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THE EFFECTS OF THE KOREAN INCOME TAXATION ON LABOR SUPPLY AND WELFARE: A PIECEWISE-LINEAR BUDGET CONSTRAINT APPROACH COMBINED WITH IV ESTIMATION

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This article presents empirical evidence about the income tax effects on labor supply and welfare in Korea. We first derive the labor supply function in the presence of progressive income taxation, and then conduct estimation of the labor supply equation with the specificities of the Korean income tax system cautiously taken into account. Econometrically, we adopt some sort of a "joint approach" of utilizing a piecewise-linear budget constraint combined with IV estimation to deal with the complex endogeneity in the wage measure: (i) tax-induced endogeneity, and (ii) measurement error coupled with division bias.

Unlike the conventional perception of non-competitive features in a developing country's labor market, empirical evidence from the Korean data shows (i) a substantial substitution response to compensated wage changes, and (ii) an equally large income effect. These results are based on two different specifications and IV estimation techniques for robustness.

Our results offer some policy implications: first, a distortion induced by income tax is not negligible in magnitude; second, labor supply responds substantially to temporary innovations, but changes very little to permanent innovations. Finally, policy simulation results using the empirical evidence suggest that excess burden is about 17% and 14% of the total tax revenue in years 1995 and 1996, respectively. The economy seems to be at the increasing part of the Laffer curve.

JEL Classification: H24, H21

Keywords: progressive income taxation, labor supply response, piece-wise linear budget constraint, IV estimation, robustness of results, the Laffer curve.

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I. INTRODUCTION

The sensitivity of labor supply response to changes in wage is a crucial parameter in the discussion of various economic issues, ranging from tax reform, pensions, welfare to business cycles. For instance, lots of policy evaluation studies on those issues utilize computable general equilibrium models that require precise estimates of labor supply responses to wage changes (e.g., Trostel (1993), Bovenberg and Goulder (1996), etc; Chun (2000) among studies on Korea). Also, extensive business cycle studies (e.g., Prescott (1986)) need a reasonably large magnitude of labor supply elasticity to simulate the observed fluctuations in the real world economy. Thus, potential usefulness of the research on measuring the labor supply elasticity cannot be overemphasized in any field containing general equilibrium features. A precise estimate of labor supply responses permits evaluation of various policy impacts and hence suggestion of more efficient policy alternatives. More narrowly in the public finance literature, the excess burden caused by distortionary progressive income taxation is a central topic along with equity issues.

This article presents empirical evidence about the income tax effects on labor supply and welfare in Korea.[1] We first derive the labor supply function in the presence of progressive income taxation, and then conduct estimation of the labor supply function with the specificities of the Korean income tax system cautiously taken into account. Econometrically, we adopt some sort of a "joint approach" of utilizing a piecewise-linear budget constraint combined with IV estimation to deal with the complex endogeneity in the wage measure: (i) endogeneity induced by income taxation, and (ii) the measurement errors in wage coupled with division bias.[2]

Unlike the conventional perception of non-competitive features in a developing country's labor market, empirical evidence from the Korean labor market shows (i) a substantial substitution response to compensated wage changes (elasticity of about 0.56 in our preferred specification), and (ii) an equally large income effect. These results are based on two different specifications and IV estimation techniques for robustness.

Our main results are as follows: first, a distortion induced by income taxation is not negligible in magnitude; second, labor supply responds substantially to temporary innovations, but changes very little to permanent innovations. Finally, policy simulation results using the empirical evidence suggests that excess burden is about 17% and 14% of the total tax revenue in years 1995 and 1996,

[1] Only a few studies examined the labor supply function using the Korean data. Most of them are about the labor force participation. An exception by Choi (1995) is based on a typical macro real business cycle model and data, so it is not comparable to this study.

[2] The wage measure is known to be (i) subject to measurement errors and (ii) also correlated with the dependent variable (hours of work) because wage is constructed by dividing earnings by hours of work.

respectively. The economy seems to be at the increasing part of the Laffer curve.

To put this paper in perspective, it is worth mentioning our estimation technique and the issues that we can deal with using the technique. It is not until relatively recently that labor supply function has been estimated using the information on the "progressivity" of income taxation (e.g., Burtless and Hausman (1979), Hausman (1981 & 1985) and Blomquist (1983 & 1986)). For instance, a vast empirical literature in labor economics analyzes labor supply without explicit consideration of taxes (see Killingsworth (1983) for a recent survey of this issue). The pioneering work by Hausman uses the information from tax-induced piecewise-linear budget constraint[3] combined with maximum likelihood estimation, which is clearly a substantial progress relative to earlier estimation methods. This technique has been adopted in many subsequent papers. Even with this advantage, however, his approach also has some weakness when measurement error is serious in the income variable, one of the regressors used in estimation. Ericson and Flood (1997), for example, noted this feature in their Monte Carlo simulation experiment. Since this paper uses survey data, which are known to be subject to measurement errors. Also, the wage measure is correlated with the dependent variable of our study (hours of work) because wage is constructed by dividing earnings by hours of work. To deal with these endogeneity problems while preserving the spirit of Hausman and others, this study combines the tax-induced piecewise-linear budget constraint approach with the instrumental variables (IV) estimation.

This study can provide some policy implications in the context of the Korean economy. So far, the notion of excess burden of income taxation has not been properly addressed despite numerous personal income tax reforms in Korea. This paper incorporates the complexities of the Korean income tax structure to the estimation of labor supply responses. Each Individual's budget constraint is constructed in order to generate accurate information on individuals' opportunity wages in estimation of the labor supply function in Korea.

Before we embark on the estimation issue, it should be noted that rigidities in the labor market may, to a certain extent, discourage the potential willingness to adjust the hours of work. For instance, fixed hours contracts, the limited availability of competing positions and liquidity traps for low-income individuals, can impose restrictions on the adjustment of hours, and thus we would expect a greater elasticity of labor supply when these institutional rigidities were to be eliminated in the future.

The rest of the paper is as follows. Section II derives the demand for leisure in the presence of progressive income taxation. Section III describes data and the estimation strategy along with a brief discussion of the structure of the

[3] As will be explained later, the progressivity of income taxation makes budget constraint piecewise-linear.

Korean income tax system. Empirical results and interpretation are given in Section Ⅳ. Using the estimation results, we also perform tax policy simulations for various hypothetical regimes including the current income taxation. Section Ⅴ concludes the paper.

Ⅱ. DEMAND FOR LEISURE IN THE PRESENCE OF PROGRESSIVE INCOME TAXES

A non-linear demand function

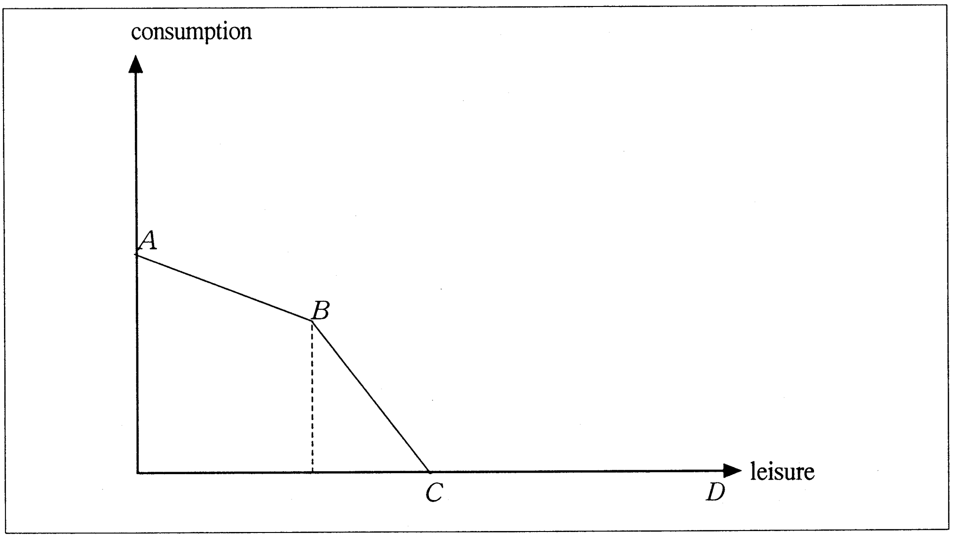
The complexity of analyzing labor supply under progressive income taxation lies in that progressive income taxation generates multiple marginal after-tax wages, all of which affect the equilibrium choice of hours of work. Progressivity hence creates a series of increasing marginal tax rates and decreasing after-tax wages with respect to hours, (i.e., a piece-wise linear budget constraint).[4] Given that, an individual selects consumption and hours of work at the same time. Although the concept of equilibrium is straightforward, actual implementation of finding equilibrium is a bit complex. All possible combinations of marginal after-tax wages and hours should be checked sequentially as follows. First, individuals begin with checking from the segment of budget constraint matching with the lowest marginal tax rate, and find their best hours of work on that segment. Second, they will consider the next segment associated with the next higher marginal tax rate to choose the best hours. They keep searching for the best hours, conditional on each segment associated with its marginal tax rate. Finally, the utility levels calculated from all the best hours for given marginal tax rates are simply compared. Of course, utility-maximizing hours will be unique as long as the utility function satisfies the strict quasi-concavity condition. Therefore, the equilibrium hours of work depend on all the marginal tax rates, and not just the equilibrium rate at which an individual finally settles. Leisure demand (or labor supply) is thus intuitively a highly non-linear and complex function. A formal derivation of the general labor supply function is a bit involved and not shown in other work. We begin with an example of two tax brackets and then generalize the result.

An example with two tax brackets

To explicitly derive the labor supply equation, we denote leisure as l, l^* as leisure at the kink point, and consumption as c. Taking an example of only two different tax brackets (hence two segments in the opportunity set) and necessarily one kink in the middle, we can describe the demand for leisure in this way.

[4] To be more specific, we need information about marginal tax rates and the matching “virtual incomes” to be discussed very soon in this subsection.

[Figure 1] Opportunity set with two marginal tax rates



Note: segment 1 = interval AB; segment 2 = interval BC

Since the utility function is quasi-concave and the budget set is convex, we can simply determine the equilibrium hours of work using the "conditional" demand function $g(\cdot)$ which means the hours of leisure that are conditional on a certain segment where an individual makes hours and consumption decisions; g is a function of wage rate and "virtual income," i.e., the total value of time endowment and non-labor income (see Appendix for more formal discussion). Because of the multiple segments and a kink, the conditions for equilibrium hours can be characterized as follows (subscripts here denote segment numbers):

If $g(w_1, VI_1) \leq l^*$, then hours are chosen at segment 1.
If $g(w_2, VI_2) \leq l^* < g(w_1, VI_1)$, then hours are chosen at the kink.
If $l^* < g(w_2, VI_2)$, then hours are chosen at segment 2. (1)

The general case

This formulation can be extended to the case of n different segments. Assuming there are n segments and therefore $n-1$ interior kinks, the leisure demand function can be generalized as follows:

$$l(w_1, w_2, \cdot\cdot, w_n, VI_1, VI_2, \cdot\cdot, VI_n; \theta) = \sum_{i=1}^{n} A1_i \cdot g(w_i, VI_i) + \sum_{i=1}^{n} A2_i \cdot l_i^* \quad (2)$$

where, $A1_i = 1$ if $D1_i = 1$ and $D2_i = 0$; otherwise 0;

$A2_i = 1$ if $D2_i = 1$ and $D3_i = 0$; otherwise 0;

$D1_i = 1$ if $l^*_{i-1} < g(w_i, VI_i)$; otherwise 0;

$D2_i = 1$ if $l^*_i < g(w_i, VI_i)$; otherwise 0;

$D3_i = 1$ if $l^*_{i+1} < g(w_i, VI_i)$; otherwise 0;

$l_{0-j} = 0$; $l_{n+j} = T$ for all nonnegative j;

θ = preference parameters.

The demand function for leisure is likewise non-linear with many discrete changes induced by dummy variables, $A1_i$ and $A2_i$. Thus the usual OLS estimation without taking into account progressive taxation cannot be justified on the intuitive ground that the effective net-of-tax wage rate (an independent variable) is a function of hours of work (the dependent variable), which is a classic case of endogeneity (more detailed empirical issues will be addressed in the next section).

Ⅲ. DATA AND ESTIMATION STRATEGY

1. The Data and Sample

Sample qualifications

The sample used for this study is extracted from the Daewoo Panel Survey data base containing information about year 1995 (surveyed in year 1996). This panel data set was developed in 1993 and has been surveyed a while to allow for a longer follow-up study of randomly sampled individuals. The data base is designed in a fairly similar way to the Panel Study of Income Dynamics (PSID) data base of the University of Michigan. It has two separate data sections, the family data set and the individual data set like the PSID.

Since we use cross-sectional variations in wage and income across individuals to identify the parameters for labor supply response, "permanent" measures of wage and income are needed. Data in recent years after the Asian Financial Crisis of 1997 contain lots of "transitory" components arising from economic uncertainty and instability, and the wage and income variables may not fully represent permanent measures. Consequently, we rather focus on the before-crisis data of year 1995.

The qualifications for this study's sample are prime-aged, non-self-employed, and male workers who are also the main income earners for their households. Also, their labor income, non-labor income, age, years of education, number of children, hours of work should not be missing to be qualified for the sample.[5]

The prime-aged male sample can be justified to reduce problems associated with the sample selection issues and they are consistent with the tradition of the labor economics literature on similar issues. For some individuals, the hours of work exceed a reasonable limit. Those working for more than two-thirds of 8760 hours in a year are thus eliminated from the sample.[6] The age range is also restricted to below 55, to avoid the complication arising from retirement decisions. To discuss marginal tax rates and other related variables, we need to briefly review the Korean income tax system.

2. The Korean Income Taxation and Construction of Tax Variables

Formal structure

The Korean income tax structure consists of basically two parts: deductions and progressive tax rates. Unlike most other countries, deductions are not just tied to the number of dependent family members or other special reasons, but are also tied to the total amount of tax calculated from the tax schedule: the final tax levied is reduced by 20%, with the reduction limit of up to 500,000 Wons from the total amount of tax calculated from the original tax schedule. This tax deduction functions essentially as some sort of a tax credit or a negative sur-tax.[7]

A rather peculiar feature of the Korean tax system is often viewed as a result of the government's efforts to balance the tax burden between wage earners and the self-employed. That is, the incomes of the self-employed are known not as transparent as the wage earners. Thus, both the standard deductions and the deductions on the total amount of tax play the role of reducing the tax burden of wage earners in such a way that they balance out the tax burden between the two groups (if not completely, then at least to narrow the discrepancies in the tax burden).

For the sample year 1995, deductions are classified as labor income deduction, personal deduction, and special deduction. For the labor income deduction, the first 3,100,000 Wons out of total labor income is deducted and any part above 3,100,000 Wons is deducted by 30% with the total deduction limit being 6,900,000 Wons. Personal deduction consists of the basic deduction of 720,000 Wons, the spouse deduction of 540,000 Wons, the dependent family deduction of

[5] Since female labor supply decisions depend on quite different factors compared to their male counterpart, and because of the limited number of female workers surveyed in the data set, this study focuses on males who are supposedly more homogeneous and who constitute a major portion of the labor force.

[6] The Daewoo data set surveys weekly hours of work. By multiplying 52 to the hours data, the annual hours of work variable is constructed.

[7] Note that a typical sur-tax is a tax on tax, such as the education tax in Korea that is imposed on the liquor tax. Deductions on the assessed amount of tax are therefore, conceptually equivalent to a negative sur-tax.

480,000 Wons (for children below the age of 20, siblings, and elderly persons), the deductions for the disabled and the elderly above the age of 65, 480,000 Wons. Special deductions include insurance payments, education expenses, medical expenses, etc.

Statutory tax rates vary from the lowest rate of 5% to 45% progressively with six brackets (see Table 1). Deductions on the amount of tax are allowed for the labor income tax and the taxes levied on workers' savings in the form of stock holding, purchase of a certain range of stocks with a uniform 20% deduction rate and its reduction limit of up to 500,000 Wons, etc. Therefore, it should be noted that the progressivity of income taxation up to the 45% tax rate is substantially weakened by the presence of deductions on the amount of taxes.

[Table 1] The Korean Income Tex Structure in 1995

(unit, 10,000 Wons)

Assessed Income, I	Marginal Tax Rate (%)	Tax Deduction
I ≤ 400	5	20% with deduction limit of 50
400 < I ≤ 800	9	
800 < I ≤ 1,600	18	
1,600 < I ≤ 3,200	27	
3,200 < I ≤ 6,400	36	
6,400 < I	45	

Source: The Ministry of Finance and Economy, *The Synopsis of Korean Taxes, 1995.*

Constructing the marginal tax and virtual income variables: our approach

The Daewoo panel has a variable on income tax payments, but it is likely to have a low level of accuracy since individuals may not remember the total amount of income tax payments precisely. This study therefore attempts to impute an individual's income tax payment on the basis of earnings, which takes lots of work but is necessary for obtaining a more precise opportunity set for each individual. Most of the specific rules on income tax treatment are used to calculate an individual's taxable income, and for a given taxable income, an individual's budget set is derived. However, some deductions are contingent on unobservable individual-specific circumstances (e.g., insurance payments), so they are not reflected upon their taxable income measure.

Here is our approach. First, using the hours of work variable available from the individual data set, the pre-tax hourly wage is derived by dividing earnings with hours. Second, on the basis of the pre-tax wage, various deductions are considered to generate the data on taxable income, and subsequently marginal after-tax wages and kink points. The limits of labor income deduction and labor income tax deduction create virtually nine tax brackets at maximum, which is more than the six tax brackets in Table 1. Table 2 presents descriptive statistics of the sample to be analyzed. Lastly, virtual non-labor incomes (defined as the virtual income evaluated at zero hour) are calculated for each derived after-tax wage rate.

[Table 2] Description Statistics of the Sample

Variable	N	Mean	Std. Dev.	Min	Max
Age	808	35.89	7.37	19.00	55.00
Education*	808	13.06	2.35	3.00	18.00
Children	808	1.50	0.89	0	5.00
Pretax wage	808	6,008.93	3,194	692.31	30,364.37
Hours	808	3,135.96	705.40	572.00	5,824.00
mw	808	5,166.46	2,480	692.31	27,255.94
vy	808	2,589,551.04	5,330,020	0	57,364,000.00

Note: All the money terms are measured in 1995 Wons. vy = virtual non-labor income; mw = marginal after-tax wage. The years of education variable is imputed since the education variable in the Daewoo panel data base is reported in category, such as whether or not an individual obtains a certain level of education: elementary school education, middle school, etc.

3. Econometric Issues

The endogeneity issue

There are two types of endogeneity in our paper. The first one is the tax-induced endogeneity. Progressive income taxation makes the after-tax wage measure become a function of hours of work since a larger number of hours of work leads to greater earnings which faces a high tax rate under a progressive income tax system. Put differently, the marginal tax rate is *endogenously* determined in the course of utility maximization. The use of the marginal after-tax wage as a regressor thus creates a typical *endogeneity* problem in estimation. Given that t is a function of hours as $t = t(wh + y)$ where y is the non-labor income, marginal after-tax wage mw is also a function of hours:

$$mw = \{1 - t(wh + y)\} \cdot w \tag{3}$$

Also, the virtual non-labor income variable (vy) can be defined for each marginal tax rate at zero hours of work. The equilibrium vy^* depends on the starting level of non-labor income (y) and the equilibrium hours of work that is obviously affected by progressive income taxation.

$$\begin{aligned} vy^* &= f(y, h^*) \\ &= VI - Tw^* \end{aligned} \tag{4}$$

where w^* = the equilibrium marginal after-tax wage; T = the total available hours (i.e., time endowment).

As we observed in Section II, virtual non-labor income depends on the equilibrium hours of work, which are clearly affected by the tax system, and the endogeneity of vy is also clear. Therefore, in order to avoid the endogeneity problem arising from taxation, there should be some econometric treatments of marginal after-tax wage as well as of virtual non-labor income (vy).

The second endogeneity is that wages contain a high degree of measurement error. This measurement error problem is a little more complicated than the textbook case, because the wages in the data set used in this paper were constructed by earnings divided by the dependent variable of hours worked. Measurement errors in hours thereby generate variations in both the dependent variable and the denominator of the regressor, wages. This results in a spurious negative correlation between hours and wages, often referred to as 'division bias.'

Our approach to dealing with endogeneity

Quite a few approaches have been developed in the last two decades in an attempt to deal with such endogeneity problems. Hausman (1981), among others, proposed a maximum likelihood estimation approach, which utilizes all the information about each individual's budget constraint. Many subsequent econometric techniques of estimating the labor supply function have been developed upon his seminal work. Hausman (1981) and Blomquist (1996) conduct excellent surveys of the literature in this area. This study also adopts the Hausman-type piece-wise linear budget constraint approach but we implement his idea using the instrumental variables (IV) estimation instead of maximum likelihood (ML) estimation. The main reason is because ML estimation requires precise information about wage data, which does not seem to be appropriate for our wage data.

The ML estimation is more advantageous in that it uses all the information about the shape of budget constraints but it is still imperfect in that problems of measurement errors cannot be corrected (i.e., this is equivalent to using wrong data) and the Slutzky condition is very restrictively imposed on the estimation procedure.[8] Further, the difficulty of achieving convergence in estimates is another problem. The IV estimation is less costly in terms of implementation, and most importantly, it can correct for the potential problems of measurement errors in marginal after-tax wages, which are generally acknowledged as a major source of endogeneity.[9] Recently, the literature on tax and labor supply has begun to pay more attention to the issue of measurement

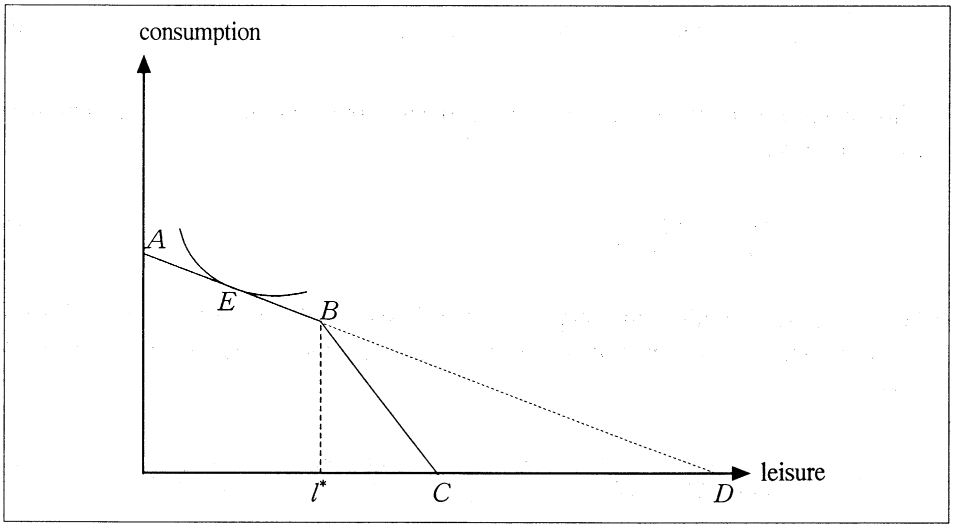
[8] Refer to MaCurdy et al. (1990) for more detail.

[9] As we will show later, IV estimation does not perform well in finite samples. To deal with this weakness, I also conduct limited information maximum likelihood (LIML) estimation.

errors in estimation [MaCurdy et al (1990), Ericson and Flood (1997)]. However, it can be asserted that the IV estimation is inferior to the ML estimation in that it does not clearly handle the observations at the kink.

Given that hours of work data are known to inevitably possess a high degree of measurement errors in any survey database, the Daewoo Panel data set would not be free of measurement errors. This aspect motivates a proper use of IV estimation with a valid set of IV's. In implementing IV estimation, the required information is: an individual's *equilibrium* marginal after-tax wage, equilibrium virtual non-labor income, *equilibrium* hours, and other demographic variables representing preferences. The reason why the set of required information reduces as above is that an individual selecting a point in a particular segment (e.g., point E in segment AB in Figure 2) will choose the same point E even if the whole budget set is an extended line (ABD) including segment AB. *Therefore, our approach does not involve any undue manipulation of information, unless the individual is at the kink.* Since no one among the sampled individuals is exactly at kink points, IV estimation can be warranteed for our study.

[Figure 2] Information Required for Equilibrium E



4. Empirical Specification

Two different empirical specifications are estimated to insure reliability of estimation results. The first one adopts a CES (constant elasticity of substitution) utility that imposes a theory-based restriction, that is, the usual Slutzy restriction, while the second one does not adopts any restriction built into the utility function. Since the two specifications are based on different models and modelling spirits are in contrast with each other, comparing the results from one specification with the other's may be useful since our interpretation becomes less dependent upon a particular approach.

Specification 1: Slutzky restriction imposed

Our approach utilizes a commonly-used direct utility function that satisfies a wide range of consumer theories including the Slutzky restriction (i.e., the requirement of quasi-concavity) built into the model. This paper derives the labor supply equation from the constant elasticity of substitution (CES) utility function as below:

$$\begin{aligned} &\max_{\{c,l\}} U(l_i, c_i) = (\phi_i c_i^{-\beta} + l_i^{-\beta})^{-1/\beta} \\ &\text{s.t.} \quad \text{(a)} \ c_i = (1-t_i)\cdot w_i h_i + vy_i \\ &\qquad\ \ \text{(b)} \ T = h_i + l_i \end{aligned} \tag{5}$$

After solving for l and c, and using the definition of the elasticity of substitution, $\lambda \equiv 1/(1+\beta)$, a series of manipulations leads to the following equation (6):

$$\ln\left(\frac{l_i}{c_i}\right) = -\lambda \ln \phi_i - \lambda \ln\{(1-t_i)\cdot w_i\} \tag{6}$$

The equilibrium hours of work is derived from our model in a non-linear way as follows:

$$h = \frac{T - \phi^{-\lambda}\cdot mw^{\lambda}\cdot vy}{1+\phi^{-\lambda}\cdot mw^{-\lambda}} \tag{7}$$

where mw is the after-tax wage. On the basis of the derived hours of work, uncompensated and compensated elasticities are defined at equations (8) and (9), respectively:

$$\varepsilon_{hw} = \frac{\lambda\phi^{-\lambda}\ mw^{1-\lambda}\cdot vy}{mw\cdot T - \phi^{-\lambda}\cdot mw^{1-\lambda}\cdot vy} - \frac{(1-\lambda)\ \phi^{-\lambda}\ mw^{1-\lambda}}{1+\phi^{-\lambda}\ mw^{1-\lambda}}, \tag{8}$$

$$\begin{aligned} \varepsilon_{hw}^{comp} &= \varepsilon_{hw} - mw\cdot\frac{\partial h}{\partial vy} \\ &= \varepsilon_{hw} + \left(\frac{\phi^{-\lambda}\ mw^{1-\lambda}}{1+\phi^{-\lambda}\cdot mw^{1-\lambda}}\right). \end{aligned} \tag{9}$$

An individual i's preference for consumption relative to leisure, ϕ_i can be posited as a function of observable individual characteristics variables such as age and the number of kids as below. Substituting this equation into equation (10) gives an empirically tractable leisure-consumption choice equation (11) that depends on marginal after-tax wage, age and the number of kids as main regressors.

$$\ln \phi_i = k_0 + k_1 age_i + k_2 kid_i + \varepsilon_i \tag{10}$$

$$\ln\left(\frac{l_i}{c_i}\right) = \beta_0 + \beta_1\ age_i + \beta_2\ kid_i + \beta_3\ \ln mw_i + \varepsilon_i \tag{11}$$

where $\beta_0 = -\lambda k_0$, $\beta_1 = -\lambda k_1$, $\beta_2 = -\lambda k_2$ and $\beta_3 = -\lambda$.

Specification 2: no Slutzky restriction imposed[10]
Specification 2 assumes the following direct utility function to arrive at a simple and empirically tractable labor supply equation:

$$\max_{\{c,l\}} U(c_i, l_i) = \left(\frac{1}{\gamma}\right)\left(h_i - \frac{\beta}{\gamma}\right)\exp\left\{-1 - \frac{\gamma[c_i + (Z\Theta + \varepsilon)/\gamma - \beta/\gamma^2]}{\beta/\gamma - h_i}\right\} \tag{12}$$

s.t. (a) $c_i = (1-t_i)\cdot w_i h_i + vy_i$

(b) $T = h_i + l_i$

Arranging for h and adding the intercept and the error term yields

$$h_i = \alpha + \beta mw_i + \gamma vy_i + Z_i\Theta + \varepsilon_i, \tag{13}$$

where Z_i = personal characteristics representing preferences.

Discussions on specifications

Compared to Specification 2, Specification 1's dependent variable in (11) is a non-linear function of leisure and consumption. This non-separable relationship between consumption and leisure may be more realistic. In contrast to the Hausman-type direct utility function approach, a potential positive correlation among regressors (e.g., between wage and non-labor income) does not occur because the non-labor income variable is treated as a part of the dependent variable (see the budget constraint (a) in equation (5)), and only wage and preference variables are explanatory variables. In this case, the source of identification comes more from how individuals adjust the ratio of leisure to consumption in accordance with wage changes. Certainly, these two approaches capitalize on different aspects of information. Although it is not exactly true that

[10] As we see below, the utility function is so general that violations of the Slutzky restriction is not precluded, which contrasts with Specification 1.

these two approaches complement with each other, it may be safer to try both alternative models to alleviate model-specific problems.

Ⅳ. ESTIMATION RESULTS

1. Estimates

Tables 3 and 4 below present estimates using the two suggested specifications [equations (11) and (13)], respectively. The OLS results followed by two IV estimates [two stage least squares (2SLS) estimates and limited information maximum likelihood[11] (LIML) estimates] are presented. The first set of IV is simply the pre-tax wage, and the second set is the well-known primary human capital variables, education and experience which are suggested by the theories on human capital. The third set of IVs includes both the pre-tax wage and human capital variables. Two different IV estimation techniques, the 2SLS and LIML estimations are undertaken to reduce the possibility of finite sample bias with the 2SLS estimation. Since LIML is known to be approximately median-unbiased even in a finite sample, it can help evaluate the quality of 2SLS estimates in a relatively small sample.

[Table 3] Estimation Results - Specification 1
dependent variable = log(l/c)

variable	OLS	IV=pretax wage	IV= human capital		IV=both	
			2SLS	LIML	2SLS	LIML
constant	-4.58 (0.25)	-3.15 (0.25)	-0.76 (0.61)	-0.67 (0.62)	-3.16 (0.25)	-3.13 (0.25)
# children	-0.07 (0.01)	-0.06 (0.01)	-0.05 (0.02)	-0.05 (0.02)	-0.06 (0.01)	-0.06 (0.01)
age	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)
log(*mu*)	-0.34 (0.03)	-0.51 (0.03)	-0.81 (0.08)	-0.83 (0.08)	-0.51 (0.03)	-0.52 (0.03)
# obs	808	808	808	808	808	808

Note: mw=marginal after-tax wage; vy=virtual non-labor income; #children=number of children; the numbers inside parentheses are standard errors. 2SLS=two stage least squares estimation; LIML=limited information maximum likelihood estimation: it is adopted to examine the presence of finite sample bias (See Staiger and Stock (1997) for the rationale).

[11] The LIML estimation is usually applied to a situation where a researcher wishes to estimate only the parameters of one structural equation. With a set of instruments for endogenous variables available, we can conduct LIML estimation without knowing the structural form of the other equations. The LIML estimator is obtained by maximizing the joint density of the dependent variables of the second-stage (structural) equation and the first-stage equation under the normality assumption with respect to all the coefficients and the error term parameters. See Amemiya (p. 235, 1985).

[Table 4] Estimation Results - Specification 2
dependent variable = log(h)

variable	OLS	IV= human capital		IV=both	
		2SLS	LIML	2SLS	LIML
constant	11.89	7.86	-38.13	12.48	12.87
	(0.12)	(8.20)	(432.21)	(0.27)	(0.43)
# children	0.02	0.05	0.61	-0.00	-0.01
	(0.01)	(0.10)	(5.25)	(0.01)	(0.02)
age	0.00	0.01	0.09	-0.00	-0.00
	(0.00)	(0.02)	(0.82)	(0.00)	(0.00)
log(mu)	-0.62	0.33	12.57	-0.90	-1.09
	(0.02)	(2.18)	(115.09)	(0.10)	(0.18)
log(vy)	0.09	-0.21	-4.65	0.23	0.32
	(0.01)	(0.79)	(41.68)	(0.05)	(0.09)
# obs	808	808	808	808	808

OLS estimates

Looking at the first column of Tables 3 and 4, we see the negative coefficient estimates that are statistically significant. Using the estimates and the formulae given in equations (8) and (9), we can recover the elasticity estimates for Specification 1: the OLS estimate -0.34 along with other estimates (see equation (11)) amounts to an uncompensated elasticity -0.40 and compensated elasticity 0.26.[12] For Specification 2, the OLS estimate of uncompensated wage elasticity is -0.62 with a high statistical significance and the OLS estimate of income elasticity is 0.09 with a high statistical significance, which is completely opposite to our prediction (that is, the quasi-concavity condition is not satisfied). This counter-intuitive result can arise because of the endogeneity of marginal after-tax wage induced by income taxation, and measurement errors in hours. As aforementioned, the pre-tax wage is constructed by dividing earnings by hours, so that measurement errors in hours carry into the pre-tax wage. Of course, as measurement errors in hours get larger, so do the measurement errors in the pre-tax wage (hence, marginal after-tax wage also), but because of the so-called "division bias," the correlation between hours and wage turns out to be more negative. This leads to a spurious negative correlation between the dependent variable and the wage variable. These two sources of endogeneity issues warrant IV estimation with a proper set of IVs.

IV estimation results using pre-tax as an IV

The literature of income tax effects on labor supply often uses pre-tax wage as an IV for the endogenous marginal after-tax wage variable (e.g., Ericson and Flood (1997)). This tradition is implicitly based on the assumption that the

[12] Note that all these elasticities for Specification 1 are obtained from equations (8) and (9).

pre-tax wage variable is strongly correlated with marginal after-tax wage but it is not correlated with the error term of a regression equation. However, given that measurement errors are supposedly high in the hours variable, correction for endogeneity arising from income tax only is not enough to generate consistent estimates of labor supply parameters, unless measurement errors are fixed at the same time. The result from Specification 1 shows that there was little gain in using the pre-tax wage as an IV for marginal after-tax wage: the estimate of the wage coefficient was found to be -0.51 for the 2SLS and -0.34 for the OLS estimation. Meanwhile, for Specification 2 (the model without restriction), the 2SLS estimation cannot be carried out because the number of endogenous regressors exceeds that of IV's (i.e., under-identified case).

IV estimation results using human capital IV's

However, the use of human capital instruments, such as education, experience and the square terms of the previous two variables, clearly makes an improvement on the OLS estimation results.[13] For Specification 1, there is a substantial change in magnitude of the wage coefficient estimate in using human capital variables as IV's for marginal after-tax wage: the estimate of the wage coefficient is -0.81 for the 2SLS estimation in contrast to -0.34 for the OLS estimation. The 2SLS estimate -0.81 along with other estimates amounts to an uncompensated elasticity -0.05 and an compensated elasticity 0.56. The compensated elasticity of 0.56 is certainly a substantial size, but a negligible size of the uncompensated elasticity of -0.05 means that the income effect associated with a wage change is also substantially high. Considering that excess burden is an increasing function of compensated elasticity, the income tax policy should pay more attention to this evidence. For other variables such as children and age, the estimates seem reasonable. First, the estimate of the children coefficient of -0.05 means that as a dependent child is added to a family, the leisure-to-consumption ratio of the main income earner of that family decreases on average by 5%, that is, a substitution of work for leisure; second, the estimate of the age coefficient of -0.01 means that as the main income earner gets older, the leisure-to-consumption ratio decreases by 1%. This is evidence of intertemporal substitution of work for leisure, since the wage reaches its peak typically at the age around mid 50's, which is almost the end of the sample age distribution. For Specification 2, the 2SLS estimation also shows that the signs of wage and income variables are "right" (in the sense that the compensated elasticity is positive), but their statistical significance is low.

Regarding the quality of the human capital instruments, such as education, experience and the square terms of the previous two variables, both theoretically and empirically they are most influencing ones for predicting individual income, and the correlation between the human capital instruments and the error term in

[13] The validity of human capital variables has been established in labor economics.

hours equation is not likely to exist, at least in theory.

IV estimation results using both pre-tax and human capital as IV's

The third estimation is to use both pre-tax and human capital variables as a set of IVs. The estimation results from this set of IVs are not difficult to predict. If pre-tax wage has a large extent of measurement errors, then the estimates tend to lean toward the OLS estimates but human capital IVs will partially offset the tendency of getting close to the OLS estimates, depending upon their explanatory power as IVs. Overall, the estimation results show some improvement on the OLS estimation results but they are clearly smaller than the estimates using human capital variables only.

Checking for finite sample bias

According to Staiger and Stock (1997), the use of weak instruments leads to the 2SLS estimates that are biased towards the OLS estimates. One way to check this possibility is to examine the LIML estimates which are known to be approximately unbiased in finite samples. For Specification 1, virtually no difference between 2SLS and LIML estimates is found, which can be interpreted that finite sample bias is not an issue in our estimates. Meanwhile the gap is a bit larger for Specification 2. We see a fairly large gap for using human capital IV's at Specification 2, but since standard errors are also very large, we cannot tell there is an influence of finite sample bias.

Overall pattern

In summary, our results support the following. First, the OLS estimates are seriously biased to the negative direction due to the endogeneity caused by income taxation and measurement errors. Second, regardless of differences in modelling and specification, a valid set of IV's (that is, human capital IV's) raises the elasticity of labor supply to about 0.56 as a preferred estimate. Combining all the evidence together, this paper shows that labor is moderately sensitive to marginal after-tax wage changes and that income effects are also fairly high.

2. Simulating the Effect of Income Taxation on Hours of Work

Simulation framework

This section provides simulation results under some hypothetical tax regimes. We first analyze simulated effects of income taxation on hours of work first, and then of excess burden later. The methodology used for this simulation can be summarized as follows: first, using an individual's before-tax wage rate, construct individual budget constraint (remember that the number of kinks can vary across individuals). To do this, we take into account the tax system of each year and other hypothetical alternative tax systems. Second, solve the consumer utility maximization problem under piecewise-linear budget constraint for each individual. In this step, our best estimates using human capital as IV's are used to figure out the utility function. Third, take the sample mean of individuals' optimum hours of work.

Hours of work

The first scenario is when labor income tax is completely eliminated. In this case, the main result is that hours of work increase by 120 hours. This is because tax distortions are removed and we have an improvement in efficiency. The second scenario is the case of implementing proportional income taxes (i.e., no progressivity) that collect the same tax revenue as the 1995 income taxes. It may seem a little surprising that proportional income taxes increase hours by 145, which is greater in magnitude than the case of complete removal of income taxes. This can be interpreted as follows: since the income effect is slightly larger than the substitution effect, a lowered income due to proportional income taxes can lead to a greater supply of labor. Finally, we show the simulation results when the 1996 income tax system is implemented.[14] The last row of Table 5 shows that hours of work under the 1996 tax system is greater than those under the 1995 system, because of its reduced progressivity.

[Table 5] Hours of Work

scenario	N	Means	Min.	Max
1995 income taxes	792	3213.47	0	4343.05
No Taxes	792	3334.12	0	4343.05
Proportional Taxes	792	3358.86	0	4368.78
1996 income taxes	792	3224.72	0	4323.95

Note: The proportional labor income tax rate of 0.060 can generate the actual tax revenue of 1995.

Excess burden

Excess burden is calculated in Table 6 under various scenarios. We measure excess burden in a crude but straightforward way. We first derive the labor supply curve based on the estimated utility function and calculate the consumer surplus (henceforth, CS) associated with the change in wage induced by income taxation. Then by subtracting tax revenue (T) from that amount, we define a conventional measure of excess burden from taxation.

As noted above, the value of excess burden is greater under the 1995 tax regime than the 1996 counterpart because of a higher progressivity, but tax revenue is also greater under the 1995 one. It indicates that the Korean

[14] For the sake of brevity, we do not show the specific details of the 1996 tax system here. A careful review of the 1996 income tax law reveals that it has a lower progressivity than the 1995 counterpart.

economy is at the increasing part of the Laffer curve. The proportional tax regime alleviates tax progressivity to a large extent, and it therefore reduces the amount of excess burden.

[Table 6] Excess Burden and Tax Revenue

scenario	CS	Tax Revenue (T)	EB=CS-T	EB/T
1995 income tax	1,165,850	999,585	166,261	0.17
1996 income tax	807,352	705,422	101,929	0.14
proportional tax	1,014,640	999,585	15,058	0.02

Note: Unit = 1,000 Wons; The proportional tax rate is set such that the tax revenue equals the actual 1995 income tax revenue.

Ⅴ. CONCLUDING REMARKS

This article presented empirical evidence about the income tax effects on labor supply and welfare in Korea. We first derived the labor supply function in the presence of progressive income taxation, and then conducted estimation of the labor supply equation with the specificities of the Korean income tax system cautiously taken into account. Econometrically, we adopted some sort of a "joint approach" of utilizing a piecewise-linear budget constraint combined with Ⅳ estimation to deal with the complex endogeneity in the wage measure: endogeneity induced by income taxation, and (ii) measurement error coupled with division bias.

Unlike the conventional perception of non-competitive features in a developing country's labor market, empirical evidence from the Korean labor market shows (i) a substantial substitution response to compensated wage changes (elasticity of about 0.56 in our preferred specification), and (ii) an equally large income effect. These results are based on two different specifications and Ⅳ estimation techniques for robustness.

Our results offer some policy implications: first, a distortion induced by income tax is not negligible in magnitude; second, labor supply responds substantially to temporary innovations, but changes very little to permanent innovations. Finally, policy simulation results using the empirical evidence suggests that excess burden is 17% and 14% of the total tax revenue in years 1995 and 1996, respectively. The economy seems to be at the increasing part of the Laffer curve.

Some informal discussion of our results may be useful in understanding the implications. Despite some rigidities in the labor market, such as fixed hours contracts, limited availability of competing jobs, and liquidity traps for low income groups, labor supply is found to be moderately sensitive to wage incentives. If the labor market restrictions mentioned above were eliminated, greater labor supply responses would be expected.

Given the possibilities of rising income inequality and the subsequent high demand for redistribution, the role of income tax and the extent of progressivity are likely to be given more attention. In line with this work, subsequent research on the evaluation of the previous income tax reforms seems warranteed in preparation for future income tax reforms. For a more comprehensive study, databases with greater observations and precision on income and hours of work variables are required. At the same time, more sophisticated estimation techniques dealing with measurement errors and restrictions on models need to be studied in order to understand the sensitivity of estimates to model specifications. A Monte Carlo evaluation of the models used in the paper is a promising route to pursue.

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Appendix: Leisure Demand with Piece-wise Linear Budget Constraint

The relationship between expenditure B, leisure l, leisure l^* at kink point, and consumption c (or budget) is defined as follows:

$$B = w_1 l + c \qquad \text{if } l \leq l^*$$
$$B = w_1 l^* + w_2(l - l^*) + c \qquad \text{if } l > l^* \tag{A-1}$$

The above relationship also can be expressed in a different framework as follows:

$$B = w_1 l + c \qquad \text{if } l \leq l^*$$
$$\hat{B} = w_2 l + c \qquad \text{if } l > l^* \tag{A-2}$$

where $\hat{B} = B + (w_2 - w_1) l^*$. In contrast to B, $\hat{B}$ is called "virtual" income in the second segment with wage w_2. Note that it varies in accordance with the change in the marginal after-tax wage. For the sake of notational consistency, it may be more convenient to introduce VI_i to denote virtual income defined at wage w_i in segment i. Thus $\hat{B}$ in the current case amounts to VI_2.

Given the above discussion, it is possible to define the conditional leisure demand function for conditions such as $l \leq l^*$, or $l > l^*$, then as follows:

$$l = g(w_1, VI_1) \qquad \text{if } l < l^*$$
$$l = l^* \qquad \text{if } l = l^* \tag{A-3}$$
$$l = g(w_2, VI_2) \qquad \text{if } l > l^*$$

where $g(\cdot)$ is called the 'conditional demand function' because it represents the hours of leisure conditional on a segment or kink where individuals settle. Given that individuals are offered three options to choose from, i.e., segment 1, segment 2, or the kink, the utility maximizing hours of leisure (hence hours of work) is determined by the following conditional indirect utility function:

$$\begin{aligned} V(w, VI) &= \max_{l, c} [U(l, c)] \quad s.t. \ c + wl = wT \\ &= U[g(w, VI), VI - w \cdot g(w, VI)] \end{aligned} \tag{A-4}$$

Since most countries' income tax systems are progressive, the budget set individuals face turns out to be piecewise-linear and convex. Thus, individuals' budget constraints involve some kinks, and some individuals have at maximum, as many kinks as the number of tax brackets minus one. In the case of two tax brackets, we can describe the leisure demand under three possible scenarios as follows:

If $V(w_1, VI) > U(l^*, c^*)$, $V(w_1, VI_1) > V(w_2, VI_2)$, and $g(w_1, VI_1) < l^*$.
then hours are chosen at segment 1. (A-5-1)

If $V(w_2, VI_2) > V(w_1, VI)$, $V(w_2, VI_2) > U(l^*, c^*)$, and $g(w_2, VI_2) > l^*$.
then hours are chosen at the kink. (A-5-2)

If $U(l^*, c^*) > V(w_1, VI_1)$, and $U(l^*, c^*) > V(w_2, VI_2)$
then hours are chosen at segment 2. (A-5-3)