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# Quitting and Labor Turnover

## Microeconomic Evidence and Macroeconomic Consequences

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To prevent trained workers from quitting to open their own businesses, firms pay higher than market "efficiency wages" to reduce turnover. What is the impact of macroeconomic shocks and policy innovations, such as labor market reform, in an economy where this is of central importance?

## Summary findings

Combining microeconomic evidence with macroeconomic theory, Krebs and Maloney present an integrated approach to wage and employment determination in an economy where firms pay above market "efficiency wages" to prevent trained workers from quitting.

The model offers predictions about the behavior of formal employment, labor turnover, and segmentation in response to formal sector productivity shocks (including economic growth and tax reductions), changes in the desirability of self-employment (formal sector tax rates), and the cost of training a new worker.

They use panel data from Mexican labor surveys to estimate the quit function derived from the model and the results support their view that transitions from formal salaried work to informal self-employment are quits rather than fires. (Quitting is positively related to the mean self-employment income and the probability of being rehired and negatively related to the mean formal salaried wage.) They then use the parameters estimated from the quit function to calibrate the model economy and simulate the impacts of economic shocks and policy innovations and find the impact on employment, turnover, and segmentation to be substantial.

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# Quitting and Labor Turnover:

# Microeconomic Evidence and Macroeconomic Consequences[*]

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# 1. Introduction

Recent work on efficiency wage models has produced an internally consistent macro-theory of involuntary unemployment (underemployment)[1] whose basic assumptions and implications have largely been corroborated by empirical micro-studies.[2] Although the microeconometric work was motivated by macroeconomic theory, it has never been fully integrated into a macroeconomic framework.[3] In this paper we offer one version of such an integrated approach. More precisely, we first develop an efficiency wage model with labor turnover (Phelps 1968, Stiglitz 1974, Salop 1979, Hoon and Phelps 1992) and show that the worker's decision problem gives rise to a quit-rate function. We then use microeconomic data to estimate this quit-rate function and to test the specification suggested by economic theory. Finally, microeconomic evidence and macroeconomic model are combined to evaluate the quantitative effects of changes in economic policy and other macroeconomic shocks on the wage rate, the turnover rate, and employment in the long-run (steady state analysis).

The efficiency wage model with labor turnover we employ is in principle applicable to any type of movement of labor across sectors in any country (Bulow and Summers 1986). However, the original literature on this type of efficiency wage model has mainly focused attention on unemployment in developed countries (Phelps 1968, Salop 1979, Phelps and Hoon 1992). We, on the other hand, test and calibrate our model using panel data on the movement of Mexican workers between the formal salaried and the informal self-employed sector. Our choice of the data set was motivated by the following two considerations.

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[1]See Katz (1986) and Woodford (1994) for surveys.

[2]See Katz (1986) and Layard, Nickell, and Jackman (1991) for surveys.

[3]The quantitative papers by Danthine and Donaldson (1990,1995) and Kimball (1994) on efficiency wage models with shirking (Shapiro and Stiglitz 1984) consider microeconomic evidence when calibrating the macroeconomic model, but do not incorporate a microeconomic estimation equation into the macroeconomic model as we do. In this sense, we feel that we have come closer to a full integration of the two fields of labor economics and macroeconomics. See also Blanchard and Katz (1997) for a statement in favor of such an integrated approach.

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First, the efficiency wage model with labor turnover captures well a number of features of LDC labor markets, and in particular the Mexican case we consider. The literature suggests that the self-employed informal sector comprises both workers rationed out of formal salaried jobs as well as a relatively prosperous "upper tier" that may prefer self-employment.[4] In other words, the literature is consistent with one of the central ideas of the efficiency wage model with labor turnover, namely that at each point in time workers are voluntarily leaving their formal-sector job for self-employment and simultaneously self-employed workers are unsuccessfully trying to reenter the formal sector. Moreover, neither minimum wages nor unions are credible explanations for the observed segmentation.[5] Finally, Constitutional proscriptions against firing suggest quitting as the dominant mode of job separation.

Second, our data set has an important time dimension which allows us to estimate the quitting response of individual workers to changes in macroeconomic conditions. Given our final goal of quantitative macroeconomic analysis, this feature of the data set seems essential. In addition, the data on self-employed workers offer a measure of the benefits (payoffs) to not being employed in the formal sector that displays substantial variations over time. These variations in self-employment benefits are important since they provide us with an additional test of the "quitting theory" which predicts that labor turnover is positively correlated with expected benefits to self-employment and that the quit-rate function is symmetric: the benefits-elasticity of quitting is equal to the negative of the wage-elasticity of quitting. Moreover, if the symmetry property of the quit-rate function is supported by the data on self-employed workers, we may use it as a working hypothesis (until refuting evidence is forthcoming) and apply it to unemployment. This opens the door for an assessment of the quantitative macroeconomic effects of changes in unemployment benefits without

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[4] Harris and Todaro (1970) offer the canonical statement of the dualistic (rationing) view and Fields (1990) discusses the "two-tier" view of the informal sector.

[5] Bell(1996) finds no evidence that minimum wages are binding. Maloney and Ribeiro (1998) find evidence of union influence on employment, but none on wage setting.

directly estimating the elasticity of quitting with respect to unemployment benefits, usually an impossible task given the lack of temporal variations in these benefits.

Our empirical estimates of the determinants of labor flows from the salaried to the self-employed sector strongly support the specification suggested by the quitting theory: the individual probability of job separation is decreasing in the formal-sector wage (the expected payoff to staying) and increasing in benefits to self-employment and the probability of finding a formal-sector job (the expected payoff to leaving). Moreover, the above mentioned symmetry property of the quit-rate function cannot be rejected. When the microeconomic estimates are used to calibrate the macroeconomic model, we find the long-run effects of macroeconomic shocks on wages, labor turnover, and (formal-sector) employment to be substantial. The strong employment response found here stands in stark contrast to the disappointingly small unemployment effects reported by Danthine and Donaldson (1990,1995) and Kimball (1994) who calibrate an efficiency wage model with shirking (Shapiro and Stiglitz 1984) to US unemployment data.[6]

This paper can be interpreted as providing a two-stage "test" of the real world relevance of efficiency wage models with labor turnover. In the first stage, microeconomic data are used to estimate and test what we believe to lie at the heart of this type of efficiency wage model, namely the quit-rate function. If the coefficients are found to be significant and of the correct sign, in a second stage the estimated quit-rate function is incorporated into the macroeconomic model and the calibrated model economy is used to assess the quantitative importance of efficiency wages. This second-stage check is important since there seems to be little value in having a macroeconomic theory of unemployment (underemployment) which is supported by microeconomic data but implies an almost constant unemployment (underemployment) rate. In this paper we present one fully worked out example of this two-stage procedure in the hope that it will spur interest in further

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[6]Danthine and Donaldson (1990, 1995) explicitly consider aggregate uncertainty by solving a stochastic dynamic general equilibrium model. Kimball (1994) studies the dynamic and steady state effects of macroeconomic shocks in a deterministic model, but his quantitative result on employment variations is obtained by comparing steady state equilibria.

applications to different countries and different sectors. Such work is likely to add an important dimension to the existing empirical literature which has either completely focused on the micro-level or solely relied on cross-country regressions.[7]

The paper is organized as follows. Section 2 develops the model. Almost all derivations, and in particular the discussion of the worker's decision problem, is relegated to the Appendix. Section 3 presents the empirical analysis of the panel data on Mexican workers and some additional information on the Mexican labor market. The specification for the estimated quit-rate function is dictated by the theory developed in Section 2. In Section 4 the macroeconomic model is calibrated and the simulation results are presented. Section 5 concludes.

## 2. The Model

The model is a discrete-time, neoclassical growth model with a labor market characterized by labor turnover, employment-adjustment costs (hiring and training costs), and wage-setting by firms. The analysis will be confined to equilibria in which a number of economic variables grow at a constant rate equal to the exogenous rate of technological progress (balanced growth path).

### a) Workers

There is a large number of ex-ante identical, infinitely-lived workers. Workers' preferences over random consumption sequences allow for a time-additive expected utility representation. Workers do not participate in financial markets and therefore do not save or dissave. Hence, each worker's

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[7]See, for example, Phelps (1994), Nickell (1997), and Phelps and Zoega (1998) for empirical work using cross-country regressions. Blanchard and Jimeno (1995) conduct an interesting case study comparing two countries, Spain and Portugal. The method outlined in this paper provides a formal procedure for quantifying the importance of efficiency wages in explaining the different macroeconomic experiences of two countries.

consumption level is equal to his current disposable income.[8]

In each period a worker devotes a fixed amount of time to one of the following two activities: working in the formal sector or working in the informal sector of the economy. Our informal-sector data in the empirical section are taken from the self employed and we will therefore call a person working in the informal sector a self-employed worker. In each period, a worker, regardless of his current employment status, receives an idiosyncratic shock determining the relative attractiveness of employment versus self-employment ("taste-shock", change in expected payoff to self-employment). After observing the shock realization, an employed worker makes a quit/stay decision and a self-employed worker makes a search/no-search decision. Whereas an employed worker automatically becomes self-employed when deciding to quit a job, a self-employed worker who decides to search for formal-sector employment receives a job offer only with probability less than one.

The Appendix A1 discusses the Bellman equation associated with the worker's decision problem and analyzes the resulting optimal decision rule. The optimal decision rule gives rise to a quit-rate function, $q_i = \tilde{q}(w_i, w, p; \tau, b)$, where $q_i$ stands for the quit rate experienced by firm $i$, $w_i$ for the (growth-adjusted) wage paid by firm $i$, $w$ the average (growth-adjusted) wage, $p$ for the probability of finding (formal sector) employment when not employed, $\tau$ for the tax rate on formal-sector labor income, and $b$ for the average (growth-adjusted) pecuniary benefits from self employment.

Let $q(w, p; \tau, b) \doteq \tilde{q}(w_i, w, p; \tau, b)|_{w_i = w}$ be the economy-wide quit-rate function when all

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[8]In a sense, this assumption renders the model classical rather than neoclassical. It is mainly made for tractability reasons since it trivially determines the wealth distribution of workers (no wealth). Without this assumption the wealth distribution is in general non-trivial and has to be computed as part of the equilibrium, except when there is complete consumption insurance. The assumption of restricted capital market participation is also made in Danthine and Donaldson (1990,1995) for the same tractability reason. Kimball (1994) does not treat capital accumulation and therefore does not deal with wealth effects. Phelps (1994) emphasizes wealth effects, but nowhere develops a complete general equilibrium model with endogenize wealth distribution. We hope to dispense with this assumption in future work.

firms pay the same wage. Clearly, this function is identical to the quit-rate function in an economy with only one representative firm. The function $\tilde{q}(.)$, however, is the function entering into the profit maximization problem of an individual firm (see Appendix A2) in a many-firm economy. In Appendix A1 we show that the individual quit-rate function, $\tilde{q}(.)$, satisfies

$$\frac{\partial \tilde{q}}{\partial w_i} < 0 \quad ; \quad \frac{\partial \tilde{q}}{\partial w} > 0 \quad ; \quad \frac{\partial \tilde{q}}{\partial p} > 0 \quad ; \quad \frac{\partial \tilde{q}}{\partial b} > 0 \quad ; \quad \frac{\partial \tilde{q}}{\partial \tau} > 0 \quad ; \tag{1}$$

and that the economy-wide quit-rate function, $q(.)$, satisfies

$$\frac{\partial q}{\partial w} < 0 \quad ; \quad \frac{\partial q}{\partial p} > 0$$

$$\frac{\partial q}{\partial \tau} = \frac{1}{b}\frac{\partial q}{\partial b} = -\frac{1}{w}\frac{\partial q}{\partial w} > 0 \quad . \tag{2}$$

The empirical analysis conducted in Section 3 tests the sign and symmetry restrictions (2) and finds strong evidence in favor of them. Our panel data on worker transition provide no information about the quit-rate function of an individual firm in a many-firm economy, $\tilde{q}(.)$. Appendix A1, however, shows that the two marginal quit-rate functions (approximately) satisfy

$$\frac{\partial \tilde{q}}{\partial w_i}(w_i, w, p; \tau, B)\big|_{w_i = w} \equiv \mu(w, p; \tau, B)\frac{\partial q}{\partial w}(w, p; \tau, B) \tag{3}$$

$$\mu(w, p; \tau, b) \doteq \frac{1 - \beta_w(1 - q(w, p; \tau, b))(1 - p)}{1 - \beta_w(1 - q(w, p; \tau, b))} \quad ,$$

where $\beta_w$ is the discount factor of workers. Expression (3) enables us to make quantitative predictions about the impact of economic policy knowing only the economy-wide quit-rate function $q(.)$. The parameter $\mu$ measures the difference between the reduction in the quit-rate when an individual firm raises its own wage and the reduction in the quit-rate when all firms raise their wages simultaneously.

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b) *Capitalists (Firms)*

There are $i = 1,...,N$ infinitely-lived capitalist with identical preferences who each own one firm with identical production technology. There is one good which can be used for consumption and investment purposes. Firm $i$ combines capital and labor to produce output. Adjusting the amount of labor employed is costly since there are hiring and training costs. We assume that adjustment costs are fully paid by firms.[9]

Taking the economy-wide wage as given, each firm $i$ chooses a sequence of consumption (of owner $i$), capital, investment, employment, hiring, and own-wage which maximize the capitalist' life-time utility subject to the relevant constraints. The decision problem faced by firm (capitalist) $i$ is fully spelled out in Appendix A2. The resulting Euler equations for the growth-adjusted variables are

$$\lambda_{it} = \beta_c (1+g)^{-\rho} \lambda_{i,t+1} \left( 1 - \delta + \frac{\partial F}{\partial k_i}(k_{i,t+1}, l_{i,t+1}) \right)$$

$$\gamma_{it} = \beta_c (1+g)^{1-\rho} \left[ \gamma_{i,t+1}\left(1 + h_{i,t+1} - \tilde{q}(w_i, w, p)\right) + \lambda_{i,t+1}\left( \frac{\partial F}{\partial l_i}(k_{i,t+1}, l_{i,t+1}) - w_i - T(h_{i,t+1}) \right) \right] \quad (4)$$

$$\lambda_{it} = c_{it}^{-\rho} \quad ; \quad \gamma_{it} = \lambda_{it} T'(h_{it}) \quad ; \quad \gamma_{it} = -\lambda_{it} \left( \frac{\partial \tilde{q}}{\partial w_i}(w_i, w, p) \right)^{-1} ,$$

where $\beta_c$ and $\rho$ are the capitalist' discount factor and coefficient of relative risk aversion, $c_{it}$ her growth-adjusted consumption level, $k_{it}$ the capital stock per efficiency unit of labor, $h_{it}$ the hiring rate, $l_{it}$ the fraction of the labor force employed in the formal sector, and $\lambda_{it}$, $\gamma_{it}$, Lagrange multipliers associated with physical, respectively human, capital accumulation constraints. The

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[9]In our model with credit rationed workers owning no wealth, only the firm can afford to pay these costs. Even if workers are not credit rationed but human capital created by training is firm specific, the firm is likely to bear the full cost of training (Salop 1979, Hoon and Phelps 1992, Phelps 1994). Of course, we do not consider indirect means by which workers can be made to bear some of the adjustment costs. Wages rising with tenure is one example.

multiplier $\gamma_{it}$ is the (utility) value of a trained employee to the firm (the analog to Tobin's q). Further, $\delta$ is the depreciation rate of physical capital, $F(.)$ a standard neoclassical production function, and $T(.)$ the adjustment cost function.

### c) The Government

The government collects taxes and spends the tax receipts on consumption goods. We assume that tax receipts are equal to outlays in each period and that therefore the fiscal budget is always balanced. For simplicity, we assume that informal-sector workers and capitalists are not taxed so that the tax revenue, which is equal to fiscal spending, is $(\tau w l)N$.

### d) Steady State Equilibrium

We are interested in symmetric steady state (balanced growth) equilibria. Such an equilibrium is defined as a list of (growth-adjusted, per-capitalist) values for output, $y^*$, capital $k^*$, capitalists' consumption $c^*$, (formal-sector) employment $,l^*$, real wage, $w^*$, and hiring (quitting) rate, $h^* = q^*$, such that:

i) Given the quit-rate function, $\tilde{q}(.)$, and expected labor market conditions, $(w^*, p^*)$, $y^*, k^*, l^*, h^*, c^*, w^*$ are the solution to the capitalists' (firms') optimization problem if the initial capital stock and stock of trained employees is $(k^*, l^*)$.

ii) The quit-rate function, $\tilde{q}(.)$, is the solution to the worker's optimization problem.

iii) Expectations are fulfilled, that is, expected values are equal to actual values.

Because of the assumption of constant returns to scale, the marginal products only depend on the capital to labor ratio: $\dfrac{\partial F}{\partial k}(k,l) = f'(\tilde{k})$ and $\dfrac{\partial F}{\partial l}(k,l) = f(\tilde{k}) - f'(\tilde{k})\tilde{k}$ with $\tilde{k} = k/l$ and $f(\tilde{k}) = F(\tilde{k},1)$. Using the definition of a steady state equilibrium and Equation (4), we immediately derive the following characterization of a steady state equilibrium. The growth-adjusted capital stock per employed worker is

$$\tilde{k}^* = f'^{-1}\left(\frac{(1+g)^\rho}{\beta_c} + \delta - 1\right)$$ (5)

For given $\tilde{k}^*$, the equilibrium wage rate, $w^*$, and the equilibrium probability of finding a job, $p^*$, are the solution to

$$f'(\tilde{k}^*) - f(\tilde{k}^*)\tilde{k}^* - w^* - T(\zeta(w^*,p^*)) - \left[1 - \beta_c(1+g)^{-\rho}\right]T'(q(w^*,p^*)) = 0$$

$$T'(q(w^*,p^*)) + \frac{1}{\mu(w^*,p^*)\frac{\partial q}{\partial w}(w^*,p^*)} = 0 \ .$$ (6)

Finally, the equilibrium values of the remaining variables are determined by [10]

$$h^* = q^* = q(w^*,p^*) \quad ; \quad l^* = \left(1 + \frac{h^*}{p^* v(1-q^*)}\right)^{-1} \quad k^* = \tilde{k}^* l^* \ ;$$

$$c^* = F(k^*,l^*) - \delta k^* - w^* l^* - T(h^*)l^* \ ,$$ (7)

where $v(1-q^*)$ is the fraction of self-employed workers searching for a formal-sector job. The parameter $v$ is a constant which is discussed in more detail in Appendix A1.

Evidently, the two equations (6) determining the equilibrium values $w^*$ and $p^*$ are equivalent to

$$Z - w^* - T(q(w^*,p^*)) - r T'(q(w^*,p^*)) = 0$$

$$T'(q(w^*,p^*)) + \frac{1}{\mu(w^*,p^*)\frac{\partial q}{\partial w}(w^*,p^*)} = 0 \ ,$$ (8)

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[10]The consumption of a worker if employed is $w^*(1-\tau)$ and if self-employed is $b$. The government consumes $(\tau w^* l^*)N$.

where $Z = f(k^*) + f'(k^*)k^*$ is the marginal (revenue) product of labor and $r = 1 - \beta_c(1+g)^{-\rho}$ the real interest rate.

It is often useful to depict the solution to (8) as the intersection of a downward-sloping "labor demand curve" and an upward-sloping efficiency (incentive) wage curve. To the extend that the first equation in (8) expresses the optimal employment choice by firms and the second equation represents the optimal wage setting by firms, this terminology seems justified. The first equation in (6) implicitly defines a function $w = w^d(p)$ with

$$\frac{dw^d}{dp} = -\frac{(T' + rT'')\frac{\partial q}{\partial p}}{1 + (T' + rT'')\frac{\partial q}{\partial w}} . \tag{9}$$

Since $\frac{\partial q}{\partial w} < 0$, $\frac{\partial q}{\partial p} > 0$, $T' > 0$, and $T'' \geq 0$, the curve $w^d(.)$ is downward sloping if and only if $|\frac{\partial q}{\partial w}|(T' + rT'') < 1$. For small $rT''$ this condition is always satisfied since $|\frac{\partial q}{\partial w}|T' = \frac{1}{\mu} < 1$ (this follows from the second equation in (8)). Note also that if the real interest rate is non-negative, $\mu > 1$ is a necessary (and if $rT'' \approx 0$ a sufficient) condition for the $w^d$-schedule to be downward sloping. Thus, in order to have a labor demand function with a negative slope, the reduction in the quit-rate due to the increase of the individual firm's wage must be larger than the reduction in the quit-rate when all firms simultaneously increase their wage, which is generally true in the model considered here.

The second equation in (8) implicitly defines a function with

$$\frac{dw^s}{dp} = -\frac{T''\frac{\partial q}{\partial p} - \left(\frac{1}{\mu}\frac{\partial q}{\partial w}\right)^{-2}\left[\frac{\partial^2 q}{\partial p \partial w} + \frac{\partial \mu}{\partial p}\frac{\partial q}{\partial w}\right]}{T''\frac{\partial q}{\partial w} - \left(\frac{1}{\mu}\frac{\partial q}{\partial w}\right)^{-2}\left[\frac{\partial^2 q}{\partial w^2} + \frac{\partial \mu}{\partial w}\frac{\partial q}{\partial w}\right]} . \tag{10}$$

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There is no straightforward way of signing the expression (9).[11] Our empirical results suggest that the quadratic and cross-derivative terms are zero. If in addition $T'' = 0$, we have $\frac{dw^e}{dp} = -\frac{\partial \pi}{\partial p} / \frac{\partial \pi}{\partial w^e}$ which turns out to be positive for the range of parameter values considered in this paper. Hence, the efficiency wage curve is upward-sloping.

*e) An Extension: Vacancies and Matching*

The efficiency wage model developed so far shares one important feature with traditional search models,[12] namely an endogenously determined labor turnover rate. However, it also differs from those models in important ways. First, in the efficiency wage model firms set wages in contrast to the Nash bargaining solution usually deployed by the search literature. In a sense, the efficiency wage model is the limit case of the bargaining model in which firms have all the bargaining power and are therefore in a position to make a take-it-or-leave-it offer to workers. Second, the search literature deploys a matching (hiring) function relating the number of hires, $hl$, to the number of vacancies, $v$, and the number of unemployed $1 - l$. This matching function describes the efficiency of the job reallocation process. In this section, we briefly discuss the possibility of incorporating a matching function into the efficiency wage model developed here.

For the sake of concreteness, consider the case in which the matching function is of the Cobb-Douglas type, $hl = v^\alpha (1 - l)^{1-\alpha}$, where we assumed for simplicity that all unemployed (self-employed) workers are searching for a formal-sector job.[13] Suppose further that the only adjustment cost is the cost of posting a vacancy and that the unit cost of a vacancy is a constant, $c$. Hence, the total cost of changing the employment level is $\tilde{T} = cv$. Eliminating the number of vacancies, $v$, yields a total adjustment cost $\tilde{T} = c(hl)^{1/\alpha}(1 - l)^{(1-1/\alpha)}$ and a cost of adjustment per employee of

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[11]The sufficiency conditions for the firm's optimization problems do not guarantee an upward-sloping curve.

[12]See Blanchard and Katz (1997) and Rogerson (1997) for recent surveys.

[13]Recall that in our notation $h$ is the hiring rate and $hl$ is total hires of one firm. For simplicity, we have set the number of firms to one: $N = 1$.

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$T = c\,h^{1/\alpha}\left(\dfrac{l}{1-l}\right)^{(1/\alpha-1)}$. Thus, we have an adjustment cost function which is convex in the hiring rate, $h$, but also depends on the employment level, $l$. This dependence of the "training and hiring costs" on the employment level is the only difference to the previous model formulation. It is, however, straightforward to incorporate the more general adjustment cost function into the efficiency wage model resulting into three steady state equations in the three unknowns $w^*, p^*, l^*$. We plan to conduct quantitative policy analysis for such an extended model with a general matching technology in the future. The efficiency wage model developed in the last sections can be thought of as the special case in which $\alpha = 1$ since then we have $T = c\,h$, that is, an adjustment cost function which only depends on the hiring rate. Incidentally, this function is linear, a property we assume in the quantitative section 4.

## 3. Microeconomic Data Analysis

This section uses micro-economic data from Mexico to estimate the quit-rate function and to test the model's predictions about the determinants of quitting behavior. The quit-rate function estimated here is used in Section 4 for macroeconomic policy analysis.

### a) Data Description

The National Urban Employment Survey (ENEU) conducts extensive quarterly household interviews in the 16 major metropolitan areas and is available from 1987 to 1993. The sample is selected to be geographically and socio-economically representative. The statistical agency (INEGI) expanded it significantly over the period by adding municipalities, however, we include only those present in every year of the survey to prevent changes in composition. The questionnaire is extensive in its coverage of participation in the labor market, wages, hours worked, etc. that are traditionally found in such employment surveys. INEGI's treatment of sample design, collection, and data cleaning is careful. Surveys and documentation of methodology are available on request.

The ENEU is structured so as to track a fifth of each sample across a five quarter period. To construct the panels, workers were matched by position in an identified household, level of education, age and sex to ensure against generating spurious transitions. Using just the first

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variables to concatenate and following changes in sex across the panel led to mismatching (or misreporting) of under .5 percent. Taken together, we have 24 complete panels of 5 periods spanning a total of 28 quarters where transitions could occur across a seven year period which includes a time of recession (1987-88), recovery (1989-91), and then stagnation (1992-1993).

Though the model deals with decisions to be self-employed generally, we further narrow the population by only considering self-employed workers in the "informal" sector. We use the term 'informal' here to refer to those unprotected by labor law, more specifically, owners of firms under 16 employees who do not have social security or medical benefits. In fact, under 1% of these firm have more than 5 employees so the definition corresponds closely to that commonly used in the development literature. Formal salaried workers are defined as those in firms of over 16 workers who enjoy labor protections. To eliminate the "self-employed" in consulting firms or other high end activities, we analyze male workers with a high school education or less between the ages of 16-65.

The dependent variable is a 0, 1 index that captures whether the worker moved during a particular quarter. If he should move back to salaried employment and then move again to self-employment, this is counted as a second quit. The macro wage and benefit variables employed in the regression analysis, $\log w_t$ and $\log b_t$, are the median for the entire sample (spanning five panels) for each quarter. The probability of being hired, $p_t$, is the number of the self-employed who transition to the salaried sector, as a fraction of those looking for a salaried job. While we know the total number of self-employed, we do not observe the share searching in each period which theory predicts should vary with macro-shocks. We assume that this fraction is proportional to, or at least highly correlated with, the standard measure of search, the unemployment rate. The probability $p_t$ is therefore proxied by $\tilde{p}_t$, the number of the self-employed moving into salaried work divided by the number of unemployed. Even though we thereby avoid the need for time series data on the search intensity, we still require information about the sample average of this variable in order to rescale the estimated coefficient appropriately when conducting the macroeconomic simulations in Section 4. To this end, we use the survey response from the National Micro-Enterprise Survey (ENAMIN) which in 1992 re-interviewed roughly 11,000 of those in the 1991:4 ENEU who

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declared themselves self-employed. In particular, it asks the motivation for opening the business and offers eight non-exclusive responses. 13.5 percent responded that they could not find work as a salaried worker and another 3.2 percent responded they were laid off at their previous job. We use the rounded up number of 20% in our baseline model as an estimate for the average fraction of self-employed workers searching for a formal-sector job (see Section 4).

The last two columns of table 1 present the summary statistics for the variables used in the regression analysis. On average 2.5% of salaried workers transit into self-employment in one quarter. The standard deviations also suggest substantial variation in the macro variables across the period.

*b) Econometric Specification and Results*

We are interested in implementing an empirical procedure allowing us to estimate the quit-rate function $q = q(w,p,b)$. In the Appendix we show that if workers' utility is logarithmic and if the optimal decision rule is approximated by a first-order Taylor expansion, then we can write

$$q = \Phi\left(\alpha_0 + \alpha_w \log w + \alpha_p p + \alpha_b \log b + \theta^j\right), \tag{11}$$

where $\Phi(.)$ is the distribution function of an unobserved, worker-specific shock variable $\theta^j$. The random variables $\{\theta^j\}_{j \varepsilon J}$ are identically distributed and capture all differences in taste and ability across workers influencing their quitting decision. The relevant derivatives of the quit-rate functions are then given by $\frac{1}{w}\frac{\partial q}{\partial w} = \alpha_w \varphi(x)$, $\frac{1}{b}\frac{\partial q}{\partial b} = \alpha_b \varphi(x)$, and $\frac{\partial q}{\partial p} = \alpha_p \varphi(x)$, where $\varphi(x)$ is the probability density evaluated at $x = \alpha_0 + \alpha_w w + \alpha_p p + \alpha_b b$. Hence, the inequalities (2) expressing the implications of the theory now read $\alpha_w \leq 0$, $\alpha_p > 0$, and $\alpha_b > 0$ and the symmetry relation says

$\alpha_w = -\alpha_p$. There are two difficulties with implementing (11) econometrically.[14]

First, the discussion in the Appendix only deals with the case of deterministic changes in the macroeconomic variables $w$, $b$, and $p$ whereas the data are better described by a stochastic process $\{(w_t, p_t, b_t)\}_{t=0}^{\infty}$. If, however, the process of macro variables, $\{(w_t, p_t, b_t)\}_{t=0}^{\infty}$, is Markovian, a straightforward extension of the analysis shows that the optimal decision rule of workers still gives rise to a quit-rate function

$$ q_t = \Phi\left(\alpha_0 + \alpha_w \log w_t + \alpha_p p_t + \alpha_b \log b_t + \theta_t^j\right), \qquad\qquad (12) $$

since the current macro state $(w_t, p_t, b_t)$ is a sufficient statistic for the future evolution of the relevant macro variables (we again assumed a first-order Taylor approximation). With some weak additional assumptions, it can also be shown that the restriction imposed upon the signs of the coefficients $\alpha_w, \alpha_p, \alpha_b$ still hold. From a quantitative point of view, the quit-rate function derived in the Appendix corresponds to the quit-rate function when macroeconomic variables follow a random walk (highly persistent macroeconomic shocks). Given our short sample period (28 observations over seven years), we do not attempt to test the random walk assumption.

Second, if we only use the macro variables $w_t, p_t, b_t$ as right-hand-side variables, we certainly loose a large amount of information about economic variables influencing the decision of an individual worker since any observed difference in behavior is automatically attributed to the unobserved idiosyncratic shock, $\theta_t^j$. On the other hand, if we use the observed wage of individual workers on the right-hand-side (plus additional human capital variables), as is done by previous

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[14] There is an extensive literature on structural estimation of Markov decision processes (See Eckstein and Wolpin(1989) for a review and Daula and Moffitt (1995) in the labor literature). In contrast to most of this literature, we do not recover the structural (preference) parameters from the estimated coefficients $\partial q / \partial x_n$ since our macroeconomic policy experiments can be conducted without it. Estimates of preference parameters, however, would be essential for a quantitative welfare analysis.

cross-sectional studies estimating quitting equations,[15] we mix together (transitory) micro- and (permanent) macro-shocks since both types of shocks cause the individual wage to change. In this paper, however, we are mainly interested in the quitting response of individual workers to permanent macro shocks. These difficulties with using the currently observed individual wage are also the reason why we do not attempt to estimate the quit-rate function of an individual firm, $q_i = \tilde{q}(w_i, w, p, b)$. Our approach to this problem is to add to the right-hand-side of (12) additional individual-specific human capital variables:[16]

$$q_t^j = \Phi\left(\alpha_0 + \alpha_w \log w_t + \alpha_p p_t + \alpha_b \log b_t + \sum_k \alpha_k H_{tk}^j + \theta_t^j\right). \qquad (13)$$

The particular specification (13) with $\theta_t^j$ satisfying standard error-term assumptions could, for example, arise as the linearized solution of the worker's dynamic programming problem under the following conditions. Suppose we decompose the individual wage and the individual self-employment benefits as follows

$$\log w_t^j = \log w_t + \log \eta_{wt}^j$$

$$\log b_t^j = \log b_t + \log \eta_{bt}^j, \qquad (14)$$

where the macroeconomic variables, $\log w_t$, $\log b_t$, follow a Markov process, or more specifically a random walk. Moreover, assume that the evolution of the idiosyncratic wage and benefit component is given by

$$\log \eta_{wt}^j = \sum_k \gamma_{wk} H_{kt}^j + \varepsilon_{wt}^j$$

$$\log \eta_{bt}^j = \sum_k \gamma_{bk} H_{kt}^j + \varepsilon_{bt}^j, \qquad (15)$$

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[15]See, for example, Pencavel (1972), Krueger and Summers (1988), and Campbell (1993).

[16]Though in the empirical analysis we do not growth adjust either $w$ or $b$, in the log-formulation such an adjustment would be entirely captured in the intercept term, $\alpha_0$.

where the $\gamma_{wk}, \gamma_{bk}$ are constants, the human capital variables $H_{kt}^j$ follow a Markov process, for each $t = 0, 1, \dots$ the random variables $\{\varepsilon_{wt}^j\}_{j \varepsilon J}$ and $\{\varepsilon_{bt}^j\}_{j \varepsilon J}$ are identically and independently distributed, and for each $j \varepsilon J$ the processes $\{\varepsilon_{wt}^j\}_{t=0}^\infty$ and $\{\varepsilon_{bt}^j\}_{t=0}^\infty$ are serially uncorrelated. In principle, these assumptions are not too restrictive as long as the observed variables, $H_k^j$, exhaust the list of relevant idiosyncratic variables. In practice, however, there are always unobserved variables relevant for the worker's quitting decision whose existence causes a violation of our error-term assumption. We employ a random effects probit routine with estimates of Huber-While robust standard errors (see below) to ameliorate this problem.

The technology for estimating mover-stayer models in a rotating panel context is not presently developed.[17] As Maddala(1987) notes, simply pooling the data and then using standard probit techniques would yield consistent but inefficient estimates because the correlation across observations is not being exploited. As an intermediate approach, we maintain the integrity of each of the 24 panels, but "pool" them to form one large four-period panel (the first quarter is used to establish the worker in the formal sector) of 100,978 observations. Each observation includes the human capital variables and move-stay index particular to the individual, as well as the two macro-earnings variables and the proxy for the probability of finding a job corresponding to the potential move's location in the span of 28 periods. We then estimate the transition equation using STATA's panel probit routine.[18] This permits estimating Huber-While robust standard errors as a measure to ameliorate violations of the assumptions on $\varepsilon_{wt}^j$ and $\varepsilon_{bt}^j$ made above.

The results presented in the first two columns of table 2 strongly support the specification

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[17]A substantial literature exists on limited dependent models in a panel context (see Maddala 1983 and Baltagi 1996 for overviews) and continuous dependent variables in an incomplete or rotating panel context (see Nijman, Verbeek and van Soest 1991 for a recent overview), but there is no literature analyzing limited dependent variables in a rotating panel context.

[18] As Maddala(1987) notes, random effects probit estimators are consistent while the fixed effect estimators are not, in additional to being computationally difficult. We find it unlikely that there is any correlation between the random individual effects and the macro explanatory variables that would require use of a fixed effects estimator.

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suggested by our theory. The two earnings elasticities enter of predicted sign and significantly at the .1% level. A rise in self-employed earnings relative to formal-sector earnings leads to more workers trying their hand at self-employment. Our proxy, $\tilde{p}_t$, for the probability of finding a formal sector job also enters as expected and very significantly offering direct support to the efficiency wage dynamic postulated here. The higher the probability of finding another job in the formal sector, the more likely a worker will risk starting his own business. A more complete model with squares and cross terms of the macro variables was also estimated but none of these additions were significant and the results are not reported. Also consistent with the model, a $\chi^2$ test cannot reject the symmetry of the two income related elasticities at the 5% level. The next two columns present the results when this constraint is imposed. As expected, they are very similar and are used in the simulations.

The human capital variables enter significantly in both regressions. Since in the present specification they explain the idiosyncratic component of the wage-benefit differential, the signs of the combined effects (evaluated at the mean) are plausible. Increased schooling may plausibly lead to a larger differential, and hence a lower propensity to move, because of a greater demand for skills in the formal salaried sector. Conditioning on schooling, more experience may raise the probability of success in the self-employed sector, lower the differential and hence raise the probability of moving.

The regressions were also run with an alternative dependent variable that dropped observations after the first quit and yielded similar results. We also compared the results to the theoretically consistent standard probit techniques on the pooled sample and found them very similar (available on request).

Our estimation results confirm the most basic implications of the "quitting theory". Even though this is not the place for a detailed analysis of the full range of alternative views of job-separation, we point out that the estimation results are inconsistent with the simplest "firing theory",

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that is, the theory that termination of existing worker-firm matches is mainly a decision made by firms. To see this, suppose that the quit-rate is a constant independent of any economic factors. Suppose further that the firm's decision problem is identical to the one discussed in our efficiency wage model with the only exception that the wage is determined in a competitive labor market, the labor supply function being derived from a standard labor/leisure choice of workers. Consider now the response of the economy, which is initially in steady state, to a negative productivity (demand) shock. The dynamic response is likely to be an increase in firing and a reduction in hiring by firms since the new optimal employment level is lower. In addition, reduced demand for labor can be expected to decrease the wage. Hence, firing (the left-hand-side variable) is negatively correlated with the wage and the probability of finding a job (hiring) and this theory therefore predicts $\alpha_w < 0$ and $\alpha_p < 0$. If formal-sector and informal-sector productivity shocks are uncorrelated or positively correlated, which is a reasonable assumption, we have in addition the prediction $\alpha_b \leq 0$. Thus, two of the three inequalities are rejected by the data. We should also mention that if we consider an exogenous change in the wage (change in minimum wage) for constant productivity, similar reasoning yields $\alpha_w > 0$ , $\alpha_p < 0$ , $\alpha_b = 0$, which is even more strongly rejected by the data.

## 4. Macroeconomic Policy Analysis

Section 2 developed a macroeconomic model with labor turnover. The previous section estimated an aggregate quit-rate function $q(w,p;\tau,b)$ using microeconomic data. In this section, we combine the theoretical analysis with the empirical estimates in order to assess the quantitative effects of different macroeconomic shocks on the wage rate, the turnover rate, and formal-sector employment. This is done by implicitly differentiating Equation (8) with respect to the parameters under consideration and thereby calculating the effect on the wage rate and the probability of finding a job. The effect on the labor turnover rate and formal-sector employment is then calculated using

$$dh = dq = \frac{\partial q}{\partial w} dw + \frac{\partial q}{\partial p} dp + \frac{\partial q}{\partial \tau} d\tau$$

$$dl = \left( 1 + \frac{h^*}{p^* v(1-q^*)} \right)^{-2} \frac{1}{p^* v(1-q^*)} \left( \frac{h^*}{p^*} dp - dh \right)$$

(16)

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for the case of a tax reduction program. Analogous expressions are used for changes in other parameters.

*a) Calibration*

In order to make quantitative statements, we have to assign values to several parameters. We first discuss a baseline version of the model and then proceed to explore the sensitivity of our results to variations in the parameter values. To be consistent with the empirical work, we assume that the entire labor force consists of formal-sector workers and self-employed individuals.

An essential part of the model is the adjustment cost function $T(.)$. The comparative statics result depend on $T'$ and $T''$. The value of $T'$ is determined by theory through the second equation in (10). Since we have no data allowing us to estimate $T''$, we assume $T'' = 0$, that is, we assume that convexities in adjustment costs are weak (Section 2e provides one scenario in which this is the case). This assumption has the further advantage that the initial level of the equilibrium real interest rate is irrelevant for the quantitative impact of macroeconomic shocks.

Another building block of the model is the economy-wide quit-rate function $q(.)$ whose properties determine the (local) effectiveness of economic policy. We take as values for the first-order derivatives the point estimates of Section 3 and assume, in accordance with the empirical results, that all second-order derivatives are zero.[19]

The function $\mu(.)$ entering the second equation of (8) is calculated using the expression (3) with the values, $h^* = q^* = 0.02448$, $p^* = 0.2148$, and $\beta_w = 0.9$. The quarterly separation rate of 0.02448 is directly taken from the data and is the averaged, quarterly fraction of formal-sector employees

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[19]Instead of rewriting equation (8) in terms of log-wages, we simply normalize the equilibrium wage before the policy change to one. Thus, we have $\partial q/\partial w = -\partial q/\partial \tau$. The estimates of $\partial q/\partial x_n$ are constructed by multiplying the estimated coefficients $\alpha_n$ by $\varphi(x)$. In the case of $\partial q/\partial p$, the estimate of $\partial q/\partial \tilde{p}$ is further multiplied by .2148/6.313 yielding an estimate for $\partial q/\partial p$.

leaving for self-employment. The probability of finding a job, $p^* = 0.2148$, is calculated using the formula $p^* = \dfrac{h^*}{(1/l^*-1)v(1-q^*)}$ with a hiring (quitting) rate $h^* = q^* = 0.02448$, a formal-sector employment level $l^* = 0.637$, and a fraction of self-employed workers searching for a formal-sector job, $v(1-q^*)$, taken to be 0.2 (see the discussion in Section 3 for the value 0.2). The implied value of $v$ is 0.21. Assigning a value to $\beta_w$ is complicated by the assumption that workers do not participate in capital markets, which implies that we cannot simply follow the real business cycle literature and infer the discount factor from the long-run real interest rate (rate of return to capital). Of course, if workers' discount factor were equal to the discount factor of capitalists, then this procedure would still be valid. But one reason why workers have only a small amount of wealth might be exactly their impatience relative to capitalists. We decide to use a discount factor $\underline{\beta_w = 0.9}$ for the baseline model, which is considerably lower than the 0.96 used in the real business cycle literature.[20] Table 2 summarizes the choice of parameter values for the baseline model.

*b) Simulation*

Consider first a tax reduction program which lowers the tax on formal-sector labor income, $\tau$, by 1% but leaves the (after-tax) earnings of self-employed workers, $b$, unchanged. For simplicity, we also assume that any change in government revenues is met by a corresponding change in government spending so that the fiscal budget is balanced before and after the tax reform. As shown in table 4, the quantitative effects of such a tax reform on all three variables of main interest is substantial: the before-tax wage increases by 0.68%, the labor-turnover rate decreases by 2.63% (of its initial value of .02448), and the formal-sector employment level rises by 0.91% (of its original level of 0.637).

Figure 1 shows the effect of the tax reduction program as shifts in the labor demand and efficiency wage curve. The labor demand curve shifts to the right: for given before-tax wage, $w$,

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[20]Of course, the value of 0.96 is derived by considering US data.

a tax reduction increases the after-tax wage reducing quitting which in turn increases the demand for labor and therefore $p$. The efficiency wage curve shifts to the left. Taken together, we conclude that the wage unambiguously rises, but the effect on $p$ is ambiguous. The decrease in $p$ shows that the change in the efficiency wage curve dominates. Even though $p$ decreases, formal-sector employment increases because of the pronounced reduction in equilibrium hiring.

We can also evaluate the welfare consequences of the tax reform. Clearly, workers gain in the ex-ante and in the ex-post sense since the labor income (and therefore consumption) of formal-sector workers increases and the earnings of informal-sector workers has not changed. The consumption of capitalists might increase or decrease depending on the shape of the production and training cost function as can be inferred from the expression for equilibrium consumption of capitalists (7). Finally, the effect on government revenue, $(\tau w l)N$, is in general ambiguous since there is a direct effect (the decrease in $\tau$) which tends to reduce revenues but two indirect effects which tend to increase revenues (the increase in $w$ and $l$). For the Mexican case considered here the average tax rate is a very small 8% which implies that the direct effect dominates and the tax revenues are reduced. As mentioned above, in our simulation we assumed that this downfall in receipts is matched by an equal reduction in outlays. Finally, it is worth mentioning that output of the formal-sector economy is always increased simply because more workers are employed in the formal sector. If the productivity of the formal sector is higher than the productivity of self-employed workers, then the reallocation of workers across sectors unambiguously raises total output. Hence, in principle both workers and capitalists can always be made better off if the government redistributes (in a non-distortionary fashion) some of the gains of formal-sector employees to capitalists.

Consider now a decrease in the earnings of self-employed workers, $b$, by 1% of its original value.[21] One possible reason for such a decrease in $b$ is improved tax collection in the informal

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[21]For simplicity and for lack of precise data, we assume that initially $w = b = 1$.

sector. Alternatively, one can think a drop in the demand for goods produced in the informal-sector (non-tradable goods). Clearly, if $\frac{\partial q}{\partial \tau} = -\frac{\partial q}{\partial b}$ (recall $b = 1$), a hypothesis suggested by theory and supported by our empirical evidence, then a 1% decrease in $b$ is equivalent to a 1% increase in $\tau$ except that in the former case the after-tax income of formal-sector employees increases by 1.68% and in the latter case by 0.68%. Notice, however, that the ratio $w(1-\tau)/b$, which measures the pecuniary reward of formal-sector work relative to informal-sector work (earnings gap), rises in both cases by the same amount, namely 1.68%.

Let us now turn to the discussion of events shifting the labor demand curve only. First, suppose that the growth-adjusted marginal (revenue) product of formal-sector work, $Z$, increases by 1%.[22] Such an increase in $Z$ could arise, for example, if along the development path the ratio of formal-sector productivity to informal-sector productivity increases because secular technological progress disproportionally favors the formal sector. As a second example, one can think of product and/or labor market deregulation as well as a reduction in labor taxes paid by firms. It also follows from equation (8) that a reduction in the average training cost (for constant $T'$ and $T''$) is equivalent to an increase in $Z$ by the same amount.[23] The qualitative impact of any of these events is illustrated in Figure 2. For given wage $w$, a higher marginal product of labor increases the demand for labor which in turn increases hiring and therefore the probability of finding a job -- the labor demand curve shifts to the right. Since the efficiency wage curve is unchanged but downward sloping, the wage rises but the probability of finding a job decreases in the new equilibrium.

The second line in table 4 summarizes the quantitative effects of a 1% increase in $Z$ which are very similar to the previous case: the before-tax wage increases by 1.56%, the turnover rate

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[22]For simplicity, we set $Z = w = 1$, that is, we assume that training cost are "small" compared to wage cost.

[23]Observe, however, that an increase in $Z$ by 1% of its initial value is very different from a decrease in training cost by 1% of total training cost as long as $T$ (average training cost) is considerably smaller than $Z$

declines by 2.19%, and the employment level rises by 0.93%.

Finally, we turn to changes in the real interest rate, $r$. It follows immediately from Eq. (8) that a 1% (100 basis points) drop in $r$ is equivalent to an increase in $Z$ by $T'$%. Since $T' = (\mu \frac{\partial q}{\partial w})^{-1} = \underline{10.53}$ in the baseline model, the impact on all endogenous variables is very large. The linear approximation used here, however, is certainly not appropriate for changes of such a magnitude and the implied changes of the endogenous variables therefore appear unrealistically large. On the other hand, our analysis indicates that the real interest rate is one of the most important variables, a result consistent with the finding by Phelps and Zoega (1998) using unemployment cross-country regressions. Notice also that even though fiscal policy has no effect on the real interest rate in the basic model developed in this paper, leaving changes in the discount factor of capitalists and/or changes in productivity growth as the only sources of interest rate changes, an OLG version of the model along the lines developed by Blanchard (1985) and used by Hoon and Phelps (1992) would deliver a link between fiscal policy and the real interest rate. Moreover, the equation system (8) can also be viewed as representing the equilibrium conditions of a small open economy version of the model with exogenous world interest rate $r$.

*c) Sensitivity analysis*

This section discusses how parameter uncertainty affects the simulation results. Our approach is to change one parameter value at a time and to report the effects of an increase in $Z$ for the new parameter constellation (results for changes in $\tau$ are similar). First we decrease the discount factor of workers, $\beta_w$, from its original value of 0.90 to 0.80. In another experiment, we change our estimate of the fraction of self-employed workers searching for a formal-sector job, $v(1-q^*)$, from its original value of 0.20 to 0.30. Finally, we also consider decreases in the absolute value of the quit-rate elasticities by one standard error. Table 5 summarizes the results and reveals that the parameter variations do not change our main conclusions. Indeed, the response of the economy is surprisingly robust to changes in parameter values.

## 5. Conclusion

In this paper we incorporated microeconomic evidence about Mexican workers moving into self-employment into a macroeconomic efficiency model with labor turnover and used the calibrated model economy to evaluate the quantitative effects of changes in economic policy and other macroeconomic shocks. As we have already mentioned in the Introduction, an application of this method to different countries and unemployment is high on the agenda for future research. In this respect, an interesting question is whether the calibrated model economy generates a wage curve (Blanchflower and Oswald 1994), that is, a negative relationship between wages and unemployment. A glance at table 3 confirms that at least for the case considered here, a wage curve does indeed arise, that is, regardless of the type of macroeconomic shock there is always a negative association between the formal-sector wage and self-employment.

There are several extensions of the model analyzed in this paper which seem promising. First, allowing for a more realistic matching technology (see Section 2e) establishes an interesting link between search intensity and efficiency wages. Second, a comparison of the market outcome with the (constrained) efficient allocation could offer valuable theoretical insights. Finally, a stochastic version of the model with aggregate uncertainty would permit the study of business cycles. We plan to study these extensions in future work.

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## Appendix.

### A1. Worker's decision problem

*a) Representative firm economy*

There is a continuum of ex-ante identical, infinitely-lived workers whose total probability mass is normalized to $N$ (the number of firms). Each worker has preferences over random consumption sequences, $\{C_{wt}\}_{t=0}^{\infty}$, that are time- and state-additive with logarithmic one-period utility function[24]

$$U_w(\{C_{wt}\}_{t=0}^{\infty}) = \lim_{T \to \infty} E\left[\sum_{t=0}^{T} \beta_w^t \log(C_{wt})\right], \tag{A1}$$

where $\beta_w$ stands for the worker's pure discount factor. Workers are either employed in the formal sector (employed) or work in the informal sector (self-employed). Workers do not participate in capital markets and their consumption level is therefore equal to their current disposable income. Hence, if we denote the formal sector wage by $W_t$, the tax rate on labor income from formal-sector work by $\tau$, and the net pecuniary benefit to self-employment by $B_t \Theta_t$, we have

$$C_{wt} = \begin{cases} W_t(1-\tau) & \text{if employed in formal sector in period } t \\ B_t \Theta_t & \text{if self-employed in period } t \end{cases} \tag{A2}$$

Here $B_t$ is the average benefit from self-employment and $\Theta_t$ a worker-specific (random) component. For given wage rate and benefits, a worker chooses a quit/search rule which maximizes (A1) subject to the budget constraint (A2).

We are interested in an equilibrium growth path along which consumption, $C_{wt}$, and wage, $W_t$, grow at a constant rate equal to the growth rate of technological progress, $g$. Thus, we introduce the following growth-adjusted variables: $c_{wt} = C_{wt}/A_t$, $w = W_t/A_t$ with $A_t = A_0(1+g)^t$ being the exogenous parameter of labor efficiency. We also assume that average self-employment benefits, $B_t$, grow at the rate $g$ and define: $b = B_t/A_t$. We have dropped the time-subscript on growth-adjusted wage and benefit payments to indicate that these variables are expected to be constant, an expectations turning out to be correct

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[24]The log-utility assumption is not essential (CRRA-utility would suffice), but provides a direct link to the empirical section in which log-wages are used in the regressions.

in equilibrium. To ensure that the worker's optimization problem is well-defined, we assume $\beta \ln(1+g) < 1$. In this case, maximization of (A1) subject to (A2) is equivalent to solving:

$$\max_{T \to \infty} \lim E \left[ \sum_{t=0}^{T} \beta^t \log(c_{wt}) \right] \tag{A3}$$

$$\text{subject to}: c_{wt} = \begin{cases} w(1-\tau) & \text{if employed in formal sector in period } t \\ b\, \Theta_t & \text{if self-employed in period } t \end{cases}$$

There are two sources of idiosyncratic uncertainty: uncertainty about the idiosyncratic component of self-employment benefits and uncertainty about the individual employment status. We assume that the sequence of shocks, $\{\theta_t\}_{t=0}^{\infty}$ with $\theta_t = \log \Theta_t$, is a sequence of identically and independently distributed random variables with distribution function $\Phi(.)$ and density function $\varphi(.)$.[25] Further, the probability of finding a formal sector job when searching is a constant, $p$. The decision problem (A3) therefore displays a recursive structure and the corresponding Bellman equation reads

$$V^e(\theta, x) = \max \left\{ \left\{ \log(w(1-\tau)) + \beta_w \int V^e(\theta', x)\, d\Phi(\theta') \right\} ; \right.$$
$$\left. \left\{ \log b + \theta + \beta_w \int V^s(\theta', x)\, d\Phi(\theta') \right\} \right\} \tag{A4}$$

$$V^s(\theta, x) = \max \left\{ \left\{ \log b + \theta + \beta_w \int V^s(\theta', x)\, d\Phi(\theta') \right\} ; \right.$$
$$\left. \left\{ p\left( \log(w(1-\tau)) + \beta_w \int V^e(\theta' x)\, d\Phi(\theta') \right) + (1-p)\left( \log b + \theta + \beta_w \int V^s(\theta' x)\, d\Phi(\theta') \right) \right\} \right\},$$

where $x = (w, p, \tau, b)$. Further, $V^e(\theta, x)$, respectively $V^s(\theta, x)$, denotes the (utility) value of pursuing the optimal policy when employed, respectively self-employed, when the macroeconomic state is $x$.

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[25]Although most of the properties of the quit-rate function also hold for general Markov processes, the particular expression for $\mu$ (see A9) would of course change.

It follows from (A4) that the optimal strategy is to define a cut-off value, $\theta_c = \theta_c(x)$, and to quit a formal-sector job if $\theta \geq \theta_c$ and to search for a formal-sector job if $\theta \leq \theta_c$. Moreover, the optimal cut-off value is implicitly defined by the following equation

$$\theta_c - \log(w(1-\tau)/b) - \beta_w E\Delta V(\theta_c, x) = 0$$

$$E\Delta V(\theta_c, x) \doteq \frac{1-p}{1 - \beta_w(1-p)\Phi(\theta_c)} \left[ \Phi(\theta_c) \log(w(1-\tau)/b) - \int_{\theta' \geq \theta_c} \theta' \, d\Phi(\theta') \right].$$

(A5)

The economy-wide quit-rate function is then simply given by $q(x) \equiv 1 - \Phi(\theta_c(x))$, which establishes the link between the solution to the worker's decision problem and the quit-rate function entering into the firm's decision problem. Using a probit model in Section 3 amounts to assuming a normally distributed $\theta$ and a linear approximation for the function $\theta_c(x)$. Finally, the fraction of self-employed workers searching (applying) for a formal sector job is $\Phi(\theta_c(x))$.

Since $\frac{\partial q}{\partial x_n} = -\varphi(\theta_c)\frac{\partial \theta_c}{\partial x_n}$ for $x_n = w, p, \tau, b$, the properties about the partial derivatives of the quit-rate function stated in Eq. (2) follow from implicitly differentiating (A5) and signing the result. In order to calculate the function $\mu(.)$, we use the following expression:

$$\frac{\partial \theta_c}{\partial w} = \frac{\frac{1}{w} + \beta_w \frac{\partial E\Delta V}{\partial w}}{1 - \beta_w \frac{\partial E\Delta V}{\partial \theta_c}}$$

(A6)

$$= \frac{1}{w} \frac{1 + \frac{\beta_w(1-p)\Phi(\theta_c)}{1-\beta_w(1-p)\Phi(\theta_c)}}{1 + \varphi(\theta_c) g_1(\theta_c, x)},$$

where $g_1(\theta_c, x)$ is a function independent of the probability density $\varphi(\theta_c)$.

Suppose now that there is a (growth-adjusted) fixed cost of searching, $f = \log F$. In this case, the optimal policy is to define to cut-off values, $\theta_{c1}$ and $\theta_{c2}$, and to quit a formal-sector job if $\theta \geq \theta_{c2}$ and to start searching if $\theta \leq \theta_{c1}$. Moreover, we have $\theta_{c2} = \theta_{c2}(x)$ implicitly defined by an equation analogous

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to (A5) and $\theta_{c1} = \theta_{c1}(x) = \theta_{c2}(x) - f/p$. For the quantitative analysis both the derivatives of the quit-rate function, $\frac{\partial \zeta}{\partial x_n} = -\varphi(\theta_{c2}) \frac{\partial \theta_{c2}}{\partial x_n}$, and the derivatives of the search-rate function, $\frac{\partial s}{\partial x_n} = \varphi(\theta_{c1}) \frac{\partial \theta_{c1}}{\partial x_n}$, play an important role. The empirical analysis provides us with detailed information about $\frac{\partial q}{\partial x_n}$, but good data on $\frac{\partial s}{\partial x_n}$ are lacking. However, since we have $\theta_{c1}(x) = \theta_{c2}(x) - f/p$, the following expressions relate the search-rate function to the (observed) quit-rate function: $\frac{\partial s}{\partial x_n} = -\frac{\varphi(\theta_{c2} - f/p)}{\varphi(\theta_{c2})} \frac{\partial q}{\partial x_n}$ and $\frac{\partial s}{\partial p} = -\frac{\varphi(\theta_{c2} - f/p)}{\varphi(\theta_{c2})} \left[ \frac{\partial q}{\partial p} + \varphi(\theta_{c2}) \frac{f}{p^2} \right]$.

In principle, the above relationship in conjunction with information on search cost, $c$, and the distributional characteristics of the idiosyncratic shocks, $\theta$, could be used to calculate the response of the search intensity to aggregate shocks. However, the expression also makes clear that the quantitative answer crucially depends on distributional assumptions determining the ratio of probability densities evaluated at the cut-off value, $\frac{\varphi(\theta_{c2} - f/p)}{\varphi(\theta_{c2})}$. In this paper, we choose not to make assumptions about the distributional characteristics of $\theta$.[26] Instead, we impose simplifying assumptions rendering all results independent of the probability density evaluated at the respective cut-off value. More specifically, we deal with the problem of unobserved search intensity by assuming that search costs are small, that is, $f \to 0$. In this case, the derivatives of the search intensity function are simply given by the negative of the derivatives of the quit-rate function:

$$\frac{\partial s}{\partial x_n} = -\frac{\partial q}{\partial x_n}.$$

The assumption of small search cost seems to create a problem by itself since in this case the quitting/search model developed so far implies that $s = 1 - q$, which is not the case for the data set we consider. However, even if there are no search costs, the above relationship need not hold if the idiosyncratic shock process exhibits serial correlation. In the case of serial correlation, there is still one common cut-off value for employed and self-employed, but the (stationary) distributions are different because of self-selection, that is, the quit rate is $1 - \tilde{\Phi}(\theta_c)$ but the search intensity is $\bar{\Phi}(\theta_c)$ and therefore $s \neq 1 - q$. Since we only have a very limited knowledge of the serial correlation properties of this idiosyncratic process, we only deal with the extreme case in which there are two types of workers. The behavior of type I workers is correctly described by the Bellman equation (A4) (no serial correlation). Type two workers, on the other

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[26]Especially when $\theta$ is interpreted as "taste-shock", such a procedure seems very questionable.

hand, never move (no stochastic shock) and therefore stay either in the formal or the informal sector forever (for the time span covered by our data). If a fraction $v$ of the total labor force is correctly characterized by the Bellman equation (A4) (type I), then the search rate is given by $s(x) = v(1 - q(x))$, which is the expression used in the text.[27] Notice that $v$ is a number independent of $x$.

*b) Many* Firms

We consider now an economy in which $i = 1, \ldots, N$ identical firms set wages in an uncoordinated fashion (they play a Nash game). Except for this modification, the economy is identical to the one considered in part a). For simplicity, we again consider the case of no search cost. The Bellman equation of a worker who is currently employed by firm $i$ paying wage $w_i$ reads

$$\tilde{V}^e(\theta, w_i, x) = \max\left\{ \left\{ \log(w_i(1-\tau)) + \beta_w \int \tilde{V}^e(\theta', w_i, x)\, d\Phi(\theta') \right\} ; \right.$$
$$\left. \left\{ \log b + \theta + \beta_w \int V^s(\theta', x)\, d\Phi(\theta') \right\} \right\}, \tag{A7}$$

where $V^s(.)$ is the value function of the Bellman equation (A4) (assuming all other firms are paying wage $w$). The optimal strategy is again to define a cut-off value, $\theta_{ci} = \tilde{\theta}_c(w_i, x)$, and to quit a formal-sector job if $\theta \geq \theta_{ci}$ and to search for a formal-sector job if $\theta \leq \theta_{ci}$. Moreover, the optimal cut-off value is implicitly defined by the following equation

$$\theta_{ci} - \log(w_i(1-\tau)/b) - \beta_w E\Delta\tilde{V}(w_i, \theta_{ci}, x) = 0$$

$$E\Delta\tilde{V}(w_i, \theta_{ci}, x) = \frac{\Phi(\theta_{ci})}{1 - \beta_w \Phi(\theta_{ci})}\left[ \log(w_i(1-\tau)) - p\log(w(1-\tau)) - (1-p)\log b - p\beta_w E\Delta V \right] \tag{A8}$$

$$- \frac{(1-p)}{1 - \beta_w \Phi(\theta_{ci})} \int_{\theta \geq \theta_{ci}} \theta\, d\Phi(\theta).$$

The quit-rate function of firm $i$ is then given by $\tilde{q}(w_i, x) \equiv 1 - \Phi(\tilde{\theta}_c(w_i, x))$.

Since $\frac{\partial \tilde{q}}{\partial x_n} = -\varphi(\theta_{ci})\frac{\partial \tilde{\theta}_c}{\partial x_n}$ for $x_n = w, p, \tau, b$ and $\frac{\partial \tilde{\zeta}}{\partial w_i} = -\varphi(\theta_{ci})\frac{\partial \tilde{\theta}_c}{\partial w_i}$, the properties

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[27]This formula changes once we allow for the possibility that the fraction of formal-sector-only workers is different from the fraction of informal-sector-only workers.

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about the partial derivatives of the quit-rate function stated in Eq. (1) follow from implicitly differentiating (A5) and signing the result. In order to calculate the function $\mu(.)$, we need an explicit expression of the following derivative:

$$\frac{\partial \tilde{\theta}_c}{\partial w_i}\Big|_{w_i = w} = \frac{\frac{1}{w} + \beta_w \frac{\partial E \Delta \tilde{V}}{\partial w_i}\Big|_{w_i = w}}{1 - \beta_w \frac{\partial E \Delta \tilde{V}}{\partial \theta_{ci}}\Big|_{w_i = w}}$$

(A9)

$$= \frac{1}{w} \frac{1 + \frac{\beta_w \Phi(\theta_c)}{1 - \beta_w \Phi(\theta_c)}}{1 + g_2(\Theta_c, x)\, \varphi(\theta_c)},$$

where $g_2(.)$ is a function independent of the density $\varphi(\theta_c)$.

We are interested in the ratio

$$\mu \doteq \frac{\frac{\partial \tilde{q}}{\partial w_i}\Big|_{w_i = w}}{\frac{\partial q}{\partial w}} = \frac{\frac{\partial \tilde{\theta}_c}{\partial w_i}\Big|_{w_i = w}}{\frac{\partial \theta_c}{\partial w}}.$$

(A10)

Expression (A10) depends on the probability density evaluated at the cut-off value, $\varphi(\theta_c)$, which is difficult to pin down without a very detailed knowledge of the distributional characteristics of the random variable $\theta$. Evoking again the principle of "independence of results from irrelevant distributional details", we ask for an approximation yielding an expression for $\mu$ which is independent of $\varphi(\theta_c)$. One such approximation is to take the limit $\varphi(\theta_c) \to 0$, that is, to evaluate $\mu$ at small values of $\varphi(\theta_c)$. In this case, (A10) becomes Equation (5) used in the text (observing that $\Phi(\theta_c) = 1 - q$).

## A2. Capitalist' Decision Problem

There are $i = 1, \ldots, N$ identical, infinitely-lived capitalist with time-additive preferences over consumption sequences, $\{C_{it}\}_{t=0}^{\infty}$:

$$U(\{C_{it}\}_{t=0}^{\infty}) = \sum_{t=0}^{\infty} \beta_c^t \frac{C_{it}^{1-\rho} - 1}{1 - \rho}.$$

(A11)

In (A11) $\beta_c$ stands for the pure discount factor of capitalists and $\rho$ for their coefficient of relative risk aversion.

Each capitalist owns one firm. Each firm $i$ (owned by capitalist $i$) combines capital $K_{it}$ and labor $L_{it}$ to produce output $Y_{it}$. Changes in the employment level create adjustment cost. Hiring new workers is associated with recruitment and training cost. In the case of training cost, we assume that training takes one period and that the human capital created through training is destroyed once the worker quits (match specific human capital), that is, newly hired workers always have to be trained regardless of their previous work experience. Following Phelps and Hoon (1992), whose specification of employment adjustment cost derives from Hayashi's treatment of capital adjustment cost (Hayashi 1982), we assume that the total cost of training and hiring is independent of the capital stock and that net output produced is linear homogenous in $(K_{it}, A_t L_{it}, A_t H_{it})$, where $A_t$ stands for the (common) efficiency of labor and $H_{it}$ for the number of workers hired by firm $i$. More precisely, we assume that output net of adjustment cost is equal to $F(K_{it}, A_t L_{it}) - \tilde{T}(A_t H_{it}, A_t L_{it})$, where $F(.,.)$ is a standard neoclassical production function and $\tilde{T}(.,.)$ is a linear homogenous function. Moreover, the adjustment cost function satisfies: $\frac{\partial \tilde{T}(x,y)}{\partial x} > 0$, $\frac{\partial \tilde{T}(x,y)}{\partial y} < 0, \frac{\partial^2 \tilde{T}(x,y)}{\partial x^2} \geq 0$. Notice that we permit the case of linear adjustment costs, $\frac{\partial^2 \tilde{T}(x,y)}{\partial x^2} = 0$, for which adjustment to the optimal employment level is instantaneous.

Each firm employs a large number of workers. Firm $i$ chooses sequences of consumption (of owner $i$), capital, investment, employment, and hiring as well as a wage rate[28] which maximize (A11) subject to the constraints[29]

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[28]We only allow the firm to choose one wage rate, not an entire sequence of wage rates. Deriving the quit-rate function from the worker's Bellman equation when the firm can choose arbitrary wage sequences $\{W_{it}\}_{t=0}^{\infty}$ is a nightmare.

[29]We assume that each self-employed worker produces what he consumes, namely $b$. If $b$ is interpreted as unemployment benefits, then it should be added to the right-hand-side of the last last constraint.

$$K_{i,t+1} = (1-\delta)K_{it} + I_{it}$$

$$L_{i,t+1} = (1-q(w_i,x))L_{it} + H_{it}$$

$$Y_{it} = F(K_{it}, A_t L_{it}) \tag{A12}$$

$$Y_{it} = C_{it} + I_{it} + w_i A_t L_{it} + \tilde{T}(A_t L_{it}, A_t H_{it})$$

$$K_{i0}, L_{i0} \quad \text{given}.$$

Introduce the following growth-adjusted: $k_{it} = K_{it}/A_t$, $i_{it} = I_{it}/A_t$, $c_{it} = C_{it}/A_t$, $y_{it} = Y_{it}/A_t$ (recall that the size of the labor force is normalized to one). Introduce further the hiring rate $h_{it} = H_{it}/L_{it}$ and let $l_{it} = L_{it}$. Clearly, maximizing (A11) subject to (A12) is equivalent to solving the following optimization problem:

$$\max \sum_{t=0}^{\infty} \tilde{\beta}_c^t \frac{c_{it}^{1-\gamma} - 1}{1-\gamma}$$

$$\text{subject to}: \quad k_{i,t+1} = \frac{1}{1+g}\left[(1-\delta)k_{it} + i_{it}\right]$$

$$l_{i,t+1} = \left[1 + h_{i,t+1} - \tilde{q}(w_i,x)\right]l_{it} \tag{A13}$$

$$F(k_{it}, l_{it}) = c_{it} + i_{it} + w_i l_{it} + T(h_{it})l_{it}$$

$$k_{i0}, l_{i0} \quad \text{given},$$

with $T(h_{it}) \doteq \tilde{T}(h_{it}, 1)$ and the growth-adjusted discount factor $\tilde{\beta}_c = \beta_c(1+g)^{1-\gamma}$. To render the capitalist' maximization problem well-defined, we require $\tilde{\beta}_c < 1$. Writing down the Euler equations associated with the optimization problem (A13) leads to Equation (4).[30]

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[30]The sufficiency conditions require certain assumptions about the second-order derivatives of the quit-rate function. We do not attempt to derive these properties from the Bellman equation (A4) and (A7).

**Table 1.**

| Summary Statistics | | | | | |
|---|---|---|---|---|---|
| Var | Nobs | Mean | Std. Dev. | Min | Max |
| move | 100978 | .02448 | .1545 | 0 | 1 |
| hire | 100978 | .6313 | .1866 | .34 | 1.13 |
| mw1 | 100978 | 1.674 | .05319 | 1.51 | 1.76 |
| mw3 | 100978 | 1.856 | .1060 | 1.54 | 1.94 |
| exp | 100978 | 21.61 | 13.01 | 0 | 62 |
| exp2 | 100978 | 636.3 | 684.9 | 0 | 3844 |
| sch | 100978 | 7.302 | 2.808 | 0 | 11 |
| sch2 | 100978 | 61.2 0 | 37.02 | 0 | 121 |

**Table 2.**

| Probit Regression | | | | | | |
|---|---|---|---|---|---|---|
| | Unconstrained | | Symmetry Imposed | | Summary Statistics | |
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Mean | Std. Err. |
| move | | | | | .0245 | .1545 |
| log w | -1.3153 | .3895 | | | 1.674 | .05319 |
| log b | .8879 | .1965 | | | 1.857 | .1060 |
| log w - log b | | | -.6436 | .1522 | -.183 | .06625 |
| $\tilde{p}$ | .3122 | .05647 | .3650 | .04801 | .6310 | .1866 |
| school | -.08249 | 0.01231 | -.08253 | 0.01231 | 7.302 | 2.808 |
| (school)$^2$ | .004241 | 0.000968 | .004232 | 0.000978 | 61.204 | 37.02 |
| experience | .03200 | .002887 | .03200 | .002886 | 21.612 | 13.00 |
| (experience)$^2$ | -.000535 | .0000556 | -.000536 | .0000556 | 636.327 | 683.9 |
| constant | -1.6167 | .3860 | -2.3195 | .06131 | | |
| Nobs | 100978 | | 100978 | | | |
| Significance | $\chi2(6)=440.8$ | p=0.00 | $\chi2(5)=440.7$ | p=0.00 | | |
| Test of $\alpha_w=-\alpha_b$ | | | $\chi2(1)=3.41$ | p=.065 | | |

**Table 3.**

| Parameter Values for Baseline Model | |
|---|---|
| Quit-rate elasticity $\partial q/\partial w = -\partial q/\partial b = -\partial q/\partial \tau$ | -.03737 |
| Quit-rate elasticity $\partial q/\partial p$ | .06231 |
| Formal-sector employment $l^*$ | .637 |
| Average turnover rate $q^* = h^*$ | .02448 |
| Fraction of self-employed searching for a job $v(1-q^*)$ | .20 |
| Workers' discount factor $\beta_w$ | .90 |
| Implied average probability of finding a job $p^*$ | .2148 |
| Implied parameter $\mu$ | 2.54 |
| Implied parameter $v$ | 0.21 |

**Table 4.**

| Policy Effects: Baseline Model | | |
|---|---|---|
| | Tax reduction $\Delta \tau = -.01$ | MPL increase $\Delta Z = .01$ |
| Wage change $\Delta w$ | .0068 [0.68%] | .0156 [1.56%] |
| Probability change $\Delta p$ | -.000281 [-0.13%] | .000776 [.36%] |
| Turnover rate change $\Delta q$ | -.000643 [-2.63%] | -.000535 [-2.19%] |
| Employment change $\Delta l$ | .00577 [0.91%] | .00589 [.93%] |

**Table 5.**

| Sensitivity Analysis: Effects of $\Delta Z = .01$ | | | | |
|---|---|---|---|---|
| | $\beta_w = .80$ | $v(1-q^*) = .3$ | $\partial q/\partial w = -.0285$ | $\partial q/\partial p = .0541$ |
| $\Delta w$ | .0222 | .0183 | .0156 | .0157 |
| $\Delta p$ | .002407 | .000579 | .000593 | .000789 |
| $\Delta q$ | -.000803 | -.000628 | -.000409 | -.000544 |
| $\Delta l$ | .00802 | .00687 | .00449 | .00599 |

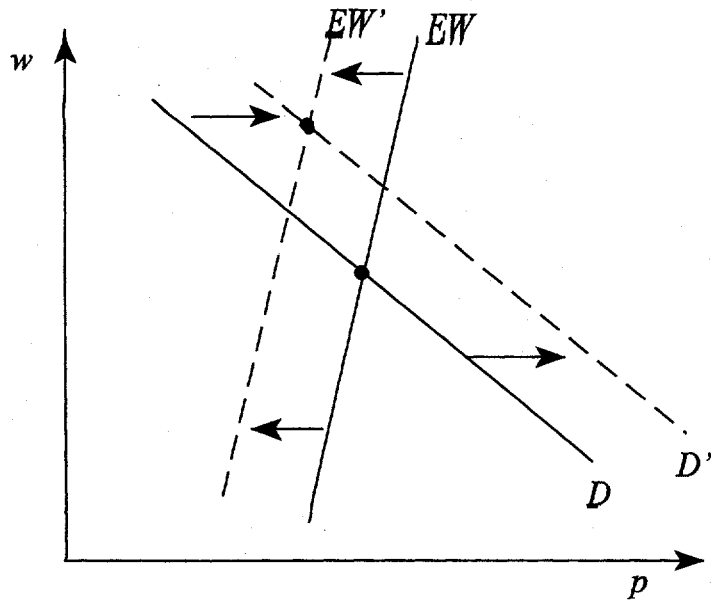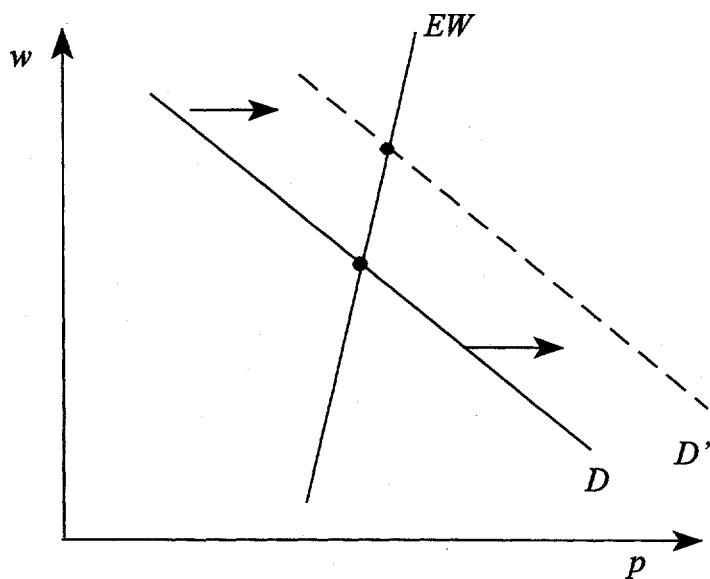**Figure 1.** A reduction in labor-income tax.



**Figure 2.** An increase in the marginal revenue product of labor

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