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Cost of policy choices: A microsimulation analysis of the impact on family welfare of unemployment and price changes

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ABSTRACT

This paper calculates the welfare cost to families of an unemployment shock. Using U.S. data, we find an average annualized expected dollar equivalent welfare loss of $1,156 when the unemployment rate rises by one-percentage point. Relative to single families, the welfare loss is greater for married families and increases with education. We also estimate that a loss in purchasing power of 1.8% generates the same amount of welfare loss as a one percentage point rise in the unemployment rate. Additionally, the magnitude of the shock to purchasing power that a family is willing to endure to avoid a one percentage point increases in the aggregate unemployment rate rises with income. The results in this paper informs policy makers about the distributional implications of decisions likely to affect labor markets.

1. Introduction and background

The purpose of this paper is to evaluate the welfare cost of a shock to unemployment for families with different characteristics. We apply the microsimulation methodology to estimate parameters of a labor supply model within the context of a family utility framework for married couple households, and within the context of a unitary utility framework for single households. Estimated parameters from the utility model are used to simulate the expected welfare loss from a rise in the aggregate unemployment rate, accounting for the negative income shocks and changes in non-market time, with the recognition that each person's probability of unemployment is impacted differently by a softening of the labor market.[1]

Previous studies have explored the costs of unemployment almost exclusively through a macroeconomic lens. Okun's (1962) law is often used to describe the loss in output that is generated from an additional one-percentage point rise in the unemployment rate.

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[1] Non-market time is a combination of time spent on leisure, household production and other activities outside paid labor.

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Gordon et al. (1973) detail the deficiencies of Okun's Law (alone) for measuring the welfare effects of a rise in the unemployment rate because the relationship does not account for the value of non-market activity. And rather than explore the cost of a specific shock to unemployment, some focus more on the welfare costs of economic *volatility* over time (e.g. Lucas, 1991; Krusell and Smith, 1999).[2]

An exception to the macroeconomic approach to measuring the welfare costs of unemployment is found in Hurd, (1980). Hurd uses estimated individual labor supply elasticities (or, rather, the slope of the labor supply function) to calculate the payment required to make a person indifferent between working the desired hours at a prevailing wage rate, or being forced to work fewer hours than desired because of unemployment. This payment is interpreted as the cost of unemployment. Our methodology employs a similar concept in that we estimate the welfare loss of deviating from desired hours, but we estimate utility function parameters in order to calculate actual loss in welfare (i.e., utility) as opposed to just the loss in income that would come from unemployment. Among other things, this allows us to account for any potential welfare gain from an increase in non-market activity that comes with non-employment. The methodology also allows a comparison of welfare loss across families of different characteristics, irrespective of the actual utility *level* of those families (either independently or relative to one another).

DiTella et al. (2001) also offer an estimate of the utility-constant cost of unemployment and provide a segue to the second part of the analysis in this paper. They assess the relative importance of high unemployment vs. high inflation in explaining variations in demographic-neutral aggregate levels of satisfaction across countries and time. They find that unemployment reduces overall satisfaction more than inflation. They motivate their analysis by stating that, "…reducing inflation is often costly, in terms of extra unemployment…," (DiTella et al., 2001, 335). This trade-off is also acknowledged by Gordon et al. (1973) as a motivation for undertaking their assessment of the welfare cost of higher unemployment. However, they note that their assessment will not take account of, "…the benefits associated with the lower inflation rate made possible by higher unemployment," (p. 135).[3] De Neve et al. (2017) also find a significant positive relationship between changes in macroeconomic conditions and individuals' assessments of well-being with the added revelation that negative shocks have a more dramatic effect on well-being than positive shocks.[4]

The potential trade-off between unemployment and inflation suggested by these papers is of particular interest to U.S. Federal Reserve monetary policy makers whose actions are guided by what is known as the "Dual Mandate" of full employment and stable prices, which is spelled out in Section 2A of the Federal Reserve Act:

> “The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates.”[5]

While we do not model inflation in this paper, the second part of the analysis estimates the size of an exogenous shock to purchasing power that would generate the same welfare loss as a one percentage-point shock to unemployment. Since the only consumption price in the model is the numeraire price of consumption, we simulate a loss in purchasing power by adjusting the value of the other components of the model that enter in real dollars – wages and non-labor income. We are then able to say something about how the individual family views the trade-off between rising unemployment and decline in purchasing power.

The distributional implications of monetary policy has a fairly long history. Krusell and Smith (1999) and Krusell et al. (2009) demonstrate that Lucas' (1991) very small estimates of the cost of business cycle volatility doesn't hold at the lowest points of the income distribution (also see Mukoyama and Şahin, 2006). And, while there is general agreement that monetary policy is not responsible for the secular increasing trend in inequality since the early 1980s, it is also agreed that monetary policy has a differential impact across the income distribution and, hence, has a role to play in cyclical inequality (for example, see Bernanke, 2015; Nakajima, 2015; Amaral, 2017; Carpenter and Rodgers III, 2004; Coibion et al., 2017). The analysis in this paper finds differential welfare implications for changing labor market environments by education and marital status. In considering the welfare costs of unemployment and loss in purchasing power, we do not suggest that the FOMC thinks of unemployment or inflation as policy levers, but, rather, that these are economic outcomes that can be influenced by policy choices. If this were not the case, then the Dual Mandate would be pointless.

We find that the annualized expected welfare loss generated by a one-percentage point shock to the unemployment rate is equivalent to $1,156, on average across all families. And even though the probability of job loss is less for those with higher education, their potential income loss is greater, making the expected welfare loss for those with higher education greater than for those with relatively lower education. In addition, married families’ expected loss is greater than that of single families (both in levels and as a share of total annual income). This higher expected loss for married families translates into a higher equivalent loss in purchasing power for married families than for single families; married families are willing to tolerate greater loss to purchasing power to avoid unemployment as compared to single families are.

[2] Barlevy (2005) provides a good overview of the literature concerned with the welfare cost of volatility.

[3] In spite of this implied negative relationship between unemployment and inflation, Berentsen et al. (2011) identify a positive relationship between unemployment and inflation in very low frequency data (the long run).

[4] A related literature is concerned with macroeconomic *levels* and subjective well-being. For example, see Proto and Rustichini (2013) and Stevenson and Wolfers (2013).

[5] See http://www.federalreserve.gov/aboutthefed/fract.htm.

2. Methodology

Microsimulation is a popular methodology often applied to assess the impact of a specific policy on welfare (for example, see Fiorio, 2008; Blundell et al., 2000; Bahl et al., 1993; Blundell, 1992; Gustman, 1983). Here, rather than evaluate a specific policy, we simulate the impact of the economic consequences of any policy that is expected to negatively affect the labor market. The main advantage to the theoretical framework we employ for this exercise is that it is constructed from a standard joint (unitary for singles) family utility model. For married couples, labor supply is jointly estimated. The utility function does not include unemployment as a direct input in the optimization problem. However, changes in unemployment and purchasing power can be brought to bear on the welfare outcome by simulating the impact these environmental changes have on behavior and income, hence family utility.[6]

2.1. Family utility framework

The model described in this section nests the simpler case of single households. Empirically, the single family version of the model implies constraining hours and wages of the second household member to zero, as well as constraining all utility parameters concerning the second member to be zero.

Family labor supply decisions are modeled in a neoclassical joint utility framework often referred to as the "unitary" model. This model can be thought of as a reduced-form specification of family decision-making. The model yields a clear-cut expression of family welfare that allows for cross wage effects on each member's labor supply decision. Assumptions of the unitary model are often rejected in favor of a bargaining structure, or, more generally, the collective model, for modeling intra-familial decisions making (for example, see Apps and Rees, 2009; McElroy, 1990). However, a collective model framework provides no concept of measurable household welfare, which is what we are after in this analysis. What matters from the perspective of this article is how a policy outcome impacts a family's welfare, providing less emphasis on the implications in terms of decision-making structure within the household. Additionally, there is evidence that the choice of structure for household decision making has very little implication for conclusions in microsimulation exercises (see Moreau and Bargain, 2005). Further, Blundell et al. (2007) find that both collective and unitary models are consistent with their household labor supply model estimated in the U.K. We do not argue here that the unitary model is generally "better" than the collective model, but rather that it is more appropriate for the research questions in this article. The question posed in this paper requires differentiability of the utility function in order to make use of the indirect utility function to draw conclusions about changes in family welfare.[7]

Within the framework of the neoclassical family labor supply model, a family maximizes a utility function that represents household welfare. Assuming, for simplicity, that there are only two working members of the household (husband and wife), the family chooses levels of non-market time (e.g., leisure, household production) for each member and a joint consumption level in order to solve the following problem:

$$\max_{(L_1, L_2, C)} U = U(L_1, L_2, C)$$
$$\textit{subject to} \quad C = w_1 h_1 + w_2 h_2 + Y. \tag{1}$$

Define T as total time available for an individual; $L_1 = T - h_1$ will be referred to as the husband's non-market time, and $L_2 = T - h_2$ will be referred to as the wife's non-market time; h_1 is the labor supply of the husband; h_2 is the labor supply of the wife; C is total money income (or consumption with price equal to one); w_1 and w_2 are the husband's and wife's after-tax market wage, respectively; and Y is non-labor income. L_1 and L_2 correspond to *all uses of non-market time*, including home production activities. Since we are not concerned about the distribution of different types of non-market time within the household in order to assess total family welfare, distinguishing leisure from household production is not necessary.[8] In addition, the model does not distinguish between unemployment and non-participation; both states are included in the non-employment status. The implications of this are discussed later in Section 2.3.

The solution to the maximization problem in Eq. (1) can be expressed in terms of the indirect utility function, which is solely a function of the wages of the husband and wife and non-labor income of the family:

$$V(w_1, w_2, Y) = U\{[T - h_1^*(w_1, w_2, Y)], [T - h_2^*(w_1, w_2, Y)], [w_1 h_1^*(w_1, w_2, Y) + w_2 h_2^*(w_1, w_2, Y) + Y]\}, \tag{2}$$

where $h_1^*(w_1, w_2, Y)$ and $h_2^*(w_1, w_2, Y)$ correspond to the optimal labor supply equations (desired hours) for the husband and wife, respectively. By totally differentiating the indirect utility function, we can simulate the change in welfare that results from changes in optimal hours of work and consumption in response to changes in wages and non-labor income (also see Apps and Rees, 2009, 263):

[6] While economists often consider economic conditions (such as unemployment or inflation) as an outcome of economic processes (see Hall, 1981, 432), they are certainly exogenous to an individual family's decision making process.

[7] Also see Browning et al. (2006), who show that the unitary model, unlike the collective model, is well behaved and satisfies the Slutsky condition.

[8] Apps and Rees (2009) are highly critical of family utility models that do not include measures of household production, but they acknowledge that not much can be done without the availability of richer data (p. 108). The model presented here uses an aggregated measure that includes household production, leisure as well as other activities outside market job. Additionally, we do include the number and age of children as determinants of labor supply decisions since the presence of children may affect the comparative advantage between husbands and wives in non-market work.

$$dV = -U_1 dh_1^* - U_2 dh_2^* + U_3 dC^*, \tag{3}$$

where U_1 and U_2 are the family's marginal utility of the husband's and wife's non-market time, respectively, and U_3 is the family's marginal utility of consumption. It is this equation that gives us the change in family welfare that will result from a shock to unemployment or a shock to prices. It is clear from Eq. (3) that the change in welfare not only depends on the individual labor supply responses, but also on the family's marginal evaluation of a change in non-market time and income.

2.2. Estimation of utility function parameters and labor supply elasticities

Simulating the impact on family welfare of higher unemployment and shock to purchasing power requires the estimation of labor supply elasticities of each family member with respect to changes in their own and each other's (in the case of married-couple families) wages, elasticities with respect to non-labor family income, as well as the changes in the probability of employment (extensive margin elasticities); i.e., the probability of being at an interior solution on the budget constraint. There are many divergent empirical issues raised in the literature related to estimating labor supply elasticities. While the focus of this paper is on the simulation exercise itself, the simulation does require labor supply elasticities and it is, therefore, worthwhile to address some of the empirical issues. Most of these issues, including the potential for endogeneity of wages and non-labor income, are addressed in detail in online Appendix A. The goal here is to produce reasonable labor supply elasticities; we deem them to be reasonable if they are consistent with the literature. Toward that end, the methodology adopted takes the simplest approach possible while maintaining basic theoretical and empirical integrity. We also illustrate that the estimated labor supply elasticities are well within the range of the existing literature, which contains significant variation in modeling assumptions.

The requirement of simplicity here primarily derives from the goal of quantifying the family-level utility changes. In order to obtain estimates of the pieces of the change in utility in Eq. (3), a specific functional form of utility must be specified. Following others (e.g., Hotchkiss et al., 2012, 1997; Heim, 2009; Ransom, 1987), we estimate a quadratic form of the utility function:

$$U(Z) = \alpha(Z) - (1/2)Z'\mathrm{B}Z, \tag{4}$$

where Z is a vector with elements $Z_1 = T - h_1$, $Z_2 = T - h_2$, and $Z_3 = w_1h_1 + w_2h_2 + Y$; α is a vector of parameters and B is a symmetric matrix of parameters. This functional form has the advantage of being a flexible functional form in the sense that it can be thought of as a second order approximation to an arbitrary utility function. Furthermore, it is well-behaved when Amemiya's (1974) internal consistency conditions are met (this is established in Appendix A). In addition, it is possible to produce analytical closed-form solutions for both the husband's and wife's labor supply functions. Obtaining the first order conditions of this unconstrained maximization problem results in a system of equations linear in h:

$$\frac{\partial U}{\partial h_1} = \Omega_1 h_1 + \Omega_2 h_2 + \Omega_3 = 0 \tag{5}$$

$$\frac{\partial U}{\partial h_2} = \Omega_2 h_1 + \Omega_4 h_2 + \Omega_5 = 0 \tag{6}$$

This system can be solved simultaneously, and the desired hours become $h_1^* = f(w_1, w_2, Y)$ and $h_2^* = g(w_1, w_2, Y)$, which represent the desired number of hours the members of a household would like to work, given the parameters that define their household utility function, wages, and non-labor income. Details of this derivation are reported in online Appendix B.

Observed hours ($\tilde{h}$), however, might differ from the optimum hours due to stochastic errors, such that:

$$\tilde{h}_1 = \begin{cases} h_1^* + e_1 & \textit{if } h_1^* + e_1 > 0 \\ 0 & \textit{otherwise} \end{cases}$$
$$\tilde{h}_2 = \begin{cases} h_2^* + e_2 & \textit{if } h_2^* + e_2 > 0 \\ 0 & \textit{otherwise} \end{cases}, \tag{7}$$

where we assume that (e_1, e_2) follows a bivariate Normal distribution with mean 0 and covariance matrix Σ. This model can be thought of as a simultaneous Tobit model, with working hours censored at zero, where we have four kinds of families: those where both husband and wife work, those where only one of the spouses works (two cases), and those where neither of them work. (Of course, for singles, this simplifies to two cases – the individual working or not working.) Allowing for hours adjustment along the extensive margin for the wife when assessing labor supply responses to wage changes have been found to make a significant difference when assessing total labor supply response (for example, see Heim, 2009; Eissa et al., 2008), however, extensive margin hours adjustments appear to be unimportant for men (for example, see Heim, 2009; Blundell et al., 1988). Considering the simulation of possible unemployment for both men and women, allowing for husbands with zero hours of work is important, so they will be included in the analysis.

Allowing for the presence of non-workers raises one empirical issue identified by Keane (2011) that must be addressed: market wages are not observed for individuals who do not work. To obtain estimates of those wages, we take the standard approach in the literature of estimating a selectivity-corrected wage equation (Heckman, 1974) using regressors observable for both working and non-working individuals.[9] The resulting parameter estimates are then used to predict wages for non-working men and women based on their observable characteristics.

The maximum likelihood function corresponding to the joint labor supply optimization problem can be written as follows:

$$L = \prod_{i=1}^{N} \left[\left(\frac{1}{\sigma_1 \sigma_2}\right) \psi\left(\frac{\tilde{h}_1 - h_1^*}{\sigma_1}, \frac{\tilde{h}_2 - h_2^*}{\sigma_2}, \rho\right) \right]^{(H=1,W=1)}$$
$$* \left[\frac{1}{\sigma_1} \varphi\left(\frac{\tilde{h}_1 - h_1^*}{\sigma_1}\right) \left\{ 1 - \Phi\left(\frac{\sigma_1 h_2^* - \rho\sigma_2(\tilde{h}_1 - h_1^*)}{\sigma_2 \sigma_1 \sqrt{1-\rho^2}}\right) \right\} \right]^{(H=1,W=0)}$$
$$* \left[\frac{1}{\sigma_2} \varphi\left(\frac{\tilde{h}_2 - h_2^*}{\sigma_2}\right) \left\{ 1 - \Phi\left(\frac{\sigma_2 h_1^* - \rho\sigma_1(\tilde{h}_2 - h_2^*)}{\sigma_2 \sigma_1 \sqrt{1-\rho^2}}\right) \right\} \right]^{(H=0,W=1)} * \Psi\left(\frac{-h_1^*}{\sigma_1}, \frac{-h_2^*}{\sigma_2}, \rho\right)^{(H=0,W=0)}, \tag{8}$$

where φ and Φ correspond to the probability density and cumulative distribution functions of a univariate normal distribution, and ψ and Ψ represent the probability density and cumulative distribution functions of the bivariate normal distribution. For singles, this likelihood function reduces to the univariate case. Also, $H = 1$ if the husband is working and $W = 1$ if the wife is working (0 otherwise), σ_i ($i = 1,2$) represents the standard deviations of (e_1, e_2) and ρ is the correlation between the stochastic errors.

Obtaining reasonable estimates of labor supply elasticities is essential in order to obtain credible estimates of the change in utility through the simulation exercise described below. Issues that are well known in the literature relating to the estimation of labor supply elasticities and the implications of those issues to the problem at hand are addressed in detail in online Appendix A.

With the expectation of heterogeneity in preferences across families, particularly of different age, education, and income levels (see Keane and Wasi, 2016; Deaton, 2018), we estimate different sets of parameters for families based on the husband's education level for married couples, and head of the household's education for single families. In addition, we estimate different sets of parameters for male and female singles. In other words, we estimate five sets of parameters for married families (full sample; and four levels of husband's education) and 10 sets of parameters for singles (full sample for men and women separately; then for each education level separately for men and women).[10]

2.3. Expected welfare loss from a shock to aggregate unemployment

We simulate the impact of a rise in the unemployment rate as an exogenous shock to the stochastic errors in Eq. (7). If, for example, an employed husband loses his job, then $e_1 = -h_1^*$. This also implies that the estimated welfare impact of unemployment is, by construction, zero if neither of the spouses is working.

The probability of each family member being hit by job loss is a function of his or her demographic characteristics (gender, race, age, and education), as well as time and location (details provided below). If the marginal effect on the probability that the husband loses his job when the aggregate unemployment rate rises by one-percentage point is p_1 and the marginal effect on the wife's probability of losing her job is p_2, then the expected change (loss) in family welfare (dV from Eq. (3)) due to a positive probability of job loss is given by:

$$\begin{aligned} Exp\{dV|_{p_{1>0},p_{2>0}}\} &= (1-p_1)(1-p_2)dV\,[dh_1^* = 0,\, dh_2^* = 0,\, dC^* = 0] \\ &+ p_1(1-p_2)dV\,[dh_1^* = -h_1^*,\, dh_2^* = 0,\, dC^* = -w_1 h_1^* + \tau_1 wba_1] \\ &+ (1-p_1)p_2 dV\,[dh_1^* = 0,\, dh_2^* = -h_2^*,\, dC^* = -w_2 h_2^* + \tau_2 wba_2] \\ &+ p_1 p_2 dV\,[dh_1^* = -h_1^*,\, dh_2^* = -h_2^*,\, dC^* = -w_1 h_1^* - w_2 h_2^* + \tau_1 wba_1 + \tau_2 wba_2] \end{aligned} \tag{9}$$

The first term on the right hand side of Eq. (9) is the expected change in utility if neither the husband nor the wife loses their jobs. The second term is the expected change in utility from only the husband losing his job. The third term is the expected change in utility from only the wife losing her job. And the last term in this expression is the expected change in utility of both persons losing their jobs. For singles, this expected utility reduces to just two terms corresponding to the increased probability that the individual becomes non-employed and one minus that probability.

The change in aggregate unemployment is assumed to be strictly an exogenous shock and does not play a role when the family members choose the optimal number of hours to work. And, except for being related through characteristics a husband and wife might have in common (such as age, race, state of residence, etc.), the marginal effects of job loss for husband and wife, in married-couple households, are otherwise independent of each other.[11]

When a family member loses his/her job, the family loses his and/or her earnings, but that earnings loss may be offset somewhat by receipt of Unemployment Insurance. Details of how we estimate the weekly benefit allowance (*wba*), eligibility, and expected take-

[9] For purposes of identification, the Heckman selection equation uses non-labor income, number of children in the household, and spouse education (for married households) as exclusion restriction variables.

[10] There are many other dimensions across which utility function parameters could vary. We expect that differences across marital status and education/income would be most pronounced, however additional heterogeneity (across age, race, and number of children) is allowed for through the a_1 and a_2 found in Eq. (B1); estimates of their components are reported in Appendix E, Tables E1 and E2.

[11] Additionally, market wages are assumed to be sticky (e.g., see Kahn, 1997), therefore assumed to not be a function of unemployment in this static framework.

up rate (τ) are provided in online Appendix C.[12] The fact that take-up rates are below 100% reflects the choice of some individuals who lose their jobs to exit the labor force, rather than remain unemployed.

The family may also be able to offset earnings loss through previous savings. However, based on our calculations using the Survey of Consumer Finances (SCF) (available upon request), it is unclear how the presence of savings would differentially impact the estimations of expected welfare loss across families from a rise in the unemployment rate. For example, in 2016, 48.9% of households had zero liquid savings and 27.9% of those with savings had $6,000 or less in savings. Additionally, there is no consistent variation across income deciles in households' average total liquid savings as a share of the average total income (or as a share of average earnings). So, even though wealthier households are more likely to save (i.e., more likely to spend less than they earn at any point in time, as also seen in the SCF), the ability of a typical high-income family to replace lost earnings with savings (and maintain their usual level of consumption) does not appear to be significantly different than that of a typical low-income family.[13]

The marginal impact of a change in the unemployment rate on the probability of job loss is obtained by estimating the probability of non-employment as a function of the aggregate unemployment rate.[14] Each person is assigned to one of 64 specific demographic groups (based on two gender, two race, four age, and four education classifications). The impact of a rise in the state/year aggregate unemployment rate on the probability of non-employment for a member of that group is determined by 64 separate time-series probit estimations using observations from the March supplement of the Current Population Survey from the time period 2003–2013 with year and state fixed-effects.[15] We choose a 10-year period to average the marginal effects across the most recent business cycle prior to the years of analysis. For example, the smallest marginal effect of a one-percentage point increase in the aggregate unemployment rate was estimated to be a 0.056 percentage point decline in employment for white women, between 35 and 44 years old, with at least a college degree. Therefore, p_2 for a woman with these characteristics is set equal to 0.00056. The largest marginal impact was estimated to be a 2.4 percentage point employment decline for white men, between the ages of 18 and 34, with less than a high school degree. Therefore, p_1 for a man with this set of characteristics is set equal to 0.024. Given a set of estimated utility function parameters, and estimated probabilities of job loss, the family-specific impact on expected utility of a one-percentage point rise in the unemployment rate is given by Eq. (9).

The model does not explicitly depend on the labor market environment (i.e., the prevailing aggregate unemployment rate) at the time of optimization. The model specification assumes that whatever non-employment exists is optimal (or, within a random error term of optimal). This means that if some of the observed non-employment is technically unemployment, it is by choice – the person's market/offered wage is less than his/her reservation wage. This optimization can be thought of as taking place in the aggregate at the natural rate of unemployment. We estimate utility function parameters using data from 2015 to 2016, a period of time which most sources consider the economy to be at or near the natural rate of unemployment (for example, see Federal Reserve Bank of Philadelphia, 2017). Therefore, this time period provides an environment in which we can interpret observed non-employment behavior as near optimal.

3. Data

The Current Population Survey (CPS) is administered by the U.S. Bureau of Labor Statistics each month to roughly 60,000 households.[16] The survey has a limited longitudinal aspect in that households are interviewed for four consecutive months, not interviewed for eight months, then interviewed again for four months. Households, families, and individuals can be matched across these survey months if they remain in the same physical location. In survey months four and eight, the household is said to be in the "outgoing rotation" group and members of the household are asked more detailed questions about their labor market experience, such as wages and hours of work.

We make use of the CPS outgoing rotation groups in March, April, May, and June from 2015 to 2016 in order to construct the samples for which the family labor supply model is estimated. We combine as many months as possible across two years in order to construct the largest data set possible to meet the demands of the challenging estimation problem. Detailed non-labor income is obtained by matching each family to their March supplement survey, which is the month in which this information is collected. Households that couldn't be matched to the March data are excluded from the analysis.

We restrict the sample further for two reasons. The first is for structural reasons to make the observations conform better to the theoretical model. These restrictions involve limiting the sample to households with members between 18 and 64 years of age and excluding households with unmarried same- or opposite-sex adults/partners or children older than 18 years old. It is unclear in these households how to assign the "husband" and "wife" labels and potential additional adult labor supply is not accounted for in the model. We also exclude households in which the main activity of both members is being a student, being retired, or self-employment. We expect that those younger than 18, older than 64, students, and retired individuals have additional constraints on their

[12] For simplicity, we assume that all other sources of non-labor income are not affected by the shock of unemployment.

[13] Whereas higher-income families are more likely to have any savings at all to be able to help smooth consumption, Aaronson et al. (2019) suggest that lower-income families rely on credit to help smooth consumption in the event of a job loss. Of course, the longer term consequences of depleting savings or exhausting credit in the event of job loss is beyond the scope of this paper.

[14] Details of the estimation procedure and a sample of estimated marginal effects are provided in online Appendix D. An increase in non-employment (either from unemployment or out of the labor force) will necessarily reflect job loss.

[15] This procedure is similar to that employed by Gramlich (1974) in his assessment of the distributional consequences of unemployment.

[16] We obtained the CPS data set from IPUMS. See Flood et al. (2015).

optimization problem not considered here. In addition, it is difficult to estimate market hourly earnings (wage) for someone who is self-employed. Given the nature of their activities, in a short period of time, reported earnings can be negative, even if, in the long term, the market value of a self-employed worker's time would be positive.

Because the simultaneous estimation of nonlinear labor supply functions is challenging, we also "trim" the data in various ways to eliminate outliers that cause difficulties in the estimation process. Less than five percent of the sample is eliminated based on the following restrictions: non-positive after-tax weekly household income, negative non-labor income, after-tax hourly wages greater than $600 or less than $0.50, or an estimated marginal tax rate 75% or higher or lower than −60%.

Information on the detailed sources of non-labor income, number of children, and earnings available from the CPS is used to calculate the marginal tax rate on earnings (wages) and the total tax liability (in any year of interest) using the National Bureau of Economic Research (NBER) TaxSim tax calculator. The calculator is more complete than we have information for from the CPS, so we made assumptions for the missing values as recommended by TaxSim managers. For example, there is no information in the CPS that would allow one to calculate itemized deductions (mortgage payments, charitable contributions, etc.), so values of zero are entered for the missing information. Although unlikely to affect tax rates, this will likely lead to an over-estimate of taxes paid for higher income individuals, since they would likely receive a higher deduction through itemization.[17]

Online Appendix E contains the means for the full sample and for each sub-sample based on education, for married and single families (respectively). We have a total of 20,163 married families and 15,485 single families in our sample. Among married families, about 88% of husbands and nearly 70% of wives are working (with both percentages increasing in husband's education). Husbands work more hours (43) and earn a higher after-tax hourly wage ($21.33 after tax) than their wives, who work about 37 hours and earn $16.16 after tax. Husbands are slightly older than wives, at 45 vs. 43 years of age. Wives are slightly more educated than their husbands. The families have roughly $347 per week in (virtual) non-labor income. Virtual non-labor income is what the non-labor income for the family would be if the portion of the non-linear constraint they are on were extended to the vertical axis. The average federal (state) marginal tax rate across families is 20% (4%).

Women comprise 56% of the single-persons sample. On average, women have slightly more education; are slightly younger than the men; work fewer hours (39 vs. 42 for single men); have about the same non-labor (virtual) income; have a greater number of children; and earn lower wages. Roughly half of all singles have never been married (46% of women and 54% of men).

4. Results

4.1. Utility function parameter estimates and labor supply elasticities

Maximum likelihood estimates of the utility function parameters for both married and single families are presented in online Appendix F, along with the average labor supply elasticity and marginal utility estimates for married and single families. For purposes of placing the estimated elasticities in context of the literature, Fig. 1 illustrates the intensive margin elasticities along with estimates from previous studies. Note that own wage elasticities are averaged across workers and non-workers. It is well known that varying assumptions can produce a wide array of labor supply elasticities (see Mroz, 1987); our estimates generally fall within the range of those found in the literature.

Note that married women's own wage elasticities are higher than married men's elasticities, indicating that women's labor supply is more responsive to changes in their own wages. In addition, married women are more responsive to changes in their own wages than are single women, who average an own-wage elasticity very close to that of single men. The estimated negative cross-wage elasticities (among married families) indicate that husbands and wives view their non-market time as substitutes, which is consistent with the existing literature. Cross wage elasticities for husbands and wives correspond to families in which both members are working. Both men and women present the expected negative income elasticity. The bottom line from these estimates is that the simulation will be based on behavior reflected through labor supply elasticities consistent with those estimated by others, using different data, empirical models, and for different purposes. Online Appendix G provides a sensitivity analysis (discussed more below) showing that our results are robust to variations in labor supply elasticities.

4.2. Expected welfare loss from a shock to unemployment

By dividing the calculated expected loss in welfare from a one-percentage point rise in the unemployment rate (in *utils*) by the family's marginal utility of income/consumption (U_3), we get a dollar value of that expected welfare loss. Table 1 reports the annualized dollar value for the expected welfare loss from a positive shock to unemployment for families of different types and education levels (the loss as a share of total household income is also reported).

Workers at higher education levels earn higher wages, putting upward pressure on the expected welfare loss from losing their job. For example, the average annual income for families with at least a college degree is roughly twice as large as for families with less than a high school degree (i.e., roughly $87,000 vs. $42,000). Therefore, families with higher education (higher earnings) have much

[17] http://www.nber.org/~taxsim/; see also Feenberg and Coutts (1993). In addition to the detailed income source information from the CPS data, we also include information on property tax, CPS imputed capital gains and capital losses. All married households are classified as if they were declaring taxes jointly and the main earner is identified as that with the highest total earned income. The tax simulation was implemented using the Stata taxsim interface.

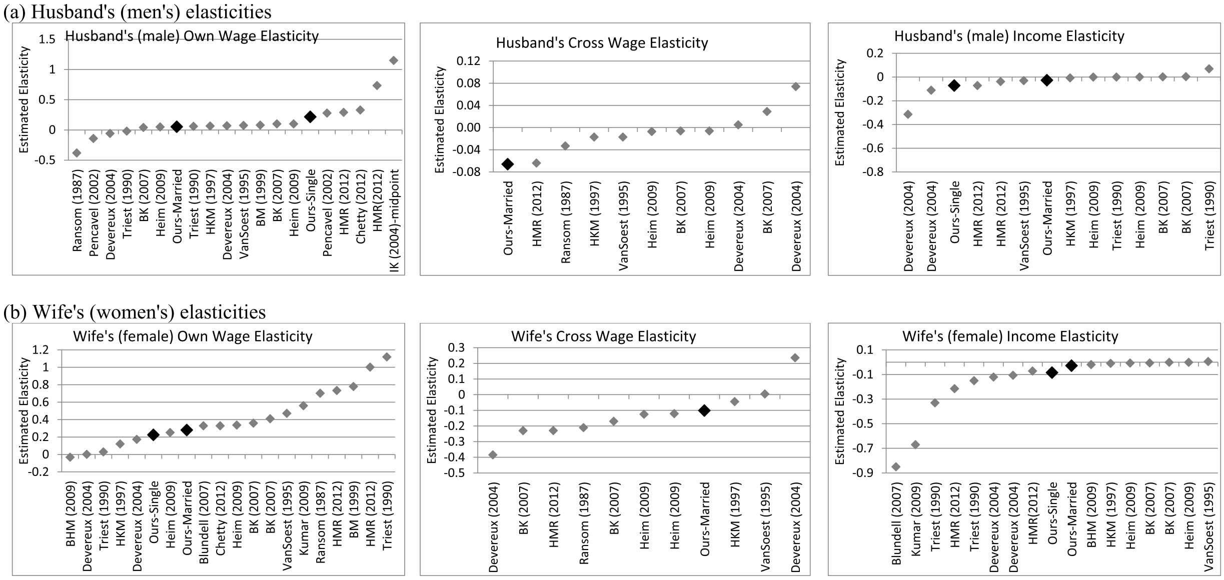

Fig. 1. Comparison of intensive margin elasticity estimates with the literature.
Notes: Sources of literature estimates are (Devereux, 2004; Hotchkiss et al., 2012;Moore, 1997; Heim, 2009; Blau and Kahn, 2007; Triest, 1990; Pencavel, 2002; Ransom, 1987; Blundell and Macurdy, 1999; Kumar, 2009; Bishop et al., 2009; Imai and Keane, 2004; Chetty, 2012; van Soest, 1995). Also see Keane (2011) and McClelland and Mok (2012) Many fewer sources provide estimates for participation elasticities, but ours fall within the literature bounds (available upon request).

Table 1
Average welfare loss of a negative shock to employment by family type and education.

	Married families	Single families
All education types	$1,944 [$1,735–$2,197] 2.85%	$131 [$122–$141] 0.29%
Less than high school	$818 [$587–$1,230] 1.90%	$7 [$0–$57] 0.03%
High school	$1,501 [$1,244–$2,001] 2.47%	$94 [$78–$119] 0.25%
Some college	$1,769 [$1,488–$2,169] 2.55%	$184 [$158–$211] 0.46%
College or more	$2,970 [$2,382–$3,824] 3.30%	$1,039 [$349–$4165] 2.04%
Single family type		
married, spouse-not-present		$153 [$128–$173] 0.32%
separated		$125 [$106–$140] 0.31%
divorced		$128 [$116–$138] 0.26%
widowed		$75 [$60–$87] 0.16%
never married		$139 [$125–$149] 0.32%

Note: Education refers to single head of household or husband education for married families. Full sample estimates are used to report results for the full sample and the education specific estimates are used to report results by education group. 95% confidence intervals are in brackets; they were obtained through bootstrapping with 199 repetitions. Percents reflect average across families of the welfare loss as share of total family income.

more to lose if they experience job loss. However, a higher education level also means a lower probability of job loss, putting downward pressure on the expected welfare loss from rising unemployment. For example, a one percentage point rise in the unemployment rate increases the probability of job loss for someone with less than a college degree by 1.23 percentage points, whereas the marginal effect on someone with a college degree is only 0.54 percentage points, on average.

Based on the results in Table 1, we see that, since the expected welfare loss increases with education, the impact of the potential of losing higher wages dominates the lower job loss probability. To better visualize the differences across families, the estimates in Table 1 are plotted for both married and single families (Fig. 2, panel a). The largest difference in estimates across both married and single families is that between the most and least educated, illustrating that the loss of income is likely dominating the higher probability of employment loss.[18]

[18] The very imprecise estimate of the welfare loss among college educated singles could likely be coming from the estimated negative wage elasticity. Based on the literature, this is more likely to be found among high-earning workers, suggesting that the income effect from a wage change on hours dominates the substitution effect.

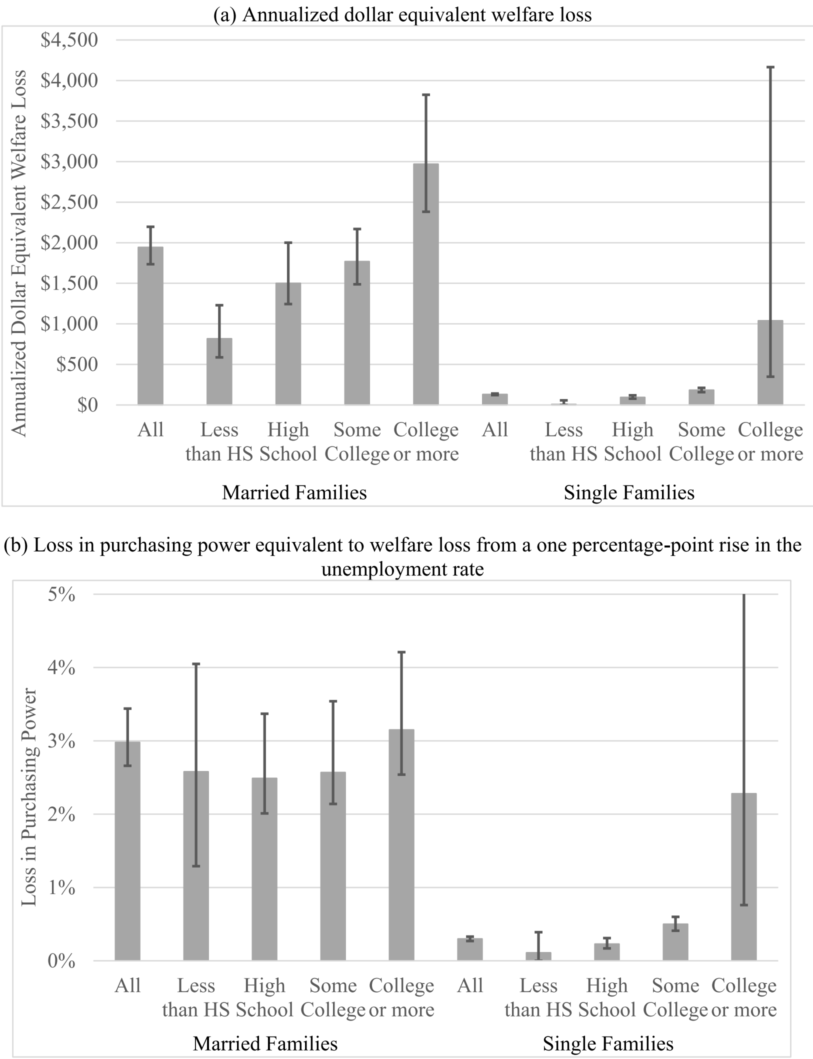

Fig. 2. Graphical representation of the annualized welfare loss and equivalent loss in purchasing power arising from a one percentage point rise in the aggregate unemployment rate (shown with 95% confidence intervals).
Note: See notes to Table 1.

The average annualized expected welfare loss for the whole sample is $1,156. This estimate of expected welfare loss is much lower than that found in Hurd (1980), who estimates an individual welfare loss per unemployment spell of about $7,000 (in 2012 dollars). Likely the main reason Hurd's estimate is so much higher than ours is that we are estimating the *expected* welfare loss from losing a job, rather than the actual cost of a specific job loss. Also, his model does not allow for any positive utility gained from additional non-market time that results from unemployment, nor the potential mitigating effects of unemployment insurance. Additionally, Hurd does not allow for substitution of non-market time between husband and wife, which will over-state the losses for men.

There is a significant difference between single and married families (in both levels and as a percent of annual family income) – the average expected welfare loss overall is $1,944 among married families, whereas the average annualized expected loss is only $131 among singles. To get some idea of where this sizable difference might be coming from, we decompose the change in welfare into each of its components: differences in non-employment probabilities, change in hours for each family member, change in total consumption, and changes in the marginal utilities (since we are moving families to a different point on their indifference curve). The results of this decomposition are found in Table 2. Note that the decomposition is performed for the average married and average single families, whereas the welfare losses reported in Table 1 reflect the average loss across families (while the total loss estimates differ slightly, the relative comparison is the same).

There are four possible employment outcomes for married families and two possible employment outcomes for single families when the unemployment rate increases. The lowest probability of job loss occurs for women in the average married family, followed by the average single women, men in the average married family, and then the average single man. Regardless of family type,

Table 2
Decomposition of the weekly welfare loss for the average married and average single family from a one percentage point increase in the aggregate unemployment rate.

	Average married family					Average single man			Average single woman		
	No job loss	Both husband and wife lose job	Husband loses job	Wife loses job	TOTAL	Single man does not lose job	Single man loses job	TOTAL	Single women does not lose job	Single women loses job	TOTAL
p	98.20%	0.01%	1.08%	0.72%		98.84%	1.16%		99.22%	0.78%	
dh_1^*	0	−37.80	−37.80	0		0	−34.06		–	–	
dh_2^*	0	−25.92	0	−25.92		–	–		0	−30.44	
dC^*	0	−967.63	−633.43	−334.20		0	−481.68		0	−384.00	
U_1	5.602	−14.96	−14.14	4.78		132.51	86.02		–	–	
U_2	4.221	0.56	3.59	1.19		–	–		67.57	39.72	
U_3	0.297	0.39	0.37	0.31		8.50	10.75		4.95	6.14	
$Exp\{dV\}$	0	−926.32	−769.93	−73.72	−8.92	0	−2,248.22	−26.08	0	−1,148.68	−8.96
$ equivalent	0	−$3,120	−$2,593	−$248	-$30	$0	−$209	−$3	$0	−$187	−$2
Annualized					-$1,562			−$160			−$94

Note: Subscript "1" refers either to the husband, or single man; "2" refers to wife or single women. Notation corresponds to Eqs. (3) and (9). $U_{1/2/3}$ correspond to the marginal utilities of the husband's/single man's non-market time, wife's/single woman's non-market time, and consumption, respectively. As an illustration of how the estimates in the table are used to construct $Exp\{dV\}$, consider the case of the average single man, where p is the probability of each outcome (the final value is then divided by the marginal utility of consumption, U_3, under no job loss to get the weekly dollar equivalent of lost welfare:

$$Exp\{dV\} = p_{jobloss}\{-U_1 dh_1^* + U_3 dC^*\} + p_{nojobloss}\{-U_1{*}0 + U_3{*}0\} = 0.0116\{-86.02{*}(-34.06) + 10.75{*}(-481.68)\} + 0.9884\{-132.51{*}0 + 8.5{*}0\}.$$
$$= -26.08$$

preferences behave as expected. When someone becomes non-employed (i.e., an increase non-market time and a decrease in income), the marginal value of their non-market time (U_1 and U_2) declines and the marginal value of consumption/income (U_3) increases. One important difference between married families and single families is that whenever the husband loses his job, the family's marginal utility of his non-market time (U_1) becomes negative – there is a tremendous loss in welfare from the husband not working.

Concluding that the welfare *loss* from a one percentage point rise in the unemployment rate is greater for married families than for single families, and is greater for the more educated, does not say anything about the welfare *levels* of different family types or education levels. The losses estimated here from a rise in the unemployment rate also do not imply that an analogous decline in unemployment would generate a symmetric gain in welfare for families. In fact, De Neve et al. (2017) find that subjective well-being is more sensitive to negative economic conditions than to positive economic conditions. Further, the model in this paper is not well-suited to assess employment gains since it is predicated on the assumption of full employment.[19]

4.3. Equivalent welfare loss from a shock to purchasing power

In order to illustrate how we simulate the loss in purchasing power needed to generate the same expected welfare loss of a one percentage point rise in the unemployment rate, the total derivatives in the indirect utility function from Eq. (3) ($dh_1^*,\ dh_2^*,\ and\ dC^*$) are expanded and the terms are rearranged to isolate those reflecting changes in wages and non-labor income ($dw_1, dw_2, and\ dY$):

$$dV = \left\{-U_1\frac{\partial h_1}{\partial w_1} - U_2\frac{\partial h_2}{\partial w_1} + U_3\left[w_1\frac{\partial h_1}{\partial w_1} + h_1 + w_2\frac{\partial h_2}{\partial w_1}\right]\right\}dw_1$$
$$+\left\{-U_1\frac{\partial h_1}{\partial w_2} - U_2\frac{\partial h_2}{\partial w_2} + U_3\left[w_1\frac{\partial h_1}{\partial w_2} + h_2 + w_2\frac{\partial h_2}{\partial w_2}\right]\right\}dw_2$$
$$+\left\{-U_1\frac{\partial h_1}{\partial Y} - U_2\frac{\partial h_2}{\partial Y} + U_3\left[w_1\frac{\partial h_1}{\partial Y} + 1 + w_2\frac{\partial h_2}{\partial Y}\right]\right\}dY. \quad (10)$$

The only consumption price in our model is that of the numeraire price of consumption. Therefore, we can reflect a loss in purchasing power by changing the other components that enter the model in real dollars. Eq. (10) shows how family welfare is

[19] Welfare costs of a rise in the unemployment rate discussed here also do not take into account the potential long term consequences of job loss on the mental and physical health of those impacted and/or their children or on lifetime wealth (for example, see Golberstein et al., 2016; Sullivan and Wachter, 2009; Mathers and Schofield, 1998; Krueger et al., 2016; Gathmann et al., 2018). Nor does our estimate of the expected welfare cost of rising unemployment take into account any fear that families or individuals might have of losing their job (as DiTella et al., 2001 claim their survey of happiness does).

Table 3
Average loss in purchasing power equivalent to the welfare loss from a rise in the unemployment rate by one percentage point, estimated by family type and education.

	Married families	Single families
All education types	2.98% [2.66% – 3.44%]	0.30% [0.27% – 0.33%]
Less than high school	2.58% [1.29% – 4.05%]	0.11% [0% – 0.39%]
High school	2.49% [2.01% – 3.37%]	0.23% [0.17% – 0.31%]
Some college	2.57% [2.14% – 3.54%]	0.50% [0.41% – 0.6%]
College or more	3.19% [2.54% – 4.21%]	2.28% [0.76% – 34.15%]
Single family types		
married, spouse-not-present		0.34% [0.29% – 0.39%]
separated		0.30% [0.25% – 0.35%]
divorced		0.28% [0.25% – 0.3%]
widowed		0.18% [0.15% – 0.2%]
never married		0.33% [0.29% – 0.37%]

Note: Education refers to single head of household or husband education for married families. Full sample estimates are used to report results for the full sample and the education specific estimates are used to report results by education group. 95% confidence intervals are in brackets; they were obtained through bootstrapping with 199 repetitions.

affected by changes in wages and non-labor income, directly, and also through each person's labor supply elasticities. Of course, there are no cross-elasticities that enter the calculation in a single family's change in utility.

If prices increase by i, one nominal dollar of income would only be able to buy $1/(1 + i)$ of any particular composite good. This implies that the value, or purchasing power, of nominal wages and nominal non-labor income declines by $-[i/(1 + i)]$. Given that we are considering a one-time change in the level of prices, we assume that nominal wages are sticky over the same time period, thus there are no adjustments on wages or non-labor income over the horizon of analysis (e.g., see Kahn, 1997), hence there is a decline in purchasing power by the same percent as the price increase.

Calculating the equivalent welfare cost from a loss in purchasing power, then, amounts to finding the value of i that equates Eqs. (9) and (10):

$$\begin{aligned} Exp\{dV|_{p_{1>0},p_{2>0}}\} = &\left\{-U_1\frac{\partial h_1}{\partial w_1} - U_2\frac{\partial h_2}{\partial w_1} + U_3\left[w_1\frac{\partial h_1}{\partial w_1} + h_1 + w_2\frac{\partial h_2}{\partial w_1}\right]\right\}\left(-\frac{i}{1+i}{*}w_1\right) \\ &+ \left\{-U_1\frac{\partial h_1}{\partial w_2} - U_2\frac{\partial h_2}{\partial w_2} + U_3\left[w_1\frac{\partial h_1}{\partial w_2} + h_2 + w_2\frac{\partial h_2}{\partial w_2}\right]\right\}\left(-\frac{i}{1+i}{*}w_2\right) \\ &+ \left\{-U_1\frac{\partial h_1}{\partial Y} - U_2\frac{\partial h_2}{\partial Y} + U_3\left[w_1\frac{\partial h_1}{\partial Y} + 1 + w_2\frac{\partial h_2}{\partial Y}\right]\right\}\left(-\frac{i}{1+i}{*}Y\right). \end{aligned} \tag{11}$$

In other words, i is the percent increase in the consumption price level that generates, for each family, the same expected change in utility as a one-percentage point rise in the aggregate unemployment rate. This one-time price level change will be able to tell us something about how the individual family would experience the trade-off between a rise in unemployment and a loss in purchasing power.

Table 3 presents the equivalent loss in purchasing power by marital status and education. For the full sample, the average equivalent loss in purchasing power is 1.82% (with a median of 0.83%). The results in Table 3 are also illustrated in Fig. 2, panel (b). The equivalent loss in purchasing power is much lower among single families at 0.30% (0.21% at the median). Since a one-percentage point rise in the unemployment rate is not as costly to them, singles, if given a choice, would not willingly endure as large a loss in purchasing power in order to avoid a rise in unemployment.

If we interpret this valuation of a shock to purchasing power as reflective of a short-term reaction to unanticipated inflation, this result is consistent with Burdett et al. (2016) who find that singles are much more likely to hold cash than non-singles, which loses value more quickly with inflation than other assets; they conclude that, "…inflation is a tax on being single" (p. 352).[20] Although they address the cost of inflation, and we simulate the cost from a loss in purchasing power, the lower estimated cost from a loss in purchasing power among singles is consistent with the conclusions of Burdett et al. (2016), who find that inflation (which can be thought of as a loss in purchasing power *if* it affects prices and not wages) is more costly for singles because, "…being single is cash intensive" (p. 337); also see (Dong et al., 2015). In addition, Burdett et al. find that among the non-married, inflation is likely to be costliest to those who are widowed; we find the same, as illustrated in Table 3.

Another potential comparison for these results is the work by DiTella et al. (2001). Their analysis across countries and time finds that, "a 1-percentage-point increase in the unemployment rate equals the loss brought about by an extra 1.66 percentage points of inflation" (p. 339). Again, their analysis is quite different from the one presented here – they estimate life satisfaction as a function of unemployment and inflation across many countries and time. And, although they do not provide the nuances seen here across demographics, their estimated inflation-generated loss of happiness (or, welfare) equivalent to 1pp rise in the unemployment rate is

[20] Note that inflation can be thought of as a loss in purchasing power *if* it affects prices and wages do not adjust (also see Aruoba et al., 2016; Dong et al., 2015). Other research (Alm et al., 2002) has identified a tax on singles (relative to others with similar economic and demographic characteristics) through the structure of the U.S. tax system.

within the range of the equivalent loss in purchasing power presented in Table 3.

Online Appendix G contains the results from a sensitivity analysis for the equivalent loss in purchasing power presented in Table 3. For the full sample of married families, the alternate loss in purchasing power, using alternative elasticities found in the literature, range from a low of 2.69 to a high of 3.95%. For single men and women, there is no measurable difference in the estimates using alternative labor supply elasticities. The estimates presented here for the expected welfare cost of unemployment and its equivalent shock to purchasing power are clearly not being driven by differences found between our labor supply elasticities and those in the rest of the literature.

4.4. Loss in purchasing power vs. unemployment shock trade-off

There is a rich literature that estimates the cost of inflation in terms of how much consumption one would be willing to give up to lower inflation. Estimates range between 0.5% and 10%.[21] The larger the estimate, the more consumption one would be willing to give up to reduce inflation. There is a large literature assessing the distributional effects of inflation (see Amaral, 2017 for a review) suggesting that since inflation is not as costly to wealthy individuals, they would not be willing to give up as much consumption to avoid inflation. Or, inversely, they would be willing to endure greater inflation to avoid higher unemployment (potential loss to consumption).

Using results presented above, Fig. 3 illustrates the shock to purchasing power that is equivalent to the welfare loss from a rise in unemployment, that welfare loss as a share of income (roughly, loss in consumption), and the ratio of the two across the income distribution. The loss in purchasing power equivalent to the welfare loss from a one percentage-point rise in the unemployment rate (panel a) increases with income in the lower half of the income distribution, then basically flattens out. The expected welfare loss from an increase in unemployment, as a percent of income (panel b), also rises in the lower half of the income distribution, but then declines as income continues to rise.

Since the ratio of the two (panel c) is increasing in income, higher income families are willing to endure a greater loss in purchasing power to avoid a rise in unemployment and lower income families are not willing to endure as much loss in purchasing power to avoid the same thing.[22] This result is consistent with results from the literature summarized by Amaral (2017) – lower income families are more cash dependent, and thus are hurt more from an unanticipated increase in inflation; higher income families are more likely to be borrowers, thus benefiting from an unanticipated increase in inflation; and families in the top quartiles rely more on earnings as an income source, thus making the potential loss of earnings through a rise in the unemployment rate more painful. While our consideration of a loss in purchasing power is not the same thing as a rise in inflation, the short-term effect of a shock might be argued to have similar welfare implications.

5. Conclusions and policy implications

This paper presents evidence that, on average, the expected loss to family welfare of a one-percentage point rise in the aggregate unemployment rate is equivalent to an annualized dollar amount of $1,156. We also find a considerable amount of heterogeneity across families, which means that aggregate averages yield very different answers than looking more closely at population subgroups. For example, the expected welfare cost of a shock to unemployment is much higher among married (vs. single) families and increases for both in education and income levels.

We also find that a loss in purchasing power of about 1.8%, on average for all families, produces a welfare loss equivalent to that generated by a one percentage point shock to unemployment and is much lower for single families than for married families. On average singles would only be willing to trade a loss in purchasing power of roughly one-third of a percent to avoid a one percentage point rise in the unemployment rate, whereas married families would tolerate a loss in purchasing power of up to three percent to avoid the same degree of unemployment rate shock.

Additionally, we find that higher income families are willing to endure a greater loss in purchasing power to avoid a rise in unemployment than lower income families. This conclusion holds for both married and single families, suggesting that, regardless of family structure and overall dollar equivalent value of the expected loss from a rise in the unemployment rate, the willingness to endure a loss in purchasing power to avoid higher unemployment rises consistently across the income distribution.

The distributional consequences of monetary policy were publicly on the minds of the U.S. Federal Open Market Committee (FOMC) in 2019. During this year members of the FOMC participated in a series of "Fed Listens" public events as part of its monetary policy framework review.[23] One of the considerations of this review includes the distributional consequences of monetary policy (see Clarida, 2019). The analysis in this paper affirms other results in a long-standing literature showing that monetary policy has differential impacts across the income distribution (for example, see Coibion et al., 2017; Krusell et al., 2009). The results here are driven by differences across households in the probability of being hit by unemployment that might arise from contractionary

[21] See Lagos et al. (2017) for a review of estimates from the literature.

[22] This comparison is made separately for married and single families in online Appendix H. In spite of the dramatically different annualized dollar amount of expected loss from a one percentage point rise in the unemployment rate, and hence tolerance for a loss in purchasing power, the ratio of the two across the income distribution is similar across family types.

[23] For information about this review process, see https://www.federalreserve.gov/monetarypolicy/review-of-monetary-policy-strategy-tools-and-communications-fed-listens-events.htm.

(a) Welfare loss from a loss in purchasing power equivalent to the welfare loss from a rise in the aggregate unemployment rate

(b) Welfare loss from 1pp increase in the aggregate unemployment rate (% of total income)

(c) Ratio of welfare loss from loss in purchasing power vs. welfare loss from unemployment shock

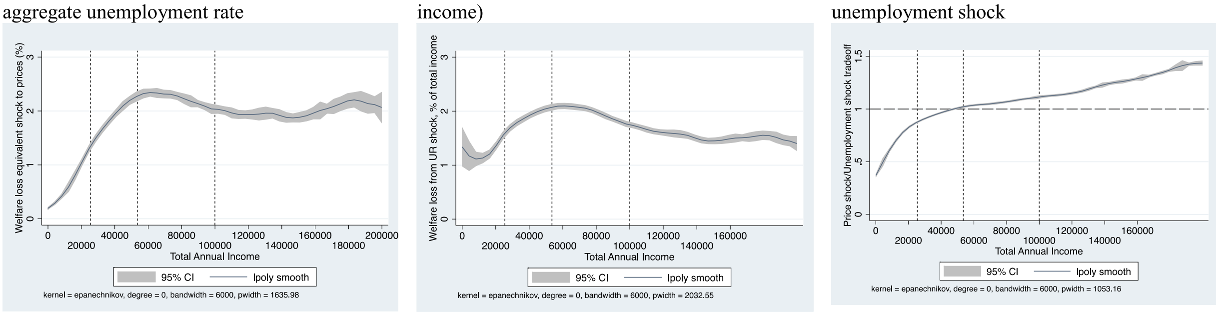

Fig. 3. Comparing welfare losses from a price shock vs. an unemployment shock across the income distribution, full sample averages.
Note: Percent of the sample noted by dashed lines at maximum household income for those in the bottom 20%, the sample median, and the min household income for those in the top 20%. Comparable 2015 median household incomes reported for the U.S. by the Census Bureau can be found here: https://goo.gl/XkzVMR.

monetary policy, differences in earnings potentially lost, and by differences in the valuation of leisure by different members of a household.

The Fed's Dual Mandate essentially requires that those who suffer the most from the consequences of contractionary monetary policy are at least being taken into consideration. However, a low-interest rate environment (as existed in the U.S. in 2019) may make this more difficult. As Coibion et al. (2017) point out, interest rates bounded by zero effectively become contractionary if economic conditions say they should be lower. Consequently, avoiding the zero-bound, or appealing to non-traditional monetary policy strategies, may be required in such an environment to effectively adhere to the directive of the Dual Mandate.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmacro.2019.103167.

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