A Survey of Labour Supply and an Empirical Illustration from Recent Canadian Data

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Abstract: Modeling labour supply decision has always been of interest to policy-makers. This study aims to outline some fundamental issues on labour supply and provide some simple yet helpful guidelines on estimating labour supply. Some Canadian empirical studies dealing with estimating labour supply per se as well as its applications are reviewed. Using cross-sectional micro data from the 2006 Canadian Census of Population, an empirical illustration regarding the estimation of labour supply of Canadian males is conducted. The estimated wage and income elasticities are generally consistent with some early findings.

1. Introduction

The study of labour supply has been of interest to many active labour economists in the past few decades. As Killingsworth (1983) stressed in his well-known survey piece, these studies can shed light on many aspects of labour economics. For example, they may be used to test the implications of the simple static labour supply model. They may be used to explore the causal factors of some interesting phenomena and trends in the labour market (*e.g.* the constantly increasing labour force participation rate of female). Furthermore, the estimation of labour supply as well as its underlying economic behaviour is of interest because policy makers can propose more efficient tax and welfare policies in conjunction with the empirical results which aim to increase work incentives and improve the overall well-being of the society.

This paper is aimed at presenting some notions that form the basis of the studies of labour supply. For the first part of the paper, I conduct a survey and outline several important issues concerning labour supply, including the theories of the static labour supply model and some of its extensions and drawbacks, a sketch of related empirical challenges, as well as the applications of theories of labour supply model. Also, some Canadian empirical studies dealing with estimating labour supply per se as well as its applications are reviewed. For the second part, I select a model based mainly on the simple static model to estimate the labour supply of Canadian males using cross-sectional data drawn from the 2006 Census of Canada. Although the model and methodology I used may not be at the forefront of this area, it does provide an empirical illustration of a very basic model using recent data.

The results are presented for a sample of married and single Canadian males pooled together as well as a sample of husbands only. Each sample has been divided into two age groups. The estimated results for the wage elasticities are generally quite small in magnitude but are consistent with the findings of early studies. The estimates of income elasticities for the entire sample and the two age groups all suggest that the assumption that leisure is a normal good is valid. The estimates of compensated elasticities are also consistent with the theory of labour supply model.

I begin my study by reviewing the relevant literature on labour supply and its estimation. Some fundamental theories regarding the one-period labour supply model will be briefly reviewed in that section. Then the empirical section, including sample restrictions and construction, follows. The econometric model that I estimate is outlined in section 4. Some potential problems I encounter throughout the study and how I tackle them are also specifically discussed in that section. Then I present and interpret my regression estimates in the results section. In the end some conclusions will be made in section 6.

2. Survey and Literature Review

2.1 Simple Static Labour Supply Model

Admittedly, there are a number of ways to estimate labour supply equation. However, it is one thing to carry out the estimates applying some unique technique but quite another to compare the validity and limitation across different studies. In order for those to be comparable and to facilitate the comparisons given different datasets used and different ways of constructing core variables in different studies, one needs to adopt a general framework that can underlie the application of varying techniques in terms of estimation. As proposed by Blundell and MaCurdy (1999), one needs to "provide a synthesis in which results from each data source can be compared" so that "meaningful and comparable results can be derived from each if the implications of the estimated function are carefully considered" (page 1587). As such, I will place my emphasis upon a typical, static, one-period labour supply model that has been widely studied and commonly adopted across many other quite influential studies.[1]

The mechanism is outlined as follows. Assuming each individual's utility is quasi-concave and has a general form of

$$U(C, L, A) \quad (2.1.1)$$

where C represents total consumption of a composite good, L represents time allocated to leisure, and A represents the individual's particular attributes that can measure the heterogeneity among the population of interest, whether observable or unobservable—for instance, their tastes for work.[2] The individual's problem is to maximize her utility level subject to the following budget constraint:

$$C + wL = Y + wT \quad (2.1.2)$$

where w is the hourly wage level when working, Y is non-labour income level, and T is the total amount of time per day that an individual could dispose of. An interior solution given by the assumption that individual works a positive number of hours is yielded by the following first-order conditions:

$$U_C(C, L, A) = \mu \quad (2.1.3)$$

And

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[1] Since this study only deals with individual labour supply at a given point of time, some sophisticated models such as life-time labour supply model will not be discussed. However, they are equally important if one needs to thoroughly understand the theories lie behind the supply side.

[2] For example, if one assumes that the utility function is in the form of Cobb-Douglas utility function, $U = C^{\alpha}L^{1-\alpha}$, then individual's information regarding attributes can be provided by the parameter α.

$$U_L(C, L, A) = \mu w \quad (2.1.4)$$

where μ designates the shadow price of additional utility. Combining equations (2.1.3) and (2.1.4), we can obtain a condition for optimal choices of consumption and leisure assuming an interior solution:

$$MRS_{L,C} = \frac{U_L(C, L, A)}{U_C(C, L, A)} = w \quad (2.1.5)$$

where $MRS_{L,C}$ is the marginal rate of substitution between leisure and consumption. This condition stipulates that at the margin, the utility derived from consuming one extra unit of leisure should be *w* times greater than the utility that would be lost due to consuming one less unit. Since the hourly wage rate is taken as given, but the *MRS* varies according to the location of allocation between consumption and leisure an individual ends up with, it is possible that the following inequality holds:

$$\frac{U_L(C, L, A)}{U_C(C, L, A)} > w \quad (2.1.6)$$

In this case leisure is valued more than consumption at the margin. As such one will obtain a corner solution in which $L = T$, implying the individual supplies zero hours of work. The marginal rates of substitution that yield the inequality above when evaluated at $L = T$ is also termed the reservation wage, denoted as w_R in this study.

$$w_R = \frac{U_L(C, T, A)}{U_C(C, T, A)} \quad (2.1.7)$$

The above discussion on the relationship between the market wage rate and individual's reservation wage is essentially critical to the analysis of the individual's participation decision. When an individual who works is observed, her optimal choice between leisure and consumption can be solved using the interior optimal condition and the budget constraint which is assumed to be binding:

$$C^* = C^*(w, Y, A) \text{ and } L^* = L^*(w, Y, A) < T \qquad (2.1.8)$$

and combined with the time allocation constraint $H = T - L$, the optimal choice of hours of work can also be readily obtained:

$$H^* = H^*(w, Y, A) \qquad (2.1.9)$$

where optimal choice of labour supply, H^*, is a function of individual's market wage level, non-labour income level, and particular attributes.

Given a change in the wage rate, the total effect on individual's hours of work can be decomposed into substitution effect and income effect, which has an analog in basic consumer theory. The substitution effect is represented by the compensated (Hicksian) change in labour supply with respect to the wage, which is the partial derivative of H^* with respect to the wage rate w, holding income constant, and the income effect is represented by the partial derivative of H^* with respect to the non-labour income Y. The uncompensated (Marshallian) wage effect on labour supply can thus be broken down into compensated (Hicksian) wage elasticity and income elasticity according to the well-known Slustky equation:

$$\epsilon_U = \epsilon_C + \frac{wH^*}{Y} \frac{\partial \ln H^*}{\partial \ln Y} \qquad (2.1.10)$$

where ϵ_U represents the uncompensated wage elasticity, which implies the percentage change in individual's responsiveness to labour supply corresponding to a one percent change in the wage rate; ϵ_C represents the compensated wage elasticity, which implies the percentage change in labour supply corresponding to a one percent change in wage rate if she were to remain at the same utility level as in the situation before wage change; and $\frac{\partial \ln H^*}{\partial \ln Y}$ represents the income elasticity, which implies the percentage change in labour supply given a one percent change in individual's income level.

Theoretically, ϵ_C is always assumed to be positive, and $\frac{\partial \ln H^*}{\partial \ln Y}$ is considered to be negative due to the assumption that leisure is a normal good. However, it is exactly this plausible assumption that might cast doubt on the other seemingly solid findings on labour supply. Is leisure necessarily normal to every individual in the universe? For most of the population it is. But one could argue that there are certain kinds of people who would be willing to provide more labour supply as their income increases, perhaps because they find themselves valued by others during work, and they value that feeling of acceptance highly. As far as this type of individual having such preferences is concerned, the net effect is quite clear-cut. However, for the majority of the population, it is reasonable to conclude that the net effect of a wage increase is ambiguous if leisure is assumed to be a normal good. Moreover, although from the theoretical perspective the net effect is measured in terms of the sum of the two components, from the empirical perspective it is the uncompensated wage elasticity and the income elasticity that can be estimated directly, and the compensated one that would be deduced from the outcomes of the former two.

2.2 Extensions of the Simple Static Model

Now that the simple static labour supply model has been briefly introduced, I will move on to some extensions or reformulations of the model, which allow one to get a taste of what possible further theoretical developments exist, and they might shed light on some drawbacks of the simple static model.

2.2.1 Family Models

Based on the fact that there is no clear definition of property or non-labour income examined by the model and in the literature, the way different studies define it varies substantially. Many studies thus incorporate labour supply of family members in order to make the model richer. There are three main approaches which have been at the forefront of this mainstream modification of the model (see Killingsworth, 1983, chapter 2).

The first one is dubbed the "male chauvinist" model. The essential idea of the model is that the husband's income could be a determinant of the wife's decision for her labour supply but not vice versa, *i.e.*, husband would not take his wife's level of earnings into account when he decides whether or not he should work, and how many hours of work he should supply. Instead, the husband's labour supply only depends on his own wage rate and property income of the family. In short, the story of the model is explicitly expressed as the name "male chauvinist" implies.

The second one is coined family utility-family budget constraint model according to Killingsworth(1983). Instead of maximizing one individual's utility subject to his or her particular budget constraint, this model treats all family members as one behavioral unit, and aggregates all family members' earnings so that the analysis can be carried out in a similar fashion as in the case of the individual. As one could imagine, the decision of labour supply thus becomes highly complex and interactive among several family members rather than a decision that can be made solely on his/her own. As a consequence, there will no longer be only one substitution effect arising from a change in the budget constraint. Within this framework, one needs to distinguish two substitution effects, namely, the own-substitution effect and the cross-substitution effect (they are labeled in the literature as the own-wage elasticity and the cross-wage elasticity). The former is caused by a change in the family member's own wage level, whereas the latter is the effect of a change in the wage of some other family member on this particular family member's choice of hours. It is also argued that the sign of the cross-substitution effect due to a rise in family member *i*'s wage on family member *j*'s labour supply is ambiguous. It can be positive if the leisure times of the two family members are complements, or negative if they are substitutes. However, in spite of the ambiguity of the sign, the cross-substitution effects should be the same in magnitude for a given level of change in wage regardless of whether family member *i* has an effect on *j* or the other way around.

Although researchers are aware of the other substitution effect which is generated by the interactions among family members, when it comes to the joint work decision of the family, a lot of studies tend to assume that the cross-substitution effect equals zero. By doing so, a small modification of the static model is readily made in which the non-labour income of the individual includes not only property income but also other family members' earnings in total. It is the total family utility that determines each family member's independent tradeoff between leisure and consumption rather than the utility of one particular individual. Put differently, this model is indifferent to the allocation of a given family's consumption; it only treats the total consumption of a family. Since it is the total consumption level that matters instead of individual's own consumption, it seems meaningless to distinguish the non-labour incomes among family members of a given household.

The third one is coined the individual utility-family budget constraint model. As the name implies, the main difference from the previous model is that each family member maximizes his/her own utility function, whose arguments are individual's own leisure time allocation and total family consumption subject to a budget constraint. For the sake of illustration, I will focus more on a "bargaining" model, which is a variant of the prototype (later this "bargaining" model has been modified to the collective model developed in Chiappori, 1988, which states that household choices arise from individual preferences). In the family utility-family budget constraint model, given a certain amount of increase in the property income, whether this amount is received by the husband or the wife makes no difference to the change in the individual's labour supply, since it is the total amount of property income that matters. In contrast, the bargaining model stresses that the distribution of an increase in property income among family members does play an important role in the labour supply decision of one particular family member. From the perspective of the collective model, there should be some kind of "sharing rule" (Chiappori, 1992) which deals with the income redistribution among family members. Whoever gets to have a large portion of the increase in income will have relatively strong bargaining power, and thus will be in a dominant position in the family. Whether the individual can dominate in property income will in turn affect his/her labour supply behavior. A main reason for this stems from the individual utility in the sense that each of the family members is assumed to have a particular preference regarding his/her own leisure, which is driven by how much he/she can obtain without working. The family members no longer behave as one behavioral unit, as in the family utility model.

2.2.2 Time Allocation Model

An important assumption underlies the simple static model is that individual's time schedule of a certain period is completely constituted by leisure and time at work. The choice between the two is mutually exclusive. This assumption is deemed unrealistic and made merely for the sake of tractability of the simple model, since in reality, one's time allocation is more complicated than just making a choice between the two. For example, a household may sometimes face a choice between purchasing a takeout meal for dinner and spending a lot of time on preparing food for its family members. If they have a backyard, they might have to consider whether they should clean the yard and grow some flowers by themselves or simply pay some money to hire a decent gardener, so that they could save the time to enjoy other pleasurable activities. In essence, the present problem is that the time they would spend on making food or cleaning the backyard by themselves would not be counted as leisure time, and it barely brings any utility to any of the family members.

Apparently, a straightforward solution is to incorporate non-market work time into the model. In other words, the model should be extended to the extent that various kinds of activities related to household production (non-market work) can be distinguished. This is the so-called time allocation model introduced by Becker (1965). Allowing for such a distinction not only makes the basic model richer and more precise in terms of fitting reality, but it also alters the prediction on the effect of the respective component of individual's livelihood activities in the sense that household production is associated with "disutility" (see Cahuc and Zylberberg, chapter 1) but still has to be taken account into the budget constraint independently.

Consider the following application. Many empirical findings commonly report that the wage elasticity of women is higher than that of men. One possible explanation is that women generally devote more time to household-related activities than men, and this distinction between men and women is consistent with the time allocation model. However, it is also argued that the time allocation model does not differ much from the simple static model. One can think of the conventional model as a special case of the time allocation model in which there is no time devoted to household production.

2.2.3 Reformulation in Terms of Time Dimension

In the meantime, the static labour supply model has casted some doubts on its suitability because no information is available from the solution of the optimization problem in regards to the time horizon that applies to the variables of interest. In particular, which period's property income should be treated as the one that fits the model? And as a consequence, is it the weekly hours of work or annual hours of work that should be affected? Would it be more of an issue of short period or long period? Although being aware of the problem caused by the ambiguity of the static model in terms of the time period considered, one still faces a challenge in conducting empirical work, for it is hard to specify a clearly defined period that is suitable for the static model. Even if it is somewhat feasible, one may also find difficulty in practice when it comes to the availability of data. The complication raised by having to determine the time period stems from the static nature of the model, which is a limitation. Thus, it is argued that labour supply is more of a dynamic rather than a simple static issue. In regards to the problem of how today's decision would affect tomorrow's equilibrium, many alternative models that stress more the importance of time dimension have been proposed in the past few decades, such as the intertemporal family labour supply model and the lifecycle labour supply model.

2.2.4 Reformulation in Terms of the Budget Constraint

The simple static model assumes that the individual's budget constraint is continuous and linear within the range of positive labour supply. However, this assumption is merely ideal. It is not necessarily true that the individual's budget constraint is always continuous so as to form a tangency solution to the utility maximization problem (*i.e.* an interior solution). In other words, there are some situations in which the budget constraint is discontinuous or even discrete. Some questions naturally follow. Under what circumstances do we take account of discontinuous budget constraint? What is the consequence that this change in the budget constraint brings to labour supply behavior?

On one hand, for the sake of intensive management and production organization, firms prefer a working-time regime in which each worker has been assigned a pre-determined length of work time, implying individuals might not be able to change their work schedule on the margin freely along a continuum according to their own will. This in turn implies that there is usually a lower bound or perhaps an upper bound as well for the amount of labour they supply. On the other hand, the individual's personal factors, such as health condition, could also truncate the budget line such that a certain segment of the line is not available any more. This in fact implies an upper bound of the individual's labour supply which he/she cannot exceed. In addition, it is also mentioned that unemployment might serve as another reason why one instead might be dealing with a discontinuous budget constraint. By relaxing the assumption of a clearing labour market, the individual can be unemployed for a certain period. He would thus not be able to supply as much as he would be willing to, thus setting an upper bound for a reason in addition to the case of limitations due to personal factors. In short, workers are often severely constrained as to the number of hours that they can supply.

Allowing for the possibility of discontinuous budget seems to cause overemployment, underemployment or nonparticipation according to the relationship between the marginal rate of substitution and the slope of the budget line if it were to exist.[3] Roughly speaking, one major consequence is that no tangency (interior) solution will be obtained. In other words, the marginal rate of substitution between leisure and consumption is no longer equal to the slope of the "virtual" budget constraint line. In this atypical case, it is hardly possible to determine the substitution and income effects, respectively, which the conventional model aims to rely on, due to the "rationing" of work time that firms request. Nonetheless, the substitution effect appears to perfectly offset the income effect since the time of work is always constant and equal to the "ration".[4] To see why, one can simply consider a situation in which an individual has to work H_R hours when his wage rate is w_1. If the wage rate rises to w_2, he will be in a situation where his indifference curve is not tangent to the "virtual" budget line, since he has no other choice but to continue to work H_R hours as long as the corresponding indifference curve lies above the one yielded by zero hours of work or full leisure.

Moreover, another reason why the labour supply function should not always be continuous is that in reality, labour supply inevitably involves some fixed costs (see further discussion in Killingsworth 1983, chapter 2). In fact the simple static model in which continuity holds for labour supply has always assumed zero fixed cost. There are two kinds of cost that have been focused on most in the literature—fixed-money cost and fixed-time cost. Relaxing the assumption of zero fixed cost, either in terms of money or time, would also alter the implications of the model. In particular, the individuals'

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[3] Nonparticipation can be considered a special case of underemployment in this regard.

[4] This conclusion only applies to the special case in which individuals get to choose either staying out of the work or working an exact amount of time assigned by the employer (i.e., there are only two points in the *(C,L)* plane). In the case of a range of the work time requested by the employer, one might still be able to break down the analysis into substitution effects and income effects.

available labour supply will exhibit discreteness or partial discreteness, as in the case of rationing on work. Perhaps this model is able to explain why in reality one rarely observes some people who only work for very few hours during a week. For example, if one lives two hours away from his workplace and it takes him 20 dollars every day to commute between home and workplace, it will be surprising to see him work there only three hours per day for a low wage level of, for example, 10 dollars per hour. He might simply be better off quitting the job so as to avoid all those inevitable fixed money cost and time cost that would have been incurred if he were to work for very few hours.

2.3 Summary of Empirical Findings on Estimating Labour Supply

2.3.1 What Has Been Discovered?

Provided that the theories underlying the framework of the model are plausible, one would naturally expect the compensated own-substitution effect of a wage change to be positive *a priori*. In fact, according to empirical findings, this has not always been the case because the estimated own-wage elasticities turn out to be sometimes not significantly different from zero or even negative quite frequently. Even for those studies which did discern positive own-wage elasticities, they vary a lot in magnitude. Admittedly, one of the reasons is that they might have focused on different subgroups in terms of sample restrictions which have different inherent elasticities. But perhaps more worthy of attention, the wide variation across all of these estimates may be caused by "misspecification, measurement problems, and the like" to some extent (Killingsworth, 1983, page 107).

Nonetheless, researchers could still reach agreement on some of the general findings across various empirical works. For example, the uncompensated wage elasticities for male labour supply are usually very small in magnitude, ranging from -0.03 to 0.14 (see Killingsworth, 1983) according to the second-generation empirical findings (they generally appear to be negative in the first-generation studies but still quite inelastic) [5]; the income elasticities are estimated to be very inelastic for males, ranging from -0.160 to 0.000 (see Killingsworth, 1983) according to the first-generation empirical findings (the second-generation findings commonly report somewhat higher income elasticities but still small in magnitude); women appear to be more responsive in their labour supply than males due to the fact that the estimates of elasticities (both wage elasticities and income elasticities) of women are generally greater and more significant; evidence of gently backward-bending labour supply schedule can only be found in male labour supply while for females it is positively sloped most of the time.

However, as Killingsworth (1983) stressed, the range of estimates is simply "too wide to be of much practical value" (page 128) for the purposes of evaluating policy. Even though eliminating some of the studies that suffer from apparent defects in terms of sample restriction or variable measurement and thus obtaining a more "purified" evaluation, one still ends up with an unsatisfactory range of estimates that could barely play an important role in policy analysis. Now that a rough idea of some of the early empirical findings has been introduced, in what follows I will restrict my attention to some post-1980 analyses that dealt specifically with the Canadian labour market.

Nakamura and Nakamura (1981) compared the estimated wage elasticity of Canadian women with that of American women. They retrieved data from the State Public Use

[5] The second-generation studies refer to the studies on labour supply as of 1983. The first-generation studies refer to some even earlier works. They differ mainly in estimation methods. The second-generation studies are considered more sophisticated than the first-generation studies.

Sample of Basic Records of the 1970 U.S. Census and the Family File of the Public Use Sample of the 1971 Canadian Census. Their sample is restricted to wives aged from 25 to 59 years old for both countries. Their empirical framework involves a model of labour force participation, a wage offer equation, and a labour supply equation, which are estimated separately for seven age groups.

The whole estimation procedure is threefold. First, they estimated the probability of being in the labour force using a basic probit model that takes sample selection bias into account. In the probit model, the authors include years of education, number and composition of children, virtual income, age of wife at first marriage, state or provincial unemployment rate, and a measurement of local job opportunity. Second, the wife's offered wage is modelled by the following equation:

$$\ln w = \alpha_0 + Z\alpha_1 + R\alpha_2 + \hat{\lambda}\alpha_3 + u \qquad (2.3.1)$$

where Z is a vector of personal characteristics, R is a vector of regional macroeconomic variables, $\hat{\lambda}$ is a vector of inverse Mills ratios estimated which are derived from the first-step probit model, and u is a disturbance term. More specifically, Z includes the wife's years of education, the number of children younger than 6, the age at first marriage, and a race dummy. R includes local unemployment rate and a variable indicating local availability of jobs. Lastly, the hours-of-work equation takes the following specification:

$$h_i = \gamma_0 + \gamma_1 \widehat{\ln w_i} + (\gamma_1 \xi) \ln\{1 - TX[(E_H)_i + \hat{w}_i h_i^*, A_i]\} + Z_i^* \gamma_2 \qquad (2.3.2)$$

$$+ \gamma_3 (E_H T)_i + \sigma_2 \hat{\lambda}_i + V_i^*$$

where h_i represents the hours of work of the wife, $\hat{w}_i$ is the imputed wage rate, TX is the marginal tax rate on the wife's earnings at h hours of work, E_H is the husband's income before taxes, A is the asset income before taxes, Z^* is a vector of personal characteristics that affect a wife's asking wage, $E_H T$ denotes the non-labour income to be paid at zero hours of work for the wife, and $\hat{\lambda}_i$ represents the estimated inverse Mills ratio. The marginal tax rate is calculated by some algorithm which takes arguments of the sum of the husband's earnings and the wife's earnings and family assets. More specifically, Z^* includes five variables characterizing the wife's fertility status, a language dummy (for Canada only), and $E_H T$ divided by the number of persons in the family.

They introduce an iterative method to take account of the endogeneity stemming from incorporating taxes into the model. Specifically, higher wages cause more hours of work, which in turn cause a higher marginal tax rate. The mechanism of this method is outlined as follows: (1) start by assigning 1 to h_i^*; (2) calculate $1 - TX[(E_H)_i + \widehat{w}_i h_i^*, A_i]$ corresponding to the marginal tax rate of first hour of work for each wife; (3) run regression according to equation (2.3.2) on all the regressors including the one calculated in step (2); (4) use the estimated coefficients to obtain predict hours of work evaluated at $h_i^* = 1$; (5) replace h_i^* in step (2) with the predicted values of h_i obtained in step (4); (5) repeat (2), (3) and (4) until the two successive sets of estimated coefficients "are sufficiently close to each other in terms of percentage changes" (page 473). Then the iterative procedure is terminated. The authors prove that this method could yield consistent estimates. Further, the endogeneity problem in the wage variable is also resolved due to the implementation of the imputed wage, which is basically an instrumental variable derived from the wage offer equation.

The authors report mostly negative uncompensated wage elasticities ranging from -0.390 to 0.204; the magnitude depends on the specific age group that has been examined.

Although the absolute values of elasticity estimates for the two countries differ from each other as expected due to inter-country differences in labour force behavior and different tax systems, the signs are the same for the most part. The exceptions are the age groups of 50-54 years and 55-59 years. For the age group of 50-54 years, the labour supply schedule of American wives appears to be backward-bending as the general pattern of estimates for other age groups, while the estimated gross wage elasticity for Canadian wives is positive. For the age group of 55-59 years, it is the opposite case. Surprisingly, these estimates are closer to what the studies on labour supply of men have found rather than that of relevant studies for women. More precisely, they contradict the findings of some previous studies in which the uncompensated wage elasticities are significantly positive and relatively high in magnitude.

The estimated income elasticities are consistently negative throughout all the age groups for both the U.S. and Canada. In regards to the compensated wage elasticities, they are generally positive, which is consistent with the theory of static labour supply, but for a few age groups they appear to be slightly negative. Besides, they confirmed the assumption that tax rates have some influence on women's decision about whether to work or not. Specifically, women's decision on how many hours of work they should spend in the labour market is positively related to the change in the tax rates. In other words, they find that women tend to work more hours if tax rates are increased. In this case, the substitution effect would predict that they work fewer hours, but the greater income effect might push them to work longer hours.

One possible reason why their estimated labour supply curve shows that form is that in their labour supply equation, they do not include the individual's education level. Many researchers suggest that education level of the individual is highly associated with his/her hours of work. Another reason might be that they do not include a variable that captures the actual work experience in the probability-of-working equation and the wage equation. Instead, they use age at first marriage and number of children age 6 or less as proxies. In their wage equation, they also include a variable that is computed to measure the opportunity for jobs in the individual's area of residence. This variable is a function of the proportion of national employment in a specific occupation category that is female, total employment in the occupation in his/her area of residence, and the population of females aged 15 or over residing in the area. This variable is considered to be endogenous since wage rate is associated with occupation. In addition, they not only include a series of variables to control for child status in their hours-of-work equation, but also include one in their wage equation, which is considered to cause endogeneity problem as well.

Since the estimates by Nakamura et al were quite striking at that time, many researchers have attempted to find the reason why this anomaly arises. Robinson and Tomes (1985) examined the wage elasticity of labour supply for Canadian women. The advantage of their study over the Nakamuras' lies in the dataset they use. They point out several drawbacks of the census data that were used in Nakamura and Nakamura (1981) in which measurement error is not only inevitable but also a severe problem, since actual wage rate and actual hours of work are unavailable using census data. Instead, they use data from the 1979 Quality of Life Survey to estimate whether it is the income effect or the substitution effect that dominates the labour supply decisions of female, and how responsive the quantity supplied of labour is to changes in the hourly wage.

The exogenous variables in their study include the husband's labour supply and the presence of pre-school and school-aged children. They use the standard model "in order to facilitate comparison with other studies and reduce the probability that the backward-bending supply curve for females occurred because of the inclusion of 'special' variables included in particular studies but not common across studies" (page 158). Unlike Nakamura and Nakamura (1981), their population of interest includes both single and married women. In the hours-of-work equation, they include the woman's wage rate and the husband's earnings. They estimate separately a market wage equation and a reservation wage equation. By doing so, a participant is identified if the market wage rate is greater than the reservation wage. Analogous to the specification in Nakamura and Nakamura (1981), they also include years of schooling in the market wage equation. The regressors in the market wage equation differ greatly from those in the labour supply equation. Only the woman's age is used as a common regressor. Their sample is composed of two subsamples: one is the hourly wage sample in which the respondents report their hourly wage directly; the other is the hourly paid sample in which the wage rate can be deduced indirectly. They also employed the Heckman's two-step correction to estimate for each of the subsamples. In contrast to Nakamuras' method, they did not make use of the imputed wage. Therefore, the inverse mills ratio, which is obtained from the probit estimation of being a worker in the hourly wage (or hourly paid) subsample, is only added to the hours-of-work equation to correct for selection bias. Finally, they also use the explanatory variables in the market wage equation as instrumental variables in order to correct for the wage endogeneity. Specifically, the instrumental variables they use are constituted by the woman's years of schooling, age, current tenure, language, and location.

The estimated results are quite robust to the two subsamples and to the different approaches they employed for each subsample. By finding a negative elasticity of labour supply, the authors conclude that their findings are consistent with the results of Nakamura and Nakamura (1981), who found that the labour supply curve for females is backward-bending. It exhibits a similar pattern to what the earlier empirical works found for labour supply curve of males. They tend to agree with the Nakamuras' argument that there is no significant disparity between the male's labour supply elasticities and the female's labour supply elasticities.

Smith and Stelcner (1988) investigate the empirical validity of the traditional model of labour supply by re-examining the labour supply behaviour of married Canadian women. Their approach closely follows that of Nakamura and Nakamura (1981). In particular, they employed Heckman's procedure to deal with the potential selectivity bias. They also applied Nakamura's iterative procedure (for details, see the above discussion on Nakamura and Nakamura, 1981) to mitigate the endogeneity problem stemming from both the net wage and virtual income, while in Nakamuras' study only wage is endogenous. The reason is that in their own study, they define both wage and virtual income as after-tax quantities, which in turn are dependent on the individual's labour supply. Also, they treat the husband's labour supply decision as exogenous. In contrast, they do not have as many variables as in Nakamura and Nakamura (1981) to capture the composition of children for a married woman, and they do not include a measure for local job opportunities in the wage offer equation. In the probit model, virtual income (assumed to be independent of the participation decision) is also used to predict the probability of being a worker, aside from other variables on characteristics, such as age, education, etc. In the wage equation, the inverse Mills ratio constructed from the probit estimates is added alongside with other standard wage-determining variables. Then using the coefficient estimates of the wage equation, they compute the "fitted net wage rate", which is essentially the imputed wage as mentioned above. Finally, they estimate the regression for the hours-of-work equation on the fitted wage rate and virtual income alongside of other control variables while applying the Nakamuras' iterative method until consistent estimates are obtained.

Their sample was derived from Household / Family File of the 1981 Canadian Census of Population. They restricted their sample to married couples with wives aged from twenty to fifty-four years old who participated in the labour market and received positive wages from the labour market in the year prior to the Census year. Furthermore, they divided the sample into two age groups to study the particular behaviors of each group—younger wives aged from twenty to thirty-four, and older wives aged from thirty-five to fifty-four. The estimates of own-wage elasticities for younger wives and older wives differ slightly in terms of both magnitude and significance. Overall, the own-wage elasticity of the entire sample is relatively small and positive, but somewhat insignificant at the 5 percent level, which means their re-examination does not totally support what the Nakamuras find (a backward-bending labour supply schedule). It is worth further evaluation why the estimates contradict each other in terms of different signs while they use the same method and the same data source (both use census data although the period of interest is different). In the meanwhile, it is simply possible that the labour supply behavior of Canadian married women has evolved over the time interval between the two studies.

In sum, there is a limited number of studies within the Canadian literature on estimating labour supply per se aside from the applications to tax and welfare programs, and they have not been updated in decades. Perhaps the main reason lies in the difficulties in disentangling purely exogenous wage changes resulting from the fluctuations of labour supply.

2.3.2 Empirical Challenges

As can be seen clearly from the reviews above, some of the studies find positive own-wage elasticities, while the others conclude that labour supply schedule is actually backward-bending, in other words, can be viewed as hump-shaped, which conforms to what the static labour supply model predicts. According to the theory, due to the relative dominance between substitution effect and income effect resulting from a wage change, labour supply schedule is not supposed to be monotonic. As a matter of fact, some studies can actually find on average to what extent the tastes of work would mutate as the wage rises (in other words, can find where the kink point is located). Nevertheless, is the labour supply curve really backward-bending? This question cannot be answered unless the empirical challenges researchers are confronted with can be tackled properly. In sum, the empirical challenges are nightmarish, which might explain why there are not too many articles regarding estimating labour supply per se.

As mentioned above, the empirical outcomes regarding estimated wage elasticities and income elasticities are far from satisfactory, which raises some doubts on the validity of the conventional model itself. Admittedly, the conventional model has many limitations, as discussed in details on the extensions above. But one cannot deny the fact that it forms the basis of other complicated analysis of labour supply, and its beauty lies in its simplicity. Moreover, some other reasons might also have more weight in explaining why the predictions of the model have often failed to be validated empirically.

One of the reasons why the empirical literature does not always validate the predictions of the theoretical model may lie in the budget constraint. The budget constraint not only can be discrete or partially continuous, but also can be nonlinear or piecewise linear (see Cahuc and Zylberberg, 2004, chapter 1). Consider a case in which individual receives an hourly wage rate of w and is not taxed when he only works for some short time every day, since his income level does not exceed the lowest income tax threshold. If he increases his work time to a certain level that exceeds a boundary h^* corresponding with the lowest income tax threshold, he will then be taxed at a rate of t. In other words, the individual will receive a wage w if his work time is less than h^*, and $w(1-t)$ if it exceeds h^*. This complicates deriving the solution from individual's preference and budget constraint. Since the budget line is now piecewise linear, the solution to the optimization problem would be piecewise as well, depending on which piece of the budget line the individual's indifference curve lies on.

For the case of dichotomy of the budget, there are three solutions (see the example of solutions in the book by Cahuc and Zylberberg, 2004, chapter 1) to the choice of labour supply, including zero hours of work when w is lower than his reservation wage evaluated by the marginal rate of substitution at the point of full leisure. Therefore, using only one equation instead of a system of equations to estimate might be quite misleading. In reality, there are more than one or two tax brackets as considered in the above case, which implies one would observe multiple kink points in the *(C,L)* plane. For different individuals confronted with different tax rates, one may end up with totally different locations of optimal choices lying on segments representing different tax brackets. The precise solutions are thus quite complicated. Therefore, using the simple static model within which there is only one uniform equilibrium towards which the worker is adjusting might be even more misleading for that matter, not even to mention that the budget line could actually exhibit a mixed property of discreteness and nonlinearity.

Another major problem in conducting empirical analysis is selection bias. This problem is considered more severe when dealing with female labour suppy, especially for married women. The population of interest is composed of workers and non-workers, with only the former reporting a positive wage level. In essence, if one were to estimate the wage elasticity of labour supply by simply applying the OLS method to the whole sample including workers and non-workers, it is considerably questionable in the sense that it is impossible for researchers to observe the actual hours they would be willing to offer for working and corresponding true wage level they would be receiving if they were to work. As Cahuc and Zylberberg (2004) proposed, this straightforward method "fails to distinguish decisions about participation in the labour market from those about the numbers of hours an agent is prepared to offer (page 32)."

Some early studies suggested that the way to take account of the non-workers is to set their labour supply equal to zero. But by doing so the problem cannot be mitigated because this method implicitly assumes that the labour supply equation could be applied generally, which is not accurate in the sense that the labour supply equation can be applied only if the observed wage level of individual is greater than his or her reservation wage. However, if one were to exclude those non-workers from the sample, one will be dealing with a sub-sample of workers only who report a positive wage in the dataset. As such, he neglects the problem of selection bias, which leads to biased and inconsistent regression estimates. In addition, as Killingsworth (1983) showed, the OLS fit is most likely to be flatter and more elastic than the true one.

Therefore, the correct estimates of labour supply may require some more sophisticated estimation methods that can tackle the problem of selection bias. One typical way is to apply the Heckman Two-Step Procedure. In the case of estimating labour supply, this procedure is usually extended to a three-stage method. For the first two stages, the methods that are used in different studies dealing with selection bias are essentially the same, while they differ mainly in the third stage. To correct for the bias stemming from selecting observations non-randomly from the population (estimating hours of work for workers only in my case), the first step is to formulate a model to estimate the probability of being in the labour force, which can be carried out by estimating the following probit regression:

$$P(T = 1|Z) = \Phi(Z\,\gamma) \qquad (2.3.3)$$

where $T = 1$ if the individual is a participant, Z is a vector of personal characteristics, and Φ is the cumulative distribution function of the standard normal distribution. Note that normality assumption is required in the Heckman's procedure. Then the estimated coefficients, $\hat{\gamma}$, can be utilized to predict the probability of being a participant for any individual in the sample.

The second stage is to estimate a wage equation for the subsample of workers:

$$w = X\beta + u \tag{2.3.4}$$

where w is the offered wage rate, X is a vector of personal characteristics, and u is a disturbance term. Due to the presence of selection bias, the unobservable factors that affect the individual's underlying wage is likely to be correlated with some factors that cause the individual to participate. Therefore, it is impossible to obtain unbiased estimates, since the expected value of the disturbance is non-zero. If the non-participants had exactly the same notional labour supply relationship as participants, there would be no bias involved. One would have a random sample. According to Heckman, this bias can be considered as a consequence of specification error in the form of omitted variable. Once the magnitude of the bias is taken into account, the problem of selection bias can be corrected. This correction involves constructing a variable called the inverse Mills ratio (also known as Heckman's lambda) which is a transformation of the estimated coefficients, $\hat{\gamma}$, from the probit model estimate. If this constructed variable, $\hat{\lambda}$, were included as an additional explanatory variable in the wage equation, as in

$$w = X\beta + \omega\hat{\lambda} + u \tag{2.3.5}$$

then unbiased and consistent estimates could be readily obtained.

The final stage also makes use of the inverse Mills ratio to account for the problem of selection bias in the hours-of-work equation, since hours of work are only observed for workers. In the mean time, account should be taken of the endogeneity problem of the wage variable. One typical way to deal with both problems is to run the following regression on the subsample of workers:

$$h_i = \alpha_0 + \beta_0\widehat{w}_i + \beta_1 V_i + Z_i\gamma + \delta\hat{\lambda}_i + \mu_i \tag{2.3.6}$$

where h_i represents hours of work, V_i represents the property income of the individual, μ_i is a disturbance term, Z_i is a vector of personal characteristics, and $\widehat{w}_i$ is the imputed wage computed by $\widehat{w}_i = \hat{\beta} X_i$, where $\hat{\beta}$ is the estimated coefficient of the wage equation corrected for selection bias. As such, the imputed wage could serve as an instrumental variable and thus facilitate to obtain unbiased estimates for the wage elasticities.

One practical challenge while applying the Heckman procedure is the issue of identification, which in this case means disentangling the participation decision modeled in the equation of the probit model, with the decision on how many hours to supply conditional on participation. This identification is achieved via an exclusion—one includes one or more variables in the first-stage equation that is excluded from the second-stage equation. If both equations included the exact same set of regressors, then the two effects would be confounded with each other. The identification of the two effects, which in theory are distinct, is not empirically reliable.

Lastly, the most common problem is endogeneity on the grounds that some unobservable characteristics that affect labour supply decision could also have some correlation with the individual's wage level. For example, the individual's taste of work could affect how many hours he/she would like to work while it is correlated with his/her wage level. In this case the expected value of the disturbance term would not be equal to zero, leading to biased estimates. It is argued in many studies that the endogeneity problem is most likely caused by measurement error and simultaneity between labour supply and wage rate. The simultaneity problem arises because in a competitive labour market, the wage change is always generated by shifts in both labour demand and labour supply at the same time. If it were generated only by shifts in labour demand, which makes it exogenous, then it is straightforward to trace out the labour supply curve by observing shifts only in labour demand corresponding to wage changes. However, labour supply is not fixed most of the time, so that the wage change is jointly determined by both supply and demand.

Perhaps the problem of measurement error can be illustrated more properly by taking Smith and Stelcner (1988) as an example. Although they seem to have properly estimated the wage elasticities by making use of some appropriate estimation methods, the validity of those methods still awaits further evaluation. In particular, measurement error in their analysis mainly arises from the way they constructed the hourly wage variable. Since only annual earnings rather than the hourly wage is reported in the Census file, it is difficult to measure the actual individual hourly wage, and the typical way to include it into the model is to divide the reported annual earnings by the reported total hours of work. This operation of division could cause measurement error and even some minor reverse causality on the grounds that the dependent variable in the labour supply equation can in turn affect the independent variable, which is the hourly wage in this case. As Bound et al. (1989) pointed out, labour supply and hourly wage rate are usually incorrectly measured in numerous studies, given the evidence that they find systematic biases in labour supply and wage data by interviewing workers and comparing interview responses with firm records (see Heckman, 1993). In fact, even though the authors were aware of this potential flaw, they still proceeded that way, perhaps because there are no other good options. One possible solution might be to directly obtain the data from firm records. However, researchers do not usually have the access to that type of data, and even if they do one can still not guarantee that the data the firms provide is not contaminated with any kind of measurement error. Besides, one would not have a random representative sample.

2.4 Application of the Labour Supply Model

In the past several decades, the most attention in terms of the application of the model has been focused on the effects of a wide variety of tax and welfare policies on labour supply. Blundell and MaCurdy (1999) assert that the most dramatic changes in tax system and welfare programs have been implemented in many industrial countries in the past few decades. In a nutshell, the intention of recent policy reforms is to create stronger work incentives which could bring along more in-work benefits to the individuals who are willing to participate in the labour market than those who merely receive social assistance while staying out of the labour force. However, many questions, such as how effective those reforms are, have not been resolved, and many labour economists are still investigating this issue.

In order to do so, the simple static model has to be adapted so as to take into account tax and welfare policies, and fortunately it has been proved that the labour supply model is in practice a good tool to start with regardless of what specific kind of programs is under inspection. In other words, the simple framework of static labour supply model can be extended by incorporating tax and welfare parameters to analyze the effects of most kinds of policy changes.

Fortin and Lacroix (2002) conduct a survey concerning tax and welfare effects on labour supply. As we all know, in reality individuals are often confronted with a progressive tax system. They have shown that the budget constraint should be altered to fit into a "piecewise convex function" since the income tax increases with the taxable income, which in turn increases with the number of hours of work (the typical features of a progressive tax system). In the case of progressive tax system, the effects of a change in the tax parameter are certainly more equivocal, depending on which income tax bracket the individual falls into. It is hard to gain insight into the potential impacts associated with changes in marginal tax rates and government transfers on labour supply, since substitution effects and income effects induced by those changes usually work in opposite directions.

The challenge on the empirical level is considerable. Nonetheless, several plausible strategies have been developed so that at least ideally, there is some way to estimate the impacts of those policies on the behavior of labour force. Most of the strategies are based on estimating the labour supply function, since it could serve as a proxy to ascertain individual's preferences, which in turn has everything to do with his response to policy changes. Therefore, it has been argued that once the parameters of labour supply function are properly estimated, the effects of policy changes can also be derived. In their paper, they outlined two main strategies that have been widely accepted by many researchers—the Natural Experiment approach (NE approach) and the Microeconometric (Structural) approach. The NE approach is also dubbed the Difference-in-Difference approach. It has some features in common with the typical experimental methods used in natural science in the sense that it distinguishes a "treatment group" which is affected by the policy change in a certain period, and a "control group", which in contrast is unaffected. The estimates of potential policy effects are thus straightforward when it comes to the comparison between the outcomes of "treatment group" and the outcomes of "control" group. Researchers can simply compare the before-after change for the "treatment group" to the before-after change for the "control group". If the natural experiment is well-designed, the change in the rate of return to working can be treated as exogenous, and researchers can draw inference based on the change in the outcome variable (participation or hours of working).

A lot of studies that try to evaluate the effects of tax and welfare programs use longitudinal data. One potential problem of doing so is that one may find difficulties in disentangling the actual impact of tax and welfare programs from some other simultaneous factors such as periodic impacts of business cycle. The NE approach seems to have some advantage in comparison with other approaches. However, it is not always easy to find a good "control group", and a critical assumption is that the same trends were affecting both groups in the same fashion over the two time periods.

Although NE approach seems to be easy to carry out under proper assumptions, its drawback is also distinct in the sense that it might not be able to predict the potential impacts of several other simultaneous policy changes. For that matter, it might be a good option to apply the Microeconometric (structural) approach to cover the shortcomings of the NE approach. The structural approach can be used to "estimate all the preference parameters and therefore provides global information which can be used to simulate the effect of any reform on labour supply" (Fortin and Lacroix, 2002, page 15). Most structural methods require very stringent assumptions as well (for example, normality of the stochastic terms, and no correlation between regressors and the stochastic terms). They usually also assume that the individual has perfect information on the tax and welfare parameters that affect his/her labour supply decision. In terms of the economic model, those methods usually require more complex consideration on the individual's preference and the budget constraint so that the simple static labour supply model does not suffice while applying these methods. As a consequence of greater complexity, the estimation methods required are also more advanced (for example, maximum likelihood methods, GMM and non-parametric approaches).

Green and Riddell (1997) employed the Natural Experiment approach to examine the effects of 1990 change to the entrance requirement of Unemployment Insurance (UI) on the duration of employment. Before the 1990 change, the entrance requirement in terms of weeks worked varies across different provinces and regions, ranging from 10 to 14 weeks depending on the local unemployment rate. The higher the local unemployment rate, the less stringent the entrance requirement was. After the 1990 reform of the UI program, the threshold was established at a uniform of 14 weeks. They employed the static labour supply model to analyze theoretical outcomes of the reform in terms of extensive and intensive margins. They pointed out that the aggregate effect on weeks worked is ambiguous, since some individuals would increase hours worked in order to qualify for benefit, but others would simply choose not to participate in the labour force. In order to investigate this issue, they carried out empirical analysis using data from the 1989 and 1990 Labour Market Activity Surveys (LMAS), which collects information on individual's labour market activity in the previous calendar year. They focused on individuals residing in UI regions where the unemployment rate at the moment was sufficiently high. In other words, the treatment group is those individuals residing in UI regions where the increase in the entrance requirement is substantial, whereas the control group consists of those individuals residing in UI regions where there was only a minor change or no change at all. The general finding is that the 1990 UI reform does have an impact on the behavior of the labour force residing in UI regions that experienced an "upheaval" as opposed to the control group, which has shown little change after the reform. More notably, for a subgroup of those individuals who worked between 10 and 13 weeks before the UI reform, there is some evidence that they actually increased their working time sufficiently instead of some minor increases to just qualify for the UI program benefits.

Christofides et al (1997) aim to discover the relation between welfare participation and labour market behavior. On the basis of static labour supply model augmented by a social assistance program, they carried out some analyses of comparative statics concerning the changes in the welfare parameters. In particular, they studied the theoretical implications of welfare participation, labour force participation and hours of work resulting from an increase in the guaranteed amount of the program, and a decrease in the clawback rate at which benefits are last as the recipients work and earn wages. It seems unambiguous that greater generosity leads to higher welfare participation. In regards to the labour force participation, more people are predicted to quit the labour force market due to a rise in the guaranteed amount. In the case of a decrease in the benefit-reduction rate, work incentives are expected to increase, all other factors held constant. In regards to the hours supplied, the increase in the guaranteed amount gives rise to a pure income effect, which suggests that individuals would decrease their working hours. A decrease in the benefit-reduction rate gives rise to both income and substitution effects. Whether substitution effect or income effect dominates depends on individual's preference and on which part of the budget constraint he is initially located. Overall, the impact of welfare parameters on hours worked is inconclusive.

Making use of a bivariate probit model, they address the problem of selection bias. According to the bivariate probit estimates, the population of interest is divided into four subsamples: welfare beneficiaries who are in the labour force, non-beneficiaries who are in the labour force, beneficiaries who are not in the labour force, and non-beneficiaries who are not in the labour force. In particular, they identify welfare participants and labour force participants according to the following criteria:

$$P_W = 1 \; if \; P_W^* > 0$$

$$P_W = 0 \; if \; P_W^* \leq 0$$

$$P_{LF} = 1 \; if \; P_{LF}^* > 0$$

$$P_{LF} = 0 \; if \; P_{LF}^* \leq 0$$

where P_W and P_{LF} are indicators of welfare participation and labour force participation, respectively. P_W^* and P_{LF}^* are estimated using a set of exogenous variables that can determine the probability of participating in welfare and the probability of being in the labour force. These exogenous variables include a set of variables describing personal characteristics (such as age, education, disability status, visible minority status, immigrant status, etc.), dummies indicating the receipt of income from pensions and unemployment insurance (most studies usually approximately measure the amount of the individual's property income instead of using a dummy), an indicator for job training, the guaranteed amount of the social assistance program, the benefit-reduction rate on earned income, and the imputed wage rate. The imputed wage rate is calculated using the standard probit estimation of the Heckman procedure. Moreover, they use reduced-form labour supply equations in which the dependent variable is annual hours worked to separately estimate hours of work for both welfare participants and non-participants who report positive labour supply.

In the hours-of-work equations, the explanatory variables are generally similar to those in the bivariate probit equations, while the known wage of a labour force participant enters instead of the imputed wage. The welfare parameters (the guaranteed amount and the benefit-reduction rate) enter the hours-of-work equation only for welfare participants. The inverse mills ratios constructed from the bivariate probit estimates are included to account for the problem of selection bias. There are two estimated inverse mills ratios in each of the hours-of-work equations because the individual faces a decision of welfare participation and labour force participation simultaneously. Their data are taken from 1988-1989 LMAS. The population of interest is composed of four subgroups: single males, single females, lone fathers and lone mothers.

Their results suggest that there is some link between welfare program participation and labour market behavior. However, welfare parameters generally do not affect the individual's welfare participation and labour market behavior very significantly as in the manner suggested by the theoretical model. Rather, some non-welfare-related variables, including pecuniary ones and non-pecuniary characteristics, seem to affect labour supply more systematically. However, they do find a strong link between labour market earnings and welfare participation: those who are predicted to have lower earnings are more likely to be welfare beneficiaries.

Barrett and Cragg (1998) attempted to fill a gap in literature that existed at that time concerning the understanding of the dynamics of welfare participation of Canada. Their study is well-known in the field of Canadian social assistance, but tied only indirectly to labour supply. Aware of the great difference from the US welfare programs in the sense that Canadian programs are typically more generous and have lower entrance barriers, they focus on the composition of Canadian welfare participants and the participation patterns in terms of durations spent on benefits and exits. In particular, they chose British Columbia to be a benchmark and pooled data over the period 1980-92 from the monthly case records of the social assistance programs provided by the BC administration of social welfare programs. They focused on the Basic Income Assistance (IA) program, which is a component of Guaranteed Available Income for Need (GAIN) in the BC.

Their sample is divided into nine demographic groups according to the individual's employability, marital status, and fertility status. Using the longitudinal data, they find that the proportion of employable individuals who rely on welfare has increased significantly during the period. In addition, single mothers do not account for a big proportion of welfare recipients, which was contrary to public perceptions. By estimating the hazard rates (welfare exit rates) and survivor probabilities, they characterize the completed welfare spell distribution of the whole sample. The estimated survivor probabilities for welfare dependence confirm their expectation that "the recipients' inability to work and the presence of very young children in the household are associated with longer welfare spells" (page 178). In contrast to estimated results by other studies which report that the recipients in the U.S. tend to remain in the program for a long period (especially for single mothers), Canadians seem to rely on welfare only as a form of short transition. Most welfare spells do not exceed three months in durations, while in the case of their American counterparts, the welfare spells are usually in the measure of years. The estimated survivor functions for off-welfare spells suggest that the probability of staying out of the welfare program generally decreases as time goes on for all the demographic groups. However, the most drastic decreases occurred over the first year. This implies that a big proportion of welfare beneficiaries return to the program within one year. In fact, 24% to 30% welfare beneficiaries re-enter the program within only the first three months.

Thus the authors argue that to judge the effectiveness of a welfare program, one should not only rely on assessing the welfare spell, but also on the times of repeated use of the program. On one hand, the estimated hazard rates suggest that as welfare spell length increases, a participant is less likely to leave the program. Perhaps this finding is consistent with the prediction of the static labour supply model, which predicts that individuals who did not participate in the labour market would most likely remain out of the labour force after an increase in their welfare benefits. On the other hand, even though most welfare recipients seem to remain on welfare only for a short time, there are some findings that a large proportion also returns to the program within a short period, suggesting a high incidence of repeated welfare use for Canadians (at least for those who reside in the BC). However, this does not provide sufficient evidence about disincentive effects of welfare on labour supply, since some of the recipients might return to the program in conjunction with temporary or seasonal jobs. Nonetheless, this kind of study can be utilized to shed light on the policy changes to the labour market in the direction towards helping those people who periodically rely on social assistance realize the goal of permanent self-sufficiency. And I suppose the future resolution for that matter will be found in the dynamic labour supply model, which is beyond the scope of this paper.

2.5 Summary

As stressed in Heckman (1993), there are two margins that one needs to distinguish between when dealing with the issue of labour supply. One is the extensive margin (i.e., choice of participating or not) and the other is the intensive margin (i.e., how many hours of work to supply). It is thought that the extensive margin rather than the intensive margin has shown the most responsiveness in terms of labour supply choices to the policy changes in the past decades. For that matter, one might be able to reconcile the motivation of the policy reforms (to increase work incentives) with the fact that male labour supply has been decreasing (mainly on the intensive margin), whereas female labour supply has seen some remarkable increase (mainly on the extensive margin) in the past few decades.

All in all, labour supply in practice is far more complicated than a choice driven by only the variables of wage and income. As discussed above, many problems that the studies of labour supply are required to address rely on the incorporation of some other factors, such as household production, intrafamilial interactions, taxation and transfer payments, and fixed costs of labour market entry. Although a great number of empirical works have been carried out, the wide range of the estimates of wage and income elasticities (either for males or females) and the fact that there is no consensus regarding estimates yet both suggest that they are still insufficient to answer some questions that labour supply researches seek to tackle. For example, there is the dramatic increase in the extensive margin for females. Is it really due to the policy reforms that are aimed at increasing work incentives all these years? Or is it simply the outcome of a series of substantial wage increases for female? Or is it due to improvements in household technology (*e.g.*

invention of more advanced home appliances) that enables women to be less attached to housework? It is more likely that it is due to the combined effects of all the factors mentioned above.

More notably, the simple static labour supply model includes only pecuniary variables that affect an individual's decision either on participation or the number of hours of work he would supply. And indeed the majority of empirical works regarding this topic emphasized estimating the wage and income elasticities. However in the meantime, many of the results also suggest that some non-pecuniary characteristics of individuals could also affect their labour supply decision, even so much as to affect it more significantly than pecuniary variables for some subgroups. For example, health status might also be a very important indicator of labour supply. The traditional model suggests that an individual will work only if his market wage is higher than his reservation wage. This prediction is based on a premise that all individuals considered are healthy. However, even if one's market wage is higher than his reservation wage, he still might not be able to supply any amount of labour or only few hours due to, for example, physical disability or some chronic diseases. As a matter of fact, there have been more and more recent studies that attempt to unveil the effects of those factors that are not commonly discussed. For example, the effect of having diabetes on labour supply and income, the relationship between booming gaming industry and constantly decreasing male labour supply, and the like.

3. Empirical Illustration Based on Recent Canadian Data - Data

In what follows I will estimate a labour supply function for Canadian males using fairly recent data. The cross-sectional data involved in this study are taken from the Public Use

Microdata File (PUMF), Hierarchical File, 2006 Census of Population (Statistics Canada).[6] Although the public use file may seem to have some limitations, it is in fact used quite frequently in many related studies. In this study, I will also follow closely previous studies in terms of selection of variables. The final sample contained in the Hierarchical File represents one percent of the whole Canadian population. The sample is restricted to married Canadian men from twenty to fifty-four years of age. The empirical illustration is mainly based on a sample of married men although I also carry out estimation using a sample in which single men are included. Therefore, the descriptive statistics are presented for the sample of husbands only. Immigrants who landed in Canada between the year 2001 and the Census Day, May 16th, 2006 are also excluded from the sample.[7] Also, non-permanent residents[8] and the aboriginal population are excluded from the sample. Observations are also dropped for any of the following reasons: unpaid family workers or people who are self-employed, education level is not applicable, and residents from the Northwest Territories and the Yukon. In addition, I also drop observations whose information on earnings and labour supply are inconsistent. In particular, those observations involve individuals whose reported total income is less than the after-tax total income, individuals who reported zero annual employment income

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[6] The Hierarchical File, which was first introduced in the 2006 released Census File, basically contains all the important information about the sampled Canadian households and corresponding individuals. Before 2006, the census dataset used to be composed of Individuals File, Household / Dwelling File and Family File, whereas for the 2006 census, the latter two files have been replaced by the Hierarchical File.

[7] Although technically this group of people should be considered part of the Canadian community, the time length of their residence had not been long enough for them to be assimilated to the mainstream of Canadian culture that might have some influence in many aspects concerning immigrants' life including working behavior.

[8] Refers to persons from another country who, at the time of the census, held a work or a study permit, or who were refugee claimants, as well as family members living with them in Canada.

but positive number of weeks worked, and individuals who reported zero labour supply in 2005 but positive employment income.[9]

As Bound et al. (1989) pointed out, a wide variety of empirical studies on labour supply suffer more or less from measurement error. This study is not an exception. Essentially, the problem of measurement error concerning this study lies in the insufficiency of information provided by the dataset. Unfortunately, there is no listed question that asks about individual's hourly wage rate in the Census questionnaire, and even if the questionnaire included that kind of question, some individuals would not be able to provide very accurate information regarding their hourly wage rate if they are paid monthly. As a consequence, the individual's hourly wage rate cannot be directly obtained from the Census data. As a proxy, I have to compute the hourly wage rate for all the individuals who reported non-negative annual employment income and non-zero working time. The typical way to calculate it is to divide annual employment income reported in calendar year 2005 by the total hours on work for pay in that year, which are the product of total hours of work during the reference week and total weeks an individual worked during calendar year 2005.[10] Figure 1 and Figure 2 give a sketch of the percentage distribution of hours worked during the reference week and weeks worked during year 2005, respectively. As shown by Figure 1, about forty-five percent of the population of interest worked for forty hours during the reference week. This group of workers can also represent the majority of full-time workers. There are also nearly thirty percent of

[9] The income tax refers to federal, provincial and territorial taxes paid on income, after taking into account exemptions, deductions, non-refundable tax credits and the Quebec rebate. These taxes are obtained from the income tax files for persons who allowed access to their income tax data and from direct responses on the questionnaire for others.

[10] The reference week refers to the week prior to the Census Day, May 16th, 2006.

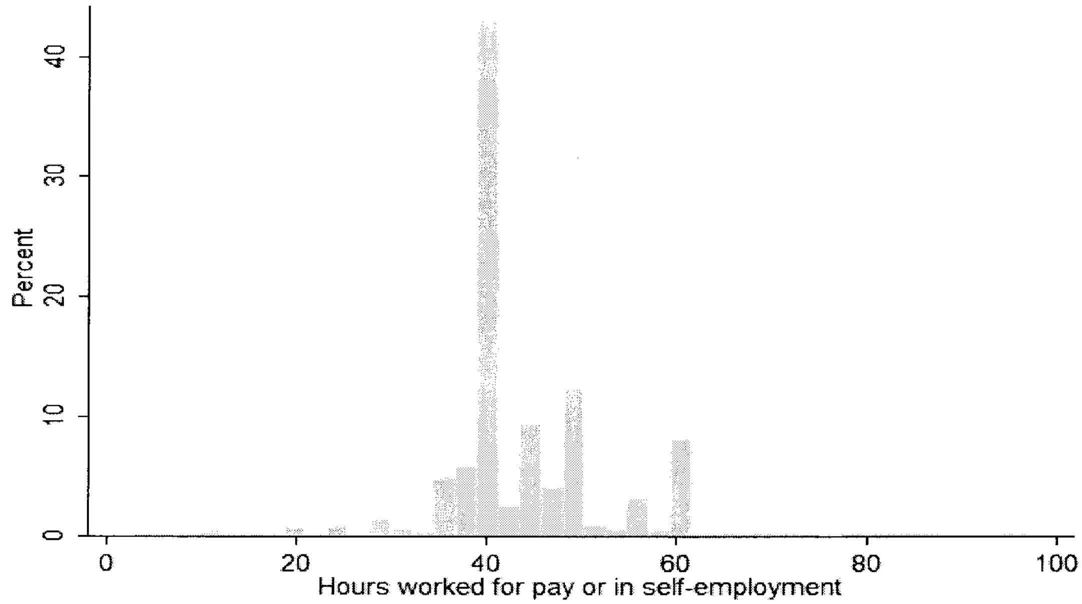

Figure 1 - percentage distribution for hours of work (husbands)

workers who seem to supply more working time than the standard length of forty hours, and among these workers, about eight percent worked for sixty hours during that week. It is also clear from Figure 2 that more than seventy percent of the population of interest worked for fifty-two weeks during 2005. In addition, the majority of the sample worked for some positive time, since the proportion of those whose information on weeks worked is missing from the data accounts for no more than one percent. In sum, the participation rate for the males in the sample is sufficiently high.

However, naively calculating the hourly wage rate by applying simple calculations can yield some unsatisfactory results. The major problem stems from the inconsistency of the work status between the Census year and the prior year. For example, an individual who worked for fifty weeks with forty hours every week and received 50,000 dollars as annual total earnings would result in his hourly wage rate being equal to twenty-five dollars per hour. If rather than reporting forty hours as the amount of time he worked in the reference week, it so happened that she had some illness and had to leave from work for some time,

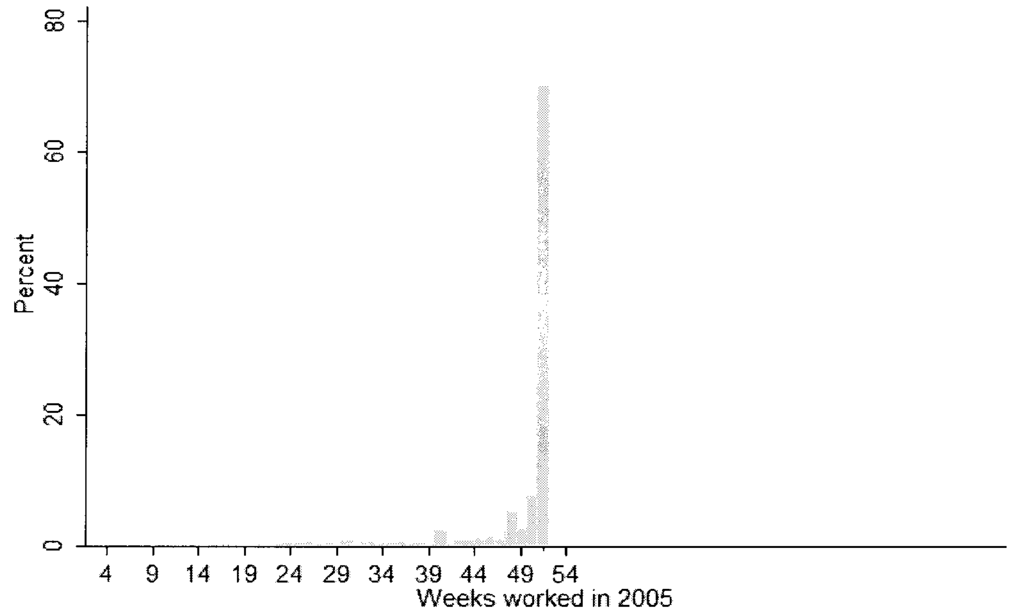

Figure 2 - percentage distribution for weeks of work (husbands)

she might have reported only one hour in the Census questionnaire, which causes her hourly wage rate equal to 1,000 dollars per hour according to this rule of calculation. And if this kind of situation happened to many individuals in the sample, the following estimation would suffer from a severe problem of measurement error. In fact, measurement error is likely whenever the variable concerned consists of a derived ratio. One could end up with having a bunch of outliers (incredibly high level of wage rates) in the sample. In order to prevent these incoordinate outliers from contaminating the estimation, I have to set up a rule of filtration.[11] By the same token, I drop those observations whose calculated annual hours of work are extremely high or extremely low. [12] By doing so I end up with a sample in which the average hourly wage rate is about 28.38 dollars. Although some outliers may still exist in the refined sample, they would

[11] The setup is somewhat arbitrary but not meaningless in any way. Specifically, individuals who reported earnings greater than 10,000 but with hours of work in the reference week less than ten hours or weeks worked in 2005 less than four weeks are excluded from the sample. And those who end up with an hourly wage rate higher than 200 dollars are also excluded after being checked carefully one by one.

[12] The threshold of annual hours of work is set at 100 hours for a lower bound and 3,120 hours for an upper bound.

not be able to affect the estimation in any important way. The final sample size is 23,419 observations.[13]

4. Model and Methodology of the Empirical Illustration

My empirical model assumes that the budget constraint is linear. In addition, I borrowed from the family model somewhat through the way I constructed my property income variable. More specifically, the property income (non-labour income) of an individual is defined as total family income minus the individual's own employment income for year 2005.[14] For the variable of hours of work, I chose annual hours of work instead of weekly hours which are constructed by the product of total hours of work during the reference week prior to the Census Day and total weeks worked in year 2005. In this way the dependent variable corresponds more with the income variable which is also an annual amount. I note again that the constructed wage level is certainly not the actual wage level, which is another source of endogeneity other than the simultaneity problem, since the explanatory variables are manifestly not independent of hours worked. Therefore, it is necessary to apply an appropriate estimation method to account for the endogeneity problem. In particular, I will be using some instrumental variables to mitigate this problem. The typical instrumental variables that many other studies have been used are education level and experience level of the individual. And many researchers also suggest that parental education might also serve as good instruments. However, parental education is not available from the Census data. Therefore I used individual's own education level without having too many alternatives, although it is likely that education

[13] Summary statistics of the whole extracted sample by age group can be found in the appendix.
[14] Total family income includes the spouse's income and children's income. In some studies, children's income is excluded from the total family income. It should not affect the analysis in any important way.

might be correlated with work preference as well, and as such it might not be qualified for a good instrumental variable. More specifically, the education level is categorized according to individual's highest degree or diploma attained. Several education dummy variables were created according to the education category the individual falls into, and the reference group for these dummies is people who do not hold a degree.[15]

The explanatory variables are composed of pecuniary variables (namely the hourly wage rate and non-labour income) and control variables that capture observable heterogeneity. Linguistic attributes variables are included in order to capture the effects of cultural differences on labour supply. For these linguistic dummy variables, the reference group is people whose mother tongue is English and speak English only. Mobility dummies are used to assess the relationship between migration and labour supply. I created two dummies for individual's mobility attributes. One is to indicate whether an individual was residing in a different province or census division five years ago, and the other indicator is similar, but the time horizon is only one year in retrospect. As such, I distinguish the two mobility variables since the time length of adjustment or assimilation needed to accommodate to a fairly new environment is also very likely to affect labour supply decisions. Regional dummies are created to measure the effects of regional labour market conditions on the individual's labour supply. The reference group for these dummies is eastern Canada (Atlantic provinces). The visible minority dummy is also included in order to assess whether people of visible minority status exhibit different labour supply patterns in comparison with non-visible minorities and non-minority individuals, which are the dominant groups of the Canadian labour force. I would expect

[15] In the category of schooling of bachelor's degree or diploma above bachelor level, I also include those people who hold a degree in medicine, dentistry, veterinary medicine or optometry.

the coefficient of this dummy variable to be negative, since discrimination is still a problem confronted by the visible minorities, which gives rise to relatively lower labour demand for visible minorities, and might in turn make them less willing to supply labour. The number of children variable is calculated according to the section of Families and Family Composition of the 2006 Census data.[16] In that section, there is a particular variable that collects information on detailed Census family status and household living arrangements. Other than those control variables mentioned above, there is another quite interesting variable in the 2006 Census data which is called HHMAINP. This variable is an identifier of the person responsible for household payments.[17] *A priori*, I would expect the effect of this indicator to be significant and positive.

The econometric model has the following main specification in semi-log form:

$$H = \delta + \alpha \ ln\, w + \beta \, ln\, V + Z\, \gamma + \varepsilon \qquad (4.1)$$

where H represents the annual hours worked, $ln\, w$ represents the natural logarithm of virtual (computed) hourly wage, $ln\, V$ represents the natural logarithm of virtual income evaluated at zero hour of labour supply, Z is a vector of observable characteristics (control variables discussed above), and ε is the disturbance term that stores all the information about unobserved characteristics.[18] The primary parameters of interest are undoubtedly α and β. The uncompensated wage elasticity evaluated at sample mean is

[16] This includes child of married couple, child of common-law couple, child in lone-parent family with male parent, and child in lone-parent family with female parent. In fact, it is more reasonable to distinguish children below six years old and above six years old, as is typically done by some other studies, since it is believed that not only the number of children counts, but also the composition of children would play a role in the labour supply decision. However, due to data limitations, the composition of children will not be reported in this study.

[17] HHMAINP=1 if this person is responsible for household payments; 0 otherwise.

[18] In addition, I also estimate for a simplest specification in which those control variables characterizing the observable attributes are excluded.

given by $\epsilon_U = \frac{\partial H}{\partial w}\frac{w}{H} = \frac{\partial H}{\partial \ln w}\frac{1}{H} = \alpha\,\frac{1}{H}$. The income elasticity evaluated at sample mean is given by $\epsilon_I = \frac{\partial H}{\partial V}\frac{V}{H} = \frac{\partial H}{\partial \ln V}\frac{1}{H} = \beta\,\frac{1}{H}$. For both of the elasticity equations, H will be replaced with the mean value of annual hours worked of the sample. Then the compensated elasticity will be backed out if one subtracts ϵ_I from ϵ_U, which is apparently a common practice in the empirical literature.

5. Empirical Results

Although simply applying the OLS technique to estimate labour supply equation could be very misleading, it is still interesting to do so since there is some slight possibility that applying other more sophisticated estimation methods might also yield biased estimates. For this reason I present the results of simply running OLS in the appendix (Table A2 and Table A3) for the sake of some readers who are interested in a comparison.

After correcting for the endogeneity problem via instrumental variables, the estimated parameters generally have the anticipated patterns.[19] The estimated coefficients of virtual income are negative throughout the subgroups and the whole sample, which is consistent with what the conventional model predicts and further confirms the assumption that leisure is a normal good. However, they are not all statistically significant at 5% level. For the group of younger males, the estimate for the effect of virtual income on labour supply is slightly insignificant. For the group of older males, the estimated coefficient is highly significant, and it seems that their labour supply is more responsive to changes in virtual income than their younger counterparts. Considering the fact that older people are usually considered to face less financial pressure than younger people, it is reasonable to

[19] See Table A4 and A5 in the appendix for all the details of regression results.

obtain a greater responsiveness to income changes. On one hand, it might be because the older workers want to work less. On the other hand, it could be because the income effects on their labour supply are systematically stronger. The separate age group estimates of wage coefficients could reveal much greater differences in responsiveness between younger males and older males. The wage coefficient for younger males is about 53.089, which is positive and slightly insignificant at 5% level of significance, whereas that for older males is 146.810, which is highly significant. The estimated coefficient of the logarithm of wage rate for the overall population is positive and significantly different from zero. A reasonable interpretation is that the substitution effect seems to dominate the income effect, at least so in terms of the sample reflecting the overall population. For the younger males one cannot rule out the possibility that the substitution effect may countervail the income effect given the insignificance of the coefficient of wage while for the older males it seems that the substitution effect dominates.

The coefficients of the indicator of person responsible for household payments all have the expected positive sign, and are significantly different from zero. A younger male appears to supply more hours of work if he is responsible for household payments than an older male. This may stem from the fact that younger males usually face greater financial pressure since their time length of financial independence is relatively shorter than older males. For the whole sample, the number of children has a significantly positive effect on labour supply, although for the younger males, its effect is somewhat insignificant, perhaps because most younger males do not have any child (the mean value of the number of children ever born for younger males is sufficiently low). Linguistic attributes do not seem to play an important role in the labour supply decision, since most estimates are not significantly different from zero. Nonetheless, there is one language group worth mentioning. Unilingual francophone men seem to supply fewer hours of work in comparison with those in other language groups, especially in the case of older males, given its relative significance compared to their younger counterparts. The coefficients of the mobility variables suggest that in general mobility has a negative impact on labour supply, especially for those who arrived at a new location within the past year, since they usually need more time to adapt themselves to local labour markets in comparison with locals or those people who arrived a relatively long time ago. However, as time goes by and they get used to a new environment, the difference in labour supply from locals gets smaller. This can be illustrated when comparing the estimated coefficients of the two mobility variables for older males. Inspecting the regional variables, it appears that workers from the provinces of the prairies seem to have the highest effective labour supply, followed by workers from Ontario. Younger males from Quebec appear to have the lowest effective labour supply compared to peers from other regions. Lastly, being a visible minority has a significantly negative impact on hours of work.

The estimated labour supply elasticities can be found in Table 1. For the reasonable range of estimates, one could refer back to Section 2.3.1. Whether significant or not, the estimated income elasticities have consistently negative sign, although they are very small in magnitude in comparison with some findings reported by other studies on male labour supply. In fact the estimated income elasticities are not of the same order of magnitude as those reported by other studies. One possible explanation is that the non-labour income involved in this study is not defined in the same way as other studies. Many early studies traditionally treat it as the spouse's income only. In contrast, as discussed in the previous section, non-labour income involved in this study actually includes all the sources of income from other family members other than the husband's earnings. Children's income also counts, although it should be small in magnitude. Therefore, it seems to be reasonable that the husband's labour supply is less responsive to a one percent increase in the non-labour income defined in this study than a same one percent increase in his spouse's income. For example, Hausman & Wise (1977) also find a low value for income elasticities of the labour supply of U.S. males. Their estimated income elasticity is about -0.01, which is based on treating non-labour income as total family income, including imputed asset income but excluding husband's wage income. In addition, it is the before-tax total income rather than the after-tax total income that is employed to construct the non-labour income variable. As such, the estimated income elasticity corresponds to changes in before-tax income level. It is reasonable to assume that an individual is less sensitive to changes in before-tax income than to changes in after-tax income, since in practice the amount that is taxed would not bring any utility to the individual. Therefore, the somewhat puzzling result of the small income elasticities seems to be justified.

The uncompensated wage elasticity for the entire sample is positive and small. And for separate age groups, the estimates both fall into the elasticity range reported by other studies, although they are small in magnitude as well. In particular, labour supply of younger males appears to be less elastic, whether in terms of wage changes or in terms of income changes than their older counterparts, since the estimated elasticities are both smaller. In regards to the compensated wage elasticities, the estimates are also satisfactory because *a priori* one would expect them to be positive no matter which

Table 1
Estimates of elasticities

	Age group		
Elasticities	20-54	20-34	35-54
Uncompensated wage	0.0615	0.0247	0.0686
	(0.0569)	(0.0400)	(0.0653)
Income	-0.0059	-0.0030	-0.0066
	(-0.0079)	(-0.0093)	(-0.0064)
Compensated wage	0.0674	0.0277	0.0752
	(0.0648)	(0.0493)	(0.0718)

Note: (a) Numbers in parentheses are estimated elasticities for a sample including single men. (b) All elasticities are based on the means of logarithm of wage rate, virtual income and annual labour supply.

demographic group is under inspection. Although in the case of male labour supply, it is not rare to obtain estimates of negative compensated elasticities, there are still a considerable number of findings that report positive ones which could conform to the implications of the simple model. In sum, the estimated elasticities are not counter to my prior expectations.

In addition, I include single men in the sample to estimate labour supply equation as a test of robustness. The similar estimation method is applied. The only difference is that marital status enters the labour supply equation in order to distinguish between husbands and single men. The estimated labour supply elasticities generally conform to the estimates using a sample of husbands only, while for the group of younger males, the estimated wage and income elasticities (evaluated at sample means of the entire sample including single men) are more significant. These results also fall into the sensible range corresponding with earlier findings. The estimated elasticities are also presented in Table 1, and the complete regression output can be found in Table A6 of the appendix.

6. Conclusion

This study aims to outline some fundamental issues regarding labour supply and to provide some simple yet helpful guidelines on estimating labour supply equations for some demographic groups. The static simple labour supply model can be adapted so as to incorporate the impacts of tax and welfare programs. However, since the empirical estimates of labour supply elasticities have been proven to be far from satisfactory due to several reasons, either in terms of model construction or estimation methods, caution should be taken when these results are used to evaluate policy changes.

Moreover, this study also carries out empirical work using fairly recent data as an example of estimating labour supply. In particular, it estimates a labour supply equation of Canadian males using the 2006 Canadian Census of Population. The estimates seem to be plausible when account is taken of the endogeneity of the hourly wage rate. Unlike estimation of female labour supply, the selection bias is a minor problem that is ignored in this study. But its correction methods are discussed. The estimated elasticities are small in magnitude, but nonetheless are consistent with findings of early studies. The estimates of income elasticities for the entire sample and the two age groups all suggest the assumption that leisure is a normal good is valid. The estimates of compensated elasticities of labour supply with respect to the wage are also consistent with the theory of labour supply model. The estimates are generally quite robust regardless of whether or not single men are included into the sample. In addition, although it seems that nowadays Canadian male's responsiveness to wage and income changes is still fairly inelastic, some non-pecuniary factors may also account for their labour supply decision as significantly as pecuniary factors do.

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Appendix

Table A1 - Descriptive Statistics

Mean values (sample: husbands only)

Variable	20-54 (1)	20-34 (2)	35-54 (3)
Age Group[a]	8.052	5.612	8.602
	(1.53)[b]	(0.57)	(1.08)
Responsible for Household Payments	0.941	0.920	0.946
	(0.24)	(0.27)	(0.23)
Annual Hours Worked	2142.545	2146.599	2141.631
	(500.29)	(506.40)	(498.91)
Wage Rate	28.383	23.931	29.387
	(19.31)	(15.43)	(19.94)
Virtual Income	42881.550	36360.780	44352.290
	(40654.21)	(32594.30)	(42121.63)
Education: university with post-graduate degree	0.059	0.042	0.063
	(0.24)	(0.20)	(0.24)
Education: bachelor's degree or diploma above bachelor level	0.180	0.208	0.174
	(0.38)	(0.41)	(0.38)
Education: university below bachelor level	0.042	0.035	0.044
	(0.20)	(0.18)	(0.20)
Education: college and non-university certificate or diploma	0.217	0.256	0.208
	(0.41)	(0.44)	(0.41)
Education: trade certificate	0.158	0.129	0.165
	(0.36)	(0.34)	(0.37)
Education: high school	0.226	0.244	0.221
	(0.42)	(0.43)	(0.42)
Language: mother tongue English, English & French spoken	0.051	0.066	0.047
	(0.22)	(0.25)	(0.21)
Language: mother tongue French, French spoken only	0.068	0.037	0.074
	(0.25)	(0.19)	(0.26)
Language: mother tongue French, English & French spoken	0.098	0.086	0.100
	(0.30)	(0.28)	(0.30)
Language: mother tongue other, English spoken only	0.574	0.642	0.558
	(0.49)	(0.48)	(0.50)
Language: mother tongue other, French spoken only or bilingual	0.241	0.209	0.248
	(0.43)	(0.41)	(0.43)

Mobility: from different province or census division five years ago	0.122	0.232	0.098
	(0.33)	(0.42)	(0.30)
Mobility: from different province or census division one year ago	0.027	0.056	0.021
	(0.16)	(0.23)	(0.14)
Region: Quebec	0.172	0.126	0.183
	(0.38)	(0.33)	(0.39)
Region: Ontario	0.436	0.461	0.430
	(0.50)	(0.50)	(0.50)
Region: Prairies	0.183	0.219	0.175
	(0.39)	(0.41)	(0.38)
Region: BC	0.129	0.120	0.131
	(0.33)	(0.33)	(0.34)
Minority: Visible Minority	0.153	0.142	0.155
	(0.36)	(0.35)	(0.36)
Number of Children Ever Born	0.575	0.073	0.688
	(0.86)	(0.34)	(0.90)
Observation	23419	4310	19109

Note: a) According to the data source, the range of the variable of age group is from 1 to 13. The age interval is five years for the age groups concerned in this study. The individual's exact age information is not available. b) Numbers in parentheses represent standard deviations.

Table A2

Simplest specification (no controls), OLS estimates for labour supply parameters (regressand: annual hours of work; sample: husbands only)

	Age groups		
	20-54	20-34	35-54
Regressors	(1)	(2)	(3)
Logarithm of wage	-32.12***	-81.22***	-24.52***
	(-7.29)	(-6.74)	(-5.16)
Logarithm of virtual income	-11.73***	-15.15*	-11.26***
	(-4.09)	(-2.12)	(-3.58)
Constant	2363.7***	2543.8***	2335.2***
	(72.08)	(30.99)	(64.91)
N	22980	4236	18744

Note: *t* statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3

Adding controls, OLS estimates for labour supply parameters (regressand: annual hours of work; sample: husbands only)

	Age groups		
	20-54	20-34	35-54
Regressors	(1)	(2)	(3)
Logarithm of wage	-50.84***	-99.49***	-43.89***
	(-11.47)	(-8.18)	(-9.19)
Logarithm of virtual income	-13.57***	-7.219	-15.14***
	(-4.65)	(-0.99)	(-4.75)
Indicator: responsible for household payments	125.4***	167.3***	113.0***
	(9.05)	(5.51)	(7.13)
Number of children ever born	15.08***	-19.35	15.32***
	(3.88)	(-0.79)	(3.75)
Language: mother tongue English, English & French spoken	44.24	14.75	49.91
	(1.80)	(0.25)	(1.84)
Language: mother tongue French, French spoken only	-64.49**	-63.97	-63.00*
	(-2.72)	(-0.99)	(-2.47)
Language: mother tongue French, English & French spoken	-1.579	-43.69	7.012
	(-0.07)	(-0.79)	(0.29)
Language: mother tongue other, English spoken only	41.82***	-7.456	50.73***
	(3.88)	(-0.27)	(4.33)
Language: mother tongue other, French spoken only or bilingual	34.06	26.27	34.29
	(1.50)	(0.44)	(1.40)
Mobility: from different province or census division five years ago	-16.95	0.555	-22.99
	(-1.59)	(0.03)	(-1.76)
Mobility: from different province or census division one year ago	-89.55***	-30.17	-120.4***
	(-4.17)	(-0.86)	(-4.42)
Region: Quebec	36.16*	-45.21	52.33**
	(2.03)	(-1.00)	(2.70)
Region: Ontario	154.8***	96.97**	167.9***
	(12.09)	(3.14)	(11.94)
Region: Prairies	172.5***	87.16**	193.4***
	(12.38)	(2.65)	(12.56)
Region: British Columbia	101.1***	16.97	119.8***
	(6.77)	(0.46)	(7.32)
Minority: Visible Minority	-111.2***	-82.03**	-115.2***
	(-9.77)	(-2.92)	(-9.24)
Constant	2188.0***	2323.3***	2175.3***
	(56.75)	(24.29)	(51.49)
N	22980	4236	18744
R^2	0.032	0.035	0.035

Note: t statistics in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table A4
Simplest specification (no controls), IV estimates for labour supply parameters (regressand: annual hours of work; sample: husbands only)

	Age groups		
	20-54	20-34	35-54
Regressors	(1)	(2)	(3)
Logarithm of wage	138.8***	70.21	150.6***
	(6.56)	(1.32)	(6.63)
Logarithm of virtual income	-11.51***	-12.50	-10.86***
	(-3.88)	(-1.71)	(-3.34)
Constant	1824.3***	2062.6***	1775.5***
	(24.83)	(11.19)	(22.17)
N	22980	4236	18744

Note: *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A5
Adding controls, IV estimates for labour supply parameters (regressand: annual hours of work; sample: husbands only)

	Age groups		
	20-54	20-34	35-54
Regressors	(1)	(2)	(3)
Logarithm of wage	133.0***	53.09	146.8***
	(6.40)	(0.96)	(6.54)
Logarithm of virtual income	-12.66***	-6.450	-14.18***
	(-4.18)	(-0.87)	(-4.27)
Indicator: responsible for household payments	83.48***	133.2***	73.25***
	(5.53)	(4.03)	(4.28)
Number of children ever born	8.543*	-12.34	12.25**
	(2.09)	(-0.49)	(2.87)
Language: mother tongue English, English & French spoken	15.65	6.189	13.51
	(0.61)	(0.10)	(0.47)
Language: mother tongue French, French spoken only	-63.68**	-56.82	-62.98*
	(-2.59)	(-0.86)	(-2.37)
Language: mother tongue French, English & French spoken	-25.82	-58.22	-20.06
	(-1.13)	(-1.03)	(-0.80)
Language: mother tongue other, English spoken only	14.45	-30.07	20.74
	(1.25)	(-1.04)	(1.64)
Language: mother tongue other, French spoken only or bilingual	9.608	-6.023	11.55
	(0.41)	(-0.10)	(0.45)
Mobility: from different province or census division five years ago	-16.24	2.260	-30.85*
	(-1.47)	(0.12)	(-2.26)
Mobility: from different province or census division one year ago	-82.62***	-32.28	-110.5***
	(-3.71)	(-0.91)	(-3.89)
Region: Quebec	18.67	-50.88	32.47
	(1.01)	(-1.11)	(1.60)
Region: Ontario	108.3***	58.63	118.6***
	(7.61)	(1.72)	(7.55)
Region: Prairies	136.3***	57.42	153.9***
	(9.10)	(1.64)	(9.23)
Region: British Columbia	60.19***	-16.38	77.23***
	(3.73)	(-0.42)	(4.36)
Minority: Visible Minority	-75.04***	-70.54*	-73.64***

	(-6.03)	(-2.45)	(-5.32)
Constant	1698.8***	1938.4***	1658.2***
	(25.32)	(11.63)	(22.44)
N	22980	4236	18744

Note: *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A6
Adding controls, IV estimates for labour supply parameters (regressand: annual hours of work; sample: both single men and husbands)

	Age groups		
	20-54	20-34	35-54
Regressors	(1)	(2)	(3)
Logarithm of wage	114.1***	74.59	136.7***
	(6.12)	(1.87)	(6.79)
Logarithm of virtual income	-15.85***	-17.42***	-13.43***
	(-19.85)	(-11.04)	(-15.10)
Indicator: responsible for household payments	239.2***	262.2***	100.4***
	(25.22)	(18.29)	(7.85)
Married	119.1***	167.1***	58.13***
	(15.08)	(10.64)	(7.11)
Number of children ever born	1.793	-22.99***	26.97***
	(0.50)	(-3.32)	(6.46)
Language: mother tongue English, English & French spoken	-41.51*	-36.26	-27.81
	(-2.03)	(-1.03)	(-1.10)
Language: mother tongue French, French spoken only	-41.95*	11.54	-80.16***
	(-2.17)	(0.33)	(-3.55)
Language: mother tongue French, English & French spoken	-45.26*	-38.49	-52.60*
	(-2.44)	(-1.17)	(-2.39)
Language: mother tongue other, English spoken only	-21.34*	-45.21*	-3.410
	(-2.08)	(-2.36)	(-0.29)
Language: mother tongue other, French spoken only or bilingual	-3.733	-59.29	34.08
	(-0.19)	(-1.61)	(1.47)
Mobility: from different province or census division five years ago	-0.750	17.73	-25.00*
	(-0.09)	(1.35)	(-2.22)
Mobility: from different province or census division one year ago	-103.6***	-121.1***	-68.40**
	(-7.01)	(-5.91)	(-3.06)
Region: Quebec	8.966	5.388	7.289
	(0.58)	(0.19)	(0.41)
Region: Ontario	76.14***	49.03*	94.50***
	(6.26)	(2.18)	(6.69)
Region: Prairies	112.7***	83.99***	132.7***
	(8.75)	(3.54)	(8.81)
Region: British Columbia	31.37*	11.17	44.93**
	(2.29)	(0.45)	(2.81)
Minority: Visible Minority	-96.52***	-101.4***	-76.92***
	(-9.32)	(-5.89)	(-6.05)
Constant	1479.5***	1602.8***	1534.8***
	(30.52)	(15.50)	(27.76)
N	42172	15989	26183

Note: *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$