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A Note on Wage Regressions and Benefits

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Abstract

In economics it is common to study how a certain policy affects the compensation that firms are willing to pay to their workers. To this end, many papers use a regression with the log of wage as dependent variable. However, wages are only a component of compensation as non-legally required benefits now amount to more than 23% of compensation in the United States. I show that, because of the presence of benefits, the effect of a policy on wages may be different from the effect of that policy on compensation. If so, the wage regression, even if it correctly estimates the effect of a policy on wages, may not correctly estimate the effect of the policy on compensation. I use a simple model of utility maximization to derive an expression for the bias of the wage regressions. I then use that expression to quantify the bias as a function of the model's parameter values. I conclude suggesting possible avenues to address this issue in future empirical work.

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1 Motivation

Usually economic models generate predictions about the effect of a policy T on the amount that an employer is willing to spend on a worker. For example, in the perfect competition model firms pay workers the value of their marginal product: if a policy increases the worker's marginal product, the compensation of the worker will go up. Based on such predictions, empirical studies then estimate a variant of the following regression:

$$ln(W) = \alpha + \epsilon_{WT} ln(T) + \gamma X + \epsilon \quad (1)$$

where ln is the natural log, W denotes wages, X is a vector of other regressors and ϵ_{WT} is the elasticity of W with respect to T.[1]

However, wages are only a component of compensation: non-legally required benefits now amount to more than 23% of compensation in the United States.[2] In the model below I show that ϵ_{WT} need not be equal to the elasticity of compensation with respect to T. As I show below, in some cases the wage regression may even get the *sign* of such effect wrong, not just its magnitude. While my results apply to any policy T which affects compensation, below I use international trade policies as examples. I will also confine my discussion to the U.S. context but the logic of this note should apply to any other country where non-legally required benefits are a part of compensation.

2 Theory

A basic model used to study the wage-benefits mix in compensation is the following (see e.g. Currie and Madrian (1999, p. 3364)).[3] Suppose that the worker's utility function is $U(B, W)$ where B are her benefits and W is her wage, both expressed in real dollars. The utility function is well-behaved (i.e. continuous, monotonic and quasi-concave). The compensation of a worker, denoted with C, is also expressed in real dollars. C includes the wage and benefits' cost of compensating a worker. The employer can "convert" C dollars into wages and benefits according to the constraint $C = PB + W$ where P is the "price" of a dollar of benefits in terms of a dollar of wages. This price captures in a simple way the fact that some employers may be more effective at providing benefits than others, i.e. their

[1] For the effect of trade-related variables on wages, see e.g. Attanasio et al. (2004), Liu and Trefler (2011), Hummels et al. (2014), Ebenstein et al. (2014) and Tempesti (2015). The policy T, rather than its natural log, $ln(T)$, enters equation (1) in some of these studies. Using $ln(T)$ simplifies the presentation below but does not affect any of the results.

[2] See the column for civilian workers in Table A of Bureau of Labor Statistics (2015b). Overall, benefits are 31.3% of compensation, with 7.6% of compensation being in *legally* required benefits such as Social Security, Workers' Compensation, and unemployment insurance. The other 23.7% of compensation is in non-legally required benefits: the employers may opt to not provide these benefits and/or the employees may opt to not receive them. The focus of this paper is on non-legally required benefits.

[3] This is also the model used to motivate the empirical analysis in Tempesti (2016). However, as explained below, in this note I use a specific functional form for the utility function. This allows me to derive an explicit expression for the difference between the elasticity of wages with respect to a policy and the elasticity of compensation with respect to that policy.

P will be lower.[4] In the following discussion, I will emphasize the fact that larger firms are much more likely than smaller firms to offer benefits (Bureau of Labor Statistics (2015a)). The relationship $C = PB + W$ acts therefore as a budget constraint for the worker who will choose her preferred bundle out of those offered to her.

Note that individuals can also purchase benefits such as health insurance individually and not through their employers. I do not model this choice for two reasons. First, individuals tend to purchase most of their benefits through their employers. For example, Gruber (2008, Table 1) finds that in U.S. in 2008 only 6.8% of the population purchases health insurance on its own as opposed to 62.2% who obtain coverage through their, or their relative's, employment. Second, if a worker purchases benefits on her own, then her reported wages will be closer to her actual compensation, i.e. what the employer spends to pay her. Insofar as our interest is on the effect of the policy T on compensation, this is an advantage.

Some additional remarks about this model are in order. First, different taxes on benefits relative to wages may also affect the wage-benefits mix: I discuss taxes in sections 2.2 and 2.3. Second, for simplicity I assume that all benefits have the same price P. In reality there is a variety of benefits, such as health insurance, life insurance, retirement plan etc., each with their own relative price. Third, the model is static and so the worker "consumes" benefits in the same period he works. However, non-legally required retirement benefits are included in B and resources devoted to retirement funds are more appropriately characterized as *deferred* consumption rather than as instantaneous consumption.[5] A dynamic model of the choice of benefits is beyond the scope of this paper.

Given the assumptions above, a worker then solves:

$$\max_{B,W} U(B,W) \text{ s.t. } PB + W = C \tag{2}$$

In the model, the worker takes P and C as exogenous and so the worker's optimal choice of (B,W) can be written as a function of P and C. In turn, P and C may be a function of the policy T. For example, trade liberalization may affect the compensation of workers in import-competing industries. Importantly, the policy T may also affect P. For example, in the popular trade model of Melitz (2003), trade liberalization reduces the size of less productive firms but increases the size of the most productive firms. If larger firms are more efficient at offering benefits, then with trade liberalization workers at more (less) productive firms may face a more (less) favorable, i.e. lower (higher), P. To sum up, the policy may affect the overall compensation of a worker and/or the price of benefits he faces and, through them, his optimal choice of B and W. By totally differentiating the optimal B and W with respect to T, we obtain the relationship between the optimal (B,W) bundle and changes in policy T as mediated by their effects on P and C:

$$\epsilon_{BT} = \epsilon_{BP}\epsilon_{PT} + \epsilon_{BC}\epsilon_{CT} \tag{3}$$

$$\epsilon_{WT} = \epsilon_{WP}\epsilon_{PT} + \epsilon_{WC}\epsilon_{CT} \tag{4}$$

[4]Woolhandler et al. (2003, p. 771) find that in 1999 U.S. employers spent $15.9 billion on administrative costs related to health care benefits, i.e. approximately 0.16 percent of GDP.

[5]The decision to purchase health insurance can also be seen as a form of investment in health (Grossman (1972) and Bundorf (2002)).

where $\epsilon_{st} \equiv \frac{dln(s)}{dln(m)}$ is the elasticity of the variable s with respect to the variable m.[6]

As argued above, economic models usually generate predictions about ϵ_{CT} which are then tested in empirical work. As equation (4) shows, ϵ_{WT} need not be equal to ϵ_{CT}. So, even if the regression model (1) is well specified, it will consistently estimate ϵ_{WT}, not necessarily ϵ_{CT}. The difference between ϵ_{WT} and ϵ_{CT} is the *bias* of regression (1). In order to illustrate the different channels through which ϵ_{WT} may differ from ϵ_{CT}, it is convenient to specify a functional form for the utility function. In Section 2.2 I then use such functional form to benchmark the bias in regression (1).

2.1 Stone-Geary Utility Function

Let the worker's utility function for benefits, B, and wages, W, be of the Stone-Geary form, i.e. let $U(B,W)$ be equal to:

$$\begin{cases} \left[\alpha B^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(W-\gamma)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} & \text{for } \sigma \neq 1 \\ B^{\alpha}(W-\gamma)^{(1-\alpha)} & \text{for } \sigma = 1 \end{cases} \tag{5}$$

where $\sigma \in [0, +\infty)$, $\alpha \in (0,1)$ and $\gamma \geq 0$.[7,8] Then it can be shown that the optimal solutions to problem (2) are:

$$B = \frac{P^{-\sigma}(C-\gamma)}{P^{1-\sigma} + A^{\sigma}} \tag{6}$$

$$W = \frac{A^{\sigma}C + \gamma P^{1-\sigma}}{P^{1-\sigma} + A^{\sigma}} \tag{7}$$

where $A \equiv (1-\alpha)/\alpha$. Using W from (7), we can differentiate $ln(W)$ with respect to $ln(P)$, respectively $ln(C)$, and obtain:

$$\epsilon_{WP} = (\sigma - 1)\left(\frac{A^{\sigma}P^{1-\sigma}}{P^{1-\sigma} + A^{\sigma}}\right)\left(\frac{C-\gamma}{A^{\sigma}C + \gamma P^{1-\sigma}}\right) \tag{8}$$

$$\epsilon_{WC} = \frac{A^{\sigma}C}{A^{\sigma}C + \gamma P^{1-\sigma}} \tag{9}$$

Here I discuss two channels through which ϵ_{WT} may differ from ϵ_{CT}. In order to distinguish these two channels, it is useful to distinguish two specific scenarios: 1) $\epsilon_{PT} = 0$ and $\gamma > 0$; 2) $\epsilon_{CT} = 0$ and $\gamma = 0$. I provide a general formula at the end of the subsection.

[6] The Appendix contains a more extended derivation of 3 and 4.

[7] γ can be interpreted as the amount of wages the worker "needs". I assume that the worker can always meet this need, i.e. that $C > \gamma$.

[8] A three goods version of this utility function is used in Matsuyama (2009). Woodbury (1983, p. 170) uses instead a translog utility function to model fringe benefits. This allows him to structurally estimate some parameters of interest such as the elasticity of substitution between benefits and wages. However, here the focus is on the true effect of a given policy on compensation, not so much on the structure of preferences, which is taken as given. As shown below, a Stone-Geary utility function allows us to come up with an expression which relates the true effect of a policy on compensation with the effect that is usually estimated using regression (1).

Case 1 $\epsilon_{PT} = 0$ *and* $\gamma > 0$

In this first case, assuming $\epsilon_{PT} = 0$ means that the policy possibly affects only C but not P. Plugging $\epsilon_{PT} = 0$ into (4), we have that $\epsilon_{WT} = \epsilon_{WC}\epsilon_{CT}$. Then, using (9), we have that:

$$\epsilon_{WT} = \frac{A^\sigma C}{A^\sigma C + \gamma P^{1-\sigma}} \epsilon_{CT} \tag{10}$$

In this case ϵ_{WT} and ϵ_{CT} have the same sign because $\epsilon_{WC} = \frac{A^\sigma C}{A^\sigma C+\gamma P^{1-\sigma}} > 0$. But given that $\gamma > 0$, $\frac{A^\sigma C}{A^\sigma C+\gamma P^{1-\sigma}} < 1$ and so $\frac{A^\sigma C}{A^\sigma C+\gamma P^{1-\sigma}} \in (0,1)$. Because of (10), this implies that $|\epsilon_{WT}| < |\epsilon_{CT}|$. Because $\gamma > 0$, the utility function displays *non-homotheticity*: benefits are a *luxury good*, i.e. they increase more than proportionally with compensation (i.e. $\epsilon_{BC} > 1$), while wages are a necessary good, i.e. they increase less than proportionally with compensation (i.e. $\epsilon_{WC} < 1$). In this scenario, the regression (1) gives the correct sign of ϵ_{CT} but it *underestimates* the magnitude of ϵ_{CT}, be it positive or negative. In this case, the difference between ϵ_{WT} and ϵ_{CT} is given by $\epsilon_{WT} - \epsilon_{CT} = -\frac{\gamma P^{1-\sigma}}{A^\sigma C+\gamma P^{1-\sigma}}\epsilon_{CT}$.

Case 2 $\epsilon_{CT} = 0$ *and* $\gamma = 0$

In this second case, assuming $\epsilon_{CT} = 0$ means that the policy possibly affects only P but not C. Plugging $\epsilon_{CT} = 0$ into (4), we have that $\epsilon_{WT} = \epsilon_{WP}\epsilon_{PT}$. Assuming $\gamma = 0$ implies that the utility function has a constant elasticity of substitution (CES), equal to σ. Plugging $\gamma = 0$ into (8), we have that $\epsilon_{WP} = (\sigma - 1)\frac{P^{1-\sigma}}{P^{1-\sigma}+A^\sigma}$. So for this second case we finally have that:

$$\epsilon_{WT} - \epsilon_{CT} = \epsilon_{WT} = (\sigma - 1)\frac{P^{1-\sigma}}{P^{1-\sigma} + A^\sigma}\epsilon_{PT} \tag{11}$$

In this scenario, ϵ_{WT} underestimates (overestimates) ϵ_{CT} depending on $(\sigma - 1)\epsilon_{PT}$ being negative (positive).[9] Equation (11) shows that the regression (1) may even get the *sign* of ϵ_{CT} wrong, not just its magnitude. A graphical example may help. Consider a worker for whom $\epsilon_{CT} = 0$ but $\epsilon_{PT} < 0$: e.g. the policy does not increase the value of the marginal product of the worker, hence her compensation is unchanged, but the policy reallocates the worker to a larger firm where the price of benefits is lower. Assume, as found in Woodbury (1983), that $\sigma > 1$, i.e. that wages and benefits are relatively easy substitutes. In this case, from (11), the worker will decrease her wages as $(\sigma - 1)\epsilon_{PT} < 0$ and $\epsilon_{CT} = 0$. But with $\epsilon_{PT} < 0$ and $\epsilon_{CT} = 0$, her budget constraint is rotating upward which allows her to obtain more benefits. Figure 1 illustrates this case. The regression (1) will estimate a negative effect of the policy on wages even though there is no effect of the policy on compensation.[10]

Case 3 *General Case*

[9] Woodbury (1983) estimates σ to be larger than 1. If so, then ϵ_{WT} underestimates (overestimates) ϵ_{CT} depending on ϵ_{PT} being negative (positive).

[10] Note that it is possible to modify the example above so that there is a small positive effect of the policy on compensation, and so $\epsilon_{CT} > 0$, but nonetheless the worker opts to reduce her wages because the price effect $\epsilon_{PT} < 0$ dominates when σ is large.

By plugging (8) and (9) in (4) we obtain the general difference between ϵ_{WT} and ϵ_{CT}:

$$\epsilon_{WT} - \epsilon_{CT} = (\sigma - 1)\left(\frac{A^\sigma P^{1-\sigma}}{P^{1-\sigma} + A^\sigma}\right)\left(\frac{C-\gamma}{A^\sigma C + \gamma P^{1-\sigma}}\right)\epsilon_{PT} - \frac{\gamma P^{1-\sigma}}{A^\sigma C + \gamma P^{1-\sigma}}\epsilon_{CT} \quad (12)$$

The regression (1) estimates ϵ_{WT}. This will be an unbiased estimate also of ϵ_{CT} if and only if $\epsilon_{WT} - \epsilon_{CT} = 0$. Equation (12) shows that, for the Stone-Geary utility function, $\epsilon_{WT} - \epsilon_{CT} = 0$ holds only if one of the following (mutually exclusive) condition holds:

I) Both terms on the right-hand side in (12) are zero, i.e. ($\sigma = 1$ or $\epsilon_{PT} = 0$) and ($\gamma = 0$ or $\epsilon_{CT} = 0$).

II) Both terms on the right-hand side in (12) are non-zero but they happen to sum up to zero, which, after rearranging terms, is equivalent to $\epsilon_{CT} = (\sigma - 1)(\frac{A^\sigma}{P^{1-\sigma}+A^\sigma})(\frac{C-\gamma}{\gamma})\epsilon_{PT}$.

2.2 Benchmarking Wage Regressions' Bias

We can use (12) to benchmark the bias of the wage regression (1). Before doing so, we need to introduce taxes in the model. I do so by adding to the model a uniform tax rate on wages. I discuss the role of progressive taxation in Section 2.3.

Suppose that there is a uniform (percentage) tax rate t on wage compensation and that the employee has wage as only source of income and that he is filing taxes as a single person.[11] Then the budget constraint becomes $PB + W_G = C$ where W_G is the gross wage and C is gross compensation. In other words, the overall worker's cost to the employer, C, equals the amount the employer spends for the worker's benefits, i.e. PB, which is paid with pre-tax dollars, and the amount the employer spends in wages, i.e. the *gross* wage W_G. But the worker does not care about the gross wage, only about her *after-tax* wage, denoted, as above, with W. Given that $W_G = W/(1-t)$ we have that $PB + \frac{W}{1-t} = C$, i.e. $\widetilde{P}B + W = \widetilde{C}$ where $\widetilde{P} \equiv P(1-t)$ and $\widetilde{C} \equiv C(1-t)$. In this case, we can just substitute $\widetilde{P}$ and $\widetilde{C}$ for, respectively, P and C in equation (12) and that equation will still hold. If we also assume that the tax rate is exogenously given, and so unaffected by the policy T, then we also have $\epsilon_{\widetilde{C}T} = \epsilon_{CT}$ and $\epsilon_{\widetilde{P}T} = \epsilon_{PT}$.[12] Putting all these assumptions together, we have:

$$\epsilon_{WT} - \epsilon_{CT} = (\sigma - 1)\left(\frac{A^\sigma \widetilde{P}^{1-\sigma}}{\widetilde{P}^{1-\sigma} + A^\sigma}\right)\left(\frac{\widetilde{C}-\gamma}{A^\sigma \widetilde{C} + \gamma \widetilde{P}^{1-\sigma}}\right)\epsilon_{PT} - \frac{\gamma \widetilde{P}^{1-\sigma}}{A^\sigma \widetilde{C} + \gamma \widetilde{P}^{1-\sigma}}\epsilon_{CT} \quad (13)$$

Consider the term multiplying ϵ_{PT} in equation (13), i.e. $(\sigma-1)\left(\frac{A^\sigma \widetilde{P}^{1-\sigma}}{\widetilde{P}^{1-\sigma}+A^\sigma}\right)\left(\frac{\widetilde{C}-\gamma}{A^\sigma \widetilde{C}+\gamma \widetilde{P}^{1-\sigma}}\right)$.

[11] For simplicity here I ignore other taxes such as the Old-Age, Survivors, and Disability Insurance (OASDI) tax and other employer's contributions such as unemployment insurance and Workers' Compensation.

[12] This is easy to see: e.g. $\epsilon_{\widetilde{C}T} \equiv \frac{dln\widetilde{C}}{dlnT} = \frac{dlnC(1-t)}{dlnT} = \frac{dlnC}{dlnT} + \frac{dln(1-t)}{dlnT} = \frac{dlnC}{dlnT}$ where the last equality is due to the fact that the policy T does not affect the tax rate t. The assumption that the policy does not affect the tax rate is not always innocuous. For example, Egger et al. (2016) document that globalization induced OECD countries to increase the tax-burden of middle-class workers and at the same time to reduce the tax-burden on the top 1% of workers.

Note that its sign depends on whether $\sigma > 1$.[13] If benefits and wages are good substitutes ($\sigma > 1$), then the sign of this term is positive. The term multiplying ϵ_{CT} in equation (13), i.e. $\frac{-\gamma \widetilde{P}^{1-\sigma}}{A^{\sigma}\widetilde{C}+\gamma \widetilde{P}^{1-\sigma}}$, is instead negative. So, if $\sigma > 1$, then the two terms multiplying, respectively, ϵ_{PT} and ϵ_{CT} have opposite sign, a point we return to below.

For the benchmark exercise, I plug the following parameter values in equation (13): $\sigma = 1.67$, $P = 1$, $t = 0.35$ $\gamma = \$12,316$, $C = \$62,640$ and $A = 1.38$ (i.e. $\alpha = 0.42$). The value for σ comes from Woodbury (1983, p.176, Table 6, column 5).[14] As in Woodbury (1983), as benchmark, I assume that the net of tax price of benefits P is 1 so that a firm can convert a dollar of wages into a dollar of benefit. I allow for the fact that the policy may increase or reduce P relative to this benchmark value. Gruber (2008, p. 574) estimates that for a typical worker, "a dollar of health insurance costs 35 cents less than a dollar of other goods purchased with after-tax wages".[15] For the value of the tax rate t, I then use 35%. The Stone-Geary utility function (5) is not defined when $W < \gamma$. As already mentioned, γ can then be interpreted as the amount of dollars an individual needs to meet his basic needs. So for γ I use the value of the the poverty line for an unmarried individual under 65 years old in 2014, i.e. \$12,316 (DeNavas-Walt and Proctor (2014, p.43)). C is the total cost of an employee to his employer. According to the Bureau of Labor Statistics "Private industry employers spent an average of \$31.32 per hour worked for total employee compensation in December 2014" (Bureau of Labor Statistics (2015c)). For a workers who works 40 hours a week for 50 weeks a year, this amounts to \$62,640, which is the value of C I use.[16] I choose the value of A (i.e. of α as $A \equiv (1-\alpha)/\alpha$) so that the share of the gross wage in gross compensation is 69.4%. This is the share of gross wage in gross compensation for private industry workers in December 2014, according to Table A in Bureau of Labor Statistics (2015c).[17] The Appendix contains more details on the computation of A.

As apparent in equation (13), the bias of a wage regression depends on both ϵ_{PT} and ϵ_{CT}. These values in turn depend on the particular policy T being studied. Here I consider the possible combinations where $\epsilon_{PT}, \epsilon_{CT} \in \{-1, 0, 1\}$. For these combinations of ϵ_{PT} and ϵ_{CT}, and for the parameter values specified above, the values of the bias in equation (13) are given in Table 1.

[13] Note that we implicitly assume that $\widetilde{C} > \gamma$. If not, then W has to be lower than γ and so the worker cannot meet her "basic needs" γ even if she chooses $B = 0$.

[14] Two remarks are in order. First, Woodbury (1983) obtains these estimates using a translog indirect utility function, which is different from the Stone-Geary utility function adopted in equation (5). Second, depending on the sample and the specification, the estimates of σ inWoodbury (1983) range from 1.23 to 9.38 (see Table 9 and 10 therein).

[15] Selden and Gray (2006, p. 1571) obtain the same estimate.

[16] Note that this figure includes all the components of compensation, i.e.: the after-tax employee earnings (not inclusive of benefits), the taxes paid by the employee (e.g. federal and state taxes and the employee's portion of the payroll tax), the taxes paid by the employer (e.g. the employer's portion of the payroll tax, unemployment insurance and Workers' Compensation), the pre-tax benefits paid by the employee (e.g. the employee's premium for health insurance and his contribution to a retirement plan) and the pre-tax benefits paid by the employer (e.g. the employer's contribution to the employee's health insurance and retirement plan).

[17] So I set the share of gross benefits in gross compensation to 30.6%. Note that, according to Bureau of Labor Statistics (2015c), 30.6% is the share, in gross compensation, of *all* employee benefits, *both the legally required and the not-legally required ones*. However, my model does not include legally required benefits, only the not-legally required ones.

Table 1: The Bias of Log Wage Regressions

ϵ_{PT} \ ϵ_{CT}	-1	0	1
-1	0.03	-0.17	-0.36
0	0.19	0.00	-0.19
1	0.36	0.17	-0.03

The values in the tables are computed using equation (13) in the text and the following parameter values: $\sigma = 1.67$, $P = 1$, $t = 0.35$ $\gamma = \$12,316$, $C = \$62,640$ and $A = 1.38$

Some comments are in order. First, when ϵ_{PT} and ϵ_{CT} have the same sign and also $\sigma > 1$, the two addends in equation (13) have opposite sign and so they tend to offset each other. That is why the bias is smaller along the diagonal of Table 1 and larger in absolute value when ϵ_{PT} and ϵ_{CT} have the opposite sign. For example, if a policy T increases compensation C (i.e. $\epsilon_{CT} > 0$) but also decreases P (i.e. $\epsilon_{PT} < 0$) , then a employee will substitute away from wages toward benefits and so the elasticity of wages with respect to T will be lower than the elasticity of compensation with respect to T.[18] Second, as Table 1 shows, the sign of the bias can be positive or negative and cannot be signed *a priori*. Third, the columns contain the true (but unknown to the econometrician) values of ϵ_{CT}: when $\epsilon_{CT} \neq 0$, the entries on the table can also be interpreted as percentage differences from the true value of ϵ_{CT}. For example, when $\epsilon_{CT} = 1$ and $\epsilon_{PT} = -1$, the bias of a wage regression will be 0.36, more than a third of the true value of ϵ_{CT}. According to Table 1, the bias of wage regressions can be sizable.

2.3 Tax Brackets

While Table 1 provides a useful benchmark, in reality the tax rate varies by income brackets. In this subsection I argue that progressive taxation constitutes an additional and independent channel through which ϵ_{WT} may differ from ϵ_{CT}. Because progressive taxation makes the budget constraint non-linear, it is harder to come up with clean expressions for the bias, such as the one in equation (13), without resorting to a lengthy taxonomy which may obfuscate the main issues. For this reason I conduct the analysis mainly graphically. Some analytical results are presented in the Appendix.

Progressive taxation is relevant for our results because the policy T may push a worker's compensation into a different tax bracket. Therefore, T may affect the tax rate faced by the worker. For simplicity, suppose that there are only two tax brackets: wage up to λ is taxed at the rate t_1; wage in excess of λ is taxed at the rate t_2, with $t_2 > t_1$. In this case, the shape

[18] This fact is relevant for empirical tests of the model in Melitz (2003). Indeed, that model predicts that trade liberalization will both increase the real compensation of workers and also reallocate workers to larger firms where presumably the price of benefits is lower.

of the budget constraint depends on whether the gross compensation C is smaller or greater than the tax threshold λ.

If $C \leq \lambda$, then the budget constraint has the simple form:

$$P(1-t_1)B + W = C(1-t_1) \tag{14}$$

If $C > \lambda$, then the budget constraint has a kink and it becomes:

$$\begin{cases} P(1-t_1)B + W = C(1-t_1) & \text{if } W \leq (1-t_1)\lambda \\ P(1-t_2)B + W = \lambda(1-t_1) + (1-t_2)(C-\lambda) & \text{otherwise} \end{cases} \tag{15}$$

Suppose that, before the policy shock, compensation was smaller or equal to λ and that the policy pushes compensation above λ. Then the budget constraint goes from being equal to (14) to being equal to (15). To isolate the role of taxes, let me ignore the previous channels through which ϵ_{CT} may differ from ϵ_{WT}. So I assume that the utility function is homothetic (i.e. $\gamma = 0$, so that $\epsilon_{BC} = \epsilon_{WC} = 1$) and that the policy has no effect on the price of benefits P (i.e. $\epsilon_{PT} = 0$).

I distinguish two relevant scenarios using Figure 2 and Figure 3. In Figure 2, before the policy, the compensation is $C_1 = \lambda$, with the associated budget constraint. In this case, the employee's optimal bundle is point D. If the policy increases compensation to $C_2 > \lambda$, then the budget constraint shifts up and becomes kinked. With a uniform tax rate t_1, the budget constraint associated to C_2 would instead be the line going from $(0, (1-t_1)C_2)$ to $(C_2/P, 0)$: for future reference, I draw the upper segment of this line as dashed. In the first scenario, which is depicted in Figure 2, after the policy increases compensation to C_2, the employee's optimal bundle is at point G. Even after the policy shock, the employee chooses along the portion of the budget constraint with slope equal to (negative) $P(1-t_1)$. So the relative price faced by the employee has not changed. In this case, the proportional change of B and W is the same and is also equal to the proportional change in C.[19] The same result holds if the compensation before (after) the policy is instead C_2 (C_1) so that the worker's optimal bundle before (after) the policy is at point G (D).

The second scenario is represented in Figure 3 where, again, the compensation is $C_1 = \lambda$ before the policy and $C_2 > \lambda$ after the policy. Point D is the employee's optimal bundle when compensation equals C_1. If, after the policy, W were to change at the same percentage rate as compensation, then the employee's optimal bundle would be point H. However, point H is outside the budget constraint associated to C_2 because of progressive taxation: as $t_2 > t_1$, the actual budget constraint is below the dashed line for $W > (1-t_1)\lambda$. In this scenario, the percentage change in W underestimates the percentage increase in compensation as the optimal value of W is below the value of W at point H. This problem is made more severe by the fact that, after the policy shock, the employee chooses along the portion of the budget constraint with slope equal to (negative) $P(1-t_2)$.[20] By our assumption that $t_2 > t_1$, we have

[19] This follows from our assumptions that the policy affects compensation ($\epsilon_{CT} \neq 0$) but not the price of benefits (i.e. $\epsilon_{PT} = 0$) and that the utility function is homothetic, i.e. $\gamma = 0$. In this case, $\epsilon_{WC} = 1$. In other words, the elasticity of after-tax wages with respect to gross compensation is 1. The same is true for the gross wage which is equal to $W/(1-t_1)$.

[20] The employee will not choose any point on the steeper segment of the budget constraint: if he did, then,

that $P(1-t_2) < P(1-t_1)$. So the employee now faces a lower relative price of benefits. As long as $\sigma > 0$, i.e. preferences are not Leontief, the employee's utility function intersects the budget constraints from above at point F, i.e. the intersection between the upper segment of the kinked budget constraint and the the ray from the origin through point D. Therefore, if $\sigma > 0$, the employee will increase his consumption of benefits more than proportionally than his wage, by choosing a point to the south-east of F, along the portion of the budget constraint between F and G.[21,22] This will increase the difference between the percentage change in W and the percentage change in C.

This graphical analysis clarifies that progressive taxation is not a problem *per se*. Indeed, in the scenario in Figure 2, the percentage change in both gross and after-tax wage is equal to the percentage change in compensation.[23] However, this is not the case for the scenario in Figure 3 where the percentage change in wage understates the percentage change in compensation.

Regarding progressive taxation, one final point needs to be addressed. As discussed below in Section 3, the regressions such as (1) usually use the log of the *gross* wage, not of the after-tax wage, as dependent variable. In Theorem .4 in the Appendix I show that, in the scenario in Figure 3, the percentage increase in the *gross* wage induced by a policy will be higher than the policy-induced percentage increase in the *after-tax* wage.[24] In this sense, using the log of the gross wage as dependent variable may reduce the bias of regression (1) which is due to progressive taxation.

3 Data

The model above relies on the sharp distinction between wages and benefits. However, in terms of data collection, the distinction is less sharp. For example, the Current Population Survey (CPS hereafter) asks about wages before taxes (i.e. gross wages) and before deductions.[25] Given that deductions may also include, e.g., the *employee*'s contribution to health insurance and to a retirement plan, this measure of wage does include some benefits too. It is possible then that using the log of the CPS wage as dependent variable would reduce the

by homotheticity, he would not have chosen point D *before* the policy.

[21] The optimal point could be G itself.

[22] It should be clear that, by the same logic, if the policy moves the optimal bundle from a point on the segment between F and G to point D, then the percentage change in W underestimates (in absolute value) the percentage *decrease* in compensation.

[23] Obviously this depends on our assumptions that $\gamma = 0$ and $\epsilon_{PT} = 0$.

[24] With Theorem .5 I also show that in this scenario the percentage increase in the gross wage induced by the policy may be even higher than the policy-induced percentage increase in gross compensation: in this case, the positive effect of the policy on compensation would be overstated, rather than understated. In other words, using as dependent variable the log of the gross wage, rather than the log of the after-tax wage, may change the sign of the bias from negative to positive.

[25] "Money wage or salary income is the total income people receive for work performed as an employee during the income year. This category includes wages, salary, armed forces pay, commissions, tips, piece-rate payments, and cash bonuses earned, before deductions are made for items such as taxes, bonds, pensions, and union dues." See the definition of *Earnings* at $https://www.census.gov/programs-surveys/cps/technical-documentation/subject-definitions.html\#earnings$

bias relative to the benchmark in Table 1.[26]

If the CPS wage was a constant (i.e. unaffected by policy) fraction of compensation, then the elasticity of the CPS wage with respect to a certain policy T would be equal to ϵ_{CT}, i.e. the elasticity of compensation with respect to T. In this case, regression (1) would estimate ϵ_{CT} if one used as dependent variable the log of the CPS wage. However, even if the CPS wage does include some benefits, the CPS wage need not be a good proxy of overall compensation. First, wages do not include the *employer*'s contribution to benefits. This amount can be substantial for some benefits, e.g. on average 80% of the total premium for health insurance coverage for a single individual plan (see Bureau of Labor Statistics (2015a, Table 3)). Second, the share of benefits which is paid by an employee - and, which, if reported accurately, is included in the CPS definition of wage - varies across occupation, industry, firm size etc. (again, see Bureau of Labor Statistics (2015a, Table 3)). Third, it is not obvious that the survey respondents understand that their portion of fringe benefits should be included in their reported wage (see Moore and Welniak (2000, Section 6.1)). Therefore, the wage data from the CPS may inaccurately include even just the employee's benefits contribution. For all these reasons, we cannot expect the CPS wage to be a constant fraction of overall compensation.

In conclusion, it is possible that using the log of the CPS wage as dependent variable would reduce the bias relative to the benchmark in Table 1. However, even when using as dependent variable the log of the CPS wage, we cannot expect the elasticity of the CPS wage with respect to a policy to be equal to the elasticity of compensation with respect to that policy.

4 Conclusion

Economic theory usually makes predictions on the effect of a policy on the compensation of workers. Regressions with the (log) wage as dependent variable are commonly used to test such predictions. In this note I have shown that these regressions may be biased because the wage elasticity to a policy need not be equal to the compensation elasticity to that policy.

To address this issue in future empirical work, two strategies seem promising. First, economists should recommend a more extensive collection of data on all the components of compensation. So far, for the United States, the Employee Benefit Survey (EBS hereafter) by the Bureau of Labor Statistics is the only dataset that, to my knowledge, contains information about all the components of compensation. However, the unit of observation of the EBS is not an individual worker, but "a "job", as determined primarily by the employer-assigned job title. Information is collected on the wages, other compensation costs, and work schedules of the individual incumbents in the sampled jobs" (Pierce (2010, p. 64-65)). So, for any job, the EBS does not contain data about e.g. the gender, race and education of the workers in such job. Given that these variables are considered important determinants of the structure of wages, their absence limits the usefulness of the EBS for empirical analysis.

Absent more comprehensive surveys on all the components of compensation, future empirical work may study the effect of the policy of interest not only on wages but also on

[26] The same is true of studies, such as Autor et al. (2014), which rely on Social Security Administration (SSA) data as this data contains information on gross earnings before deductions.

indicator dummies for the access and take-up of some of the most important fringe benefits (e.g. health insurance and retirement plans). For example, these indicator dummies are available in the National Longitudinal Survey of Youth 1979 and the March CPS and they allow researchers to study the *extensive* margin of benefits adjustment to a policy. This is e.g. the approach followed in Tempesti (2016) which studies the effect of Chinese import competition on access and take-up of employer-provided benefits. However, indicator dummies do not allow researchers to study the *intensive* margin of benefits adjustment to a policy, e.g. whether employer-provided health insurance and retirement plans become more or less generous because of the policy. For this reason, the first strategy recommended above, i.e. the development of surveys with more comprehensive information about all the components of compensation, remains preferable.

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Figure 1: Policy Affects Price of Benefits but Not Compensation

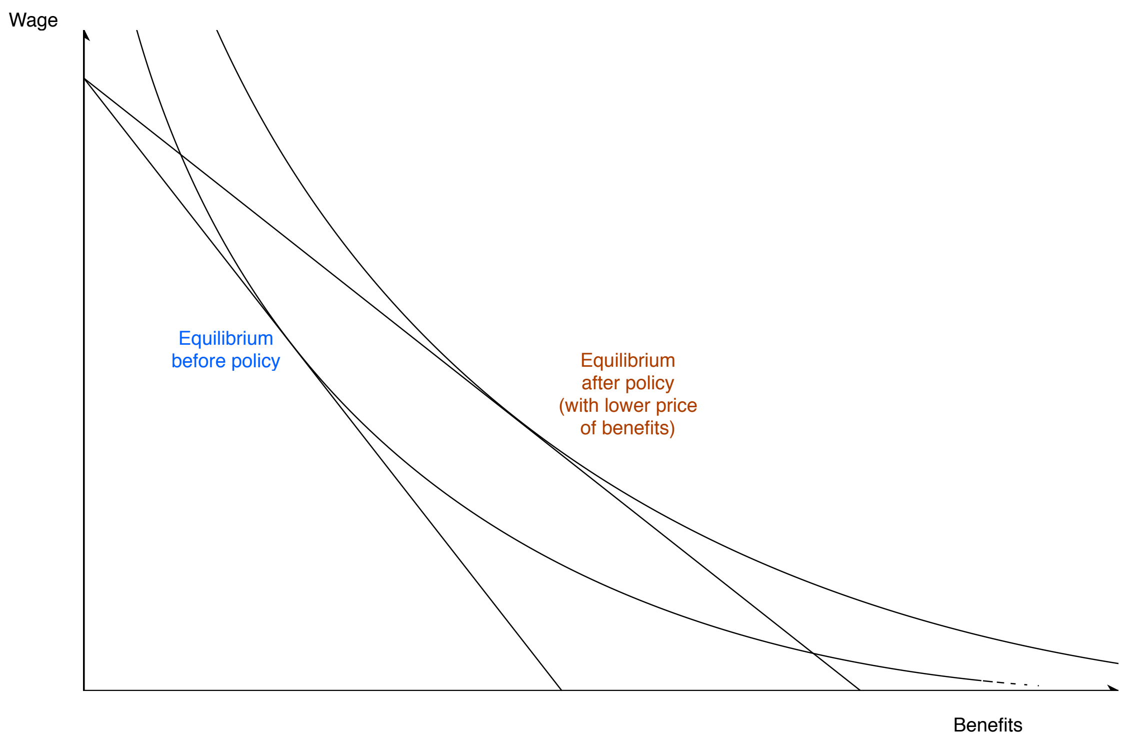

Figure 2: Change in Tax Brackets, First Scenario

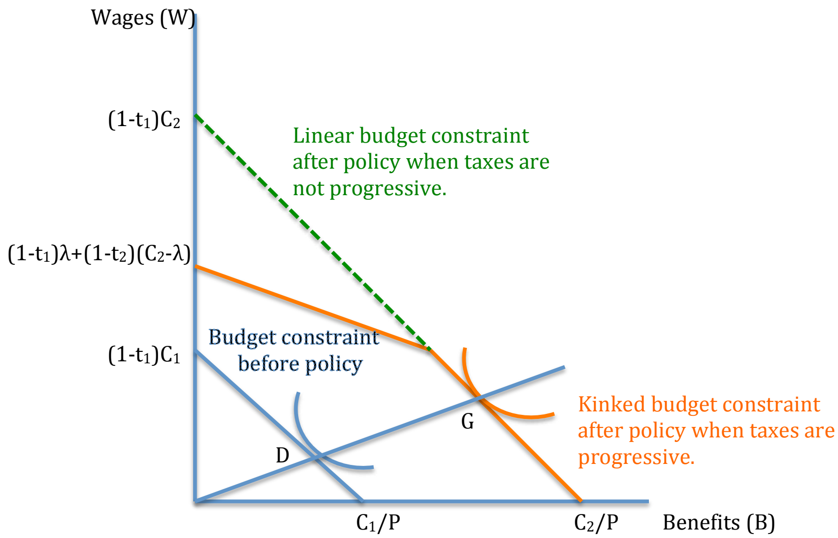

Figure 3: Change in Tax Brackets, Second Scenario