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ANTICIPATED AND UNANTICIPATED WAGE CHANGES, WAGE RISK, AND INTERTEMPORAL LABOUR SUPPLY

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ABSTRACT

Anticipated and Unanticipated Wage Changes, Wage Risk, and Intertemporal Labour Supply*

We address the question of how labour supply responds to anticipated wage growth, unanticipated wage growth, and wage risk. We use the 1989-93 panel section of the Bank of Italy SHIW, which collects individual-based quantitative expectation of future wage growth. The use of subjective expectations has several advantages. First, subjective expectations provide information on the evolution and riskiness of future wages that the econometrician may never hope to observe. Second, they allow to control directly for the forecast error, thus avoiding inconsistency in short panels. Finally, controlling for anticipated and unanticipated wage changes avoids the need of specifying instruments for the growth rate of wages, which is usually hard to predict. We find that the intertemporal elasticity of substitution is precisely estimated and slightly larger than previous micro estimates. A parametric permanent innovation in wages impacts positively the rate of growth of labour supply. The impact of wage risk is consistent with the theory, but of negligible magnitude.

JEL Classification: D91 and J22
Keywords: labour supply and subjective expectations

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1 Introduction

A long-standing question in labor economics is whether and to what extent individual labor supply responds to *anticipated* wage changes (also known as *evolutionary* wage changes). This effect is measured by the intertemporal elasticity of substitution, a popular parameter among macroeconomists. The available evidence on the magnitude of this parameter is at best mixed. Several studies conducted in the 1980s on samples of prime age males in the US (MaCurdy, 1981, and Altonji, 1986) concluded that the magnitude of the coefficient was likely negligible or playing a second order effect.[1] More recent studies, such as Mulligan (1995, 1999), have reached different conclusions and suggested the possibility of a large impact of anticipated wage changes on changes in individual labor supply. The evidence presented in these papers exploits particular episodes (such as World War II or the Exxon Valdez spill-up accident), or focuses on particular groups (such as agricultural workers or stadium vendors) where perhaps a more convincing source of anticipated variation in wages can be identified.

A related, yet less explored issue is whether and to what extent individual labor supply responds to *unanticipated* wage changes (also known as *parametric* wage changes). Attempts to estimate the impact of those changes on labor supply include MaCurdy (1981) and Bover (1986). These papers typically construct forecasts of future wages by making explicit hypotheses concerning the evolution over time of the individual wage profile and assuming that the econometrician's forecasts are unbiased. However, as outlined by Card (1991), "it is possible that individuals have better information with which to forecast future wages than is unavailable to an outside analyst. In this case, wage innovations in [a] statistical model [...] do not necessarily represent new information".

A question that has not received attention so far is whether and to what extent individual labor supply responds to wage changes that increase the variability of the lifetime wage profile, i.e. whether labor supply exhibits any precautionary behavior. In analogy with models of precautionary saving, a riskier wage profile should delay the consumption of leisure (if leisure is a normal good), and thus impact negatively the growth rate of labor supply (Low, 1999). In particular, individuals may work longer hours when young to accumulate precautionary balances, rather than providing all the precautionary savings through sacrificing consumption, as in the standard model. Moreover, accumulated wealth will increase both consumption and

[1] Similar evidence was available for the UK (Browning, Deaton and Irish, 1985).

leisure when old, i.e. it will lead to a reduction in labor supply later in life. Low (2000) presents a more formal theoretical analysis of these issues.

These three issues represent the motivation for this paper. First, the resurgence of interest on the magnitude of intertemporal substitution in labor supply warrants further research; this is an important structural parameter for policy analysis. Lucas and Rapping (1969) suggested that a large intertemporal substitution in labor supply in response to wage changes could potentially explain business cycle fluctuations. Second, it is important to understand whether unanticipated changes in wages play a role in explaining fluctuations in labor supply over the life-cycle and over the business cycle. Card (1991) notices that the literature concentrates "on one aspect of intertemporal hours variation -the response to wage growth along a known life-cycle trajectory- and [...] ignore[s] another, namely, the response to unanticipated wage innovations". On the same point, Mulligan (1998) notes that "previous econometric studies of the [intertemporal substitution] hypothesis which used panel micro data [are] unable to distinguish anticipated wage changes from those that [are] unanticipated". Finally, one would like to assess whether precautionary labor supply is important or negligible as implicitly assumed thus far in the empirical literature. As reported by Mulligan (1998): "there is no empirical evidence that precautionary motives for delaying leisure are important" or otherwise.

To address these questions one would ideally use a panel of observations on the entire life-cycle of hours and wages and other demographic information. Unfortunately, this ideal data set does not exist, neither in the US nor elsewhere. Applied researchers have to side-step this problem using either the available limited panel data (such as the PSID), or constructing pseudo-panels, as in Ghez and Becker (1975), and Browning, Deaton and Irish (1985). The latter approach, however, eliminates the individual heterogeneity that is likely to be most responsible for fluctuations in hours.

The present paper takes another route. We make use of subjective expectations collected at individual level. It is often argued, but rarely put in practice, that the nature of the variables one wants to study in the intertemporal consumption or labor literature (the expectation, the innovation, and the expected variability of wage rates, say) calls for the use of individual expectation data. We test for the effect of anticipated and unanticipated wage growth and expected wage risk on intertemporal labor supply using the 1989-1993 panel section of the Bank of Italy SHIW. This data set has the unique advantage of collecting individual-based quantitative expectations of future wage changes. The decomposition between anticipated and unanticipated wage growth is exact, because individual subjective expectations are used to construct the anticipated component and the difference between the actual realization and the subjective expectation is used to construct the unanticipated component. The same data also allow to construct a measure of anticipated variability in the lifetime profile of wages, and therefore to test for precautionary labor supply. Up to our knowledge, this is the first attempt to estimate the impact of wage risk on intertemporal labor supply using microeconomic data (for evidence on aggregate data, see Blau and Grossberg, 1989).

The paper proceeds as follows. After setting up the theoretical requirements in Section 2, Section 3 discusses the main features of the data and present descriptive evidence on the intertemporal variability in labor supply. Here we also show how subjective expectations data can be used to disentangle anticipated from unanticipated wage growth, and how to compute a measure of overall expected variability in the wage profile. Section 4 presents the main results and consider some extensions. Section 5 concludes.

2 Wage changes, wage risk and intertemporal labor supply

In this section we derive the Euler equation for labor supply and show how the structural parameters of interest can be identifed. The derivation follows MaCurdy (1981) and Card (1991). The microeconomic unit of interest is a married, prime-age male. This individual solves the following problem:

$$\max E_t \sum_{\tau=0}^{T-t} (1+\delta)^{-\tau} u\left(c_{it+\tau}, h_{it+\tau}, \mathbf{Z}_{it+\tau}\right)$$

subject to the intertemporal budget constraint:

$$a_{it+1} = (1 + r_{t+1})\left(a_{it} + w_{it}h_{it} - c_{it}\right) \tag{1}$$

where $E_t(.) = E(.\,|\Omega_{it})$ is the subjective expectation that conditions on the individual information set Ω_{it} at time t, δ the intertemporal discount rate, c consumption, h hours of work, $\mathbf{Z}$ a vector of preference shifts, a assets, r the real interest rate, and w the real hourly wage. We assume that the preferences and the budget constraint are intertemporally separable and that there are no restrictions on borrowing, saving and labor supply (i.e., the solution is interior).[2] However, we do not assume that preferences are

[2]In the period of observation (1989-1993) there were no changes in the tax code. The

intratemporally additive. The first order conditions for this problem are:

$$\frac{\partial u\left(c_{it}, h_{it}, \mathbf{Z}_{it}\right)}{\partial c_{it}} = \lambda_{it} \tag{2}$$

$$-\frac{\partial u\left(c_{it}, h_{it}, \mathbf{Z}_{it}\right)}{\partial h_{it}} = \lambda_{it} w_{it} \tag{3}$$

$$\lambda_{it} = E_t \frac{1 + r_{t+1}}{1 + \delta} \lambda_{it+1} \tag{4}$$

along with the intertemporal budget constraint (1), and where λ is the Lagrange multiplier. Equations (2) and (3) can be solved for consumption and hours of work to obtain Frisch (or λ-constant) demand functions; in this context, consumption and hours of work will depend on the wage rate, the marginal utility of wealth λ_{it}, and preference shifts.[3] The main feature of Frisch demand functions is that they keep constant the marginal utility of wealth. In particular, for hours of work one can write the approximated log-linear specification (Altonji, 1986):

$$\ln h_{it} \cong \mathbf{Z}_{it}' \alpha + \eta \ln w_{it} + (\eta + \varphi) \ln \lambda_{it} \tag{5}$$

The term $\ln \lambda_{it}$ captures all we need to know about future wages and interest rates. However, unless restrictive assumptions are made, it has very rarely a workable closed form. We comment later on this point. The parameter η is the intertemporal elasticity of substitution for labor supply. It measures the impact of an anticipated change in wages (an evolutionary change) on labor supply while keeping constant the marginal utility of wealth. The parameter $(\eta + \varphi)$ is the elasticity of hours with respect to the marginal utility of wealth. If preferences are strictly concave, and if leisure and consumption are normal goods, the following sign restrictions hold: $\eta > 0$ and $\eta + \varphi > 0$. As for φ, its sign will be negative if consumption and leisure are complements and positive if they are substitutes in utility. If consumption is independent of wages, which occurs if preferences are intratemporally additive, then $\varphi = 0$.[4]

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measures of wage, earnings and expected earnings considered in this paper are all after-taxes and social security contributions.

[3] The use of both consumption and labor supply data goes beyond the scope of this paper and is left to future research.

[4] Defining with u_i the derivative of $u\left(.\right)$ with respect to the the argument i $(i = h, c)$, and u_{ij} the derivative of u_i with respect to the argument j $(j = h, c)$, it can be shown that:

$$\eta = \frac{u_h u_{cc}}{u_{cc} u_{hh} - u_{ch} u_{hc}} \frac{1}{h}$$

One can combine (4) and (5) to obtain the (approximated) Euler equation for labor supply:

$$\begin{aligned}\Delta \ln h_{it} \quad &\cong \quad \Delta \mathbf{Z}_{it}^{\prime}\alpha + \eta \Delta \ln w_{it} - (\eta + \varphi)\left(E_{t-1} r_t - \delta\right) \\ &\quad - (\eta + \varphi)\left(\ln \lambda_{it} - E_{t-1} \ln \lambda_{it}\right) \\ &\quad + (\eta + \varphi) \ln E_{t-1}\left(e^{\ln \lambda_{it} - E_{t-1} \ln \lambda_{it}}\right) \end{aligned} \tag{6}$$

where $(\ln \lambda_{it} - E_{t-1} \ln \lambda_{it})$ is the innovation in the logarithm of the marginal utility of wealth. In previous studies the term $\ln E_{t-1}\left(e^{\ln \lambda_{it} - E_{t-1} \ln \lambda_{it}}\right)$ is part of the intercept; we allow it instead to vary across individuals in order to capture heterogeneity in wage uncertainty.

To obtain an empirically tractable specification we make two assumptions similar to those made in previous empirical work. The first assumption is that the wage rate follows a geometric martingale process with drift, i.e.:

$$\ln w_{it} = \Delta \mathbf{X}_{it}^{\prime}\sigma + \ln w_{it-1} + \zeta_{it} \tag{7}$$

where $\mathbf{X}$ is a vector of variables affecting the deterministic component of wage growth (such as age, education, and other information available to the individual but not to the econometrician), and ζ_{it} the innovation in the wage rate, i.e. $\zeta_{it} = (\ln w_{it} - E_{t-1} \ln w_{it})$. It is fair to say that this assumption is consistent with aggregate data, but less so with microeconomic data, where instead the evidence is more favorable to ζ_{it} following an MA(1) process.[5] As a partial justification, one can notice that a transitory unanticipated component has a negligible impact on labor supply because it affects $\ln \lambda_{it}$ only marginally. We address this point in the empirical section below.

The second assumption concerns the approximated form of the log of the marginal utility of wealth, and is the same as in MaCurdy (1981):

$$(\eta + \varphi) \ln \lambda_{it} = \gamma_a a_{it} + \sum_{\tau=0}^{T-t} \gamma_\tau E_t\left(\ln w_{it+\tau}\right) + \nu_i \tag{8}$$

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and:

$$\varphi = -\frac{u_{hc} u_c}{u_{cc} u_{hh} - u_{ch} u_{hc}} \frac{1}{h}$$

If $u_{ch} = u_{hc} = 0$, then $\varphi = 0$ and $\eta = \frac{u_h}{u_{hh}} \frac{1}{h}$.

[5] The MA(1) component reflects transitory shocks and measurement error in the wage variable.

where ν_i is an approximation error.[6] Note that concavity of the utility function requires γ_a and γ_τ to be negative for all τ. Given the characteristics of the wage process, it follows that the innovation in the logarithm of the marginal utility of wealth can be written as:

$$(\eta + \varphi)(\ln \lambda_{it} - E_{t-1} \ln \lambda_{it}) = \sum_{\tau=0}^{T-t} \gamma_\tau (E_t - E_{t-1}) \ln w_{it+\tau} = \Gamma \zeta_{it}$$

where $\Gamma = \left(\sum_{\tau=0}^{T-t} \gamma_\tau\right)$ is the wealth effect of a parametric permanent shift in the wage profile.[7] Note finally that:

$$-(\eta + \varphi) \ln E_{t-1} \left(e^{\ln \lambda_{it} - E_{t-1} \ln \lambda_{it}}\right) = \vartheta^\zeta var_{t-1}(\zeta_{it}) \tag{9}$$

where $\vartheta^\zeta = -\frac{\Gamma^2}{2(\eta+\varphi)} < 0$. The equality in (9) holds if the innovation in the marginal utility of wealth is normally distributed or, as an approximation, for small risks. The labor supply equation (6) can then be rewritten (neglecting from now on the approximation sign) as:

$$\begin{aligned} \Delta \ln h_{it} &= \Delta \mathbf{Z}_{it}' \alpha + \eta \Delta \ln w_{it} + \vartheta^\zeta var_{t-1}(\zeta_{it}) \\ &\quad - (\eta + \varphi)(E_{t-1} r_t - \delta) + \Gamma \zeta_{it} \end{aligned} \tag{10}$$

To see more clearly the distinction between evolutionary and parametric wage growth effects on labor supply, take the conditional expectation of (10) to yield:

$$\begin{aligned} E_{t-1} \Delta \ln h_{it} &= \Delta \mathbf{Z}_{it}' \alpha + \eta E_{t-1} \Delta \ln w_{it} \\ &\quad + \vartheta^\zeta var_{t-1}(\zeta_{it}) - (\eta + \varphi)(E_{t-1} r_t - \delta) \end{aligned} \tag{11}$$

and subtract (10) from (11) to obtain the innovation in labor supply growth:

$$\begin{aligned} \Delta \ln h_{it} - E_{t-1} \Delta \ln h_{it} &= \eta (\Delta \ln w_{it} - E_{t-1} \Delta \ln w_{it}) + \Gamma \zeta_{it} \\ &= (\eta + \Gamma) \zeta_{it} \end{aligned} \tag{12}$$

[6] The inclusion of predictable demographic variables does not affect our estimation strategy. Allowing for higher moments of the distribution of wages has little effect on our estimates (results are available on request).

[7] Note that $a_{it} - E_{t-1} a_{it} = 0$ if innovations in the real interest rate are small. Removing this assumption leaves the results qualitatively unchanged. These are available on request.

Replace (11) in (12) to obtain:

$$\begin{aligned} \Delta \ln h_{it} &= \Delta \mathbf{Z}'_{it}\alpha + \eta E_{t-1}\Delta \ln w_{it} + \vartheta^{\zeta} var_{t-1}(\zeta_{it}) \\ &\quad - (\eta + \varphi)(E_{t-1}r_t - \delta) + (\eta + \Gamma)\zeta_{it} \end{aligned} \tag{13}$$

From equation (13), the model predicts that individuals vary their labor supply in response to numerous factors. First, because of shifts in preferences, represented by the vector $\Delta \mathbf{Z}'_{it}$; second, because of anticipated evolutionary changes in the wage rate, $E_{t-1}\Delta \ln w_{it}$; third, because of a gap between the real interest rate and the intertemporal discount rate, $(E_{t-1}r_t - \delta)$; fourth, because of unexpected (permanent) parametric shifts in the wage rate, ζ_{it}; finally, because of a higher dispersion in the conditional distribution of future wage rates, the term $var_{t-1}(\zeta_{it})$.

Previous papers in this literature consider the impact of preference shifts, interest rates and anticipated wage growth, but neglect the effect of wage innovations and wage risk, which are therefore subsumed in the error term. Moreover, expected wage growth is unobservable in typical data sets, so it must be inferred from instrumental variable techniques. This approach has at least four drawbacks. First, it is hard to find good predictors for wage growth (e.g., a promotion or a change in the wage policy of the firm can be observed by the individual but unknown to the analyst). Second, the typical predictors used in these papers are age and education, which thus have to play the role of excluded instruments. But age and education are also the most obvious preference shifts one may think of, and should therefore be included in the vector $\mathbf{Z}$. In other words, these instruments are invalid if they also play the role of taste shifts. Moreover, the marginal utility of wealth is a function of all characteristics over the entire lifetime, so there are no exclusion restrictions. Third, consistent estimation requires the forecast error to be uncorrelated with the instruments, a property that holds when the time dimension of the panel is long but not necessarily in short panels (Chamberlain, 1984). Finally, it has been noticed that the estimates of the elasticities of interest tend to be sensitive to the set of instruments used.

If the marginal utility is kept constant, $\zeta_{it} = 0$ and all wage changes are anticipated. The reaction of labor supply to expected changes in the wage rate is measured by η, the intertemporal elasticity of substitution. If the marginal utility of wealth is kept constant, a higher expected wage growth suggest to work less in the current period and more in the future, thus $\eta > 0$.

To understand the role of wage innovations, consider equation (13) and suppose that the consumer faces an unexpected positive change in the wage rate, $\zeta_{it} > 0$. By the characteristics of the wage process, all unanticipated parametric wage shifts are permanent. Such shift induces a revision in $\ln \lambda_{it}$ (which decreases under the maintained assumption that $\Gamma < 0$), and therefore on labor supply. This is then a fully parametric wage change. The elasticity of current labor supply with respect to the parametric wage change, $\frac{\partial \ln h_{it}}{\partial \zeta_{it}}$, is therefore $(\eta + \Gamma)$, a parameter that combines intertemporal substitution effects ($\eta > 0$) and wealth effects ($\Gamma < 0$). The sign of $(\eta + \Gamma)$ is thus ambiguous. Blundell and MaCurdy (2000) argue that $(\eta + \Gamma)$ is the main parameter of interest for policy analysis. In fact, since changes in the tax code are usually one-shot reforms that shift the entire wage profile in the current and future periods, the full effect of tax changes on labor supply can only be appreciated by accounting for both anticipated and unanticipated wage changes.[8]

The empirical specification we consider in this paper has to take into account the fact that the SHIW elicits subjective expectations of earnings growth, rather than expectations of wage growth. However, we can use the equilibrium condition between hours and wages as given by (9) or (10) and the following change of variable, as suggested by MaCurdy (1985). Since: $y_{it} = w_{it}h_{it}$, it follows that: $\Delta \ln w_{it} = \Delta \ln y_{it} - \Delta \ln h_{it}$. A conditional version of this equality is obtained replacing realizations with expectations (i.e., $E_{t-1}\Delta \ln w_{it} = E_{t-1}\Delta \ln y_{it} - E_{t-1}\Delta \ln h_{it}$). Moreover, the relationship between the innovation in wages and the innovation in earnings is: $\zeta_{it} = (1 + \eta + \Gamma)^{-1} \psi_{it}$, with $\psi_{it} = \Delta \ln y_{it} - E_{t-1}\Delta \ln y_{it}$.[9] Replacing the last two equalities in the equation (13) and rearranging the terms yields:

$$\begin{aligned} \Delta \ln h_{it} &= \Delta \mathbf{Z}'_{it}\frac{\alpha}{1+\eta} + \frac{\eta}{1+\eta}E_{t-1}\left(\Delta \ln y_{it}\right) + \vartheta^{\psi} var_{t-1}\left(\psi_{it}\right) \\ &\quad - \frac{\eta+\varphi}{1+\eta}\left(E_{t-1}r_t - \delta\right) + \left(\frac{\eta+\Gamma}{1+\eta+\Gamma}\right)\psi_{it} \qquad (14) \end{aligned}$$

[8]Of course, the assumptions we make on the statistical form of $\ln \lambda$ and on the characteristics of the wage process are somehow "ad hoc". Nevertheless, both assumptions are very popular choices among labor economists.

[9]From the expression $\Delta \ln w_{it} = \Delta \ln y_{it} - \Delta \ln h_{it}$, the wage growth innovation is the difference between the hours growth innovation and the earnings growth innovation:

$$\zeta_{it} = \psi_{it} - (\eta + \Gamma)\,\zeta_{it}$$

where we have used the fact that, under our assumptions, the hours growth innovation equals $(\eta + \Gamma)\,\zeta_{it}$ (see (12)). The link between earnings, wages and hours that we exploit here breaks down in the presence of overtime hours paid at a premium. Moreover, the presence of unobserved taste shifts may create an endogeneity bias. We comment on this point later.

where $\vartheta^{\psi} = \frac{\vartheta^{\zeta}}{(1+\eta+\Gamma)^2(1+\eta)}$. The specification that we test in the empirical analysis is then the following:

$$\Delta \ln h_{it}^{*} = \Delta \mathbf{Z}_{it}' \beta_0 + \beta_1 E_{t-1} (\Delta \ln y_{it}) + \beta_2 var_{t-1} (\Delta \ln y_{it}) + \beta_3 (i_t - E_{t-1} \pi_t) + \beta_4 [\Delta \ln y_{it} - E_{t-1} (\Delta \ln y_{it})] + e_{it} \quad (15)$$

where h_{it}^{*} denotes measured annual hours, e_{it} includes a multiplicative measurement error in hours, measurement error in the independent variables, unobserved taste shifts and approximation errors, $E_{t-1} (\Delta \ln y_{it})$ is the subjective expectation of real earnings growth, which is directly elicited in the SHIW, the term $[\Delta \ln y_{it} - E_{t-1} (\Delta \ln y_{it})]$ denotes the innovation, which is constructed by subtracting the subjective expectation of earnings growth from the actual earnings growth realization, $var_{t-1} (\Delta \ln y_{it})$ is the conditional variance of earnings growth, and $(i_t - E_{t-1} \pi_t)$ is the real interest rate, constructed as the difference between nominal interest rate at time t and inflation expectations, also elicited in the survey.

The use of subjective expectations in this context has several advantages. First, it allows consistent estimation of all the parameters of interest, in particular of η and $(\eta + \Gamma)$, by controlling directly for $E_{t-1} (\Delta \ln y_{it})$ and ψ_{it} in estimation. In other words, we estimate an almost exact form of the intertemporal labor supply equation under the assumptions spelled out above. Since the forecast error is directly controlled for in estimation, no short panel problem should arise in this context (Chamberlain, 1984). Our estimates will thus be consistent even in the cross-section. Second, controlling for anticipated and unanticipated wage (earnings) growth avoids the needs of specifying instruments for wage growth, which is usually hard to predict in microeconomic data, and avoids imposing untenable exclusion restrictions. Moreover, estimates will not be sensitive to the instruments used because no IV procedure is needed. Finally, we exploit directly individual information on the evolution and riskiness of future wages (earnings), information that the econometrician may never hope to observe. This allows us to isolate truly expected wage changes from those that are not and provides important identifying information.

3 The data

3.1 Description

We estimate the intertemporal labor supply equation (12) using the 1989-1993 panel section of the Bank of Italy Survey of Household Income and

Wealth (SHIW). This data set contains measures of hours, earnings, consumption, income, and demographic characteristics of the household. The SHIW surveys a representative sample of the Italian resident population. From 1987 through 1995 the survey was conducted every other year and covered about 8,000 households, defined as groups of individuals related by blood, marriage or adoption and sharing the same dwelling. The most recent survey refers to 1998. Starting in 1989, each SHIW has re-interviewed some households from the previous surveys. The panel component has increased over time: 15 percent of the sample was re-interviewed in 1989, 27 percent in 1991, 43 percent in 1993, and 45 percent in 1995. Details on sampling, response rates, processing of results and comparison of survey data with macroeconomic data are provided by Brandolini and Cannari (1994). The 1989-91 panel section of the SHIW includes 2,187 households; the 1991-93 includes 3,470 households.

For the purpose of this paper, the most important feature of the SHIW is that it collected subjective information on future income in both 1989 and 1991. Several surveys contain subjective income expectations, but vary considerably as to the way expectations are elicited. In the case of the SHIW, in 1989 and 1991 each labor income and pension recipient interviewed was asked to attribute probability weights, summing to 100, to given intervals of inflation and nominal income increases one year ahead. The Appendix details the wording of the survey questions and how these are used to construct the subjective mean and variance of future earnings.

A problem with the SHIW data is that they are not available for consecutive years, but only at two-year intervals; moreover, subjective expectations stretch over a single calendar year. The interviews take place between March and September, although income, consumption and wealth data refer to the previous calendar year.[10] We thus need to assume that people do not update their information set between the end of 1989 (1991) and the date of the interview, or that their updating does not affect subjective expectations of income. This can be a strong assumption if people receive important news about the evolution of their future income between the end of 1989 (1991) and the date of the interview.

So far, the SHIW has been used to test a series of reduced form propositions in the consumption literature, most notably the impact of precautionary behavior on wealth accumulation (Guiso et al., 1993). The data have

[10]The reason for surveying in May is that previous experience has shown that people report income more accurately when filing the income tax forms, which must be returned by May 31.

also been used to address more structural questions, such as estimating the excess sensitivity of consumption to predicted income growth in a standard Euler equation framework (Jappelli and Pistaferri, 2000), or estimating the *saving for a rainy day* equation (Pistaferri, 2001), i.e. how transitory and permanent income shocks impact household saving in the standard framework of the permanent income hypothesis. However, the data have not yet been used to test labor market behavior.

In the next section we present more structural evidence on the life-cycle relationship between wage rates and hours of work. Here we limit ourselves to a descriptive analysis. The sample used in the empirical analysis below includes only male, heads of their households, married individuals aged between 26 and 59 in 1989, who report usable information on the variables of interest, in particular subjective expectations, earnings, and weekly normal hours. We exclude the self-employed and the multiple job holders. There are 1,461 individual-year observations. Sample statistics are reported in Table 1, separately for 1989, 1991 and 1993. The table shows that there is little fluctuations over time in both demographic and economic characteristics. We also report cross-sectional averages of earnings growth expectations and innovations. Both the expectation and the innovation for 1991 earnings are smaller than those for 1993; moreover, they are opposite in sign. Actual earnings growth was negative in both 1991 and 1993, but more strongly so (-0.018) in 1993, when Italy entered a recessionary period. Expected inflation is 7 percent in both years.

Before turning to the empirical analysis, it is useful to describe the distribution of hours and wages. Descriptive evidence on the life-cycle pattern of hours and wages is provided in Figures 1 and 2, where we plot the age profile of weekly normal hours of work and hourly wages for twelve cohorts whose membership is defined according to the year of birth. Here we use the repeated cross-sections of the SHIW from 1989 to 1998 but retain the sample selection criteria detailed above (i.e., we consider only males, heads of their household, married individuals aged 26-63, and exclude the self-employed and the multiple job holders). The hours profile is slightly declining over the life-cycle. The age profile of the hourly wage rate is hump-shaped as in many microeconomic data sets, and the wage decline occurs relatively late in the life-cycle (roughly after 55). Note that in the raw data hours and wages are negatively correlated, a point on which we will return later.

3.2 Reliability

Economists are usually skeptical about the informational content of subjective expectations data. Manski (2000) reports that "economists often assert that respondents to surveys have no incentive to answer questions about their preferences or expectations carefully or honestly; hence, there is no reason to believe that subjective responses reliably reflect respondents' thinking". Interestingly, economists "do not apply this reasoning to self-report of *objective* data". Based on his experience with the Survey of Economic Expectations data, Manski concludes that such conventional wisdom is unfounded: "survey respondents do provide coherent, useful information when queried about their expectations".

The reliability of the expectations data from the SHIW has already been examined elsewhere (Guiso et al., 1992; Jappelli and Pistaferri, 2000). In particular, Jappelli and Pistaferri confront inflation expectation reported by SHIW respondents with those elaborated by international institutions and find that subjective expectations are close on average to both actual realizations and to the forecasts elaborated by OECD analysts. An interesting feature is that subjective inflation expectations do not in fact mask a great number of implausible extreme values. More than 50 percent of the sample bunches the entire probability distribution for inflation between 5 and 7 percent. Moreover, there is no clear pattern of subjective expectations by region, age, education or income.

We checked the reliability of nominal earnings expectations by comparing subjective expectations with the actual realizations. In the raw data, the correlation coefficient of realized earnings and expected earnings is 0.46, which is *prima facie* evidence that subjective expectations do have informational content.[11] The correlation coefficient between realized earnings growth and expected earnings growth is instead 0.05. Jappelli and Pistaferri (2000) also compare earnings expectations with realizations for various demographic groups. Subjective expectations can be criticized because respondents may not fully understand the survey questions: households with better education might therefore give more accurate income forecasts simply because they understand the survey questions better. However, Jappelli and Pistaferri find that individuals with less education do not appear to answer the survey questions less accurately than those with more.

[11]Bernheim and Levin (1989) use the HRS to compare expected social security benefits with actual realizations and find a raw correlation coefficient of 0.41.

4 Estimation results

4.1 Basic specification

Our purpose in this section is to report and comment on the empirical estimates of the Euler equation for labor supply (15)[12] which is reproduced here with the account for the biennial nature of the SHIW data:

$$\begin{aligned}\ln h^*_{it} - \ln h^*_{it-2} &= \left(\mathbf{Z}'_{it} - \mathbf{Z}'_{it-2}\right)\beta_0 + \beta_1 E_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right) \\ &\quad + \beta_2 var_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right) + \beta_3\left(i_t - E_{t-2}\pi_t\right) \\ &\quad + \beta_4\left[\left(\ln y_{it} - \ln y_{it-2}\right) - E_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right)\right] \\ &\quad + e_{it} \qquad (16)\end{aligned}$$

Due to non-linearities in the parameters, a non-linear least squares procedure is used to identify the parameters of interest (see below) and obtaining the appropriate standard errors. The real interest rate $(i_t - E_{t-2}\pi_t)$ is constructed as the difference between the after-tax nominal interest rate on saving accounts and the subjective expectation of the inflation rate. By the virtue of heterogeneity in inflation expectations, this measure of the real interest rate displays cross-sectional variability.[13] We include the following taste shifters: age, education, regional dummies, number of children in three age bands (0-5, 6-13, 14-17), the number of additional income recipients, a dummy for working wife, and time dummies.

The following structural parameters are estimated:

- η, the elasticity of intertemporal substitution. This measures the reaction of labor supply to an evolutionary change in wages (i.e., keeping constant the marginal utility of wealth). The theory requires that $\eta > 0$.

[12] The dependent variable is the growth in annual hours of work. The SHIW elicits weekly overall hours h^n (including overtime), and months of employment m. In the empirical analysis below annual hours are defined as the product of weekly hours and weeks of employment: $h = 4h^n m$. The wage variable, whenever used, is defined as the ratio between annual earnings and annual hours.

[13] We use the nominal interest rate on saving accounts because these are very widespread in our sample, as opposed to other financial assets. In particular, 92 percent of our sample has a saving account, as opposed to 23 percent holding short-term government bonds (BOT), and 25 percent holding other assets (excluding cash). Moreover, conditioning on ownership, roughly 62 percent of the household assets are held in saving accounts. The before-tax nominal interest rates in 1989, 1991 and 1993 were 7.3, 7.79, and 7.8 percent, respectively. A flat tax rate of 30 percent was levied on the interests accrued.

- Γ, the wealth effect of a parameteric permanent shift in the marginal utility of wealth. The theory requires that $\Gamma < 0$. In turn, $\Gamma = \sum_{\tau=0}^{T-t} \gamma_{\tau}$.

- φ, a parameter that measures the extent of intratemporal non-additivity between consumption and leisure. If $\varphi > 0$ (< 0), consumption and leisure are substitutes (complements) in utility.

- ϑ^{ζ}, a parameter that measures the reaction of labor supply to wage risk. The theory requires $\vartheta^{\zeta} < 0$.

- $\eta + \Gamma$ captures the reaction of labor supply to a parameteric permanent shift in the wage profile. The theory has no sign predictions concerning this parameter.

- $\eta + \varphi$ measures the response of labor supply to the gap between the expected real interest rate and the intertemporal discount rate (and also the elasticity of the marginal utility of wealth). The theory requires $\eta + \varphi > 0$.

In the basic specification (reported in Table 2), the elasticity of intertemporal substitution, η, displays a point estimate of 0.7, with a small standard error of 0.09. This implies that along a known wage profile an expected evolutionary 10 percent increase in the wage rate produces a decline in current labor supply (and a concurrent increase in next period labor supply) of about 7 percent. This estimate is slightly larger than the one obtained by MaCurdy (1981) and Altonji (1986) for the US, and Browning, Deaton and Irish (1985) for the UK, where η is the 0-0.6 range. On the other hand, it is still quite far from the range of estimates (between 1 and 4) reported by Mulligan (1995) or studies based on aggregate data. One reason why our results are different is that we are able to control in a more effective way for uncertainty.

The effect of a wage innovation on the rate of growth of labor supply (an estimate of $\eta + \Gamma$) has a point estimate of 0.51, with a small standard error of 0.05. It is worth recalling that the sign of the impact of a permanent parametric wage shock on labor supply is generally ambiguous. However, in this particular case the intertemporal substitution effect (η) dominates the wealth effect (Γ, which has a point estimate of -0.2 with a standard error of 0.09), and hence the overall effect on labor supply is positive. Note that the results are in agreement with the theoretical prediction that $\Gamma < 0$. The implication of the estimate of $(\eta + \Gamma)$ is that a 10 percent permanent upward shift in the wage profile increases labor supply in the current period and at all future ages by approximately 5-7 percent (depending on the point of the life cycle when this is measured, with young individuals being more responsive on average because they have a longer horizon over which to allocate the wealth effect of a permanent change in the wage).[14] Such effect is larger than the one estimated with a different identification strategy by MaCurdy (1981), who finds $(\eta + \Gamma) = 0.08$ for a sample of prime-age US males. On the other hand, it agrees with what outlined by Card (1991). He stresses that "one source of systematic hours variation that is described by the labor supply model but ignored in most studies is idiosyncratic variation in the marginal utility of wealth"; he adds that "a typical person-specific wage innovation results in a significant revision to lifetime wealth".[15]

The effect of the interest rate on labor supply $(\eta + \varphi)$ agrees with theoretical predictions. In particular, it implies a point estimate of the elasticity of labor supply with respect to the marginal utility of wealth of 0.59 (with a standard error of 0.29). The estimate of φ is -0.11, but it is imprecisely measured (a standard error of 0.27). One reason for this low precision is that we are using a too crude approximation to individuals' preferences for consumption and leisure. At face value, the evidence is consistent with consumption and leisure being complements in utility, a finding similar to Browning, Deaton and Irish (1985). In the light of the large standard errors, however, we do not wish to put too much emphasis on this result.

The effect of the conditional variance of wage growth (an estimate of ϑ^{ζ}) is consistent with precautionary behavior (a negative coefficient of -0.11), and statistically significant (a standard error of 0.03). In agreement with what argued by Mulligan (1995), however, the effect of wage risk on labor supply appears negligible: a 10 percent increase in the conditional variance of future wages increases current labor supply by about 0.05 percent (evaluated at the median). Even doubling wage risk (a very extreme experiment) would thus hardly affect labor supply. The small precautionary labor supply effect is consistent with the low wealth effect noticed above. If there are small wealth effects of a particular wage realization there will be only second-order

[14]From the model above: $\Gamma = \sum_{\tau=0}^{T-t} \gamma_\tau$. If one assumes γ_τ constant over the life cycle, then $\Gamma = (T - t + 1)\,\gamma$. For young individuals ($T - t + 1 = 40$, say), $\Gamma = -0.2$, but for those only ten years away from retirement ($T - t + 1 = 10$), $\Gamma = -0.05$. Thus the wealth effect declines in absolute value and the elasticity with respect to parametric permanent wage shocks $(\eta + \Gamma)$ increases over the life cycle (from 0.5 at age 25 to 0.7 at age 65).

[15]Another interpretation of $(\eta+\Gamma)$ is that it measures cross-sectional difference in hours for individuals with different wage profiles. In our case, individuals with a 10 percent higher wage profile work approximately 5 percent more hours than individuals with lower permanent wages.

effects on utility and hence only small precautionary effects. Note that, from the model in Section 2, $\vartheta^{\zeta} = -\frac{\Gamma^2}{2(\eta+\varphi)}$. While we have not imposed such restriction in estimation, we can test whether it holds in the data. The test statistic has a borderline p-value of 4.3 percent, which supports the model.

As for the demographics, we find that once we control for expected wages, wage surprises and wage risk, they have a small and statistically insignificant impact on intertemporal labor supply. A time dummy for 1993 is statistically significant. The change in the working wife indicator captures family labor supply effects. It is theoretically justified within a conditional leisure demand framework. The estimate is positive, but not well measured (0.06 and a standard error of 0.04). It implies complementarity between head's hours and the wife's labor market participation, consistent with the notion that family members enjoy leisure together.

The evidence for intertemporal substitution seems to contradict the raw data evidence (Figures 1 and 2), where hours and wages appear to be negatively correlated in the early part of the life-cycle. A positive correlation between the age profile of hours and that of wages is typical of a simple model in which only intertemporal substitution effects exist. As equation (13) makes clear, however, the effect of wages on labor supply is only one of the possible factors at work. The factor $(\eta + \varphi)(E_{t-1}r_t - \delta)$, for instance, may induce a decline in hours over time even when wages are rising, as long as $E_{t-1}r_t - \delta > 0$. This could be due, for example, to lower intertemporal discount rates (lower impatience) at the beginning of the life cycle. In the same direction works the factor $\vartheta^{\zeta}_{it} var_{t-1}(\zeta_{it})$. Wage risk is more likely to be higher at the beginning than at the end of the life cycle (because of uncertainty resolution issues, inital job mismatch, etc.). Coupled with the interest rate effect, this may induce a decline in labor supply at the beginning of the life cycle even when wages are rising. Finally, the presence of unobserved taste shifts (which we discuss below) may come in the form of time-increasing preferences for leisure.

In sum, the comparison between estimation results and raw data evidence suggests that, at least in the early part of the life cycle, intertemporal substitution and wealth effects of wage changes (which imply positive growth rates in hours) are weaker than the combination of precautionary labor supply, interest rate, and taste heterogeneity effects (which imply negative growth rates). It confirms that the amount of variability in hours explained by the intertemporal substitution motive can be quite small, a fact that agrees with evidence available for other countries.[16]

[16]A simple numerical example can be instructive. Suppose that the average expected

4.2 Sensitivity analysis

We considered some extensions to the basic specification, performed several tests to check the robustness of the results, and explored various sources of bias.

4.2.1 Extensions and robustness checks

An important question is whether there is any substantial gain produced by the use of subjective expectations. In particular, one may wonder whether the parameters that we are estimating will be the same if subjective expectations were not available, as in standard studies of intertemporal labor supply.

The benchmark we consider to evaluate this question is the standard intertemporal labor supply regression estimated by MaCurdy (1981), where there is no control for wage innovations and wage risk and where typical instruments for $\Delta \ln w_{it}$ are a cubic in age, education, and the interaction between age and education.[17] These are then excluded from the vector $\mathbf{Z}$. In our sample, this regression produces a point estimate of the intertemporal elasticity of substitution η of 0.32 with a standard error of the same magnitude (see column 1 of Table 3). With the obvious caveat represented by the large standard error of this estimate, it is however worth noting that this number is not far, in terms of magnitude and statistical significance, from the one estimated in previous empirical work with panel data. However, it provides misleading information concerning the impact of an expected wage change on labor supply, because it neglects that information available to an individual differs from that available to the econometrician.[18] Furthermore, with the limited data available, it is impossible to obtain an estimate of

wage growth and the average innovation are 1.4 percent and 2.1 percent, respectively (these figures are consistent with the data). If $\eta = 0.7$ and $\eta + \Gamma = 0.5$, the growth rate of hours due to wage growth is about 2 percent. Evaluated at the median, the wage risk part contributes a negative growth in hours of 0.05 percent if $\vartheta^{\zeta} = -0.11$. If the gap between the interest rate and the intertemporal discount rate is 2 percent and $\eta + \varphi = 0.6$, this contributes a negative growth in hours of 1.2 percent. The growth in hours predicted by the demographics is -5 percent. Thus hours will exhibit a negative growth of about 4 percent even when wages grow on average by about 3.5 percent, consistently with the raw data and the empirical estimates.

[17] MaCurdy uses also family background variables, but these are unavailable in the SHIW.

[18] The predictive power of the first stage regression is, as usual in these cases, very low. The adjusted R^2 in the regression for the reduced form is in fact only 0.0025; the F statistic is 1.73. Wage growth is in fact very hard to predict in panel data.

the impact of parametric wage changes on labor supply or other structural parameters.

An important issue has to do with the impact of unemployment and other demand side variables on labor supply. The major criticism addressed to studies of intertemporal labor supply is in fact that employed individuals may face hours constraints. Sizeable year-to-year changes in annual hours will then be associated with movements between jobs, multiple job holding, voluntary or involuntary unemployment, a switch from full-time to part-time employment (or vice versa) or measurement error.

Ham (1986) suggests to test whether unemployment is part of the optimal plan by introducing a dummy for unemployment in the λ-constant labor supply function. His argument is that if unemployment is a voluntary choice the dummy should be statistically insignificant. In contrast, if unemployment reflects hours constraints, the coefficient should be negative and statistically significant.

We experiment by adding two variables that reflect demand conditions. The first is ΔU_{it}, the first difference of a dummy that equals one if the individual worked less than 12 months and zero otherwise. This affects 6 percent of our sample (1 percent experiment a fall and 5 percent an increase in months of employment). The second variable ΔN_t is the change in the local (province) unemployment rate. Given that we are directly controlling for the forecast error in the marginal utility of wealth through subjective expectations, least squares estimates should still be consistent. This allows us to treat the unemployment variables as exogenous.

The estimates of η and $(\eta + \Gamma)$, reported in column 2 of Table 3, are now very close to each other (an equality test has a p-value of 0.42). The estimate of Γ is small and statistically insignificant and so are the estimate of $(\eta + \varphi)$ and φ. The coefficient on the variance term halves to 0.05 but is still statistically significant. The dummy for months of unemployment has a negative coefficient of -0.65 with a standard error of 0.03. The local unemployment rate has a coefficient of -0.004 (0.003).[19] The evidence is favorable to the hypothesis of hours constraints as put forward by Ham. Ham's argument, however, has been criticized by MaCurdy (1990), who argues that the unemployment dummy is compatible with voluntary unemployment if the offered wage falls below the reservation wage. The interpretation of the unemployment dummy remains an issue of considerable debate. For example, the significance of the unemployment dummy in the labor supply equation could be the reflection of a mechanical negative correlation: workers who

[19] Inclusion of job and industry dummies has little effect.

face an increase in unemployment from one period to the next will also report a negative growth in annual hours over the same time period.[20]

A somewhat different, and perhaps more plausible way to examine the issue of hours constraint is to use direct information on the presence of these constraints. In both 1991 and 1993 SHIW respondents are asked whether they have the option of working overtime in their job. Unless people self-select in jobs where overtime is allowed, this variable can be assumed to be exogenous. To check whether hours constraints are important, we augment the annual hours specification by a dummy variable for the option of working overtime. The results are reported in column 3 of Table 3 and are very similar to those reported in the basic specification of Table 2. The estimate of the coefficient on the dummy variable for the option of working overtime is 0.05 with a standard error of 0.02, and agrees with intuition: those who are given the option of working over time may experience faster growth in annual hours (which include overtime hours). A possible interpretation of this result is that some workers are underemployed. When hours constraints are removed, faster growth in hours occurs.

4.2.2 Sources of bias

It is worth commenting on various sources of bias in our estimates. First, we examine whether the estimated impact of unanticipated wage growth on labor supply is biased because we are neglecting transitory wage innovations. To address this point, assume that wages are the sum of a permanent martingale component (as in 8) and a serially uncorrelated transitory shock (ε_{it}), a very popular characterization that agrees with panel data evidence. The wage innovation is therefore $(\zeta_{it} + \varepsilon_{it})$. The labor supply equation (11) can be rewritten as:

$$\begin{aligned} \Delta \ln h_{it}^{*} &= \Delta \mathbf{Z}_{it}^{\prime} \alpha + \eta E_{t-1} \Delta \ln w_{it} - (\eta + \varphi)\left(E_{t-1} r_t - \delta\right) \\ &\quad + (\eta + \Gamma)\left(\zeta_{it} + \varepsilon_{it}\right) + \vartheta^{\zeta} var_{t-1}\left(\zeta_{it}\right) + e_{it} \end{aligned}$$

The error term in the Euler equation for labor supply, e_{it}, now includes the term $(\gamma_0 - \Gamma)\, \varepsilon_{it}$ (if one assumes for simplicity that the variance of the transitory shock is absorbed by the intercept). This term is obviously correlated with the wage innovation $(\zeta_{it} + \varepsilon_{it})$ for which we control in estimation.

[20]Given that the focus of the paper is on prime-age males, we do not model participation. Implicitly, the assumption we make is that wage uncertainty affects hours choice, but is not incorporated in the participation decision. In a more realistic model, participation could of course depend on wage uncertainty.

It can be showed that in the simplest case in which the innovation is orthogonal to the other regressors in the intertemporal labor supply equation, the bias in $(\eta+\Gamma)$ is the product of three factors: $(\gamma_0-\Gamma)$, $\frac{\omega}{1-\omega}$, where ω is the relative importance of the transitory innovation on the overall innovation in earnings, and $(1+\eta+\Gamma)$. All these factors are positive (as long as $(\eta+\Gamma)>-1$). This suggests that the estimated long-run elasticity is likely an upper bound for the true elasticity. The bias is small if most of the variability in wages is of permanent nature.

Next, consider the possibility of unobserved taste shifts. These will create a bias due to the fact that we use earnings rather than wages on the right hand side of the labor supply equation. Equation (11) can be rewritten as:

$$\begin{aligned}\Delta \ln h_{it}^{*} &= \Delta \mathbf{Z}_{it}^{\prime}\alpha+\eta E_{t-1}\Delta \ln w_{it}-(\eta+\varphi)\left(E_{t-1}r_t-\delta\right)\\ &\quad+(\eta+\Gamma)\,\zeta_{it}+\vartheta^{\zeta}var_{t-1}\left(\zeta_{it}\right)+e_{it}\end{aligned}$$

The error term e_{it} includes error in hours and π_{it}, a taste shock, with $E_{t-1}\pi_{it}=0$. Note that earnings, wages, and taste shocks are linked through the relationship:

$$\psi_{it}=(1+\eta+\Gamma)\,\zeta_{it}+\pi_{it}$$

The source of bias is that while ζ_{it} and π_{it} are (or can assumed to be) orthogonal, ψ_{it} and π_{it} are not. In particular, $cov\left(\psi_{it},\pi_{it}\right)=\sigma_{\pi}^{2}$. If ψ_{it} is orthogonal to the other regressors of the labor supply equation, one can prove that the bias in $(\eta+\Gamma)$ is given by: $\frac{\sigma_{\pi}^{2}}{(1+\eta+\Gamma)\sigma_{\zeta}^{2}}$. This suggest that the bias is upward if $\eta+\Gamma>-1$. The bias tends to disappear when the proportion of unexplained earnings variability due to taste shocks is small.

Thus, the possibility of an upward bias in $(\eta+\Gamma)$ due to omitted transitory shocks or unobserved taste shifts cannot be dismissed. In the absence of additional information, information on the magnitude of these two sources of bias is hard to come by. The inference one can draw is that the wealth effect (Γ) is probably higher (in absolute value) than the one we have estimated above, and the effect of permanent shocks on labor supply $(\eta+\Gamma)$ smaller.

On the other hand, consider that the earnings innovation could be itself subject to measurement error, which would create a downward bias in the estimate of $(\eta+\Gamma)$. For instance, if the innovation in earnings is measured with error and taste shocks are present, the bias in $(\eta+\Gamma)$ is $\frac{\sigma_{\pi}^{2}-(\eta+\Gamma)\sigma_{\omega}^{2}}{(1+\eta+\Gamma)\sigma_{\zeta}^{2}+\sigma_{\omega}^{2}}$, where σ_ω^2 is the variance of the measurement error in ψ_{it}. In general, this bias is smaller than the one calculated in the case where only taste shocks are present. It is not clear (and perhaps impossible to determine) whether the various sources of bias balance each other out.

5 Conclusions

In this paper we have used unique information about expectations of future wages collected in the 1989-1993 panel section of the Bank of Italy SHIW to isolate anticipated and unanticipated wage changes and to construct a measure of wage risk. These are in turn related to shifts in life-cycle labor supply. This is to our knowledge a novel approach not attempted in previous empirical work.

Our empirical strategy allows to disentangle the effect of evolutionary, expected wage changes from parametric, unanticipated wage changes. Similarly to other studies in the literature, we assume that preferences are intertemporally separable. This implies that current wages do not depend on past work effort; a more complex model would relax this assumption but face serious data limitations.

We estimate an intertemporal substitution elasticity of around 0.7. This number is slightly larger than the one obtained by MaCurdy (1981), Altonji (1986), and others for the US, but smaller than the one used by macroeconomists in calibration analyses. We estimate that the impact of a permanent wage shock on labor supply, i.e., letting the marginal utility of wealth to vary in response to parametric wage shifts, is positive and about 0.5 on average. Also this number is relatively large when compared with previous evidence but relatively small when compared to macroeconomic guess-estimates. A possible explanation for the discrepancy between our results and previous evidence is that we are able to isolate in a more convincing way the effect of anticipated and unanticipated wage growth on labor supply; alternatively, the presence of taste shocks is creating an upward bias in our estimates.

Another finding of this paper relates to the role of wage risk in explaining intertemporal movements in labor supply. While the effect of wage uncertainty on labor supply is in agreement with the theory, implying that there is some adjustment, perhaps for some categories of workers or in particular stages of one's career, it is for practical purposes negligible. Finally, we find some weak evidence that consumption and leisure are complements in utility.

A Survey questions on income prospects

This Appendix draws from Guiso *et al.* (1992). In both 1989 and 1991 each labor income and pension recipient interviewed SHIW was asked the following two questions.

Inflation expectations: "On this table [a table is shown to the respondent] we have indicated some classes of inflation. We are interested in knowing your opinion about inflation twelve months from now. Suppose that you have 100 points to be distributed between these intervals. Are there intervals you definitely exclude? Assign zero points to these intervals. How many points do you assign to each of the remaining intervals?" For this and the following question the intervals on the table shown to the person interviewed are: less than zero; 0-3; 3-5; 5-6; 6-7; 7-8; 8-10; 10-13; 13-15; 15-20; 20-25; >25 percent. If the response is "less than zero", the person is asked: "How much less than zero? How many points would you assign to this class?"

Income expectations: "We are also interested in knowing your opinion about your labor earnings or pensions twelve months from now. Suppose that you have 100 points to be distributed between these intervals [a table is shown again]. Are there intervals you definitely exclude? Assign zero points to these intervals. How many points do you assign to each of the remaining intervals?".

To construct subjective expectations and variances of the variable of interest (either the rate of growth of nominal earnings or the rate of inflation), we set the upper bound of the distribution -the open interval- at 35 percent. Let $x_{i\tau}$ be the variable of interest. The subjective expectation of $x_{i\tau}$ at time $\tau-1$ is then given by:

$$E\left(x_{i\tau}|\Omega_{i\tau-1}\right)=\sum_{k=1}^{K}\left[\Pr\left(x_{k-1}\leq x_{i\tau}\leq x_{k}\right)\right]2^{-1}\left(x_{k}+x_{k+1}\right)$$

and the subjective variance by:

$$Var\left(x_{i\tau}|\Omega_{i\tau-1}\right)=\sum_{k=1}^{K}\left[\Pr\left(x_{k-1}\leq x_{i\tau}\leq x_{k}\right)\right]\left[2^{-1}\left(x_{k}+x_{k+1}\right)-E\left(x_{i\tau}|\Omega_{i\tau-1}\right)\right]^{2}$$

where x_k and x_0 are, respectively, the upper and the lower bound of the distribution, and Ω is the information set of the individual. Note that the intervals are not of the same size.[21]

Expected real earnings growth is $E\left(\Delta\ln y_{i\tau}|\Omega_{i\tau-1}\right)=E\left(\Delta\ln y_{i\tau}^{n}|\Omega_{i\tau-1}\right)-E\left(\pi_{\tau}|\Omega_{i\tau-1}\right)$, with $\Delta\ln y_{i\tau}^{n}$ denoting nominal income growth and π the inflation rate. As far as the variance of real income growth is concerned, this is defined as:

[21] More precisely, $x_0=0$ for those assigning zero probability to a negative earnings growth event, otherwise it is a value chosen by the respondent; $x_1=0.03$; $x_2=0.05$; $x_3=0.06$; $x_4=0.07$; $x_5=0.08$; $x_6=0.1$; $x_7=0.13$; $x_8=0.15$; $x_9=0.2$; $x_{10}=0.25$; $x_K=x_{11}=0.35$.

$$
\begin{aligned}
var\left(\Delta \ln y_{i\tau}|\Omega_{i\tau-1}\right) &= var\left(\Delta \ln y_{i\tau}^{n}|\Omega_{i\tau-1}\right) + var\left(\pi_{\tau}|\Omega_{i\tau-1}\right) \\
&+2corr\left(\Delta \ln y_{i\tau}^{n}, \pi_{\tau}|\Omega_{i\tau-1}\right) * \\
&\sqrt{var\left(\Delta \ln y_{i\tau}^{n}|\Omega_{i\tau-1}\right)}\sqrt{var\left(\pi_{\tau}|\Omega_{i\tau-1}\right)}
\end{aligned}
$$

Since the correlation term is unknown, we assume that it equals 1 (different values do not change the results much). This is the value that maximizes the variance of real earnings growth. Moreover, to avoid imputing a zero variance to those reporting point expectations, we calculate the variance within each interval assuming a multi-step uniform distribution. The formula is a generalization of the one given above.

Finally, we need to adjust the available subjective expectations data to the biennial nature of the SHIW. In fact, in the SHIW individuals report $E_{t-2}\left(\Delta \ln y_{it-1}\right)$, with $t = 1991, 1993$, rather than $E_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right)$, which is the variable that appears in (13). However, the variable of interest $E_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right)$ can be obtained as: $2 * E_{t-2}\left(\Delta \ln y_{it-1}\right)$ under the assumption that $E_{t-2}\left(\Delta \ln y_{it-1}\right) = E_{t-2}\left(\Delta \ln y_{it}\right)$, i.e. that expected growth rates of earnings are smooth over a period of two years. Using the same assumption, we approximate $var_{t-2}\left(\ln y_{it} - \ln y_{it-2}\right)$, which is the variable that appears in (13), with $4 * var_{t-2}\left(\Delta \ln y_{it-1}\right)$, where $t = 1991, 1993$.

References

[1] Altonji, Joseph G. (1986), "Intertemporal substitution in labor supply: Evidence from micro data", *Journal of Political Economy* **94**, S176-S215.

[2] Bernheim, Douglas B. and Lawrence Levin (1989), "Social Security and Personal Saving: An Analysis of Expectations", *American Economic Review* **79**, 97-102.

[3] Blau, Francine D., and Adam J. Grossberg (1989), "Wage and employment uncertainty and the labor force participation of married women", NBER Working Paper 3081.

[4] Blundell, Richard and Thomas E. MaCurdy (2000), "Labor supply: a review of alternative approaches", in *Handbook of Labor Economics*, vol. 3a, edited by O. Ashenfelter and D. Card. Amsterdam: North-Holland.

[5] Bover, Olympia (1989), "Estimating intertemporal labor supply elasticities using structural models", *Economic Journal* **99**, 1026-39.

[6] Brandolini, Andrea, and Luigi Cannari (1994), "Methodological Appendix", in *Saving and the accumulation of wealth*, A. Ando, L. Guiso and I. Visco eds. Cambridge: Cambridge University Press.

[7] Browning, Martin, Angus Deaton, and Margareth Irish (1985), "A profitable approach to labor supply and commodity demands over the life-cycle", *Econometrica* **53**, 503-43.

[8] Card, David (1991), "Intertemporal labor supply: An assessment", in *Advances in Econometrics*, edited by C. Sims, Cambridge University Press: Cambridge.

[9] Chamberlain, Gary, (1984), "Panel data", in *Handbook of Econometrics*, vol. 2, edited by Z. Griliches and M. D. Intriligator. Amsterdam: North-Holland.

[10] Dominitz, Jeffrey (1998), "Earnings expectations, revisions and realizations", *Review of Economics and Statistics* 80, 374-88.

[11] Ghez, Gilbert R., and Gary S. Becker (1975), *The allocation of time and goods over the life-cycle*, New York: Columbia University Press.

[12] Guiso, Luigi, Tullio Jappelli, and Daniele Terlizzese (1992), "Earnings uncertainty and precautionary saving", *Journal of Monetary Economics* **30**, 307-37.

[13] Jappelli, Tullio, and Luigi Pistaferri (2000), "Using subjective income expectations to test for the excess sensitivity of consumption to predicted income growth," *European Economic Review* ***44**, 337-58.*

[14] Low, Hamish (1999), "Self-insurance and unemployment benefit in a life-cycle model of labour supply and savings", Institute for Fiscal Studies Working Paper 99/24.

[15] Lucas, Robert E., and Leonard E. Rapping (1969), "Real wages, employment, and inflation", *Journal of Political Economy* **77**, 721-54.

[16] MaCurdy, Thomas E. (1981), "An empirical model of labor supply in a life-cycle setting", *Journal of Political Economy* **88**, 1059-85.

[17] MaCurdy, Thomas E. (1985), "Interpreting empirical models of labor supply in an intertemporal framework with uncertainty", in J. Heckman and B. Singer (eds.), *Longitudinal analysis of labor market data*, Econometric Society Monographs 10.

[18] Manski, Charles F. (2000), "Economic analysis of social interactions", NBER Working Paper 7580.

[19] Mulligan, Casey B. (1995), "The intertemporal substitution of work. What does the evidence say?", Population Research Center Discussion Paper Series 95-11.

[20] Mulligan, Casey B. (1999), "Pecuniary and nonpecuniary incentives to work in the U.S. during World War II. ", *Journal of Political Economy*, forthcoming.

[21] Pistaferri, Luigi (2001), "Superior information, income shocks and the permanent income hypothesis", *Review of Economics and Statistics*, forthcoming.

Table 1
Sample characteristics

Variable	1989	1991	1993
Age	42.07	43.26	44.81
	(8.59)	(8.69)	(8.40)
Education	10.33	9.96	9.66
	(4.30)	(4.17)	(4.07)
North	0.38	0.41	0.43
	(0.49)	(0.49)	(0.50)
South	0.45	0.40	0.37
	(0.50)	(0.49)	(0.48)
Family size	3.86	3.81	3.79
	(1.07)	(1.03)	(0.99)
Income recipients	1.64	1.68	1.75
	(0.73)	(0.74)	(0.73)
Kids 0-5	0.35	0.29	0.24
	(0.59)	(0.55)	(0.50)
Kids 6-13	0.61	0.57	0.54
	(0.76)	(0.73)	(0.72)
Kids 14-17	0.35	0.33	0.33
	(0.61)	(0.58)	(0.55)
Working wife	0.36	0.35	0.35
	(0.48)	(0.48)	(0.48)
Family income	21,415.63	21,033.32	21,617.61
	(10,642.93)	(10,752.47)	(10,605.19)
Working months	11.85	11.83	11.66
	(0.92)	(0.96)	(1.42)
Weekly normal hours	40.83	40.67	39.50
	(5.78)	(5.92)	(7.18)
Earnings	12,443.24	12,193.92	12,173.83
	(4,921.95)	(5,709.74)	(4,642.11)
Wage rate	6.49	6.50	6.88
	(2.36)	(4.67)	(3.58)
ψ_{it}	–.–	0.0028	0.0132
		(0.2521)	(0.3438)
$E_{t-1}(\Delta \ln y_{it})$	–.–	−0.0079	−0.0300
		(0.0508)	(0.0594)
Expected inflation		0.0730	0.0738
		(0.0347)	(0.0419)

Note: Standard deviations in parenthesis. The figures for income, earnings, and wages are in euro. ψ_{it} is the innovation in earnings growth, $\Delta \ln y_{it} - E_{t-1}(\Delta \ln y_{it})$.

Table 2
The estimate of the intertemporal labor supply equation

Variable or structural parameter	Estimate
Constant	−0.0032 (0.0739)
1993	−0.0683 (0.0228)
Age	−0.0001 (0.0014)
Education	−0.0014 (0.0026)
North	0.0213 (0.0301)
South	−0.0306 (0.0299)
Δ Number of children aged 0-5	−0.0252 (0.0319)
Δ Number of children aged 6-13	−0.0003 (0.0296)
Δ Number of children aged 14-17	−0.0138 (0.0249)
Δ Number of income recipients	0.0161 (0.0216)
Δ Working wife	0.0597 (0.0391)
η	0.7038 (0.0928)
$\eta + \Gamma$	0.5053 (0.0506)
$\eta + \varphi$	0.5928 (0.2892)
φ	−0.1111 (0.2748)
Γ	−0.1985 (0.0908)
ϑ^{ζ}	−0.1060 (0.0265)

Note: η is the elasticity of intertemporal substitution, $\eta + \Gamma$ the elasticity with respect to parametric wage growth, $\eta + \varphi$ the elasticity of the marginal utility of wealth, φ captures within-period non-additivity between consumption and leisure, Γ is the wealth effect of parametric wage growth, and ϑ^{ζ} the coefficient attached to the conditional variance of wage growth.

Table 3
Sensitivity analysis

Structural parameter	Standard labor supply equation (1)	Controlling for unemployment (2)	Controlling for overtime constraints (3)
η	0.3180 (0.3188)	0.2569 (0.0528)	0.7002 (0.0920)
$\eta+\Gamma$		0.3031 (0.0348)	0.4980 (0.0501)
$\eta+\varphi$		0.2225 (0.1844)	0.5941 (0.2878)
φ		−0.0344 (0.1757)	−0.1061 (0.2736)
Γ		0.0462 (0.0571)	−0.2022 (0.0897)
ϑ^{ζ}		−0.0505 (0.0105)	−0.1052 (0.0262)

Note: η is the elasticity of intertemporal substitution, $\eta+\Gamma$ the elasticity with respect to parametric wage growth, $\eta+\varphi$ the elasticity of the marginal utility of wealth, φ captures within-period non-additivity between consumption and leisure, Γ is the wealth effect of parametric wage growth, and ϑ^{ζ} the coefficient attached to the conditional variance of wage growth.

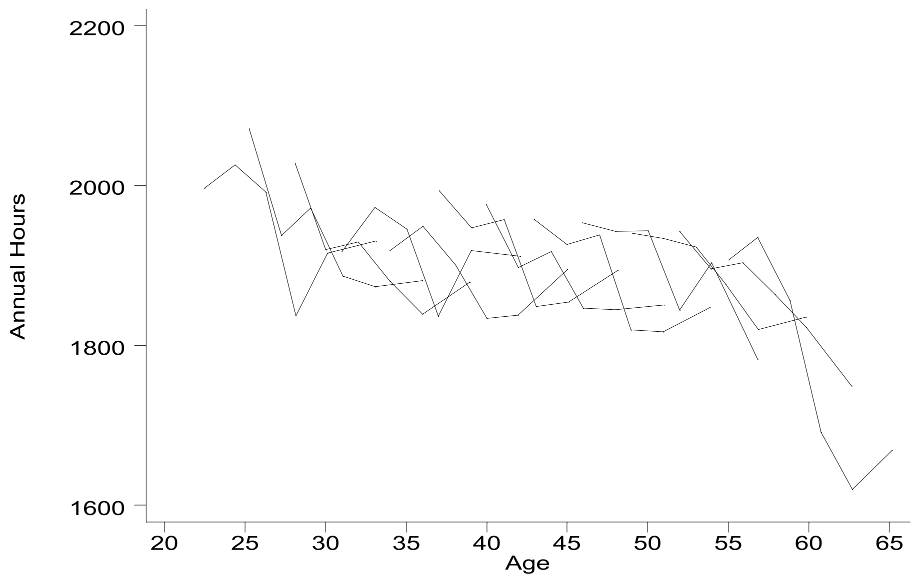

Figure 1: The life-cycle profile of annual hours

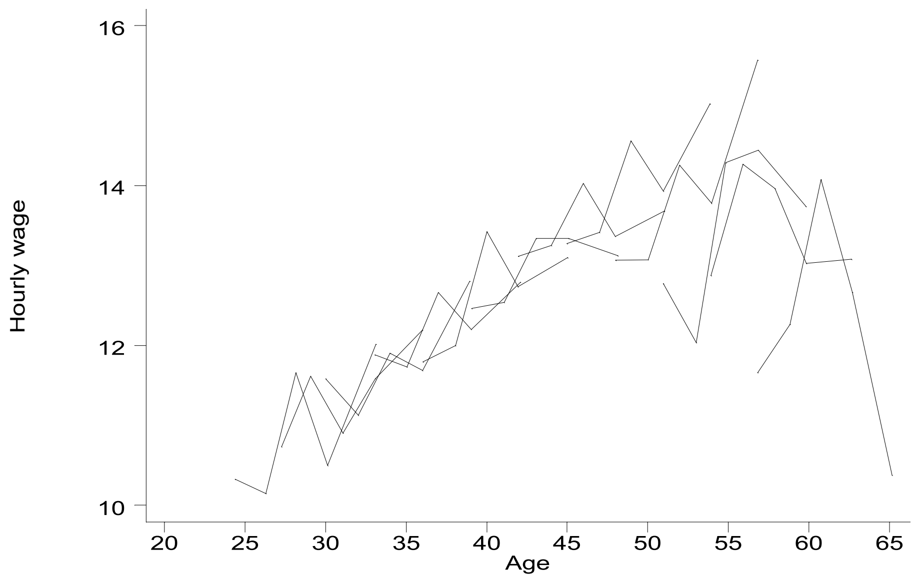

Figure 2: The life-cycle profile of hourly wages