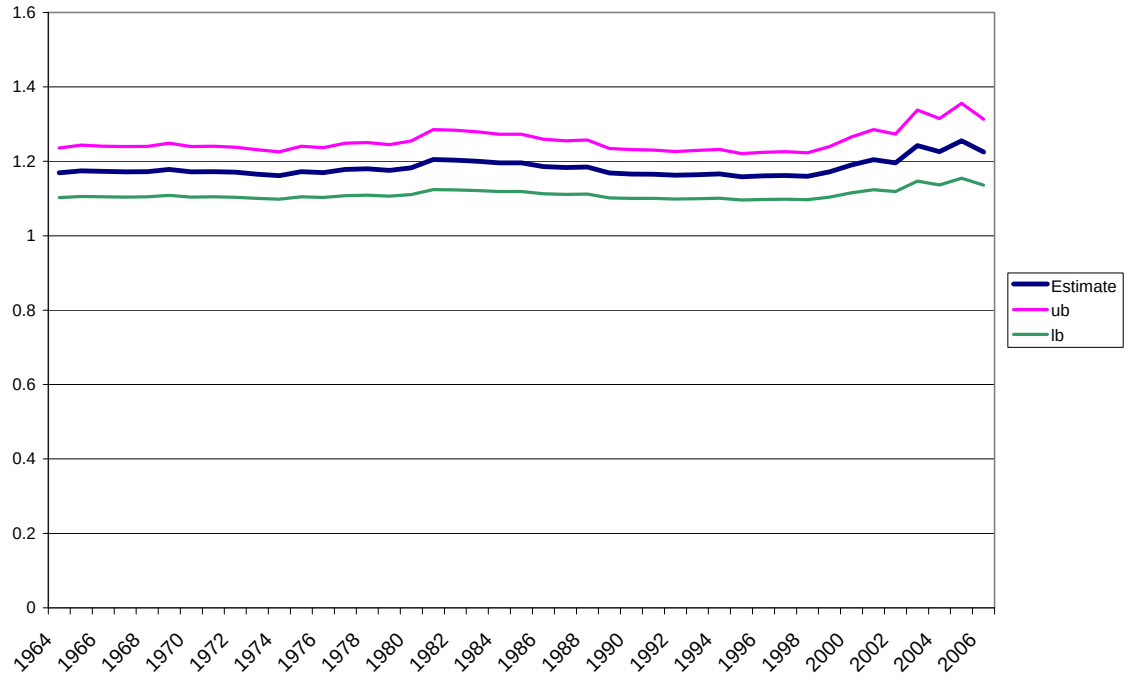
D2: Income elasticity of natural gas - British Columbia



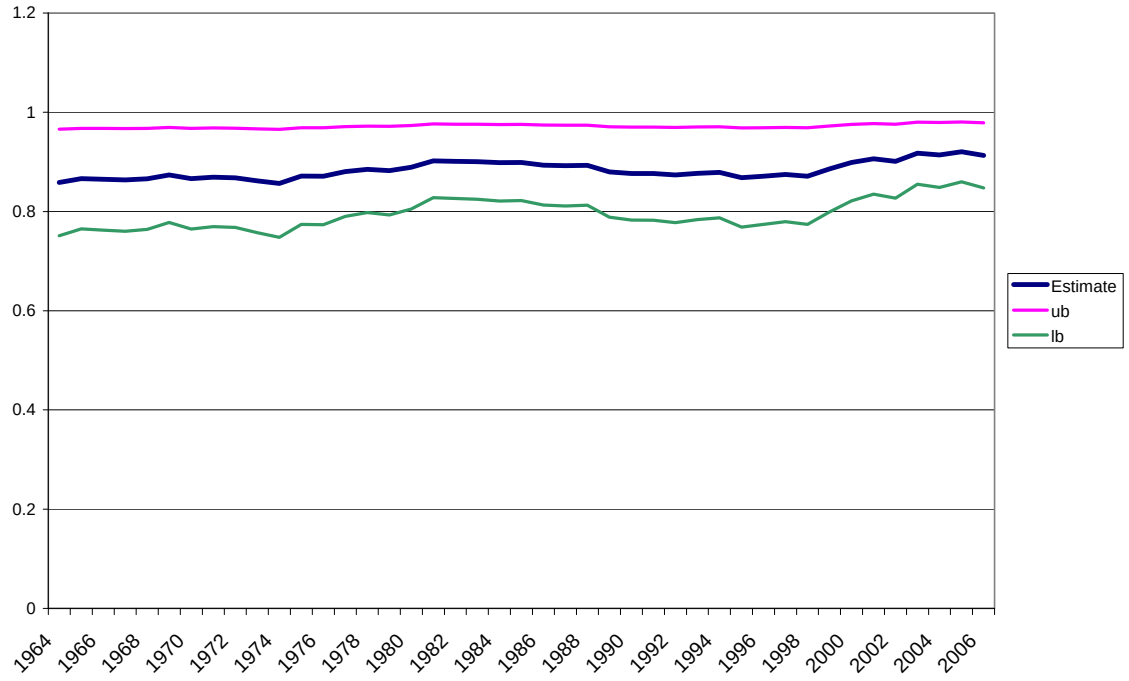
D3: Income elasticity of oil - British Columbia



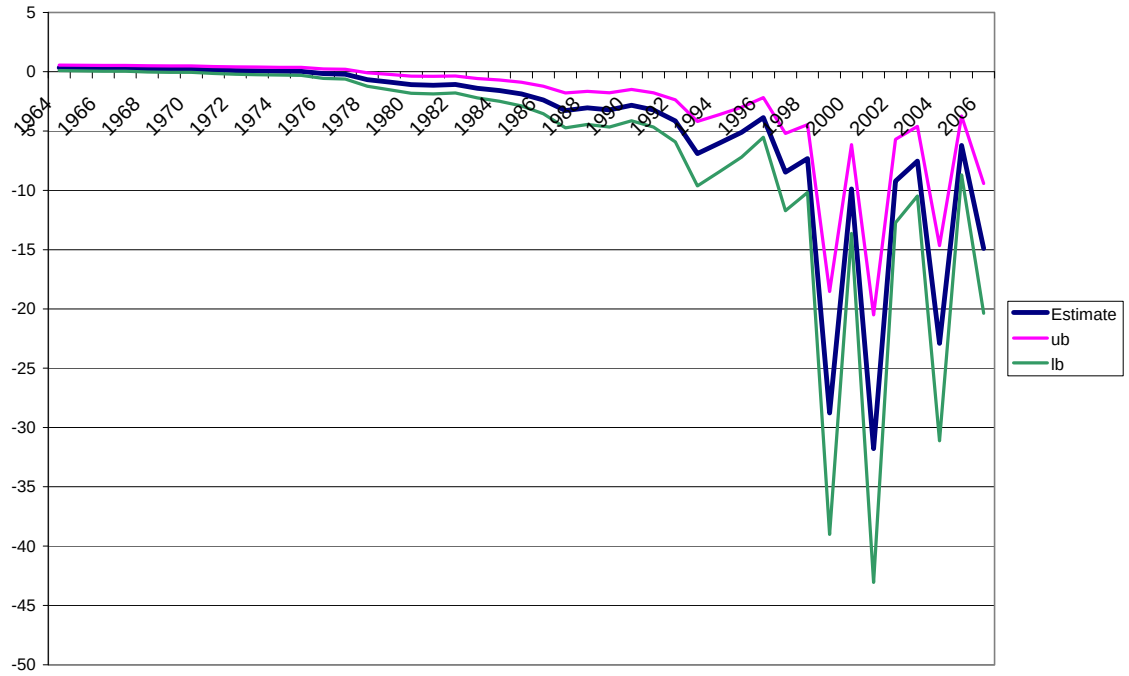
D4: Income elasticity of electricity - Alberta



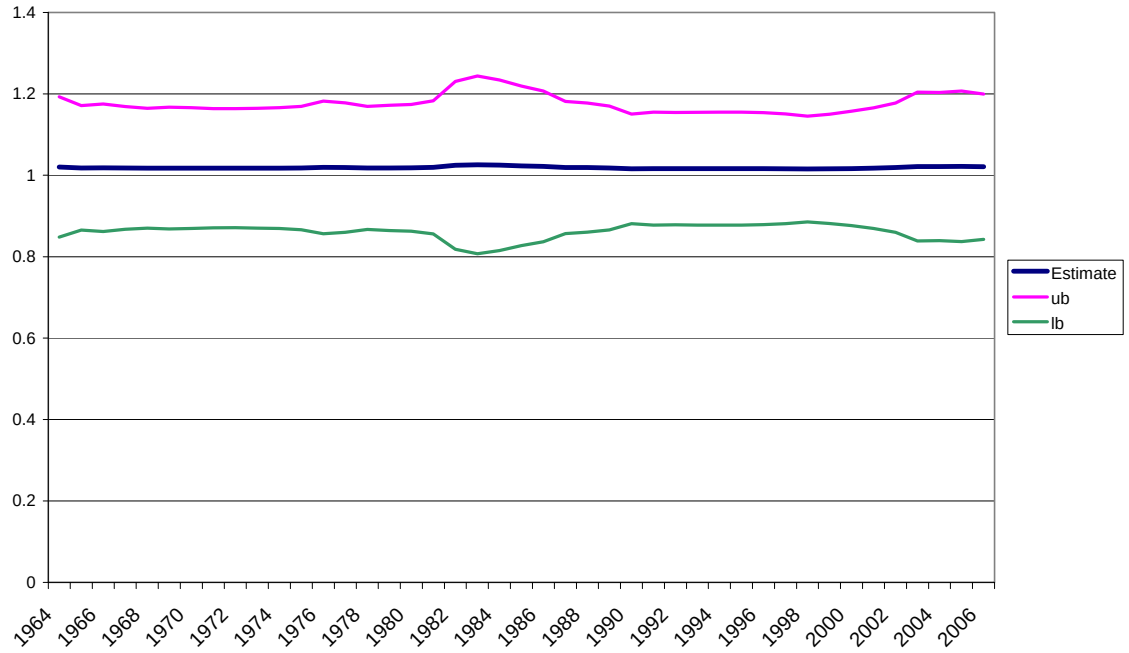
D5: Income elasticity of natural gas - Alberta



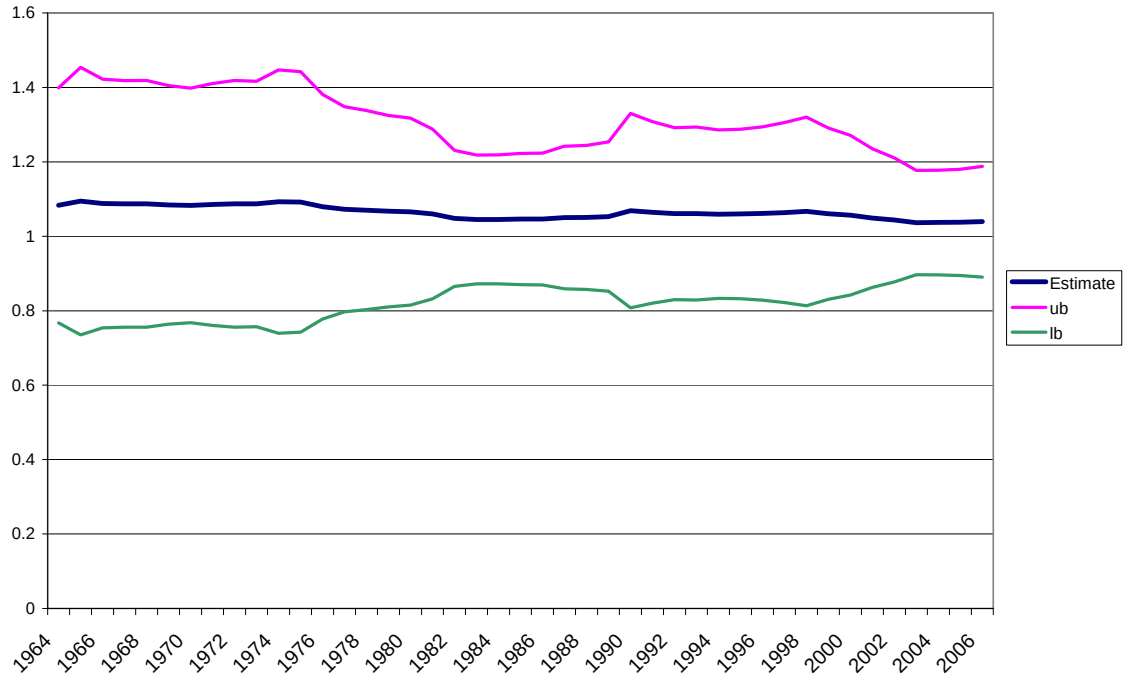
D6: Income elasticity of light fuel oil - Alberta



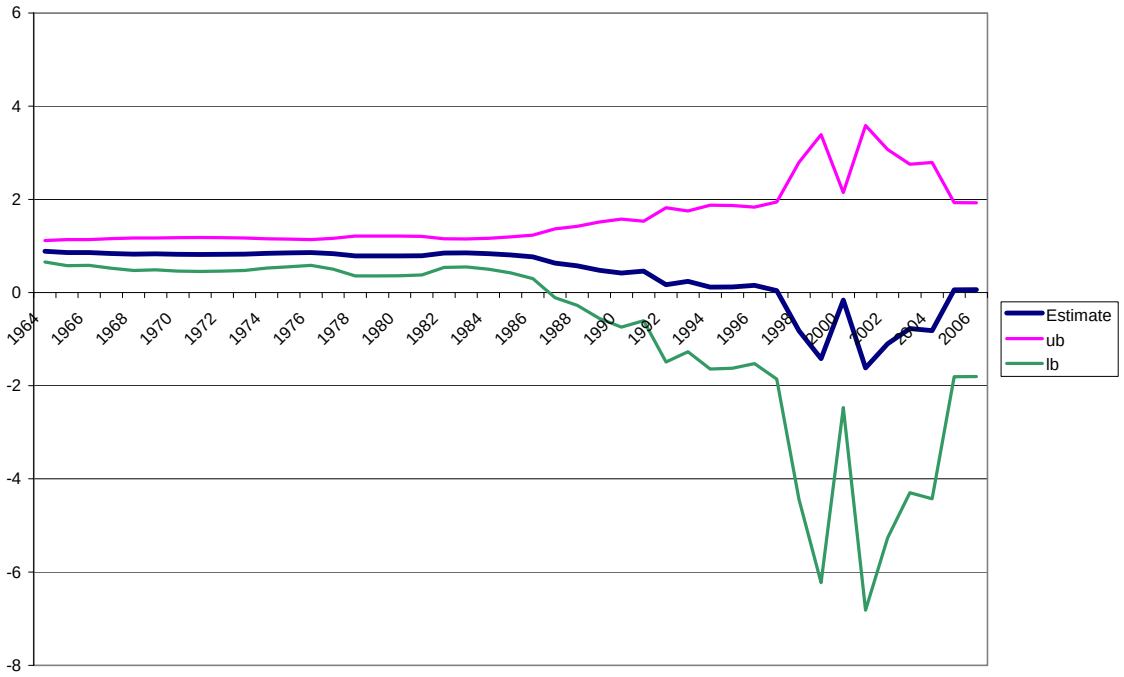
D7: Income elasticity of electricity - Saskatchewan



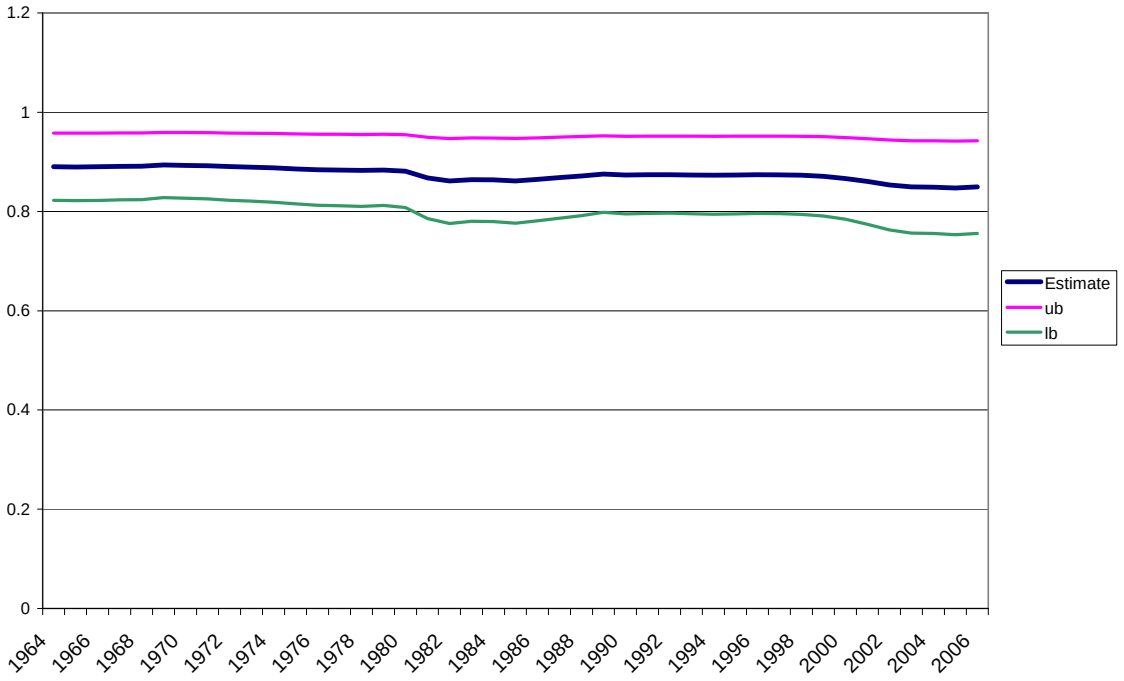
D8: Income elasticity of natural gas - Saskatchewan



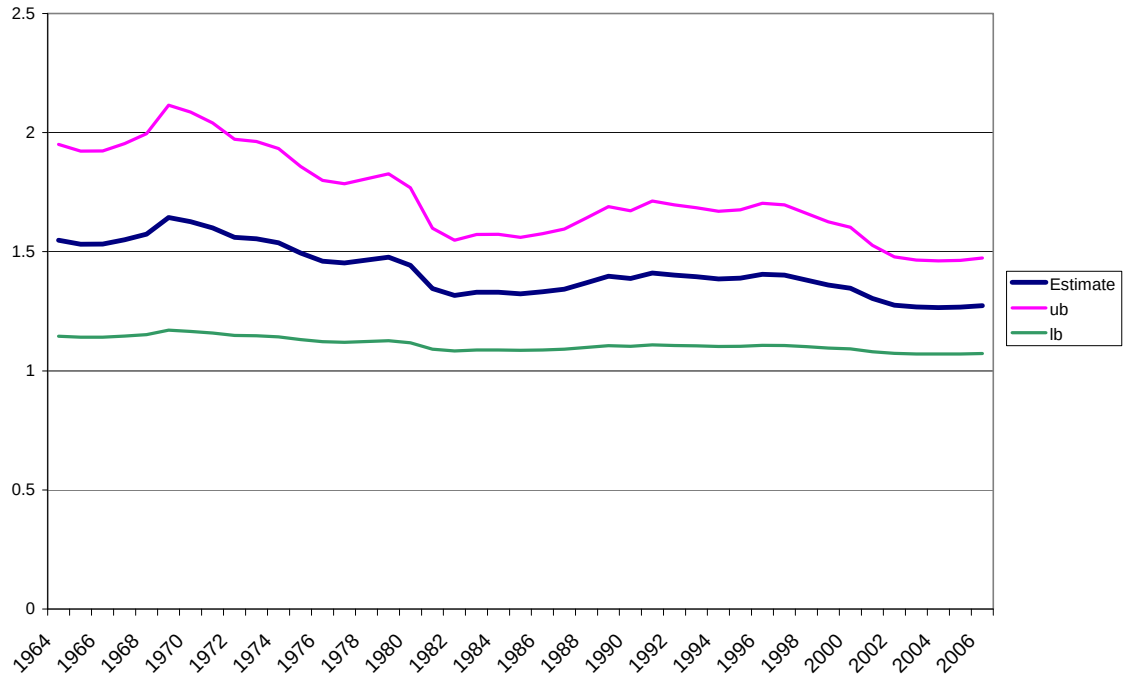
D9: Income elasticity of oil - Saskatchewan



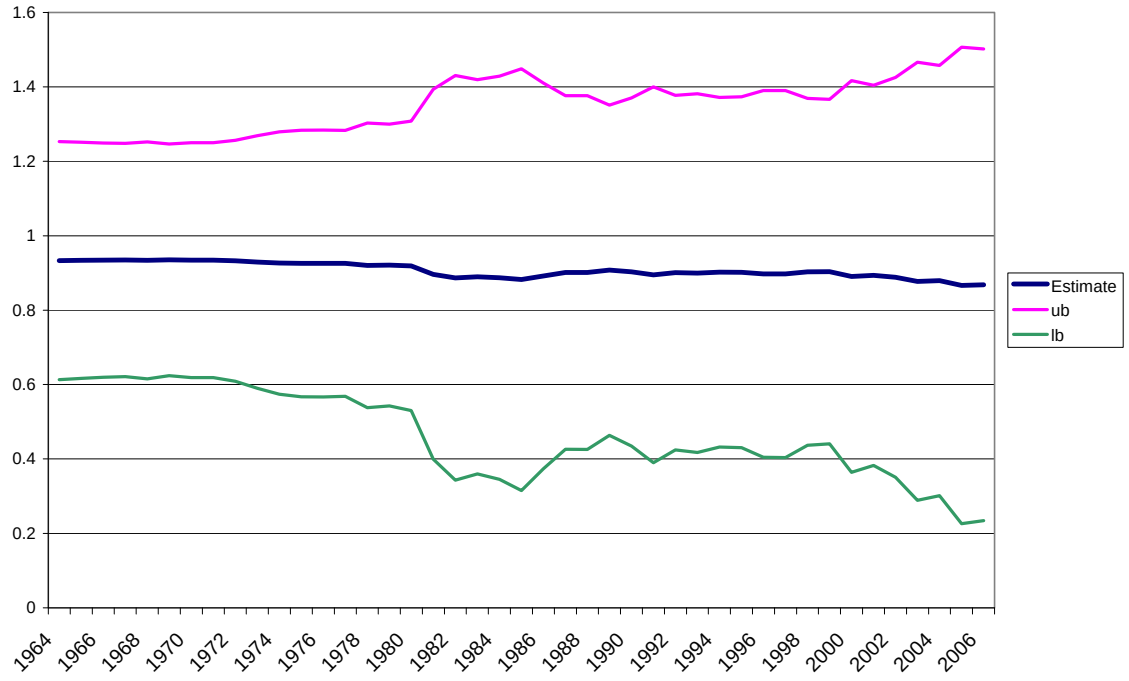
D10: Income elasticity of electricity - Manitoba



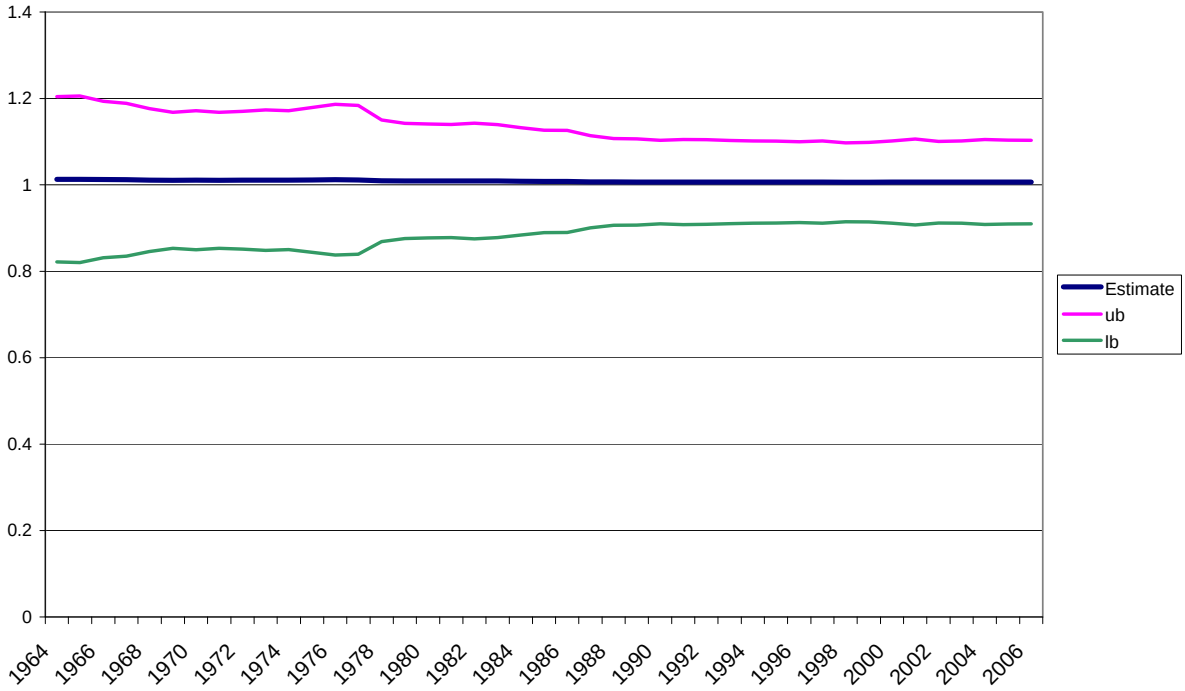
D11: Income elasticity of natural gas - Manitoba



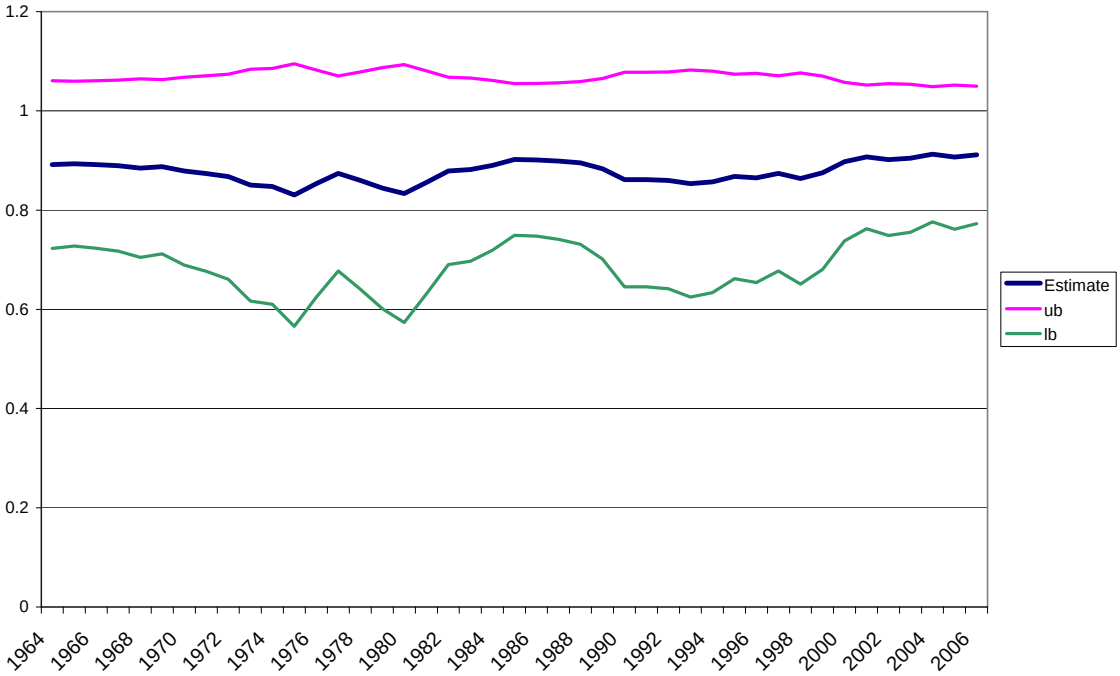
D12: Income elasticity of oil - Manitoba



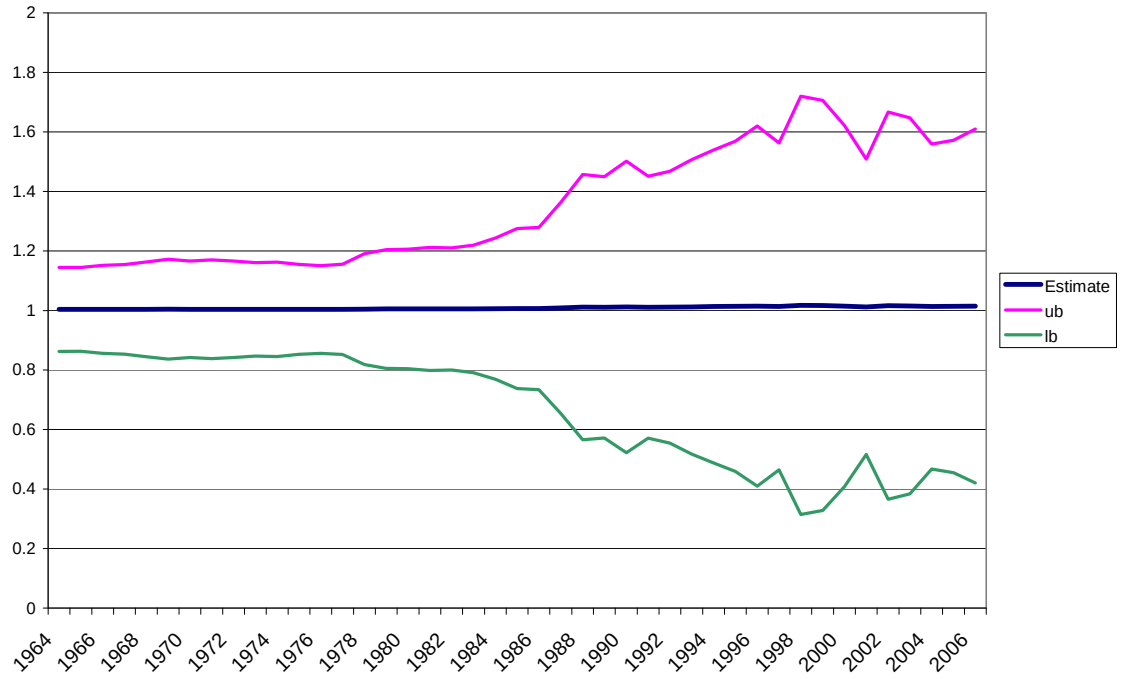
D13: Income elasticity of electricity - Quebec



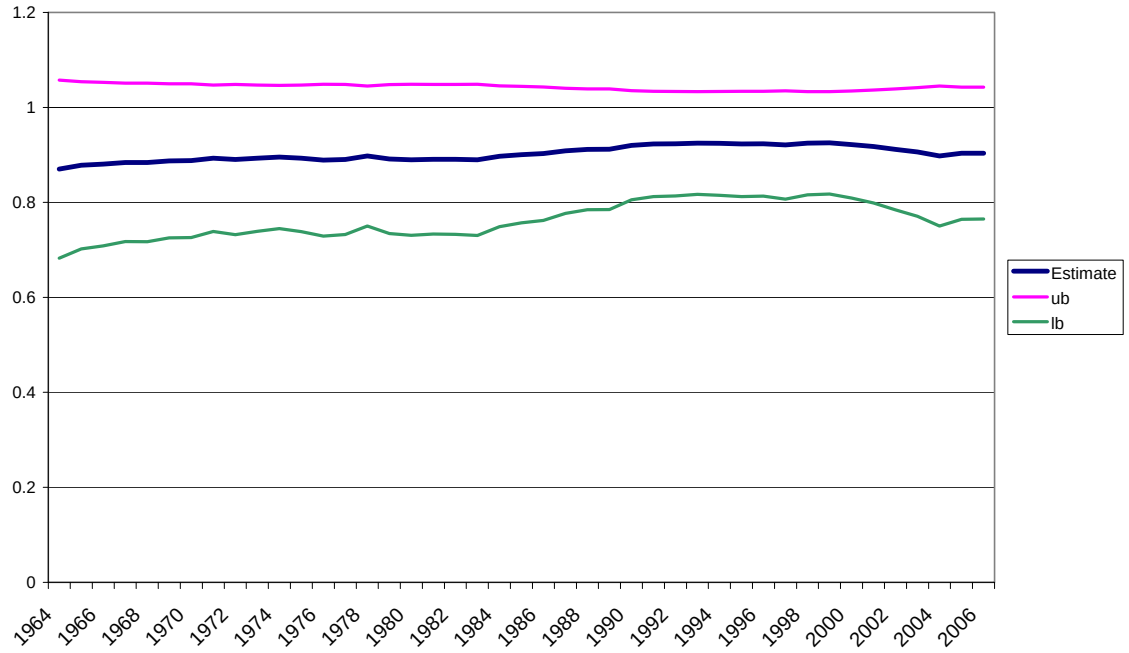
D14: Income elasticity of natural gas - Quebec



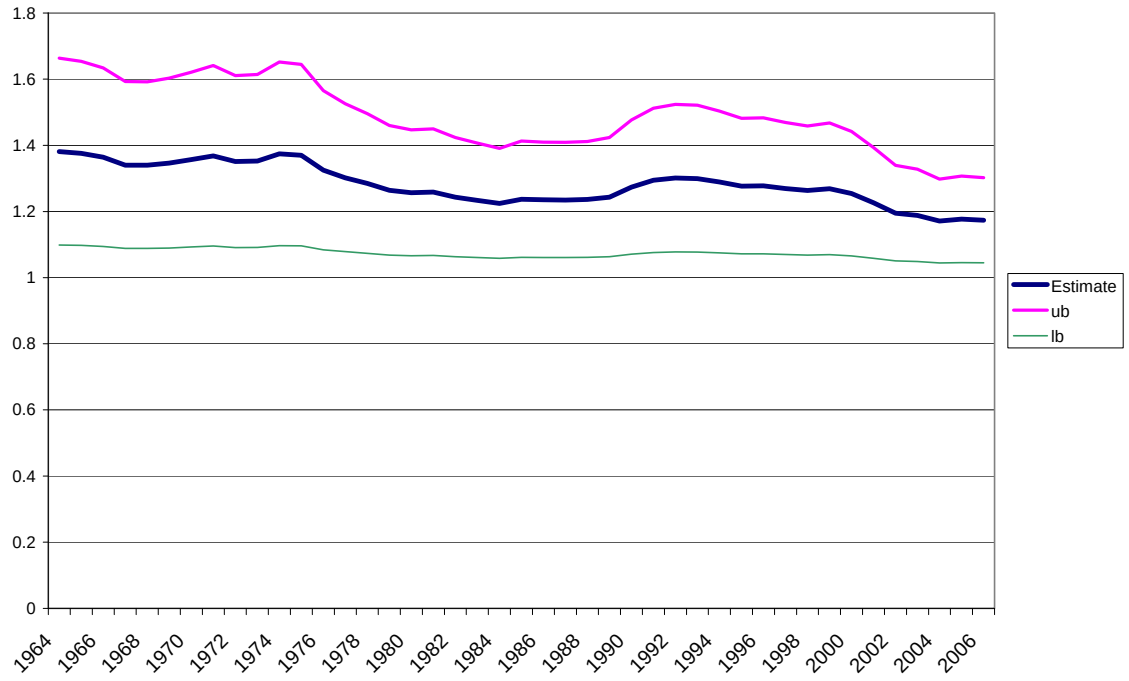
D15: Income elasticity of oil - Quebec



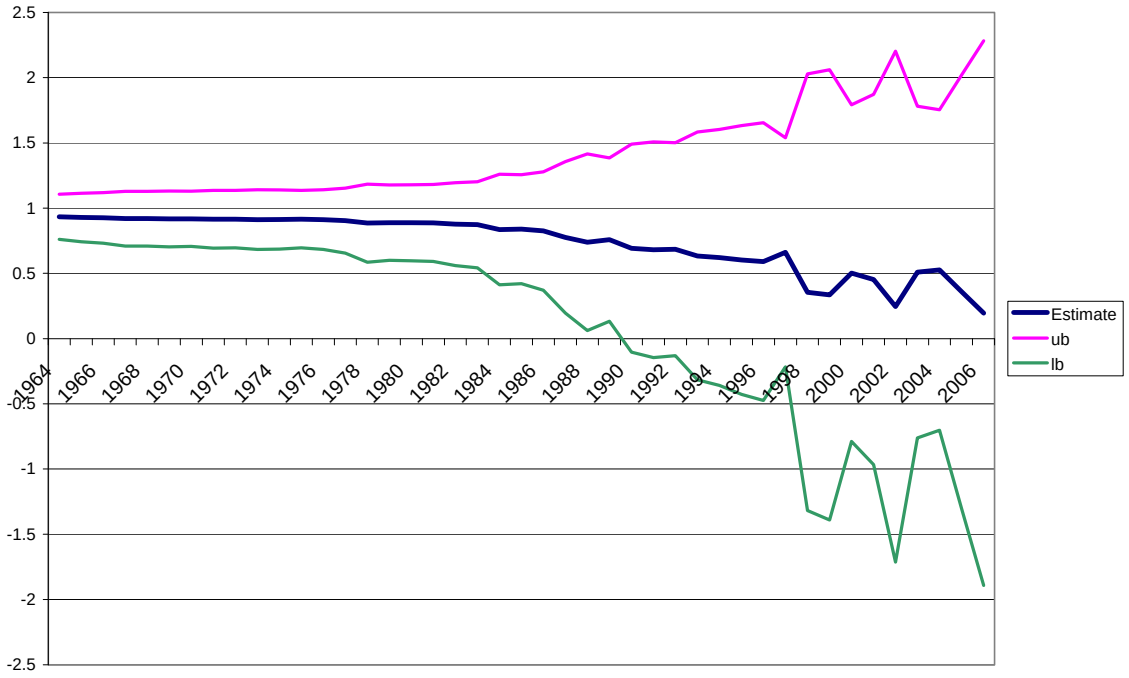
D16: Income elasticity of electricity - Ontario



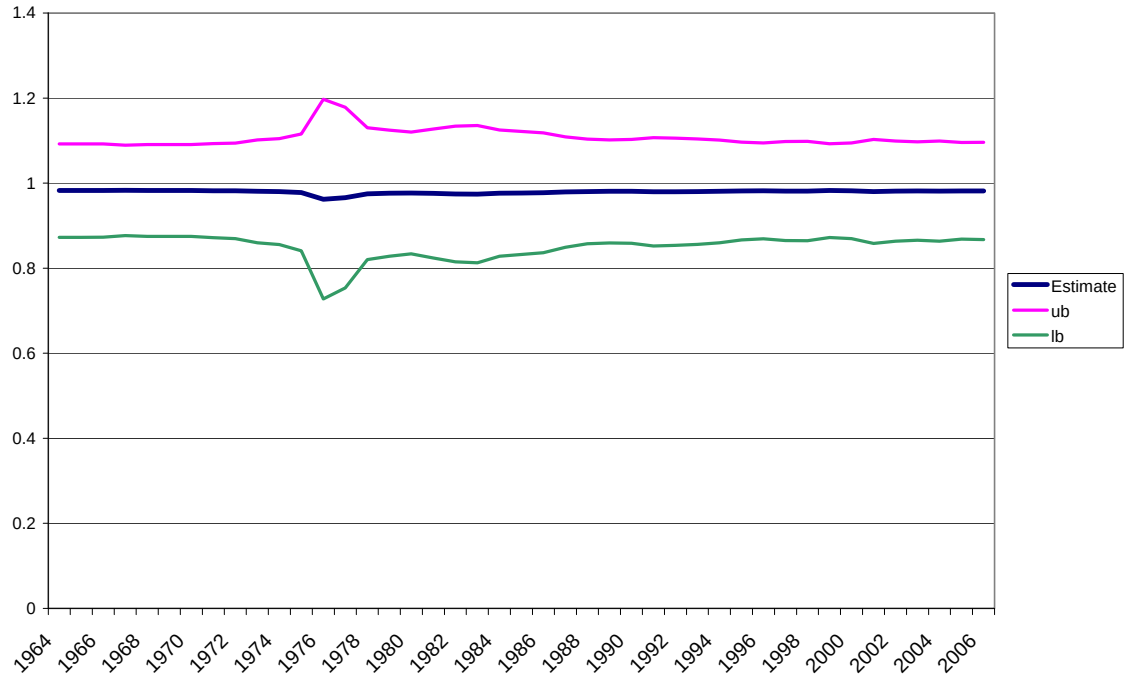
D17: Income elasticity of natural gas - Ontario



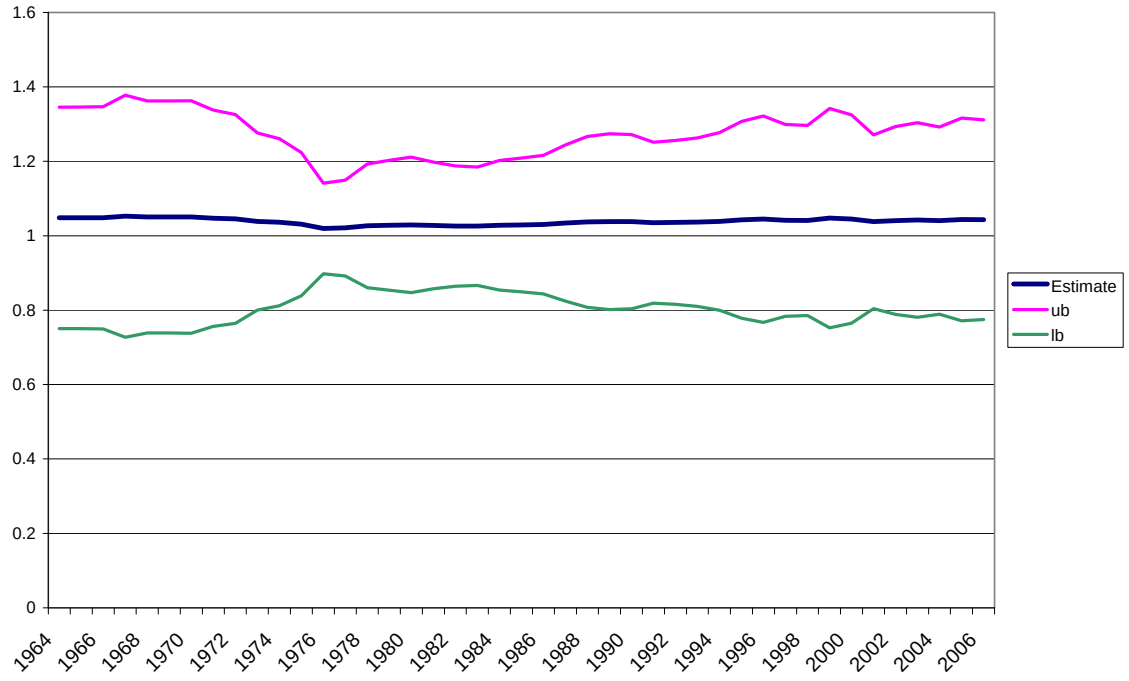
D18: Income elasticity of oil - Ontario



D19: Income elasticity of electricity - Atlantic Provinces



D20: Income elasticity of oil - Atlantic Provinces



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