Optimal Income Taxation with Unemployment and Wage Responses: A Sufficient Statistics Approach [*]

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Abstract

This paper reassesses whether the optimal income tax program features an Earned Income Tax Credit (EITC) or a Negative Income Tax (NIT) at the bottom of the income distribution, in the presence of unemployment and wage responses to taxation. The paper makes two key contributions. First, it derives a sufficient statistics optimal tax formula in a general model that incorporates unemployment and endogenous wages. This formula nests a broad variety of structures of the labor market, such as competitive models with fixed or flexible wages and models with matching frictions. Our results show that the sufficient statistics to be estimated are: the macro employment response with respect to taxation and the micro and macro participation responses with respect to taxation. We show that an EITC-like policy is optimal provided that the welfare weight on the working poor is larger than the ratio of the micro participation elasticity to the macro participation elasticity. The second contribution is to estimate the sufficient statistics that are inputs to the optimal tax formula using a standard quasi-experimental research design. We estimate these reduced-form parameters using policy variation in tax liabilities stemming from the U.S. tax and transfer system for over 20 years. Using our empirical estimates, we implement our sufficient statistics formula and show that the optimal tax at the bottom more closely resembles an NIT relative to the case where unemployment and wage responses are not taken into account.

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I Introduction

Recent decades have witnessed a large shift in the U.S. tax and transfer system away from welfare towards in-work benefits. In particular, for single mothers, work incentives increased dramatically: welfare benefits were cut and time limits introduced, the Earned Income Tax Credit (EITC) was expanded and changes in Medicaid, job training programs and child care provision encouraged work. The shift away from programs featuring a Negative Income Tax (NIT) structure (lump-sum transfers to the non-employed with positive employment taxes) towards EITC-like programs (negative employment taxes at the bottom) is prevalent in other countries including Canada, France, South Korea and the U.K.

The literature evaluating these policy reforms largely views them as successful. For single mothers, the reforms sharply reduced welfare caseloads and increased labor force participation and income (Eissa and Liebman, 1996, Meyer and Rosenbaum, 2001, Eissa and Hoynes, 2006, Gelber and Mitchell, 2012, Hoynes and Patel, 2015) and consumption levels (Meyer and Sullivan, 2004, 2008). Within an optimal income taxation framework, the various tax policy changes substantially improved welfare (Eissa, Kleven, and Kreiner, 2008). This is consistent with (Saez, 2002) who shows that the optimal income tax features an EITC-like structure at the bottom of the income distribution when labor supply responses are primarily concentrated along the extensive margin relative to the intensive margin and the welfare weight on the working poor is greater than one.

Two important assumptions in (Eissa, Kleven, and Kreiner, 2008) and (Saez, 2002) are that *all* job-seekers find work and wages are fixed with respect to the tax system. The first assumption may be appropriate during the 1990s when the U.S. unemployment rate was falling and was very low, by historical standards, but may be less realistic in more recent periods where unemployment rates exceeded 10 percent. Furthermore, even in a full employment economy, the assumption of fixed wages may be implausible (Rothstein, 2010). It is also worth noting that these assumptions rule out any labor market spillover effects of government policies. Since anyone can find a job at all times, there is no mechanism by which a boost to the labor force could "crowd out" job finding. Thus, these assumptions are at odds with the growing body of evidence that suggest, especially during times when unemployment is high, government policies may induce substantial spillover effects, particularly at the bottom end of the income distribution. It is desirable to have a theoretical framework that can account for the presence of these spillovers.

The goal of this paper is to relax the fixed wage and full employment assumptions and re-assess whether the optimal income tax features an EITC-like structure at the bottom, as in (Saez, 2002). The paper makes two key contributions, one theoretical and one empirical. Theoretically, we derive a sufficient statistics optimal tax formula in a general model that incorporates unemployment and wage responses to taxation. In the model, individuals can be out of work by choice

("non-participants") or by failing in their search to find a job ("unemployed"). This contrasts with (Saez, 2002) where all active individuals are effectively working. This addresses (Mirrlees, 1999) who writes that "a desire is to have a model in which unemployment can arise and persist for reasons other than a preference for leisure". Rather than specifying the full structure of the labor market, we pursue a sufficient statistics approach (Chetty, 2009) by allowing wages and the "conditional employment probability" - the fraction of participating individuals that are effectively working (i.e. one minus the unemployment rate) - to depend in a reduced-form way on taxes. Our theoretical results show that, for each labor market, the sufficient statistics to be estimated are: *i*) the microeconomic participation response with respect to taxation, *ii*) the macroeconomic participation response with respect to taxation and *iii*) the macroeconomic employment response with respect to taxation.[1] Unlike micro responses, macro responses allow wages and conditional employment probabilities in each labor market to respond to a change in taxes. When we consider a restricted version of the model with no cross effects, we show that an EITC-like policy is optimal provided that the welfare weight on the working poor is larger than the ratio of the micro participation elasticity to the macro participation elasticity.[2] When the micro and macro effects are equal, this collapses to the condition in (Saez, 2002). Thus, if the macro effect is less than the micro effect, as our empirical evidence suggests, the optimal policy is pushed more towards an NIT, relative to the benchmark case.

The intuition for why our optimal tax formula depends on macro employment responses and macro and micro participation responses is the following. In the absence of unemployment and wage responses, behavioral responses to taxation only matter through their effects on the government's budget because they have no first-order effect on an individual's objective by the envelope theorem (Saez, 2001, 2002). However, the latter argument does not apply to wage and unemployment responses because these responses are not directly chosen by individuals but rather are mediated at the market level.[3] Since the social welfare function is assumed to depend only on expected utilities, market spillovers due to wage and unemployment responses matter only insofar as macro responses of expected utility to taxes differ from micro responses. Moreover, since participation decisions depend only on expected utilities as well, these market spillovers are entirely captured by the ratio of macro over micro participation responses. This is related to results in Kroft (2008) and Landais, Michaillat, and Saez (2015) who show that to evaluate optimal unemployment insurance (UI), it is important to estimate the ratio of the micro and macro take-up and

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[1]For ease of exposition, we hereafter refer to microeconomic as "micro" and macroeconomic as "macro".

[2]The no cross effects restriction implies that tax liabilities in one market do not affect participation and employment levels in a different occupation.

[3]For example, higher taxes in one occupation may change equilibrium wages, and therefore labor demand of firms and the conditional employment probabilities that workers face. Such responses may also appear in occupations other than the one where the tax has changed. Moreover, the tax change may reduce the number of job seekers, thereby triggering search externalities.

duration elasticities in the presence of spillover effects, respectively.

The optimal tax formulas structure our empirical strategy which estimates the sufficient statistics that are inputs to the optimal tax formula using a standard quasi-experimental research design. Following most of the literature on labor supply responses to taxation, we focus on single women. The primary advantage is that this group is most likely to be at the margin of participating in the labor market and is thereby most affected by tax and transfer policies at the bottom of the income distribution, in particular the EITC.[4] We adopt a "cell-based" approach and define labor markets on the basis of education (high school dropouts, high school graduates, some college but no degree, and college graduates), state and year. This largely mirrors the definition of labor markets in (Rothstein, 2010). To identify the micro participation response, we rely on expansions to the federal EITC which differentially affected single women with and without children. For the macro participation and employment responses, we rely on variation in state EITC levels, as well as variation in welfare benefits within states over time. To isolate purely exogenous variation in tax liabilities coming from policy reforms, we implement a simulated instruments approach similar in spirit to Currie and Gruber (1996) and Gruber and Saez (2002). Our instrumental variables (IV) estimates show that the micro participation elasticity, for the full sample of single women, is 0.63. This generally lines up with the range of estimates reported in the literature (Eissa, Kleven, and Kreiner, 2008). Our estimate of the macro participation and employment elasticity is 0.51. Finally, we estimate how these behavioral responses vary over the business cycle, proxied by the local unemployment rate, and we find that the responses are lower in magnitude when the unemployment rate is relatively high. We also find more suggestive evidence that the ratio of the micro to macro participation responses increases during times of high unemployment.

As an illustration, we use our empirical estimates to implement our sufficient statistics formula and calibrate the optimal income tax. We demonstrate three key results. First, relative to the optimal tax schedule in Saez (2002), we find that since the macro participation response is less than the micro response, this moves the optimal schedule more towards an NIT-like tax schedule with a relatively larger lump sum payment to the non-employed combined with higher employment tax rates. Second, we show that calibrating our tax formula with smaller (employment and participation) macro responses has a much larger effect on the shape of the optimal tax profile (leading to a larger lump sum transfer and employment taxes), relative to calibrating the Saez (2002) formula with a smaller employment elasticity. This shows that it is misleading to simply calibrate existing tax formulas with macro employment elasticities, as standard intuition might suggest. Third, we

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[4]Our sample omits married women and men. Rothstein (2010) points out that the wages of similarly skilled single and married women substantially diverged in the 1990s. For this reason, it seems reasonable to assume they operate in distinct labor markets. For men on the other hand, to the extent that they are substitutable for single women, we will be understating the size of each labor market and overstating the changes in market-level average tax rates. These effects will tend to work in opposite directions.

use our empirical estimates of behavioral responses over the business cycle to show that during recessions, the optimal income tax at the bottom shifts more towards an NIT-like structure.[5]

The primary advantage of our sufficient statistics approach is its generality with respect to the underlying mechanisms. In particular, competitive models with fixed and flexible wages (Diamond (1980), Saez (2002, 2004), Choné and Laroque (2005), Choné and Laroque (2011), Rothstein (2010) and Lee and Saez (2012)) and models with matching frictions (Hungerbühler, Lehmann, Parmentier, and Van der Linden (2006) and Landais, Michaillat, and Saez (2015)) are special cases of our sufficient statistics formula. Also, our formulas are exact and do not rely on any approximations. The disadvantage of our approach however is that analytical results about the precise shape of the optimal tax schedule are harder to obtain.

Our paper builds on and contributes to the literature on labor supply responses to taxation in three ways. First, many studies in the tax literature do not clarify whether labor supply responses correspond to micro or macro elasticities. An important exception is (Rothstein, 2010) who considers labor demand responses to the EITC in the U.S. Like Rothstein (2010), our empirical work emphasizes this important distinction. Additionally, we estimate micro and macro effects, which is necessary to implement our optimal tax formula, and we use a single methodology and the same sample.[6] This avoids the concern that differences in micro and macro estimates are confounded by differences in methodologies and/or different samples. Second, our results clarify the importance of distinguishing between the effects of taxes on labor force participation and employment. Some studies use the labor force participation rate as the dependent variable (Gelber and Mitchell, 2012) while others use the employment rate (Meyer and Rosenbaum, 2001). Our optimal tax formula indicates that it is important to estimate *both* participation and employment elasticities. Third, this study adds to the large literature evaluating the impact of the EITC expansions in the 1980s and 1990s by expanding the analysis horizon until the most recent years.[7]

A number of recent papers have highlighted the distinction between micro and macro behav-

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[5] Interestingly, while governments have in general shifted away from NIT programs, in practice, transfers to the bottom get increased during recessions. For example, the U.S. significantly increased transfers to the non-employed through the Supplemental Nutrition Assistance Program (SNAP) during the Great Recession as part of the American Recovery and Reinvestment Act of 2009. This suggests that the shape of optimal income transfers at the bottom might depend on the strength of the labor market. Unfortunately, there is very little research on this question to help guide policymakers since current models by design do not allow for this possibility.

[6] A recent study by Jäntti, Pirttilä, and Selin (2015) estimates micro and macro labor supply elasticities using cross-country data from the Luxembourg Income Study (LIS) along with a single estimator. We estimate the micro elasticity using micro data and control for market fixed effects. For the macro elasticity, we pool the data to the market level and control separately for year and state fixed effects. One can show that this approach is essentially equivalent to one that estimates both the micro and macro equation in a single regression.

[7] One of the earliest papers in this tradition, Eissa and Liebman (1996) evaluate the expansion of the EITC in the Tax Reform Act of 1986 and find positive and significant participation effects, but no effect on hours of work. Meyer and Rosenbaum (2001) exploit variation in the EITC up until 1996, controlling for changes to welfare (AFDC and food stamps), Medicaid, child care subsidies, and job training during this time period. Gelber and Mitchell (2012) exploit the same reform along with a large reform to the EITC in 1993 to examine the impact of taxes on the labor force participation of single women and their allocation of time to market work versus home production.

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ioral responses. The first paper to show that both are important for optimal policy is Landais, Michaillat, and Saez (2015), who consider a model of unemployment insurance (UI) with labor market spillovers and demonstrate that the optimal benefit level is a function of the gap between micro and macro unemployment duration elasticities. While our model is related in that it deals with spillover effects, the difference is that we consider multiple income groups of the labor market and focus on the optimal non-linear income tax; particularly, optimal transfers at the bottom of the income distribution. Landais, Michaillat, and Saez (2015) on the other hand have a single labor market and focus on the optimal UI benefit level and how this should vary over the business cycle. Nevertheless, the distinction that the micro elasticity refers to responses that hold the job-finding rate (conditional on search intensity) and wages constant, while the macro elasticity allows the job-finding rate to adjust to UI benefits, is very similar to the distinction we introduce in our model. Partly inspired by Landais, Michaillat, and Saez (2015), some recent papers have tried to empirically estimate macro and micro effects of UI benefits (Lalive, Landais, and Zweimüller, 2013, e.g.) and job search assistance programs (Crépon, Duflo, Gurgand, Rathelot, and Zamora, 2013, e.g.) on unemployment durations.[8]

The distinction between micro and macro responses also plays an important role in the recent literature estimating extensive and intensive labor supply responses (See Chetty, Guren, Manoli, and Weber (2011) and Chetty, Guren, Manoli, and Weber (2012) for an overview). The terms micro and macro responses in these papers correspond to conceptually the same responses that are identified using different sources of variation in taxes. For macro, the source of variation is cross-country or business cycle whereas for micro, the source of variation is quasi-experimental. Differences between the two have been attributed to adjustment costs (Chetty, Friedman, Olsen, and Pistaferri, 2011) and optimization frictions (Chetty, 2012), an issue we abstract from in this paper. Instead, we consider responses that do (macro) or do not (micro) allow for certain equilibrium adjustment mechanisms.

This paper also relates to recent research on whether the generosity of UI benefits should depend on the state of the labor market. Unemployment benefits create a similar problem as traditional welfare benefits in that they provide transfers that are conditional on not working (or at least are at their maximum) and thus provide incentives not to work, while at the same time providing important insurance against hardship. Just as in the optimal taxation literature, the efficiency loss

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[8] Crépon, Duflo, Gurgand, Rathelot, and Zamora (2013) evaluate an experiment of job placement assistance and find evidence of negative spillover effects (i.e., crowd-out onto untreated individuals). They find evidence that these spillover effects are larger when the labor market is slack and interpret this evidence as consistent with a model of job rationing (Landais, Michaillat, and Saez, 2015). Lalive, Landais, and Zweimüller (2013) show that the unemployment spells of individuals ineligible for UI were affected by a large expansion of Austria's UI benefits. Hagedorn, Karahan, Manovskii, and Mitman (2013) estimate large macro effects of unemployment insurance policies during the Great Recession. This is inconsistent with evidence that the micro effects of UI are small (Rothstein, 2011, Farber and Valletta, 2013). The authors stress the role of labor demand, although Marinescu (2014) does not find robust evidence of UI on vacancy creation.

from providing UI is inversely related to the labor supply elasticities. Baily (1978), Chetty (2006), Schmieder, Von Wachter, and Bender (2012), Kroft and Notowidigdo (2014) and Landais, Michaillat, and Saez (2015), derive welfare formulas where the marginal effect of increasing the generosity of unemployment benefits depends on the elasticity of unemployment durations with respect to the benefit generosity. These papers provide empirical evidence that the labor supply elasticities determining the optimal benefit durations (Schmieder, Von Wachter, and Bender, 2012) and levels (Kroft and Notowidigdo 2014 and Landais, Michaillat, and Saez 2015) decline during periods of high unemployment and that the generosity of the UI system should therefore increase during these times. There are also papers that directly examine how labor supply responses to taxation vary with local labor market conditions. Closer to our setting, Herbst (2008) shows that the labor supply responses to a broad set of social policy reforms in the U.S. during the 1990s, such as EITC expansions, time limits, work requirements and Medicaid, are cyclical. Mogstad and Pronzato (2012) shows that labor supply responses to a "welfare to work" reform in Norway are attenuated when the local unemployment rate is relatively high.

Finally, our work broadly relates to research which permit labor demand variables to determine employment outcomes and welfare participation for males and females. Blundell, Ham, and Meghir (1987) shows that demand characteristics, such as unemployment rates, are important determinants of work for married females. Using the PSID, Ham and Reilly (2002) also find evidence that unemployment rates are significant predictors of work for males. While these papers focus on how demand-side factors affect the *level* of employment, our research explores whether such factors influence the *change* in employment in response to taxes and transfers. The role of demand side factors in affecting welfare use has been noted by others (see Hoynes 2000), yet their normative implications have not been fully investigated so far.

The rest of the paper proceeds as follows. Section II develops our theoretical model. Section III contains details on Institutional background and describes our data and empirical results. Section IV considers the policy implications of our theoretical and empirical findings. The last section concludes.

II   The theoretical model

In this section, we derive an optimal tax formula in a general model that is consistent with a rich set of labor market responses to taxation. Following Chetty (2009), we use this benchmark model to identify the sufficient statistics that are necessary to compute the optimal income tax. We do so first in the no-cross effect case where employment and participation responses are only on the extensive margin. This allows us to show the intuition of the main result before we go to the general formula that holds with arbitrary responses to taxes across labor markets. Our

approach contrasts with papers that have incorporated unemployment into models of optimal taxation in a more structural way such as competitive models without unemployment (Mirrlees, 1971, Diamond, 1980, Saez, 2002), models with wage rigidity and job rationing (Lee and Saez, 2012) and matching models and Nash bargaining (Pissarides, 1985).[9] Below, we illustrate how these various structural models map into our sufficient statistic formula.

II.1 Setup

Labor markets

We generalize the model in the appendix of Saez (2002) by introducing unemployment and wage responses to taxation. The size of the population is normalized to 1. There are $I + 1$ "occupations" or income levels, indexed by $i \in \{0, 1, ..., I\}$. Occupation 0 corresponds to non-employment. All other occupations correspond to a specific labor market where the gross wage is w_i, the net wage (or consumption) is c_i and the tax liability is $T_i = w_i - c_i$. The assumption of a finite number of occupations is made for tractability. It is not restrictive as the case of a continuous wage distribution can be approximated by increasing the number I of occupations to infinity. The timing of our static model is:

1. The government chooses the tax policy.

2. Each individual m chooses the occupation $i \in \{0, ..., I\}$ to participate in. Individual heterogeneity only enters the model through the cost of search, as we indicate below.

3. For each labor market $i \in \{1, ..., I\}$, only a fraction $p_i \in (0, 1]$ of participants are employed, receive gross wage w_i, pay tax T_i and consume the after-tax wage $c_i = w_i - T_i$. The remaining fraction $1 - p_i$ of participants are unemployed.

Unlike Saez (2002), we make a distinction among the *non-employed* individuals between the *unemployed* who search for a job in a specific labor market and fail to find one and the *non-participants* who choose not to search for a job.[10] For each labor market $i \in \{1, ..., I\}$, k_i denotes the number of participants, $p_i \in (0, 1]$ denotes the fraction of them who find a job and are working, hereafter the *conditional employment probability*, and $h_i = k_i p_i$ denotes the number of employed workers. The number of unemployed individuals in labor market i is $k_i - h_i = k_i(1 - p_i)$ and the unemployment rate is $1 - p_i$. The number of non-participants is k_0. The number of non-employed is $h_0 = k_0 + \sum_{i=1}^{I} k_i(1 - p_i)$.

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[9]See Boadway and Tremblay (2013) for an excellent review of optimal income taxation in models with unemployment.

[10]We simply assume job search intensity is either zero for non-participants or one for participants. Introducing a continuous job search intensity decisions as Landais, Michaillat, and Saez (2015) would add notational complexity while not substantially modifying the results.

All the non-employed, whether non-participants or unemployed, receive the same welfare benefit denoted b.[11] Therefore, the policy choice of the government is represented by the vector $\mathbf{t} = (T_1, ..., T_I, b)'$. The government faces the following budget constraint:

$$\sum_{i=1}^{I} T_i h_i = b h_0 + E \qquad \Leftrightarrow \qquad \sum_{i=1}^{I} (T_i + b) h_i = b + E \qquad (1)$$

where $E \geq 0$ is an exogenous amount of public expenditures. One more employed worker in occupation i increases the government's revenues by the amount T_i of tax liability she pays, plus the amount of welfare benefit b she no longer receives, the sum of two defining the *employment tax*.[12] The budget constraint states that the sum of employment tax liabilities $T_i + b$ collected on all employed workers in all occupations finances the public good plus a lump-sum rebate b over all individuals.

Rather than specify the micro-foundations of the labor market, we use reduced-forms to describe the general equilibrium or *macro* responses of wages and conditional employment probabilities to tax policy $\mathbf{t}$.[13] In labor market i, the gross wage is given by $w_i = \mathscr{W}_i(\mathbf{t})$, the net wage is given by $c_i = \mathscr{C}_i(\mathbf{t}) \overset{\text{def}}{=} \mathscr{W}_i(\mathbf{t}) - T_i$ and the conditional employment probability is given by $p_i = \mathscr{P}_i(\mathbf{t})$. At this general stage, we are agnostic about the micro-foundations that lie behind these macro response functions and we only assume that these functions are differentiable, that $\mathscr{P}(\cdot)$ takes values in $(0,1]$ and that $0 < b < \mathscr{W}_1(\mathbf{t}) < ... < \mathscr{W}_I(\mathbf{t})$ for all tax policies $\mathbf{t}$. The latter assumption ensures that occupations indexed with a higher i correspond to labor markets with higher skills. The functions $\mathscr{W}_i(\cdot)$, $\mathscr{C}_i(\cdot)$ and $\mathscr{P}_i(\cdot)$ encapsulate all the effects of taxes, including those occurring through labor demand and wage setting responses.

Profits do not explicitly appear in the model. There are several justifications for this assumption. First, one can assume profits away. Competitive models with constant returns to scale or models with matching frictions on the labor market and free entry as Mortensen and Pissarides (1999) are models without profits. Alternatively, we can assume that occupation I actually corresponds to firm-owners for which w_I includes profits. The incidence of tax reforms on profits are then included as changes in w_I.[14]

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[11]This is because the informational structure of our static model prevents benefits from being history-dependent. Moreover, as the government only observes income, it cannot distinguish non-participants from unemployed individuals. This latter assumption seems more realistic than the polar opposite one where the government can perfectly monitor job search. In this case, and if there is only one occupation, the government can provide full insurance to the unemployed.

[12]The literature uses instead the terminology *participation tax*, which we find confusing whenever unemployment is introduced. The *employment* tax $T_i + b$ captures the change in tax revenue for each additional *employed* worker. An additional *participant* being only employed with probability p_i, the change in tax revenue for each additional participant is only $(T_i + b)p_i$, which should correspond to the *participation* tax.

[13]We implicitly assume that an equilibrium exists and is unique. This equilibrium varies smoothly with the policy $\mathbf{t}$ in a way described by the $\mathscr{W}(\cdot)$, the $\mathscr{C}(\cdot)$ and the $\mathscr{P}(\cdot)$ functions.

[14]In such a case, we need to assume full employment in occupation I. We also need to assume that for some individuals like capital owners or CEOs, only occupation I is available, while for others, only occupations $\{0, ..., I-1\}$ are

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Labor supply decisions

The structure of labor supply is as follows. We let $u(\cdot)$ be the cardinal representation of the utility individuals derive from consumption. This function is assumed to be increasing and weakly concave. Individual m faces an additional utility cost d_i for working in occupation i and a utility cost $\chi_i(m)$ for searching a job in labor market i.[15] Individual m thus enjoys a utility level equal to $u(c_i) - d_i - \chi_i(m)$ if she finds a job in labor market i, equal to $u(b) - \chi_i(m)$ if she is unemployed in labor market i, and $u(b)$ if she chooses not to search for a job. Let $\mathscr{U}_i(\mathbf{t}) \stackrel{\text{def}}{=} \mathscr{P}_i(\mathbf{t}) \left(u\left(\mathscr{C}_i(\mathbf{t})\right) - d_i \right) + (1 - \mathscr{P}_i(\mathbf{t})) u(b)$ denote the *gross* expected utility of searching for a job in occupation i, absent any participation cost, as a function of the tax policy $\mathbf{t}$, and let U_i denote its realization at a particular point of the tax system.[16] Let $U_0 = u(b)$ be the utility expected out of the labor force.

Individual m expects utility $U_i - \chi_i(m)$ by searching for a job in labor market i. She chooses to search in labor market i if and only if $U_i - \chi_i(m) > U_j - \chi_j(m)$ for all $j \in \{0, ..., I\} \setminus \{i\}$. The set of individuals choosing to participate in labor market i is therefore $M_i(U_1, ..., U_I, u(b)) \stackrel{\text{def}}{=} \{m | i = \arg\max_{j \in \{0,...,I\}} U_j - \chi_j(m)\}$. Assuming that participation costs $(\chi_1, ..., \chi_I)$ are distributed in the population in a sufficiently smooth way and denoting $\mu(.)$ the distribution of individuals, the number k_i of participants in labor market i is a continuously differentiable function of expected utility in each occupation through: $k_i = \hat{\mathcal{K}}_i(U_1, ..., U_I, u(b)) \stackrel{\text{def}}{=} \mu(M_i(U_1, ..., U_I, u(b)))$. Participation decisions are determined through:

$$k_i \equiv \mathcal{K}_i(\mathbf{t}) \stackrel{\text{def}}{=} \hat{\mathcal{K}}\left(\mathscr{U}_1(\mathbf{t}), ..., \mathscr{U}_I(\mathbf{t}), u(b)\right) \tag{2}$$

Finally, employment is given by:

$$h_i = \mathcal{H}_i(\mathbf{t}) \stackrel{\text{def}}{=} \mathcal{K}_i(\mathbf{t}) \mathscr{P}_i(\mathbf{t}) \tag{3}$$

Micro vs. Macro Responses

A crucial distinction is the difference between macro and micro participation responses to taxes. We define the *micro* participation response to a tax change in the hypothetical case where tax changes do not affect gross wages $w_1, ..., w_I$ or conditional employment probabilities $p_1, ..., p_I$.

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available. As will be clear, our model allows for such restrictions on labor supply decisions.

  Moreover, the budget constraint (1) is equivalent to a resources constraint. To see this, one simply needs to add $\sum_{i=1}^{I} c_i h_i$ on both sides of (1) to obtain $\sum_{i=1}^{I} w_i h_i = b h_0 + \sum_{i=1}^{I} c_i h_i + E$. The left-hand side, by adding labor income and profits, corresponds to total income in the economy, while the right-hand side corresponds to total expenditures in the economy. We rule out cases where profits are positive and distributed to all individuals.

  [15]We denote $\chi_0(m) = 0$. We furthermore assume that $\chi_i(m) = +\infty$ if individual m does not have the required skill to work in occupation i.

  [16]U_i is identical across all participants because the conditional employment probability p_i and the wage w_i are identical across participants in labor market i and in particular do not vary with $(\chi_1(m), ..., \chi_I(m))$.

This is, for instance, the case for tax reforms frequently considered in the micro-econometric literature that affect only a small subset of the population, so that the general equilibrium effects of the reform on wages and conditional employment probabilities can be safely ignored. The micro response of expected utility is thus $-p_i u'(c_i)$. Moreover, from Equation (2), as taxes affect participation decisions only through expected utility levels in each occupation, the micro participation response is given by:

$$\left.\frac{\partial \mathcal{K}_i}{\partial T_j}\right|^{\text{Micro}} \stackrel{\text{def}}{\equiv} -p_j u'(c_j)\frac{\partial \hat{K}_i}{\partial U_j} \tag{4}$$

Conversely *macro* responses encapsulates wage and conditional employment probability responses. The macro response of expected utility is therefore:

$$\frac{\partial \mathcal{U}_i}{\partial T_j} = \left[\frac{\partial \mathcal{C}_i}{\partial T_j} + \frac{\partial \mathcal{P}_i}{\partial T_j}\frac{u(c_i) - d_i - u(b)}{p_i\, u'(c_i)}\right] p_i\, u'(c_i) \tag{5}$$

The term within brackets on the right-hand side of (5) in particular describes how the wage and conditional employment probability responses induce a gap between macro and micro expected utility responses. Using (2) and (5), the macro participation response is given by:

$$\frac{\partial \mathcal{K}_i}{\partial T_j} = \sum_{\ell=1}^{I}\frac{\partial \mathcal{U}_\ell}{\partial T_j}\frac{\partial \hat{K}_i}{\partial U_\ell} = \sum_{\ell=1}^{I}\left[\frac{\partial \mathcal{C}_\ell}{\partial T_j} + \frac{\partial \mathcal{P}_\ell}{\partial T_j}\frac{u(c_\ell) - d_\ell - u(b)}{p_\ell\, u'(c_\ell)}\right] p_\ell\, u'(c_\ell)\frac{\partial \hat{K}_i}{\partial U_\ell} \tag{6}$$

The micro and macro participation responses differ for two main reasons. First, utility levels in the occupation that experiences the tax change can be affected by change in the wage and in the conditional employment probability in that occupation, as we will discuss below. For micro responses, gross wages are held constant, thus $\frac{\partial \mathcal{C}_j}{\partial T_j} = -1$ and taxes are passed through one for one to the worker, while employment probabilities are also fixed and thus $\frac{\partial \mathcal{P}_j}{\partial T_j} = 0$. For macro responses on the other hand, tax adjustments may affect gross wages in a variety of ways $\frac{\partial \mathcal{C}_j}{\partial T_j} \neq -1$ while employment probabilities may also change $\frac{\partial \mathcal{P}_j}{\partial T_j} \neq 0$, e.g. due to changes in labor supply in that occupation or due to changes in vacancy creation by employers, as we will discuss below. Second, utility levels can also be affected by change in the tax liability in other occupations, explaining the summation over all occupations in (6). This could be for example because increasing taxes in occupation j may lead firms to adjust their composition of labor inputs and may change labor demand for other occupations. Moreover, it may be because the workers who are less likely to search for jobs in occupation j may look for jobs in other occupations which will thus change equilibrium outcomes in those occupations.

Social objective

We assume that the government maximizes a weighted utilitarian welfare objective that depends only on individuals' expected utilities:

$$\Omega(U_1, ..., U_I, u(b)) = \int \gamma(m) \left(\max_i \quad U_i - \chi_i(m) \right) d\mu(m) \tag{7}$$

where the weights $\gamma(m)$ may vary across individuals. In the particular case where the utility function $u(\cdot)$ is linear, it is the variation of weights with the characteristics of individuals through the heterogeneity in $\gamma(\cdot)$ that generates the social desire for redistribution, while if individual utility is concave the desire for redistribution comes (also) from individual risk aversion.[17]

The optimal policy

The government chooses the tax policy $\mathbf{t} = (T_1, ..., T_I, b)'$ to maximize (7) subject to the budget constraint (1). Let $\lambda > 0$ denote the Lagrange multiplier associated with the latter constraint. Following Saez (2001, 2002), we define the marginal social welfare weight of workers in occupation $i \in \{1, ..., I\}$ as:

$$g_i \overset{\text{def}}{\equiv} \frac{1}{k_i} \frac{\partial \Omega}{\partial U_i} \frac{u'(c_i)}{\lambda} = \frac{p_i \, u'(c_i) \int_{m \in M_i} \gamma(m) \, d\mu(m)}{\lambda \, h_i} \tag{8}$$

The social weight g_i represents the social value in monetary terms of transferring an additional dollar to an individual working in occupation i. It captures the *micro* effect on the social objective of a unit decrease in tax liability, expressed in monetary terms. Absent wages and conditional employment probabilities responses, the government is indifferent between giving one more dollar to an individual employed in labor market i and g_i more dollars of public funds. Using Equations (5) and (8), we get the following lemma (See Appendix A.1).

Lemma 1. *The first-order condition with respect to the tax liability T_j in labor market j is:*

$$0 = \underbrace{h_j}_{\textit{Mechanical effect}} + \underbrace{\sum_{i=1}^{I} \frac{\partial \mathcal{H}_i}{\partial T_j} (T_i + b)}_{\textit{Behavioral effects}} + \underbrace{\sum_{i=1}^{I} \left[\frac{\partial \mathscr{C}_i}{\partial T_j} + \frac{\partial \mathscr{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i \, u'(c_i)} \right] g_i \, h_i}_{\textit{Social Welfare effects}} \tag{9}$$

A unit increase in tax liability triggers the following effects:

1. **Mechanical effect**: Absent any behavioral response, a unit increase in T_j increases the government's resources by the number h_j of employed individuals in occupation j.

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[17]It is straightforward - and does not change our results below - to generalize this social welfare function to the case where the social planners maximizes an arbitrary concave function of individual expected utilities integrated over the population.

2. **Behavioral effects**: A unit increase in T_j induces a change $\partial \mathcal{H}_i / \partial T_j$ in the level of employment in occupation i. For each additional worker in occupation i, the government increases its resources by the employment tax $T_i + b$ that is equal to the additional tax received T_i plus the benefit b that is no longer paid.

3. **Social welfare effects**: A unit increase in T_j affects the expected utility in occupation i by $\partial \mathcal{U}_i / \partial T_j$. Multiplying by the rate $\frac{\partial \Omega}{\partial U_i} / \lambda$ at which each unit change in expected utility affects the social objective in monetary terms and using Equations (5) and (8), we get that the social welfare effect of tax T_j in occupation i is: $g_i h_i \left[\frac{\partial \mathscr{C}_i}{\partial T_j} + \frac{\partial \mathscr{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i \, u'(c_i)} \right]$. Note that because the social welfare function depends on expected utility U_i, the labor supply responses only modifies the decisions of individuals that are initially indifferent between two occupations, and thus only have second-order effects on the social welfare objective, by the envelope theorem (Saez, 2001, 2002). Conversely, wage and unemployment responses are general equilibrium (macro) responses induced by the market instead of being directly triggered by individual choices. This is the reason why these "market spillovers" show up in the social welfare effect through the term within brackets, unlike the participation responses. Because the social objective as well as participation decision depend on the tax policy only through expected utility levels in each occupation, the same terms $\frac{\partial \mathscr{C}_i}{\partial T_j} + \frac{\partial \mathscr{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i \, u'(c_i)}$ describe how macro social welfare effects differ from micro ones and how macro participation responses differ from micro ones.

Optimal benefit level

Finally, for the sake of completeness, the first-order condition with respect to the welfare benefit b is (see Appendix A.1):

$$0 = -h_0 + \sum_{i=1}^{I}(T_i + b)\frac{\partial \mathcal{H}_i}{\partial b} + g_0 h_0 + \sum_{i=1}^{I} g_i h_i \left[\frac{\partial \mathscr{C}_i}{\partial b} + \frac{1}{p_i}\frac{\partial \mathscr{P}_i}{\partial b}\frac{u(c_i) - d_i - u(b)}{u'(c_i)} \right] \qquad (10)$$

where the social marginal welfare weight on the non-employed is:

$$g_0 \overset{\text{def}}{\equiv} \frac{u'(b)}{h_0}\left[\int_{m \in M_0} \frac{\gamma(m)}{\lambda}d\mu(m) + \sum_{i=1}^{I} \frac{g_i}{u'(c_i)}k_i(1 - p_i) \right] \qquad (11)$$

In particular, if we furthermore assume there is no income effects so that $\sum_{i=1}^{I} \frac{\partial \mathscr{W}_i}{\partial T_i} = \frac{\partial \mathscr{W}_i}{\partial b}$, $\sum_{i=1}^{I} \frac{\partial \mathscr{P}_i}{\partial T_i} = \frac{\partial \mathscr{P}_i}{\partial b}$ and $\sum_{i=1}^{I} \frac{\partial \mathcal{H}_i}{\partial T_i} = \frac{\partial \mathcal{H}_i}{\partial b}$, we get that the weighted sum of social welfare weights is 1 (See Appendix A.1):

$$g_0 h_0 + \sum_{i=1}^{I} g_i h_i = 1$$

II.2   The sufficient statistics optimal tax formula

To numerically implement the optimal tax formula in equation (9), one must know the gap in utilities between employment and non-employment, the responses of net wages to taxation $\frac{\partial \mathscr{C}_i}{\partial T_j}$ and the responses of the conditional employment probabilities to taxation $\frac{\partial \mathscr{P}_i}{\partial T_j}$ that appear in the social welfare effects. We now show that there is a simpler representation for the optimal tax formula (9) in terms of the *macro* $\frac{\partial \mathcal{K}_i}{\partial T_j}$ and *micro* participation responses $\frac{\partial \mathcal{K}_i}{\partial T_j}\Big|^{\text{Micro}}$. The advantage of this representation is that we may apply conventional econometric techniques to estimate these terms.

The no-cross-effect case

To simplify the exposition and develop intuition, we begin with the "no-cross-effect" case where we assume for simplicity that $\partial \mathscr{W}_i / \partial T_j = \partial \mathscr{C}_i / \partial T_j = \partial \mathscr{P}_i / \partial T_j = \partial \hat{\mathcal{K}}_i / \partial U_j = 0$ for $i \neq j$ and $i \neq 0$. The last equality implies that labor supply responses are concentrated along the extensive margin. Moreover, we get from (5) that $\partial \mathscr{U}_i / \partial T_j = 0$, which together with (2) and (3) imply that: $\partial \mathcal{K}_i / \partial T_j = \partial \mathcal{H}_i / \partial T_j = 0$ for $i \neq j$, i.e. that the wage, the conditional employment probability, the employment level and the participation level in one occupation only depend on the welfare benefit b and on the tax liability in the same occupation, and not on tax liabilities in the other occupations. The no-cross-effect environment includes the model of Landais, Michaillat, and Saez (2015) where the wage depends on the level of tax liability but not on the marginal tax rate.

In the no-cross effect case, Equations (4) and (6) imply that we may express the macro participation response in terms of the micro participation response in the following way:

$$\frac{\partial \mathcal{K}_j}{\partial T_j} = - \left[\frac{\partial \mathscr{C}_j}{\partial T_j} + \frac{\partial \mathscr{P}_j}{\partial T_j} \frac{u(c_j) - d_j - u(b)}{p_j\, u'(c_j)} \right] \frac{\partial \mathcal{K}_j}{\partial T_j}\Bigg|^{\text{Micro}}$$

The formula (9) for the optimal tax liability in occupation j then simplifies to:

$$0 = h_j + \frac{\partial \mathcal{H}_j}{\partial T_j}\, (T_j + b) - \frac{\dfrac{\partial \mathcal{K}_j}{\partial T_j}}{\dfrac{\partial \mathcal{K}_j}{\partial T_j}\Big|^{\text{Micro}}} g_j h_j \tag{12}$$

To better relate this expression to the optimal tax literature, we define the micro participation elasticity as $\pi_j^m \overset{\text{def}}{=} -\frac{c_j - b}{k_j} \frac{\partial \mathcal{K}_j}{\partial T_j}\Big|^{\text{Micro}}$. This elasticity measures the percentage of employed workers in i who leave the labor force when the tax liability is increased by 1 percent, holding wages and the conditional employment probabilities fixed. Next, we define the macro employment elasticity as $\eta_j \overset{\text{def}}{=} -\frac{c_j - b}{h_j} \frac{\partial \mathcal{H}_j}{\partial T_j}$. From (3), the macro *employment* response η_j verifies $\eta_j = \frac{c_j - b}{p_j} \frac{\partial \mathscr{P}_j}{\partial T_j} + \pi_j$. In particular, it encapsulates conditional employment responses $\frac{c_j - b}{p_j} \frac{\partial \mathscr{P}_j}{\partial T_j}$ in addition to the macro

participation responses π_j. Moreover, wage and unemployment responses modify the macro participation responses π_j from the micro ones π_j^m, as discussed above.

Proposition 1. *The optimal tax formula in the no-cross-effects case is:*

$$\frac{T_j + b}{c_j - b} = \frac{1 - \frac{\pi_j}{\pi_j^m} g_j}{\eta_j} \tag{13}$$

The no-cross effect environment is the simplest one to understand how the introduction of unemployment and wage responses modifies the optimal tax formula compared to the pure extensive case without unemployment case considered by Diamond (1980), Saez (2002) and Choné and Laroque (2005, 2011) where it is: $\frac{T_j+b}{c_j-b} = \frac{1-g_j}{\pi_j^m}$.

There are two key differences between Equation (13) and Equation (4) in Saez (2002). First, the denominator in (13) corresponds to the macro employment elasticity, whereas Saez (2002) does not distinguish between a micro employment elasticity and macro employment elasticity that includes all the general equilibrium effects of taxation. Second, equation (13) modifies the social marginal welfare weight by the ratio of the macro to micro participation elasticity. The response of expected utility may be different at the macro and micro levels. This is because the macro responses encapsulate not only the direct effect of a tax change on consumption, but also the indirect effects of a tax change on the wage $\frac{\partial \mathscr{W}_i}{\partial T_i} \neq 0$ and on the conditional employment probability $\frac{\partial \mathscr{P}_i}{\partial T_i} \neq 0$. The ratio between the micro and macro expected utility responses corresponds exactly to the ratio of the macro to the micro participation elasticities. So the welfare effect may be larger or lower than the social welfare weight g_i. To understand why, consider a decrease in tax liability T_j. This triggers a positive direct impact on social welfare $-g_j h_j$, which is the only one at the micro level. Moreover, this decrease in tax liability typically induces a decreases in the gross wage when $\frac{\partial \mathscr{W}_j}{\partial T_j} > 0$, so the responses of wage attenuates the direct impact on social welfare. Finally, the decrease in tax liability also typically triggers a rise in job creation, i.e. $\frac{\partial \mathscr{P}_j}{\partial T_j} < 0$, so the response of the conditional employment probability reinforces the direct impact on social welfare. The macro response of participation to taxation is therefore larger (smaller) than the micro one if the impact of the conditional employment responses dominates (is dominated by) the impact of the wage responses. In particular, if the effect of the tax on the conditional employment probability happens only though a labor demand response, the macro participation response is higher than micro one if the labor demand elasticity is high enough. We therefore get:

Corollary 1. *In the no-cross-effect case, the optimal employment tax is negative whenever $g_1 > \frac{\pi_1^m}{\pi_1}$.*

According to (13), a negative employment tax (EITC) becomes optimal whenever the social welfare weight is higher than the ratio of micro over macro participation elasticity, instead of one without unemployment and wage responses, a condition that can be easily tested.

The case with cross effects

We now turn back to the general formula with cross effects, where matrix notation turns out to be convenient. For $f = \mathcal{K}, \hat{\mathcal{K}}, \mathcal{H}, \mathcal{U}, \mathcal{P}, \mathcal{W}$ and $x = T, U$, we denote $\frac{\mathbf{df}}{\mathbf{dx}}$ the square matrix of rank I whose term in row j and column i is $\frac{\partial f_i}{\partial x_j}$ for $i, j \in \{1, ..., I\}$.[18] Symmetrically, the matrix of micro responses are denoted $\frac{\mathbf{df}}{\mathbf{dx}}\Big|^{\text{Micro}}$. Moreover, $\mathbf{h} = (h_1, ..., h_I)'$ denotes the vector of employment levels, $\mathbf{g\,h} = (g_1 h_1, ..., g_I h_I)'$ denotes the vector of welfare weights times employment levels and $\cdot$ denotes the matrix product. Appendix A.2 then shows that market spillover terms $\frac{\partial \mathcal{C}_i}{\partial T_j} + \frac{\partial \mathcal{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i\,u'(c_i)}$ that appear in the social welfare effects in the optimal tax formula (9) still correspond to the ratio of macro over micro participation responses. The only difference is that in the presence of cross effects, this ratio should be understood in matrix terms. We thus get the following generalization of the optimal tax (12) in the presence of cross effects:

Proposition 2. *If* $\frac{\mathbf{d\mathcal{K}}}{\mathbf{dT}}\Big|^{\text{Micro}}$ *is invertible, the optimal tax system for occupations* $i = \{1, ..., I\}$ *solves the following system of equations in matrix form:*

$$
0 = \mathbf{h} + \frac{\mathbf{d\mathcal{H}}}{\mathbf{dT}} \cdot (\mathbf{T} + \mathbf{b}) - \frac{\mathbf{d\mathcal{K}}}{\mathbf{dT}} \cdot \left(\frac{\mathbf{d\mathcal{K}}}{\mathbf{dT}}\Big|^{\text{Micro}} \right)^{-1} \cdot (\mathbf{g\,h}) \tag{14}
$$

Equation (14) is expressed in terms of sufficient statistics. It implies that the ratio (in matrix terms) of macro to micro participation responses are the sufficient statistics to estimate, instead of the market spillover terms that depend on net wage $\frac{\partial \mathcal{C}_i}{\partial T_j}$ and conditional employment probability responses $\frac{\partial \mathcal{P}_i}{\partial T_j}$. Intuitively, because the social welfare function is assumed to depend only on expected utilities, the market spillovers that appear in the social welfare effects in (9) coincide with the terms $\frac{\partial \mathcal{C}_i}{\partial T_j} + \frac{\partial \mathcal{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i u'(c_i)}$ that describe how the macro responses of expected utility differ from the micro ones (see (5)). Moreover, because participation decisions depend only on expected utility as well, these market spillovers are entirely captured by the matrix ratio of macro over micro participation responses. Importantly, the gap between micro and macro responses does not matter for the behavioral effects, but only for the social welfare effects. This is because the matrix $\frac{\mathbf{d\mathcal{H}}}{\mathbf{dT}}$ of macro employment responses already encapsulates the unemployment and wage responses in addition to the micro participation responses.

II.3 The links between the optimal tax formula and micro-foundations of the labor market

The key result of our paper is that the optimal tax schedule can be implemented using the macro employment responses as well as the ratio of the macro over micro participation responses.

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[18] In particular, these matrices do not include partial derivatives with respect to b, nor do they include partial derivatives for occupation 0.

While the advantage of our approach is that it does not rely on any assumptions about the structure of the labor market, the downside is that it does not provide any guidance for how to interpret differences between macro and micro participation responses. In this section, we discuss how different micro-foundations yield different predictions for the relative magnitude of micro and macro participation (and to a lesser degree employment) responses. This serves to build intuition for the macro-micro gap and thereby what economic forces push the optimal tax at the bottom towards an EITC or NIT, while at the same time highlighting how our framework encompasses standard models of the labor market. Since providing an exhaustive exposition of possible models would go beyond the scope of the paper, we instead focus on two main paradigms: search-matching models and job-rationing models. These two classes of models provide a determination for the level of employment and for the unemployment rate as a function of the wage and possibly labor supply. It is worth noting that the different micro-foundations for the gross wage, such as a minimum wage, an efficiency wage or a bargained wage can be included in either of these two frameworks. We start with the search-matching paradigm before presenting the job-rationing paradigm. We then briefly discuss the competitive model and finally models with a wage moderating effect of tax progressivity.

Search and matching models with constant returns to scale (CRS)

In its simplest version, the search-matching framework (Diamond, 1982, Pissarides, 1985, Mortensen and Pissarides, 1999, Pissarides, 2000) assumes a linear (constant returns to scale) production function and a matching function which gives the number of jobs created as a function of the number of vacancies and the number of job seekers. Firms employ more workers the lower the gross wage (which makes it more rewarding for firms to hire a worker) and the more numerous job-seekers there are (which decrease the search congestions from firms' viewpoint thereby easing their recruitment). In the model, the conditional employment probability p_i is a decreasing function $\mathcal{L}_i(\cdot)$ of the gross wage and is independent of the number of job-seekers.[19] Therefore, a policy reform that increases labor supply, without affecting the gross wage, leads to a rise in employment in the same proportion as the rise in labor supply, but does not affect the employment probability.

If we consider a version of the matching model where wages are fixed, than the conditional employment probabilities are fixed, so the macro participation responses are equal to the micro ones. If we instead consider a version of the matching model where wage setting is based on wage bargaining, taxes may affect the outside option for workers as well as the match surplus and thus equilibrium wages and in turn conditional employment probabilities. To build intuition, consider the case with risk neutral workers (hence $u(c) \equiv c$) and proportional bargaining. In such a setting, workers receive an exogenous share $\beta_i \in (0,1)$ of the total match surplus $y_i - T_i - d_i - b$, so the

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[19]We derive in AppendixA.3 this standard result, as well as the proof of Proposition 3 below.

wage is given by:[20]

$$w_i = \mathscr{W}_i(T_i, b) \equiv \beta_i \, y_i + (1 - \beta_i)(T_i + d_i + b) \tag{15}$$

Combining the labor demand relation $p_i = \mathscr{L}_i(w_i)$ with the wage equation (15) and the assumption that labor supply responses are concentrated along the extensive margin provides a complete search-matching micro-foundation for the no-cross effect economy. The following proposition shows that the macro-micro participation gap is directly linked to the bargaining weights and the elasticity of the matching function with respect to the number of job-seekers $\mu_i \in (0, 1)$:

Proposition 3. *In the search-matching economy with proportional bargaining* (15)*, the micro and macro participation responses are equal either when the workers have full bargaining power so there is no wage responses, or when the Hosios* (1990) *condition* $\beta_i = \mu_i$ *for a decentralized economy without tax and transfer to be socially efficient is verified. If* $\beta_i < \mu_i$ *the macro response is lower then micro one. If* $\mu_i < \beta_i < 1$ *the macro response is larger then micro one.*

An increase in tax liability has three effects on expected utility, thereby on participation decisions. First, absent wage and conditional employment response, a rise in T_i has a *direct* negative impact at the micro level (holding w_i and p_i constant) as it reduces the net wage and thus incentives to work and to participate. Second, at the macro level, gross wages increases (through bargaining) attenuating the direct labor supply effect. Finally, the gross wage increase triggers a reduction in labor demand that amplifies the direct effect at the macro level. If the workers get all of the surplus (i.e. if $\beta_i = 1$), wages do not respond to taxation ($\frac{\partial \mathscr{W}_i}{\partial T_i} = 0$), the conditional employment probabilities are not affected so the micro and macro responses to participation are identical. On the other hand, if $\beta_i < 1$, the conditional employment probability effect dominates (is dominated by) the wage effect whenever the labor demand elasticity is (not) sufficiently elastic, which happens when the matching elasticity μ_i is higher (lower) than the bargaining share β_i. Propositions 1 and 3 imply that the optimal employment tax rate on the working poor is more likely to be negative in the no-cross effect DMP case than in the pure extensive case if the workers' bargaining power is inefficiently high, i.e, is higher than the bargaining power prescribed by the Hosios (1990) condition.[21] Therefore, in the DMP model the macro micro participation gap can be higher or lower than one, attenuating or reinforcing the arguments in favor of a negative participation tax at the bottom.[22]

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[20]A similar expression for wage bargaining appears in Jacquet, Lehmann, and Van der Linden (2014) and in Landais, Michaillat, and Saez (2015).

[21]As $\frac{\pi_j}{\pi_j^m} = \frac{\beta_j}{\mu_j}$ from (24), Equation (13) becomes $\frac{T_j + b}{c_j - b} = \frac{1 - \frac{\beta_j}{\mu_j} g_j}{\eta_j}$ which corresponds to (19b) in Jacquet, Lehmann, and Van der Linden (2014).

[22]By extending this model with intensive labor supply decision, the present model can include the central mechanism of Golosov, Maziero, and Menzio (2013) where firms have different productivity and individuals direct their search.

Job-rationing models

An older tradition in economics has proposed job rationing to explain unemployment. In contrast to the matching framework, the job-rationing framework assumes search frictions away and considers that each type of labor exhibits decreasing marginal productivity. In each labor market, employment is determined by the equality between the marginal product and the wage. Unemployment occurs whenever the wage is set above its market-clearing level. This theory of unemployment that Keynes (1936) attributed to Pigou was formalized in the disequilibrium theory (Barro and Grossman, 1971) and further developed in models that allowed for wages being set endogenously above the market clearing level (McDonald and Solow, 1981, Shapiro and Stiglitz, 1984, Akerlof and Yellen, 1990).[23]

To develop some intuition about the macro-micro participation gap in job-rationing models, we now consider a model with a single type of labor that exhibits a decreasing marginal productivity and a fixed gross wage w. This can occur for instance as a result of a minimum wage regulation. The fixed wage determines the level of employment h, independently of the number of participants.[24] We assume that individuals who participate face a heterogeneous participation cost χ that is sunk upon participation. The k participants face the same probability $p = h/k$ to be employed, whatever the participation cost χ they incur if they participate. In such a framework, a tax cut in T triggers a rise in participation at the micro level. However, provided that this tax cut occurs for a fixed wage, employment does not change, so the macro employment response is nil. Therefore, as the number of participants increases, the probability to be employed is reduced, which attenuates the participation responses at the macro level, as compared to the micro one. As a result, the optimal employment tax on the working poor is more likely to be positive in this job-rationing model without cross effect than in the pure extensive case.

There are different job-rationing models in the literature. For instance, in Lee and Saez (2012), there are different types of labor that are perfect substitutes, the minimum wage policy is explicitly an additional policy instrument and efficient rationing is assumed, so that the probability to be employed varies across participants as a function of their private cost upon working. Wages can also be made endogenous through union bargaining (McDonald and Solow, 1981) or through efficiency wages (Shapiro and Stiglitz, 1984, Akerlof and Yellen, 1990). Job rationing can also be analyzed within a search-matching framework if decreasing returns to scale is assumed for

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[23]The Keynesian and New Keynesian theories of unemployment in addition assume nominal rigidities to give a transitional role to aggregate demand management policies. See also Michaillat and Saez (2015) for an extension of the new Keynesian model in which disequilibrium due to price rigidity are smoothed by matching functions on both the labor and the product market.

[24]Note that with a fixed wage, it is no longer equivalent whether the firm or the worker pays the tax. If the firm pays the tax, then a tax cut reduces the cost of labor and increases labor demand. In this case, the government controls not only the total tax liability in an occupation, but also the cost of labor and thereby the employment level. Lee and Saez (2012) provides conditions where the government finds optimal to set the cost of labor above the market-clearing level, thereby generating unemployment in a job-rationing model.

the production function, as in Michaillat (2012). As in a job-rationing model without matching, the macro employment effect would be dampened compared to the micro one and conditional employment probabilities would fall in response to a tax decrease. This in turn generates a gap in the micro and macro participation response that captures the spillover effect on the labor market. While decreasing returns to scale may not be realistic in the long run, it may be plausible at least in the short-run during recessions with aggregate demand shortfalls. Landais, Michaillat, and Saez (2015) discuss this possibility as a possible reason that the effect of unemployment insurance benefits on employment may be larger when the labor market is tight than when it is slack and thus the moral hazard associated with UI may be less severe during a crisis. For the same reason it may be that reductions in tax levels may have a larger effect on employment in recessions than in booms and the optimal policy during recessions may look more like an NIT.[25]

Competitive models

Like job-rationing models, competitive models assume search frictions away. However, these models assume that in each labor market, the gross wage adjusts to clear the labor market so there is no unemployment. If, in addition, the technology exhibit constant returns to scale and perfect substitution across the different types of labor, labor demand is perfectly elastic and our model reduces immediately to Saez (2002).[26] In such a model, there is no difference between macro and micro responses, so the optimal tax formula depends only on the macro (or micro) employment effect of taxes. On the other hand, consider a competitive model with a constant returns to scale technology and flexible wages: there would be no unemployment, but wages may adjust to taxes due to imperfect substitution across the different types of labor. In this case the micro and macro employment responses may be different due to the wage adjustments in each labor market, but the participation gap would still capture these spillover effects. Saez (2004) showed that in such a model, the optimal tax formula can be expressed using only the micro employment response and takes the same form as Saez (2002). In the on-line Appendix, we show that this result remains valid if unemployment rates are positive but exogenous. So, the optimal employment tax is negative when the social marginal welfare weight exceeds one. However, even in this case, our optimal tax formula (14) remains valid.

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[25]Though note that we have a static framework which may not be well suited to determine time-varying optimal taxes over the business cycle.

[26]Assuming fixed w_i and p_i, equation (9) collapses to the optimal tax formula (11) in the Appendix of Saez (2002). This formula can be further specialized by assuming that labor supply responses are concentrated along the intensive margin (Mirrlees (1971) and Saez (2002, Equation (6))), along the extensive margin (Diamond (1980), Saez (2002, Equation (4)) and Choné and Laroque (2005, 2011)) or both (Saez (2002, Equation (8)))

Wage moderating effects of tax progressivity

Another strand in the literature has stressed the possibility that increases in tax progressivity may actually increase employment. For example in the monopoly union model, unions set the wage to maximize the expected utility of its members, which is increasing in the net wage and in the level of employment. Since the level of employment is decreasing in the gross wage, unions do not want to push the wage too high. If tax rates increase (become more progressive) the wedge between net and gross wages increases and therefore a one unit increase in the net wage will have to be traded off against a larger loss in employment. Thus unions may actually accept a lower gross wage in response to an increase in tax progressivity and tax increases may increase employment.[27] The main consequence of introducing the wage moderating effect of tax progressivity into the model is to make the matrix $\frac{d\mathscr{W}}{dT}$ and therefore the matrices $\frac{d\mathscr{P}}{dT}$, $\frac{d\mathscr{U}}{dT}$, $\frac{d\mathscr{K}}{dT}$ and $\frac{d\mathscr{H}}{dT}$ non-diagonal. The wage moderating effect of tax progressivity is therefore an argument against the no-cross effect restriction, which is different than the presence of labor supply responses along the intensive margin.[28]

III   Estimating Sufficient Statistics

To illustrate the practical relevance of our optimal tax formula, we estimate the sufficient statistics necessary to implement our optimal tax formula, namely the macro employment response to taxes, and the micro and macro participation responses. We follow the large empirical literature on the effects of the EITC and welfare reform in the U.S. and focus on single women throughout the last three decades. As a consequence of the gradual expansion of the EITC and the 1990's welfare reform, this group experienced substantial changes in participation and marginal tax rates differentially by number of children, within and across states. These policy reforms provide sufficient variation to identify both micro and macro participation responses and macro employment

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[27]This result has been obtained in a Monopoly unions model with job rationing by Hersoug (1984), in a union bargaining model by Lockwood and Manning (1993) or in the competitive directed search model (or wage posting) of Moen (1997) by Lehmann, Parmentier, and Van der Linden (2011). A very similar result can also hold in the efficiency wage model of Pisauro (1991) or within the matching framework with Nash bargaining (Pissarides, 1985, 1998), or with the bargaining model of top income earners of Piketty, Saez, and Stantcheva (2014). Evidence for this wage moderating effect of tax progressivity can be found in Malcomson and Sartor (1987), Holmlund and Kolm (1995), Hansen, Pedersen, and Sløk (2000) and Brunello and Sonedda (2007), while Manning (1993) and Lehmann, Lucifora, Moriconi, and Van der Linden (2015) provide some empirical support for the unemployment reducing effect of tax progressivity.

[28]In the context of our framework reduced to the case with two occupations $I = 2$, these models imply that the wage functions $\mathscr{W}_i$ not only verify $\frac{\partial \mathscr{W}_2}{\partial T_2} > 0$ and $\frac{\partial \mathscr{W}_1}{\partial T_1} > 0$, as in the proportional bargaining case, but also that the marginal tax rate, as approximated by $T_2 - T_1$, has a wage moderating and unemployment reducing effect. This implies that $\frac{\partial \mathscr{W}_2}{\partial T_1} > 0 > \frac{\partial \mathscr{W}_1}{\partial T_2}$. Within a matching model, using $p_i = \mathscr{L}_i(w_i)$, we obtain $\frac{\partial \mathscr{P}_2}{\partial T_2} < 0$ and $\frac{\partial \mathscr{P}_1}{\partial T_1} < 0$, but also $\frac{\partial \mathscr{P}_2}{\partial T_1} < 0 < \frac{\partial \mathscr{P}_1}{\partial T_2}$. Hence, making the tax schedule more progressive by increasing T_2 and decreasing T_1 increases employment in both occupations, which the government finds beneficial whenever employment taxes remain positive. Hence, compared to the proportional bargaining case, the case with a wage moderating/unemployment reducing effect of tax progressivity leads to a more progressive optimal tax schedule as formally shown by Hungerbühler, Lehmann, Parmentier, and Van der Linden (2006), Lehmann, Parmentier, and Van der Linden (2011).

responses.

III.1 Data

Current Population Survey (CPS)

Our analysis is based on data from the monthly outgoing rotation group (ORG) and the March annual data of the Current Population Survey (CPS). The March annual data spans the time period 1984-2011, while the ORG data (from IPUMS) spans 1994-2010. As our analysis sample, we select all single women age 18 to 55 who are not in the military or enrolled full time in school or college. Since there was insufficient tax variation for higher income individuals we furthermore restrict our sample to women with education less than a bachelors degree. Our theory distinguishes between individuals who choose to participate in the labor force (and are employed or unemployed) and those individuals who are actually employed. We measure these labor market states using the standard International Labor Office (ILO) criteria. A person is classified as being in the labor force if she is either employed or unemployed (i.e., actively looking for a job during the reference week and was available for work) and employed if she has been working during the reference week (or been temporarily absent from a job). [29]

Panel A of Table 1 shows descriptive statistics for the demographic characteristics of single women in the March CPS for the full sample (Column 1) and broken down by educational attainment groups (Columns 2-4), pooling all years from 1984 to 2011.[30] The age range is pretty similar across the three education groups - less than high school, high school, and some college - but there are large differences in the distribution of number of children, with lower educated single women being much more likely to be mothers. This is likely due to our sample restriction to single women since higher educated mothers are more likely to be married. Additionally, low educated women are more likely to be black or Hispanic than high educated ones. Panel B displays labor market variables by educational attainment. Lower educated women are much less likely to be in the labor force than higher educated ones and also experience higher unemployment rates.

Tax and Transfer Calculator

In order to estimate the employment and participation effects of taxes and transfers it is necessary to compute the budget sets that individuals face. For this purpose, we build a calculator that computes taxes and transfers at (nominal) income levels for single women, depending on the number of children, state and year.[31] We assume that a woman is filing as the head of the household and claims her children as dependents. To compute taxes (covering federal and state income

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[29]For complete details on sample construction and variable definitions, please see the online appendix.

[30]We do not include the CPS ORG in this table since it spans different years, but when we compare sample means for the March CPS and ORG for the same period they are extremely close.

[31]We describe in details below how we impute income that serves as an input to the calculator.

taxes, including tax credits, as well as FICA liability), we rely on the NBER TAXSIM software. We assign taxes based on state of residence, as reported in the CPS, as well as number of children, year, and income.[32] To compute transfers, in particular Aid to Families with Dependent Children (AFDC), Temporary Assistance for Needy Families (TANF) and Supplemental Nutrition Assistance Program (SNAP), we construct a benefit calculator based on rules published in the Welfare Rules Database, managed by the Urban Institute. This allows us to compute the benefits an individual is eligible for, as a function of number of children, state of residence, year and income. The shift from AFDC to TANF introduced a number of additional work and eligibility requirements for welfare recipients. For example, federal rules require a minimum number of TANF recipients to be employed and the lifetime duration of receiving TANF benefits is limited to a total of 5 years.[33] Rather than incorporate all of these policies explicitly into our empirical framework, we multiply benefits by recipiency rates constructed from the Survey of Income and Program Participation (SIPP). The new eligibility requirements are reflected in lower observed recipiency rates in our sample post-welfare reform.

We use our tax and transfer calculator to compute the incentive to work. Since we focus solely on the extensive margin in our analysis, we capture work incentives using just two measures, the transfer an individual receives when she has zero income and the tax and transfer level at the earnings level an individual obtains when working. A key difficulty is that earnings, and hence tax liabilities, are unobserved for non-employed individuals. Moreover, earnings for employed workers may be endogenous to the tax system. We proceed using two approaches. First, we impute an individual's tax liability following the approach taken in Eissa and Hoynes (2004) and Gelber and Mitchell (2012). We begin by running separate regressions for each education group (e) and year (t) of log annual earnings for individual m on state fixed effects ($\delta_{e,s,t}$) and control variables ($X_{m,e,s,t}$): [34]

$$log(w_{m,e,s,t}) = \delta_{e,s,t} + X_{m,e,s,t}\pi_{e,t} + \epsilon_{m,e,s,t} \tag{16}$$

The control variables include state fixed effects, a quadratic function of age, dummy variables for black and hispanic, and a categorical variable describing geographic location (i.e., urban versus

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[32]For an individual who resides and works in different states, the following rules apply. Generally an individual is required to pay income tax to his or her state of residence first. Then they must file as a non-resident in the state where they work, but get to take the amount of tax paid to the state of residence as a tax credit, and only pay the difference. If the amount of tax paid to the state of residence is greater than the tax bill for the work state, the individual doesn't pay anything to the work state, but still has to file. We don't take this into account in computing tax liabilities.

[33]In general, a state must have 50 percent of its single parent households and 90 percent of its dual parent households engaged in work-related activities (these include not only work but searching for work or training courses) for a minimum number of hours per week (30 hours per week or 20 hours if there is a young child). The 50 percent and 90 percent are calculated from a pool of "work-eligible individuals" which does not include single parents of children under the age of 1. States can obtain credits against the 50 and 90 percent rates for overall caseload reduction.

[34]For this exercise, we use earnings from the March CPS. To deal with misreporting we also drop observations where the implied hourly wage is less than one dollar or greater than one hundred dollars.

rural). For each individual in our sample (both the non-employed and employed), we construct predicted earnings using the regression coefficients estimated from our model. This is for the purpose of obtaining a consistent specification.[35] We then use predicted earnings to impute an individual's tax liability using TAXSIM and the benefit calculator described above.

In the Online Appendix, we present OLS regressions of participation and employment using this imputed tax liability. One problem with this approach is that the demographic distribution itself, and therefore the imputed tax liabilities, might be endogenous to tax policy. For instance, more generous transfers to single mothers with kids, but not to women without children, may boost fertility and impact earnings. To address this concern, we also rely on a simulated instrument approach based on Currie and Gruber (1996).[36] This approach isolates policy variation in tax liabilities since it uses a fixed income and demographic distribution during the sample period.

There are several steps that we take to implement this procedure. To construct the simulated *micro* tax liabilities, we first compute real earnings in 2010 dollars for each employed individual in the sample. Second, using earnings for the full sample of employed individuals across all years 1984-2011, we construct the percentiles of the empirical earnings distribution. Third, we compute for each education group, the percentage of workers that fall into each centile across all states and years. Fourth, for each year, we compute the nominal earnings level in each centile, conditional on real earnings in that year being within the bounds of the centile from step 2. Fifth, for each year, we take the nominal earnings level in each centile and we compute tax liabilities separately by number of children for each state, using the tax and transfer calculator. In the last step, for each education group, year, state and number of children, we compute the weighted-mean of the tax liabilities across centiles using the (time- and state-invariant) education distribution from step 3 as weights. This leaves us with instruments that are cell means, where the cells are defined by education group, year, state, and number of children, with variation driven solely by exogenous changes in the tax code, and not by endogenous changes in the earnings and/or demographics distribution. Finally, for the simulated *macro* tax liability, we aggregate micro tax liabilities across family types using weights for number of children that vary by education group, but are time- and state-invariant. All tax liabilities are adjusted for inflation using the consumer price index for all urban consumers with 2010 as the base year. The simulated cell average (micro and macro) tax liabilities are then matched back to the CPS data and used as instruments for imputed tax liabilities, among individuals in a given cell, in a two-stage least squares regression.

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[35]As an alternative, we tried performing a Heckman selection correction to control for self-selection using the number of children and the presence of young children in the selection equation. However, we found that the pattern of results were not very well behaved. In particular, predicted earnings for high school dropouts seemed too high and earnings for higher education levels seemed unrealistically low relative to the raw differences earnings across education groups. This is likely due to the lack of a convincing instrument for working.

[36]Gruber and Saez (2002) use this approach to estimate taxable income elasticities; however, we are not aware of any papers that use this approach to estimate extensive margin labor supply responses.

Panel C of Table 1 shows the mean imputed real earnings for each education group averaged over the years and the corresponding tax and transfer levels depending on the number of children in the household. All numbers are reported in real 2010 U.S. dollars (USD). For high school dropouts, taxes (transfers) are strongly decreasing (increasing) in the number of children. The welfare benefit for households with no children is driven entirely by SNAP since these households are ineligible for AFDC/TANF. For bachelor degree holders, the range is very small and close to 0 since most are ineligible for these mean-tested benefits. Importantly, the reported welfare benefits do not incorporate recipiency rates which are much less than 100 percent during our sample period. The last four rows report recipiency rates, as estimated in the SIPP. Each individual in the CPS is assigned a recipiency rate that we calculate from the SIPP based on education, income and year. The table reports the average of the assigned recipiency rates separately for AFDC/TANF and food stamps, and also pre- and post-1996. We see that for high school dropouts, recipiency rates are roughly 50 percent for AFDC/TANF but fall to 20 percent post-1996. For food stamps, recipiency rates are much more comparable pre- and post-1996 and equal to roughly 40 percent.[37] These recipiency rates decrease with education which reflects diminishing eligibility as earnings increase.

III.2 Empirical Method

Specification of Labor Markets

In the theoretical model, individuals sort themselves into $I + 1$ distinct occupations. For our empirical analysis, a key difficulty is ranking individuals, including the non-employed, according to their potential income if they work. For this purpose, we approximate the labor market an individual may participate in by her educational attainment (high school dropout, high school graduate, some college), state and year. We assume that individuals are perfect substitutes within labor markets and use (e, s, t) to denote these cells. This labor market definition is consistent with Rothstein (2010).

Estimating Micro and Macro Participation Responses and Macro Employment Responses

Equation (14) shows that the optimal tax schedule can be expressed in terms of macro employment responses and the ratio of macro to micro participation responses in matrix terms. Ideally one would attempt to estimate the matrix of macro participation responses $\frac{\partial \mathcal{K}_i}{\partial T_j}$, the matrix of micro participation responses $\frac{\partial \mathcal{K}_i}{\partial T_j}\Big|^{\text{Micro}}$ and the matrix of macro employment responses $\frac{\partial \mathcal{H}_i}{\partial T_j}$ for all labor markets i, j. However, this would lead to a very large number of cross effects to estimate

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[37]For AFDC/TANF, we calculate recipiency rates based on sample of mothers since single women with no children are not eligible for these programs.

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that would be difficult to identify, especially the macro responses. Thus, for the purpose of esti-mation, we focus on the no-cross effects case where the above mentioned matrices are diagonal. We also assume away income effects by estimating the responses to employment tax liabilities $T_i + b$, instead of estimating separately the responses to tax liability T_i and to benefit b.

In our model $\mathcal{H}_i$ and $\mathcal{K}_i$ correspond to the number of individuals in income group i, but for an empirical specification that uses variation across individuals and labor markets, it makes little sense to assume $\frac{\partial \mathcal{K}_i}{\partial T_i}$ or $\frac{\partial \mathcal{H}_i}{\partial T_i}$ are constant across labor markets. Instead we will estimate the effect of taxes T_i on employment and participation *rates*. We denote the employment rate in income group i, which in our empirical setting will correspond to an education group i, as $\hat{\mathcal{H}}_i$ and the participation rate as $\hat{\mathcal{K}}_i$. These are the fraction of individuals with education level i who are em-ployed or participating in the labor force, respectively. Estimating the marginal effects of taxes on employment and participation rates furthermore has the important advantage that the estimates are easier to interpret and to compare to the prior literature. For example, these estimates are straightforward to convert to employment and participation elasticities.

To obtain an econometric specification for the responses to taxation that is motivated by the theoretical model (without cross effects), we make two assumptions. First, we assume that the con-ditional employment probability and wage in a market can be written as functions of the average tax liability in that market only.[38] Second, we assume that tax liabilities vary across individuals within a labor market according to the number n of children in the household.[39] The function describing participation decisions for individual m in labor market (e, s, t) can thus be written as:

$$\hat{\mathcal{K}}_{m,e,s,t,n}(\mathbf{t}) = \tilde{\mathcal{K}}_{m,e,s,t,n}(p_{e,s,t}(T_{e,s,t}), w_{e,s,t}(T_{e,s,t}), T_{e,s,t,n}) \tag{17}$$

To estimate the micro participation response, we take a linear approximation to Equation (17), add labor market and education-by-number of children fixed effects, control variables and an error term, to get the following econometric specification[40]:

$$\hat{k}_{m,e,s,t,n} = \delta_{e,s,t} + \delta_{e,n} + T_{e,s,t,n}\beta + X_{m,e,s,t,n}\lambda + \nu_{m,e,s,t,n} \tag{18}$$

This equation implies that $\beta = \left. \frac{\partial \hat{\mathcal{K}}_{m,e,s,t,n}}{\partial T_{e,s,t,n}} \right|^{\text{Micro}}$ captures the micro participation effect. Implicit in this specification is a pooling assumption, whereby the partial derivative of taxes on participation does not vary across labor markets. We adopt this assumption for simplicity and because it is difficult to generate exogenous variation in tax liabilities that differentially affects income groups.

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[38] The restrictions on the econometric specification correspond to the no cross effect theoretical assumption that is assumed in Proposition 1 and Corollary 1.

[39] Moffit (1998) argues that the literature features very heterogeneous marriage and fertility responses to taxes and transfers across studies, with a large number of studies finding no effect. As a result, he concludes that much more research remains to be done.

[40] In the regressions, we interact all control variables with education group.

Next, to estimate macro participation responses, we aggregate the data to state-year-education averages, add education-by-year and education-by state fixed effects, and region specific linear time trends, and demographic controls to get[41]:

$$\hat{k}_{e,s,t} = \delta_{e,s} + \delta_{e,t} + T_{e,s,t}\gamma + X_{e,s,t}\lambda + \nu_{e,s,t} \tag{19}$$

The macro effect is defined as the change in individual participation probabilities if the tax liabilities for all individuals in a labor market increase by one dollar. Therefore the macro effect can be obtained as: $\frac{d\hat{\mathcal{K}}_{e,s,t}}{dT_{e,s,t}} = \gamma$.[42]

The market-level employment rate in market (e, s, t) is given by $\hat{\mathcal{H}}_{e,s,t}(T_{e,s,t}) = p_{e,s,t}(T_{e,s,t}) \times \hat{\mathcal{K}}_{e,s,t}(T_{e,s,t})$. Thus, the macro employment response is given by $\frac{\partial \hat{\mathcal{H}}_{e,s,t}}{\partial T_{e,s,t}} = p_{e,s,t} \times \frac{\partial \hat{\mathcal{K}}_{e,s,t}}{\partial T_{e,s,t}} + \hat{\mathcal{K}}_{e,s,t} \times \frac{\partial p_{e,s,t}}{\partial T_{e,s,t}}$. We will rely on a linear approximation for the market-level employment rate similar to Equation (19) and we will estimate the macro employment response in a way that is analogous to how we estimate the macro participation response.

Identification

To identify the parameter β, we require that the micro tax liability $T_{e,s,t,n}$ is exogenous, conditional on labor market and education-by-number of children fixed effects and observables. Similarly, our identifying assumption for γ is that the macro tax liability $T_{e,s,t}$ is exogenous, conditional on education-by-state and education-by-year fixed effects and observables. Thus, two independent sources of exogenous variation in tax liabilities are needed. For the micro response β, we require variation in tax liabilities across individuals *within* the same labor market. For the macro response γ, we require variation in average tax liabilities *between* labor markets.

As described above, our strategy is to generate such variation using a simulated instrument approach. The policy variation in the micro tax liability is illustrated in Figure 1a). This figure plots the average value of the micro simulated tax liability, by year and number of children, relative to the value in 1984, for high school dropouts. One can see that there is substantial variation in taxes over time and this variation is very different across the number of children. Much of this is driven in large part by the EITC. In particular, the TRA86 reform can be clearly seen in 1986-1987, but is quite small relative to the expansions in the 1990s, which also introduced differential EITC levels for parents with one or two children. Finally in 2009, the EITC was expanded for

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[41]In the regressions, we interact all controls with education group

[42]Note that without income effects, $\frac{\partial \hat{\mathcal{K}}_i}{\partial T_i} = \frac{\partial \hat{\mathcal{K}}_i}{\partial b}$. In this case, only the difference in taxes and transfers between working and not working matters $T_i - T_i(0) = T_i + b$, and therefore $\frac{\partial \hat{\mathcal{K}}_i}{\partial T_i} = \frac{\partial \hat{\mathcal{K}}_i}{\partial b} = \frac{\partial \hat{\mathcal{K}}_i}{\partial (T_i + b)}$. For our main specification, we will assume no income effects and therefore estimate directly $\frac{\partial \hat{\mathcal{K}}_i}{\partial (T_i + b)}$ thereby using both variation in T_i and b to estimate the parameter of interest with maximum power. We tested whether the condition $\frac{\partial \hat{\mathcal{K}}_i}{\partial T_i} = \frac{\partial \hat{\mathcal{K}}_i}{\partial b}$ holds and found that the difference was very small and statistically insignificant. We therefore only report results under the no income effect assumption.

parents with 3 children, as can be seen in the figure, and income taxes were cut for all family types. The identification strategy is similar to the one used by Eissa and Liebman (1996), Meyer and Rosenbaum (2001) and Gelber and Mitchell (2012).

The policy variation for the macro tax liability comes mainly from changes in state income taxes; in particular, the state-level EITCs and welfare benefits, which vary across states and over time. The large expansions of the federal EITC, that much of the literature has relied on, are not useful, since the change affected all states simultaneously and thus would be collinear with time trends. We illustrate this variation by plotting the macro simulated tax liability for high school dropouts for the largest 12 states in Figure 1b).

A potential concern with our identification strategy is that single women might move in response to a tax reform or to receive higher welfare benefits. However several papers (e.g. Meyer, 2000, Kennan and Walker, 2010) suggest that this response is at best modest, particularly for the sample of low income women that are the focus of this study. Thus, while migration responses might be important in other contexts, we do not believe that our estimates will be confounded by it.

III.3 Empirical Results

For all of our empirical results, we report Instrumental Variables (IV) estimates from a Two-Stage Least Squares (2SLS) regression. Reported standard errors in all regressions are clustered on the state level. The notes of the tables contain exact details about the regression specification. All of the OLS results can be found in the Online Appendix. Note that in interpreting these results that the tax liabilities are in units of $1000.

The top panel of Table 2 shows the IV estimates for the micro participation (Column 1) and employment (Column 2) responses to taxes and transfers based on equation (18) above. The results indicate a clear negative and statistically significant participation effect of taxes, consistent with the prior literature. We find that a $1000 increase in taxes leads to a 3.4 percentage point reduction in the participation probability which translates to an elasticity of -0.63.[43] We also see fairly similar micro responses for employment.[44]

Our elasticity estimates are somewhat large but they are within the range of elasticities that is

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[43]Following the theory, we take the marginal effect and multiply it by the ratio of the income gain from employment over the participation rate. For example, if we take the marginal effect of -0.034 and multiply it by the ratio $14.26/0.77, we get an elasticity of -0.63.

[44]The Online Appendix reports the OLS regression results. We see that the OLS participation responses are attenuated relative to our IV estimates. For the full sample, the micro participation elasticity is 0.09 and the macro participation elasticity is -0.8. The micro and macro employment responses are of a similar magnitude. This highlights the importance of instrumenting for the micro and macro tax liabilities. In general the OLS results are not very informative, for example there is a strong reverse causality issue where high participation rates will be associated with lower earnings (due to selection) and higher employment taxes. Isolating variation coming from tax policy changes is crucial in order to obtain meaningful results.

reported in the literature.[45] This is not that surprising since we use similar variation in taxes as the previous literature; in particular, variation driven by the EITC. One notable difference is that past studies typically control for state and year fixed effects, but not their interaction. This yields estimates that confound micro and macro responses (See Rothstein (2010) for a discussion of this). Nevertheless, most of the tax variation in these papers would also have come from across group variation within labor markets.

The macro participation and employment IV estimates are displayed in the second panel of Table 2. These correspond to empirical estimates from a macro-level (education-state-year cells) 2SLS regression of participation and employment rates on market-level tax liabilities, controlling for education-by-state and education-by-year fixed effects and percent black, percent Hispanic, average age, average age-squared, average number of children and their interactions with education and region-specific time trends. Since the number of observations is much smaller and since there is less variation in tax liabilities across labor markets, the coefficients are estimated less precisely. Nevertheless, there is some suggestive evidence that the macro participation and employment responses are smaller than the micro ones.

Our results on micro and macro responses to taxation are generally consistent with the meta analysis conducted in Chetty, Guren, Manoli, and Weber (2012) who report slightly larger estimates of the extensive steady-state elasticities based on micro evidence than macro evidence. It is worth noting that the macro-based studies cited in Chetty, Guren, Manoli, and Weber (2012) are based on cross-country evidence that typically comes from a limited number of OECD countries. Nevertheless, it is reassuring to note that our results are similar, based on a panel data approach across all states, over time, in the U.S.

Table 3 provides a series of robustness tests where we drop the region-specific time trends from the macro regressions and include alternative controls for pre-trends. The first column reports our baseline estimates for comparison. We see that the macro responses are very robust to controlling for division-by-year fixed effects, region-by-year fixed effects and no controls for pre-trends.

Finally, Table 4 considers behavioral responses over the business cycle. In particular, this allows us to test whether spillovers are larger in recessions, as some recent research has found. We rely on several proxies for the business cycle: the 6-month change in the unemployment rate, the state unemployment rate and an indicator for whether the unemployment rate exceeds 9 percent. Across all specifications, we see that micro and macro participation and employment responses tend to be lower when the unemployment rate is relatively high. This is consistent with results in (Schmieder, Von Wachter, and Bender, 2012) and Kroft and Notowidigdo (2014). There is also some suggestive evidence that the micro-macro participation gap increases in weak labor markets; for instance, for the 6-month change in unemployment specification, the gap is roughly 0.1

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[45]Eissa, Kleven, and Kreiner (2008) report a range of (-0.35,-1.7) with a central elasticity of -0.7.

in weak labor markets but only 0.01 in strong labor markets. We emphasize however, that lack of precision limits any strong conclusion about how the gap varies over the cycle.

Overall, these results suggest that while micro labor supply responses are sizeable and in line with what the literature has found before, they may not always be good approximations for the macro employment responses. In particular our evidence broadly suggests that macro responses tend to be lower than micro responses. Although this is some of the first evidence on the gap between micro and macro elasticities, it is however worth noting that our macro estimates are less precisely estimated than our micro ones. Such discrepancy can easily been explained by the limited policy variations at the state level over time, compared to policy variations across women with different number of kids over time. Future research should use other source of policy variations as robustness checks for our macro estimates.

IV   Simulating the Optimal Tax Schedule

In this section we show how unemployment and wage responses affect the shape of the optimal tax and transfer schedule. For this purpose we simulate the optimal tax schedule using the sufficient statistics formula for the optimal tax and transfer schedule. In line with the empirical section, we focus on the no-cross effects model with its restricted set of sufficient statistics. These simulations are very stylized and should be viewed as an illustration of the comparative statics of our optimal tax formula, that highlight the importance of taking spillovers into account. The resulting tax schedule should not be viewed as a precise attempt to derive the optimal tax schedule for any particular population.[46]

To simulate the optimal tax schedule, we solve the system of first-order conditions derived in the theoretical section for the tax levels at different income levels. The system contains $N + 2$ unknowns, the $i = 0 \dots N$ tax levels T_i as well as the lagrange multiplier λ, and $N + 2$ equations, the first-order conditions (12) and (10) and the government budget constraint (1). Since we focus on the no-cross effects model, the first-order conditions for the tax levels simplify to Equation (12).[47] We partition the income distribution into discrete bins, corresponding to the zero income level, the 3 education groups in our empirical analysis, as well as a 4th group: single women with Bachelor degrees, which we did not use in our empirical analysis due to the lack of identifying policy

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[46]Such an exercise for the U.S. would, for example, have to take into account that policy makers seem to have placed different welfare weights on different groups of single women, depending on the number of children. Backing out the implicit welfare weights in the current tax schedule given an optimal tax framework and calibrating how the tax schedule given these welfare weights would change under alternative models would be very interesting, but beyond the scope of this paper.

[47]In order to express the FOC for the benefit level in terms of sufficient statistics, we make two assumptions: a) benefits do not affect wages or job finding probabilities in any labor market and b) the social welfare function is linear in expected utilities (Benthamite Utilitarian). This can be viewed as an approximation that in practice likely does not make a big difference for the results.

variation for this group. We take the average number of individuals over all years as the population shares of the education groups and assign to each group the average income over our sample period. In order to solve the system of equations we also have to parameterize $g_i(T_i)$ and $h_i(T_i)$. Following Saez (2002) we parameterize g_i using the functional form: $g_i = \frac{1}{\lambda(w_i^0 - T_i^0)^\nu}$, where ν is the parameter describing society's parameter for redistribution. For comparability with Saez (2002) we set $\nu = 1$, but in the Online Appendix we also report results for $\nu = 0.5$. We use a first order Taylor approximation to describe h_i, which should provide a reasonable approximation as long as the optimum is close to the current policy:

$$h_i = h_i^0 + \frac{\partial \mathcal{H}_i}{\partial (T_i + b)} \left((T_i + b) - \left(T_i^0 + b^0 \right) \right). \tag{20}$$

We present simulations of the optimal tax schedule based on the formula derived in this paper, which we refer to as the KKLS formula, and contrast this tax schedule with simulations based on the optimal tax formula in Saez (2002).

Figure 2a) shows the optimal tax and transfer schedule for the 4 education groups using the employment and participation response estimates from our empirical section. The dashed line with circles shows the optimal tax schedule implied by our no-cross effects welfare formula, which relies on the micro-macro participation gap to correct for spillovers. The figure also shows the corresponding optimal tax schedule implied by the pure extensive margin optimal tax formula in Saez (2002). The Saez (2002) formula relies only on employment responses but does not specify whether these are micro or macro responses. For the solid line with stars we implement the Saez (2002) formula using our micro employment response estimates, while for the red line we use the macro estimates. Compared to using the Saez (2002) formula with macro employment responses, our formula implies a substantially higher lump sum transfer to the non-employed and higher marginal tax rates (a flatter slope). This is because our estimates imply lower macro than micro participation responses, so that the spillover effects attenuate the welfare gain of a transfer to the working poor. The Saez (2002) formula calibrated with macro employment responses implies larger transfers at the bottom than when micro employment responses are used for calibration and a somewhat flatter slope. This is because we estimate larger micro employment responses than macro ones. To highlight the differences in the slopes, Figure 2b) shows the implied employment tax rates, i.e. $\frac{T_i + b}{w_i}$, at each income level. Clearly the Saez (2002) formula with micro employment effects generates the lowest employment tax rate, although still positive and therefore not EITC-like. Saez (2002) with macro employment effects, the line with plus signs, generates larger employment tax rates and finally the KKLS optimal tax formula yields an employment tax rate that for the lowest income group is more than twice as high (25 percent) than the Saez (2002) formula with micro responses would suggest.

In Figure 3a) we show how, holding the macro employment response constant, the macro-

micro participation ratio affects the optimal tax schedule. The line with circles shows the benchmark tax schedule from Figure 2 using our optimal tax formula with our main empirical estimates. The line with stars shows the optimal tax schedule using our formula when we double the macro-micro participation ratio but everything else constant. This captures a situation where the spillovers from an increase in employment taxes are positive (more labor market participants make it easier for people to find jobs). This makes the tax profile steeper and the optimal tax is an EITC-like schedule, as Figure 3b) shows the employment tax rate is indeed negative at the bottom. The line with plus signs on the other hand shows the optimal tax schedule when we cut the macro-micro participation ratio to 0.5, thus leading to large negative spillovers where the macro response is smaller than the micro response. This makes the overall tax profile flatter and the benefits to the non-employed larger, mirroring an NIT situation.

Other papers have stressed the possibility that macro employment responses could be significantly lower than micro employment responses, particularly in the context of UI and job search assistance and this has typically been explained by the possibility of job rationing at least in the short run, especially during recessions. Our estimates in Table 4 are consistent with this view: while both macro and micro responses decline in recessions, the decline is much larger for macro responses, both with respect to employment and participation. The business cycle macro estimates suggest that spillover effects could be significantly larger during economic downturns. Figure 4 simulates how the optimal tax schedule would vary over the business cycle given our estimates from Table 4. We present results from the estimates based on the 6 month change in the unemployment rate here, but using the other measures yields qualitatively very similar results. In Figure 4a) and 4b) we show the optimal tax schedule for different business cycle states implied by our (KKLS) optimal tax formula. The transfer at zero income is around 7000 USD during a strong labor market with a relatively low employment tax of about 18 percent for moving from zero income to the first income group. During weak labor markets the simulation suggests that the transfer at zero should increase to 8000 USD per year with a much higher employment tax of about 40 percent.[48] In contrast, panels (c) and (d) of Figure 4 show the tax schedule implied by the Saez (2002) formula using the macro employment effects estimated over the business cycle.[49] While the decline in macro employment responses during weak labor markets also leads to an increase in transfers at the bottom and a slight increase in employment tax rates, the change is comparatively modest due to the absence of the spillover channel.

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[48]Interestingly the differences between weak and strong labor markets are even more pronounced if the government has a less strong taste for redistribution, as can be seen results for $\nu = 0.5$ in the Online Appendix.

[49]Using the micro employment effects yields even less variation in the optimal tax schedule over the cycle.

V Conclusion

This paper revisits the debate about the desirability of the EITC versus the NIT. We have shown that whether the optimal employment tax on the working poor is positive or negative depends on the presence of unemployment and wage responses to taxation. Our sufficient statistics optimal tax formula, combined with our reduced-form empirical estimates, indicate that the optimal policy is pushed more towards an NIT than the standard optimal tax model with fixed wages would suggest, although statistical precision limits strong conclusions about the magnitude of the macro responses.

There are several limitations to our analysis that should be addressed in future work. First, there is clearly a need for better empirical estimates of the macro effects of taxation. Most studies of macro labor supply responses rely on cross-country variation in taxes, which can be substantial. While this variation is clearly desirable for efficiency reasons, across countries, tastes for redistribution and other forms of government spending are probably correlated with taxes and employment and are difficult to fully control for. What is needed is reliable policy variation in taxes across labor markets, similar to variation in UI benefit payments that is exploited in Lalive, Landais, and Zweimüller (2013). Second, it would be very interesting to study business cycle effects of taxation more directly by introducing dynamics into the model. The approach we adopted in this paper is entirely steady-state. Finally, it would be useful to develop a model that more fully integrates UI benefits and income taxes, where benefits depend on prior wages, as is currently the policy in most developed economies.

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A   Theoretical Appendix

The Lagrangian associated to the government's program writes:

$$\Lambda(\mathbf{t}) \stackrel{\text{def}}{\equiv} \sum_{i=1}^{I}(T_i + b)\mathcal{H}_i(\mathbf{t}) - b - E + \frac{1}{\lambda}\Omega\left(\mathscr{U}_1(\mathbf{t}), ..., \mathscr{U}_I(\mathbf{t}), u(b)\right) \tag{21}$$

A.1 Derivation of Equations (9) and (10)

Differentiating (21) with respect to T_j and using Equations (5) and (8) gives (9). Differentiating (21) with respect to b gives:

$$\frac{\partial \Lambda}{\partial b} = -1 + \sum_{i=1}^{I} h_i + \sum_{i=1}^{I} (T_i + b) \frac{\partial \mathcal{H}_i}{\partial b} + \frac{u'(b)}{\lambda} \frac{\partial \Omega}{\partial b} + \sum_{i=1}^{I} \frac{\partial \mathcal{U}_i}{\partial b} \frac{\partial \Omega}{\partial U_i}$$

Differentiating $\mathcal{U}_i(\mathbf{t}) \equiv \mathscr{P}_i(\mathbf{t}) \left(u \left(\mathscr{C}_i(\mathbf{t}) \right) - d_i \right) + \left(1 - \mathscr{P}_i(\mathbf{t}) \right) u(b)$ with respect to b gives:

$$\frac{\partial \mathcal{U}_i}{\partial b} = (1 - p_i) u'(b) + p_i u'(c_i) \left[\frac{\partial \mathscr{C}_i}{\partial b} + \frac{\partial \mathscr{P}_i}{\partial b} \frac{u(c_i) - d_i - b}{p_i \, u'(c_i)} \right]$$

Using $h_0 = 1 - \sum_{i=1}^{I} h_i$ and Equations (8) and (11) leads to (10). From $\frac{\partial \mathscr{C}_i}{\partial T_i} = \frac{\partial \mathscr{W}_i}{\partial T_i} - 1$ and for $j \neq i$, $\frac{\partial \mathscr{C}_i}{\partial T_i} = \frac{\partial \mathscr{W}_i}{\partial T_i}$, the sum of (9) for all T_j minus Equation (10) leads to:

$$
\begin{aligned}
0 = & \sum_{i=1}^{0} h_i + \sum_{i=1}^{I} (T_i + b) \left(\sum_{j=1}^{I} \frac{\partial \mathcal{H}_i}{\partial T_j} - \frac{\partial \mathcal{H}_i}{\partial b} \right) - \left(g_0 h_0 + \sum_{i=1}^{I} g_i h_i \right) \\
& + \sum_{i=1}^{I} g_i h_i \left(\sum_{j=1}^{I} \frac{\partial \mathcal{W}_i}{\partial T_j} - \frac{\partial \mathcal{W}_i}{\partial b} \right) + \sum_{i=1}^{I} g_i h_i \frac{u(c_i) - d_i - u(b)}{u'(c_i)} \left(\sum_{j=1}^{I} \frac{\partial \mathscr{P}_i}{\partial T_j} - \frac{\partial \mathscr{P}_i}{\partial b} \right)
\end{aligned}
\tag{22}
$$

In the absence of income effects, a simultaneous change in all tax liabilities and welfare benefit $\Delta T_1 = ... = \Delta T_i = -\Delta b$ induces no changes in wages, conditional employment probabilities not employment levels, so that $\sum_{i=1}^{I} \frac{\partial \mathscr{W}_i}{\partial T_i} = \frac{\partial \mathscr{W}_i}{\partial b}$, $\sum_{i=1}^{I} \frac{\partial \mathscr{P}_i}{\partial T_i} = \frac{\partial \mathscr{P}_i}{\partial b}$ and $\sum_{i=1}^{I} \frac{\partial \mathcal{H}_i}{\partial T_i} = \frac{\partial \mathcal{H}_i}{\partial b}$. Plugging these equalities in (22) leads to: $g_0 h_0 + \sum_{i=1}^{I} g_i h_i = 1$.

A.2 Derivation of Equation (14)

Let $\mathcal{A}$ denotes the square matrix of rank I whose term in row j and column i is $\frac{\partial \mathscr{C}_i}{\partial T_j} + \frac{\partial \mathscr{P}_i}{\partial T_j} \frac{u(c_i) - d_i - u(b)}{p_i \, u'(c_i)}$. The optimal tax formula (9) can be rewritten in matrix notations:

$$0 = \underbrace{\mathbf{h}}_{\text{Mechanical effect}} + \underbrace{\frac{d\mathcal{H}}{d\mathbf{T}} \cdot (\mathbf{T} + \mathbf{b})}_{\text{Behavioral effects}} + \underbrace{\mathcal{A} \cdot (\mathbf{g} \, \mathbf{h})}_{\text{Social Welfare effects}} \tag{23}$$

However, Equation (5) implies that: $\frac{d\mathcal{U}}{d\mathbf{T}} = -\mathcal{A} \cdot \left. \frac{d\mathcal{U}}{d\mathbf{T}} \right|^{\text{Micro}}$. Moreover, from $\mathcal{K}_i(\mathbf{t}) = \hat{\mathcal{K}}_i(\mathcal{U}(\mathbf{t}))$, we get that: $\frac{d\mathcal{K}}{d\mathbf{T}} = \frac{d\mathcal{U}}{d\mathbf{T}} \cdot \frac{d\hat{\mathcal{K}}}{d\mathbf{U}}$ and $\left. \frac{d\mathcal{K}}{d\mathbf{T}} \right|^{\text{Micro}} = \left. \frac{d\mathcal{U}}{d\mathbf{T}} \right|^{\text{Micro}} \cdot \frac{d\hat{\mathcal{K}}}{d\mathbf{U}}$. We thus get that:

$$-\mathcal{A} = \frac{d\mathcal{U}}{d\mathbf{T}} \cdot \left(\left. \frac{d\mathcal{U}}{d\mathbf{T}} \right|^{\text{Micro}} \right)^{-1} = \frac{d\mathcal{K}}{d\mathbf{T}} \cdot \left(\left. \frac{d\mathcal{K}}{d\mathbf{T}} \right|^{\text{Micro}} \right)^{-1}$$

whenever $\frac{d\hat{\mathcal{K}}}{d\mathbf{U}}$ is invertible, in which case Equation (23) can be rewritten as (14).

A.3 The Matching model

We consider a matching economy where on each labor market i, the constant returns to scale matching function gives the employment level h_i as a function $\mathcal{M}_i(v_i, k_i)$ of the number v_i of vacancies posted and the number k_i of participating job seekers (Pissarides and Petrongolo, 2001). Creating a jobs costs $\kappa_i > 0$ and generates output $y_i > \kappa_i$ when a worker is recruited. Hence, the different types of labor are perfect substitutes.

Each vacancy is matched with probability $q_i = Q_i(\theta_i) \stackrel{\text{def}}{\equiv} \frac{\mathcal{M}_i(v_i, k_i)}{v_i} = \mathcal{M}_i(1, 1/\theta_i)$, which is decreasing in tightness $\theta_i \stackrel{\text{def}}{\equiv} v_i/k_i$. Firms create jobs whenever the expected profit $q_i(y_i - w_i) - \kappa_i$ is positive. As more vacancies are created, tightness decreases until the free entry condition $q_i(y_i - w_i) = \kappa_i$ is verified. The conditional employment probability is an increasing function of tightness through $p_i = P(\theta_i) \stackrel{\text{def}}{\equiv} \frac{\mathcal{M}_i(v_i, k_i)}{k_i} = \mathcal{M}_i(\theta_i, 1)$. Therefore, the conditional probability p_i is a decreasing function of the gross wage through $p_i = P_i\left(Q_i^{-1}\left(\frac{\kappa_i}{y_i - w_i}\right)\right)$, which determines the labor demand function $p_i = \mathscr{L}_i(w_i)$.

Under risk neutrality and proportional bargaining (15), one has for any $j \neq i$ that $\frac{\partial \mathscr{W}_i}{\partial T_j} = 0$, thereby $\frac{\partial \mathscr{P}_i}{\partial T_j} = 0$ from $p_i = \mathscr{L}_i(w_i)$, and finally $\frac{\partial \mathscr{U}_i}{\partial T_j} = 0$ from (5). Moreover, we get from $p_i = \mathscr{L}_i(w_i)$ and (5) that:

$$\frac{\partial \mathscr{U}_i}{\partial T_i} = \left[-1 + \frac{\partial \mathscr{W}_i}{\partial T_i}\left(1 + \frac{w_i}{p_i}\frac{\partial \mathscr{P}_i}{\partial w_i}\frac{w_i - T_i - d_i - b}{w_i}\right)\right] p_i$$

As $\mu_i \in (0, 1)$ denote the elasticity of the matching function with respect to the number of job-seekers, we get $\frac{dp_i}{p_i} = (1 - \mu_i)\frac{d\theta_i}{\theta_i}$ and $\frac{dq_i}{q_i} = -\mu_i \frac{d\theta_i}{\theta_i}$, so $\frac{dp_i}{p_i} = -\frac{1 - \mu_i}{\mu_i}\frac{dq_i}{q_i}$. Log-differentiating the free-entry condition $k_i = q_i(y_i - w_i)$ leads to $\frac{dq_i}{q_i} = \frac{w_i}{y_i - w_i}\frac{dw_i}{w_i}$. So, we get $\frac{dp_i}{p_i} = -\frac{1 - \mu_i}{\mu_i}\frac{w_i}{y_i - w_i}\frac{dw_i}{w_i}$, i.e: $\frac{w_i}{p_i}\frac{\partial \mathscr{P}_i}{\partial w_i} = -\frac{1 - \mu_i}{\mu_i}\frac{w_i}{y_i - w_i}$ and:

$$\frac{\partial \mathscr{U}_i}{\partial T_i} = \left[-1 + \frac{\partial \mathscr{W}_i}{\partial T_i}\left(1 - \frac{1 - \mu_i}{\mu_i}\frac{w_i - T_i - d_i - b}{y_i - w_i}\right)\right] p_i$$

Equation (15) implying that $\frac{w_i - T_i - d_i - b}{y_i - w_i} = \frac{\beta_i}{1 - \beta_i}$ and $\frac{\partial \mathscr{W}_i}{\partial T_i} = 1 - \beta_i$, we get:

$$\frac{\partial \mathscr{U}_i}{\partial T_i} = \left[-1 + (1 - \beta_i)\left(1 - \frac{1 - \mu_i}{\mu_i}\frac{\beta_i}{1 - \beta_i}\right)\right] p_i = \frac{\beta_i}{\mu_i}\frac{\partial \mathscr{U}_i}{\partial T_i}\bigg|^{\text{Micro}} \tag{24}$$

when $\mu_i > 0$ and $\beta_i < 1$, which ends the proof of Proposition 3.

Table 1: Variable Means for Single Women

	(1) Full Sample	(2) High School Dropout	(3) High School Graduate	(4) Some College
Panel A: Demographics				
Age	34.1	33.6	33.9	34.5
No Children Percent	65.1	59.6	65.8	67.0
1 Child Percent	17.7	16.9	17.8	18.0
2 Children Percent	10.8	12.3	10.6	10.3
3+ Children Percent	6.3	11.2	5.8	4.7
Mean Years of Education	12.0	9.3	12	13.3
Percent Black	21.0	24.7	21.5	18.7
Percent Hispanic	14.6	30.0	12.2	10.0
Panel B: Labor Force Status				
Labor Force Participation Rate (k_i)	76.9	55.2	78.3	85.3
Employment Rate (h_i)	70.2	45.9	71.4	80.2
Unemployment Rate $(1 - p_i)$	9.3	17.1	8.9	6.1
Panel C: Income, Taxes and Transfers (Real 2010 Dollars)				
Imputed Pre-tax Wage Earnings	17463	10021	16925	21503
Net Taxes: No Children	3929	1667	3717	5092
Net Taxes: 2 Children	-816	-1991	-1286	375
AFDC/TANF and Food Stamps: No Children	644	1355	638	359
AFDC/TANF and Food Stamps: 2 Children	3748	7177	3666	1944
Net Tax and Transfers (T_i): No Children	3285	312	3079	4733
Net Tax and Transfers (T_i): 2 Children	-4564	-9168	-4951	-1569
Net Tax and Transfers (b): Zero Income, No Children	-2070	-2055	-2069	-2077
Net Tax and Transfers (b): Zero Income, 2 Children	-11477	-11546	-11442	-11480
AFDC/TANF Recipiency Rate for Mothers: Pre-1996	29	49	25	17
AFDC/TANF Recipiency Rate for Mothers: Post-1996	11	21	10	6
Food Stamp Recipiency Rate: Pre-1996	21	41	19	10
Food Stamp Recipiency Rate: Post-1996	22	41	23	15
Number of observations	773367	138766	334359	300242

Notes: The sample is restricted to single women aged 18-55. All dollar figures are in real 2010 dollars.

Data used in each column are restricted to women with the education level in the column header.

Imputed earnings result from a linear regression of demographics on wages conditional on employment.

Net Taxes is federal, state and fica (sum of employer and employee) tax liabilities net of tax credits, including EITC.

AFDC/TANF and Food Stamps assume 100 percent recipiency among those eligible based on income.

Net Taxes and Transfers is the net of federal, state and fica (sum of employer and employee) tax liabilities and credits, AFDC or TANF payments and food stamp benefits.

Table 2: Micro and Macro Responses to Changes in Taxes and Benefits

Instrumental Variable Regressions

| LHS Variable	(1) Participation Rate: $\hat{\mathcal{K}}_i$	(2) Employment Rate: $\hat{\mathcal{H}}_i$
Micro Response		
Taxes Plus Benefits	-0.034	-0.033
	[0.002]***	[0.002]***
Num. Obs	773367	773367
Mean of Dep. Var.	0.77	0.70
Inc Gain from Employment (2010USD)	14259.0	14259.0
Tax Elasticity	-0.63	-0.66
Macro Response		
Avg Taxes Plus Benefits within Labor Market	-0.030	-0.027
	[0.017]*	[0.018]
Num. Obs	4284	4284
Mean of Dep. Var.	0.74	0.67
Inc Gain from Employment (2010USD)	12479.3	12479.3
Tax Elasticity	-0.51	-0.51

Notes: (** P<.05, *** P<.01) Standard errors clustered on state level. The sample is restricted to single women aged 18-55. The data include March CPS for 1984-2011 and Outgoing Rotations Groups for 1994-2010. The first column uses labor force participation as the outcome variable, the second column uses employment status. Taxes Plus Benefit is the net of federal (including EITC), state and fica (sum of employer and employee) taxes plus the benefits an individual would be eligible for at no earnings, adjusted for national recipiency rates. The Micro Response regressions use individual level data and include controls for age, age-squared, race, ethnicity and fixed effects for number of children and State x Year x Month. The Macro Response regressions use data that are collapsed to the state-year cell, each cell receives equal weight in the regression. Regressions include controls for percent black, percent hispanic, average age, age-squared, number of children and fixed effects for state and year and CPS region time trends. Controls in all regressions are interacted with education group.

Table 3: Macro Participation and Employment Responses to Changes in Tax Liability
IV Robustness Checks

	(1) Region Time Trend	(2) Div X Year FE	(3) Reg X Year FE	(4) No Pre-Trends
Macro Participation Response				
Avg Taxes Plus Benefits within Labor Market	-0.030	-0.035	-0.034	-0.039
	[0.017]*	[0.025]	[0.020]*	[0.017]**
Num. Obs	4284	4284	4284	4284
Mean of Dep. Var.	0.74	0.74	0.74	0.74
Income Gain from Employment	12479.3	12479.3	12479.3	12479.3
Tax Elasticity	-0.51	-0.58	-0.56	-0.65
Macro Employment Response				
Avg Taxes Plus Benefits within Labor Market	-0.027	-0.031	-0.026	-0.034
	[0.018]	[0.026]	[0.022]	[0.019]*
Num. Obs	4284	4284	4284	4284
Mean of Dep. Var.	0.67	0.67	0.67	0.67
Income Gain from Employment	12479.3	12479.3	12479.3	12479.3
Tax Elasticity	-0.51	-0.58	-0.49	-0.64

Notes: (** P<.05, *** P<.01) Standard errors clustered on state level. The sample is restricted to single women aged 18-55. The data include March CPS for 1984-2011 and Outgoing Rotations Groups for 1994-2010. The full sample is used for all columns, each column include controls described in the column header. Taxes Plus Benefit is the net of federal (including EITC), state and fica (sum of employer and employee) taxes plus the benefits an individual would be eligible for at no earnings, adjusted for national recipiency rates. The data are collapsed to the state-year cell, each cell receives equal weight in the regression. Regressions include controls for percent black, percent hispanic, average age, age-squared, number of children and fixed effects for state and year. Controls for all regressions are interacted with education group.

Table 4: Participation and Employment Responses: Heterogeneous Labor Market Conditions

	(1)	(2)	(3)	(4)
	Regression Coef.		**Extrapolated Marg. Effects**	
	Marginal Effect of Tax Liability	Interaction of Tax Liab. with Labor Market Meas.	Weak Labor Market	Strong Labor Market
Panel A: Micro Participation				
6-mo change in unemp	-0.034	0.0011	-0.033	-0.036
	[0.002]***	[0.0004]***		
State unemp. rate	-0.035	0.0012	-0.030	-0.039
	[0.002]***	[0.0003]***		
Unemp above 9 pct	-0.035	0.0053	-0.029	-0.035
	[0.002]***	[0.0013]***		
Panel B: Macro Participation				
6-mo change in unemp	-0.029	0.0043	-0.024	-0.035
	[0.017]*	[0.0030]		
State unemp. rate	-0.034	0.0011	-0.029	-0.039
	[0.018]*	[0.0012]		
Unemp above 9 pct	-0.031	0.0089	-0.022	-0.031
	[0.017]*	[0.0052]		
Panel C: Micro Employment				
6-mo change in unemp	-0.033	0.0007	-0.032	-0.034
	[0.002]***	[0.0005]		
State unemp. rate	-0.033	0.0015	-0.028	-0.039
	[0.002]***	[0.0003]***		
Unemp above 9 pct	-0.033	0.0074	-0.026	-0.033
	[0.002]***	[0.0018]***		
Panel D: Macro Employment				
6-mo change in unemp	-0.027	0.0030	-0.023	-0.030
	[0.018]	[0.0031]		
State unemp. rate	-0.035	0.0018	-0.027	-0.042
	[0.019]*	[0.0013]		
Unemp above 9 pct	-0.029	0.0112	-0.017	-0.029
	[0.017]*	[0.0060]*		

Notes: (** P<.05, *** P<.01) Standard errors clustered on state level. The Micro Response regressions use individual level data and include controls for age, age-squared, race, ethnicity and fixed effects for number of children and State x Year x Month. The Macro Response regressions use data that are collapsed to the state-year cell observations, each cell receives equal weight in the regression. Regressions include controls for percent black, percent hispanic, average age, age-squared, number of children and fixed effects for state and year and CPS Region time trends. Weak and strong labor markets marginal effects assume the market indicator is two standard deviations above or below the mean for the continuous variables.

Figure 1: The Variation in Taxes plus Benefits
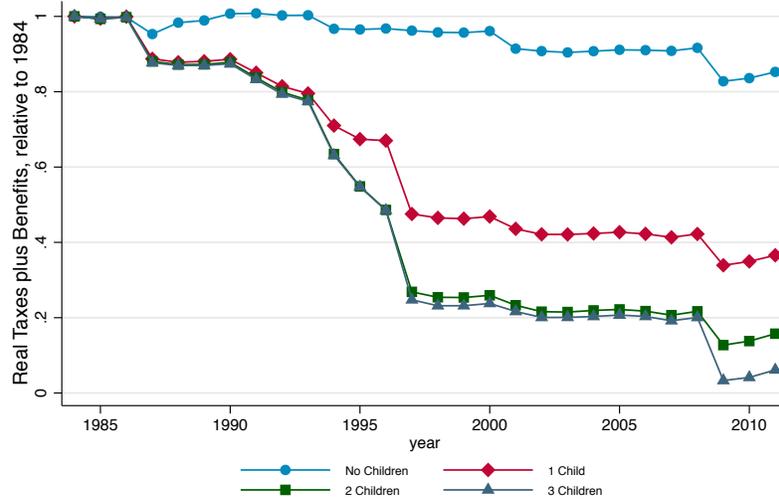

(a) Micro Variation in Taxes plus Benefits
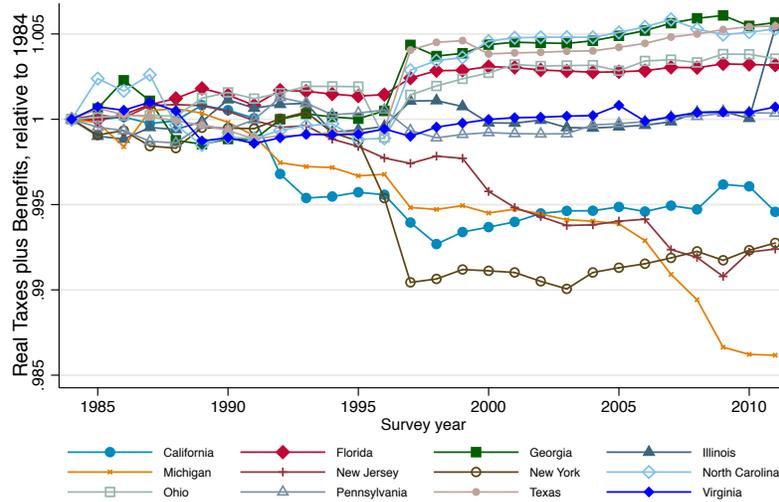
(b) Macro Variation in Taxes plus Benefits

Notes: The top figure shows the variation in taxes plus benefits for high school dropouts by number of children normalized such that 1984 equals one. Taxes plus benefits is the net of federal (including EITC), state and fica (sum of employer and employee) taxes plus the benefits an individual would be eligible for at no earnings, adjusted for national recipiency rates.

The bottom figure shows residuals from a regression of year fixed effects on the state level average taxes plus benefits with state means added back to the residual, then normalized such that 1984 equals one. Taxes plus benefits is the net of federal (including EITC), state and fica (sum of employer and employee) taxes plus the benefits an individual would be eligible for at no earnings, adjusted for national recipiency rates.

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Figure 2: Optimal Tax and Transfer Schedule Comparing KKLS Formula with Saez (2002) Formula
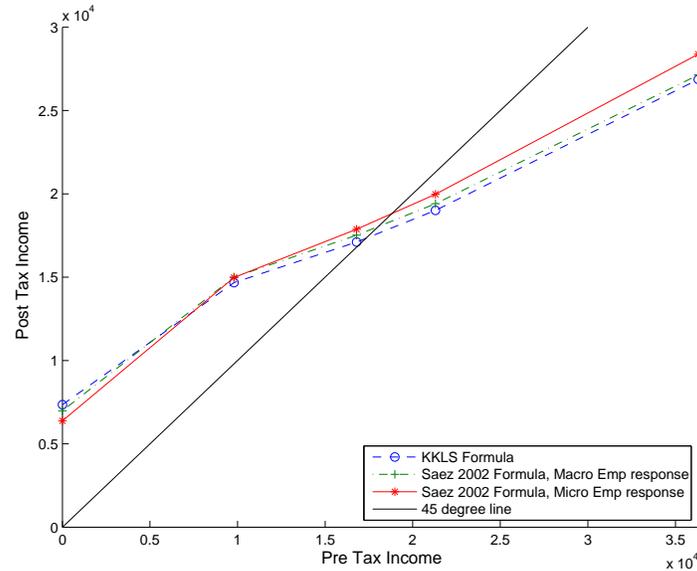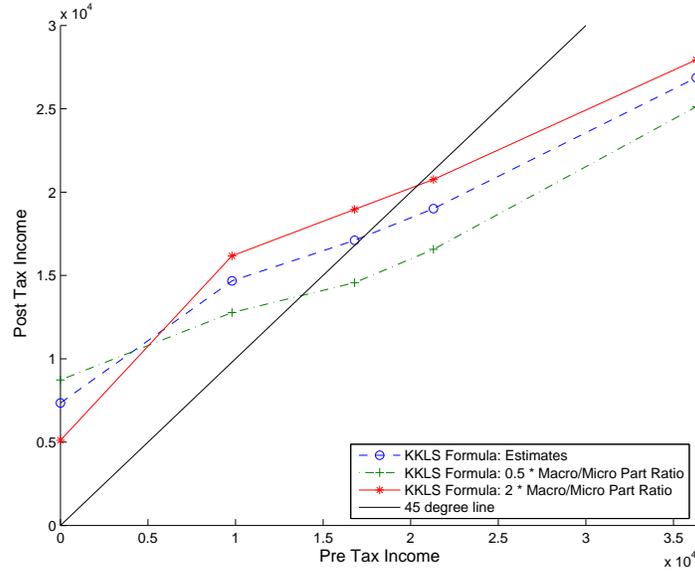

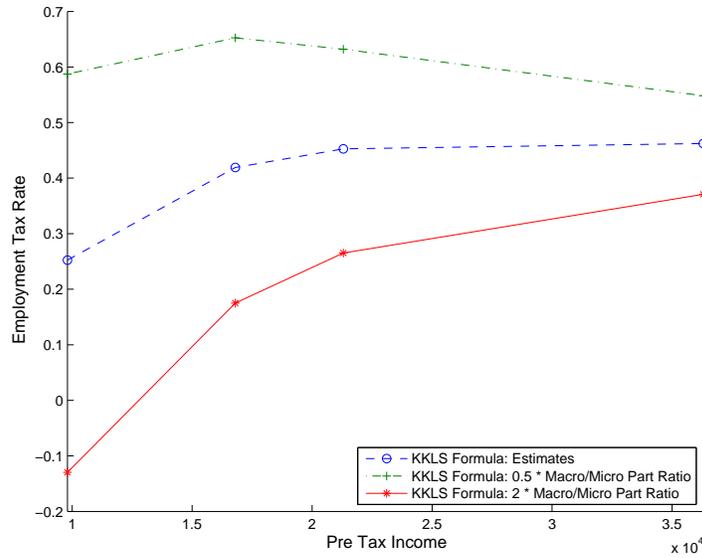(a) Comparing KKLS vs. Saez (2002) formula: Post vs. Pre-tax income
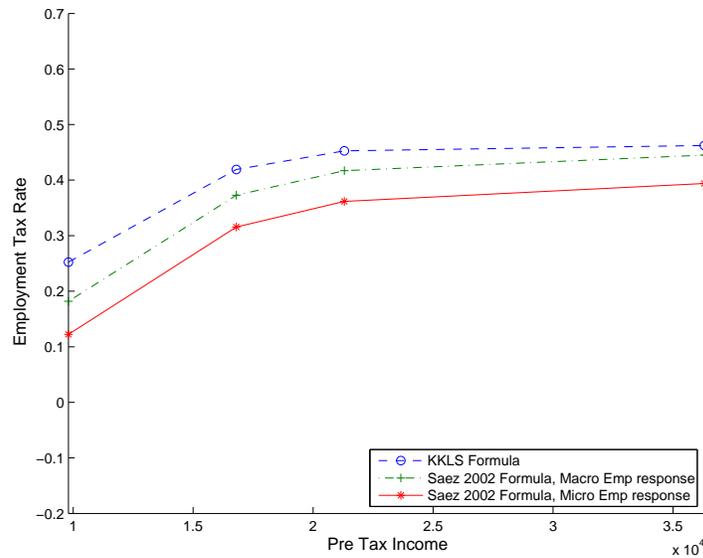
(b) Comparing KKLS vs. Saez (2002) formula: Employment tax rates

Notes: Simulations of the optimal tax and transfer schedule under alternate assumptions on employment and participation responses. Distribution of the 4 income groups is calibrated using CPS data and corresponds to the 4 education groups in the empirical section. The figure uses the participation and employment responses estimated in the paper. The line with circles uses the optimal welfare formula derived in this paper. The dashed line with plus signs uses the Saez (2002) formula based on the estimated macro responses in this paper, while the solid line uses the estimated micro employment responses in this paper.

Figure 3: The Effect of Changing the Macro Participation Effect on the Optimal Tax and Transfer Schedule


(a) KKLS formula with alternative macro vs micro participation rates: Post vs. Pre-tax income

(b) KKLS formula with alternative macro vs micro participation rates: Employment tax rates

Notes: Simulations of the optimal tax and transfer schedule under alternate assumptions on employment and participation responses. Distribution of the 4 income groups is calibrated using CPS data and corresponds to the 4 education groups in the empirical section. The top figure shows the post vs. pre-tax income relationship while the bottom figure shows the employment tax rates. The line with circles shows the optimal tax schedule given the empirical estimates and the KKLS formula. The solid line shows the optimal schedule if the macro responses are multiplied by 0.5 and the line with plus signs if they are multiplied by 2.
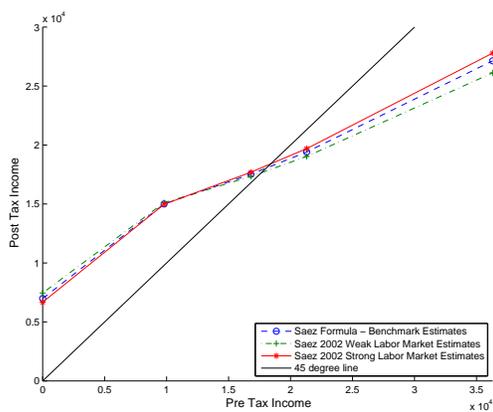
Figure 4: Optimal Tax and Transfer Schedule in Weak vs. Strong Labor Markets
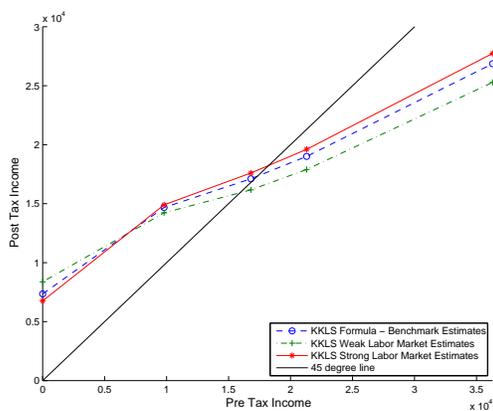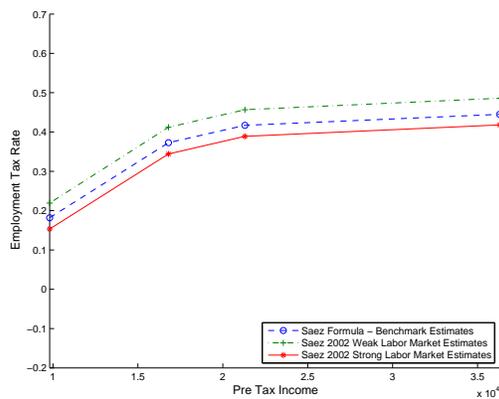

(a) KKLS formula: Post vs. Pre-tax income
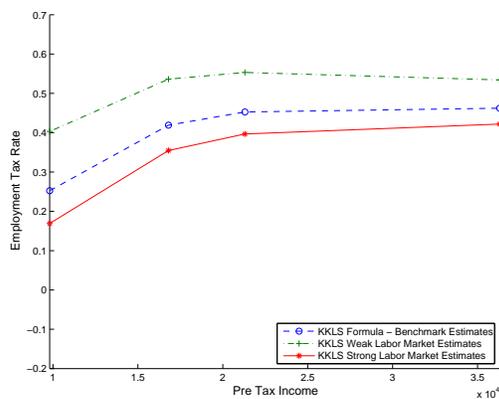
(b) KKLS formula: Employment tax rates

(c) Saez (2002) formula: Post vs. Pre-tax income

(d) Saez (2002) formula: Employment tax rates

Notes: Simulations of the optimal tax and transfer schedule under alternate macro participation responses. Distribution of the 4 income groups is calibrated using CPS data and corresponds to the 4 education groups in the empirical section. The top two figures use the KKLS optimal tax formula, the bottom two figures the Saez (2002) optimal tax formula using Macro employment effects. The line with circles corresponds to the benchmark simulation using the estimated, participation and employment responses. The solid line shows the tax schedule using the weak labor market estimates from Table 4 based on the 6 month change in the unemployment rate. The line with plus signs shows the tax schedule for the corresponding strong labor market estimates from Table 4.