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
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## Nominal Wage Contracts, Aggregate and Firm-Specific Uncertainty How High is the Private Gain from Indexation?

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# Nominal Wage Contracts, Aggregate and Firm-Specific Uncertainty – How High is the Private Gain from Indexation? \*

Stefan Laséen<sup>†</sup>

September 6, 2000

## Abstract

In this paper I investigate to what extent firm-specific uncertainty affects the gain from indexation. Earlier studies have tried to explain wage rigidity by arguing that insiders face little layoff risk due to employment fluctuations caused by aggregate shocks. However, this analysis abstracts from idiosyncratic risk and this seems hard to reconcile with recent micro-economic evidence which shows that firm-specific uncertainty explains a large part of establishments' employment changes. By numerically solving an insider-outsider model I show that the introduction of firm-specific uncertainty increases the gain from indexation considerably (from 0 to 1.5 percent of the wage). It is not evident that the gain from indexation is small enough to support an equilibrium with a constant nominal wage. According to the model, nominal wage contracts should be more prevalent, when layoff is not so costly for the worker, due to high unemployment benefits or short duration of unemployment spells.

JEL classification: E24, J41, J63

Keywords: Indexation, Wage contracts, Insider-Outsider models, Idiosyncratic shocks, Job security

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# 1 Introduction

Most labor markets cannot be adequately described as spot markets. Contracts seem to play an important role.<sup>1</sup> One role for contracts is to enable employees to share the risks from uncertain income streams with their employers.

Baily (1974) and Azariadis (1975) show that a risk-averse worker would be willing to buy insurance from the employer by agreeing to a fixed wage contract. The gain for the employer is that he could obtain a given amount of labor at a lower expected cost. Gottfries (1992) modifies the labor contract model of Baily and Azariadis in two ways. First, the focus on the source of employment variations is shifted from layoffs to hiring. Second, the wage of currently employed workers (insiders) is tied to the wage offered to newly hired workers (outsiders). The main result is that a small cost for writing a state-contingent contract is sufficient to support an equilibrium with fixed nominal wages. Hence, it is difficult to construct a simple indexed contract that is superior to a contract which stipulates a certain nominal wage. The intuition is that if the rate of inflation is low and stable, nominal wage contracts imply relatively stable and predictable real wages. Demand and supply shocks affect employment, but since these shocks mainly affect the hiring of outsiders, they are of little concern to the insiders. From the

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<sup>1</sup>Using individual data from the Current Population Survey and the Panel of Income Dynamics, Beaudry & DiNardo (1991) find that an implicit contract model describe the links between wages and labor market conditions better than a spot market model. McDonald & Worswick (1999) provide further evidence on the importance of implicit contracts: "Our results suggests that the importance of macroeconomic conditions on wages operating through implicit contracts may be a general characteristic of developed economies and so is worth further examination."

point of view of firms and insiders, nominal wage contracts may therefore be preferable.

This result hinges on the assumption that the currently employed workers face a high degree of job security. Job security for insiders follows from the assumptions that all employment adjustment take the form of fluctuations in hiring and that the wage offered to newly hired workers is tied to the wage of insiders.<sup>2</sup>

The assumption that variation in hiring is the main determinant of employment fluctuations seems hard to reconcile with the recent literature on job creation and job destruction. Microeconomic evidence from most OECD countries shows that job creation and job destruction occur simultaneously at all phases of the business cycle. Common among these studies is that a large part of establishments' employment experiences seems to be explained by idiosyncratic or firm-specific sources of uncertainty.<sup>3</sup> Davis, Haltiwanger & Schuh (1997) argue that a likely reason for heterogeneity in plant-level outcomes is uncertainty about the demand for new products. This uncertainty will in turn encourage the firm to experiment with different technologies and production facilities. Hence, the measurement of job creation and job destruction for the manufacturing sector

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<sup>2</sup>If there is no limit on the wage dispersion firms get a strong incentive to replace expensive inside workers with cheaper outside workers. Insiders would in this case have a low degree of job security.

<sup>3</sup>If aggregate shocks predominate then it follows that the correlation between job creation and job destruction is close to  $-1$ . The actual correlation is  $-0.36$ . We would also observe a variance ratio (destruction to creation) close to 1. The actual ratio is 3.4. See Davis & Haltiwanger (1999) for a survey of recent research on job creation and destruction.

casts new light on labor market dynamics. At the same time, the very nature of firm-specific shocks seems to be such that it is very hard to make wages or employment contingent on them. These costs may originate from verification problems. The reasons for the heterogeneity in plant-level outcomes ought to be very difficult to assess and verify.<sup>4</sup>

In view of this it is interesting to explore to what extent idiosyncratic or firm-specific sources of uncertainty affect the gain from indexation, or equivalently, the gain from writing state contingent wage contracts. In this paper I modify the model developed in Gottfries (1992) to investigate to what extent firm-specific sources of uncertainty affect the gain from indexation. The main difference from that model is that I let demand be affected by aggregate as well as idiosyncratic factors. I also let the productivity shocks be firm-specific. A recession, caused e.g. by an adverse monetary shock, affects all firms. The effects of the recession may however be mitigated or reinforced by demand or supply conditions that are specific to the firm. I assume that these firm-specific sources of uncertainty cannot be written into the contract, due to costs for writing and enforcing such clauses.

Hence, Gottfries' assumption that workers face a high degree of job security is mitigated when I allow for firm-specific uncertainty. The main result is that

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<sup>4</sup>There exists several reasons for contractual incompleteness, e.g. unforeseen contingencies, writing costs, enforcement costs, environmental complexity, and renegotiation. These types of "transaction costs" are discussed in Tirole (1999) and Segal (1999). The "transaction costs" prevent some aspects of future trade from being contracted ex ante, while allowing the parties to contract on these aspects ex post.

the introduction of firm-specific demand and supply uncertainty increases the gain from indexation considerably for most parameter values. The gain is higher for supply shocks. According to the model, nominal wage contracts should be more prevalent, when layoff is not so costly for the worker, e.g. due to high unemployment benefits or short duration of unemployment spells.

The model is presented in section 2. The numerical analysis and the results are presented in section 3. Section 4 contains a sensitivity analysis and section 5 concludes.

## 2 The Model

As in Gottfries (1992) the economy is populated by a large number of entrepreneurs/firms, indexed  $i$ , and a large number of workers. The sequence of events is the following (see figure 1). At the beginning of a period a fraction,  $s$ , of the workers quit for exogenous reasons. Firms write binding wage contracts with the remaining workers, who are assumed to be identical in talents and preferences. Hence, if a firm employed  $\ell_{-1}$  workers in the previous period it would enter the current period with  $n = (1 - s)\ell_{-1}$  workers employed. Then the stochastic demand shocks, aggregate money supply,  $m \in M$ , and idiosyncratic demand,  $z_i \in Z$ , or idiosyncratic productivity,  $\theta_i \in \Theta$ , are observed by firms. In order to disentangle the effects of firm-specific sources of uncertainty on the gain from writing state contingent wage contracts I will separate the analysis into two parts, one where firm-

specific productivity is held constant, and the other where firm-specific demand is held constant. The firm-specific shocks are denoted  $x_i \in X$ , where  $x_i$  equals  $\theta_i \in \Theta$  or  $z_i \in Z$ , depending on which shock is held constant. The aggregate and idiosyncratic shocks have the joint density function  $f(m, x_i)$ . The firm-specific shocks are assumed to be uncorrelated and independently distributed. Having observed these shocks, firms hire workers and set prices. Finally goods markets open, production takes place and wages are paid.

A contract between the firm and the worker may specify the insider wage, the wage paid to newly hired outsiders, and employment as a function of the shocks. As is common in most of the analysis of wage bargaining, I will rely on the "right-to-manage" assumption, i.e. that firms and workers bargain about wages, but not about employment.<sup>5</sup> Private unemployment insurance is unusual. This is probably due to the difficulty for a firm to monitor whether a worker gets another job. Moreover, the size of the payments are generally small. Thus, the contract specifies a wage payment  $w_i(m)$  to the insiders who are instructed to work for each possible outcome of  $m$ .

I also assume that it is not possible to make the contract contingent on the idiosyncratic shocks. The absence of such contingencies may be explained by costs for writing and enforcing such clauses. These costs may e.g. originate from measurement problems and asymmetric information. A key idea in the literature

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<sup>5</sup>See e.g. Oswald (1985) and Oswald (1986) or Layard, Nickell & Jackman (1997) for a discussion.

on mechanism design, which has influenced the literature on labor contracts, is that contracts can only be contingent on measures that are verifiable.<sup>6</sup> Malcomson (1997) notes that some information obviously can be made verifiable at a cost. It may however not be worth doing so if an incomplete contract can induce the contracting parties to behave sufficiently close to what is efficient. The "right-to-manage" assumption means that the firm is allowed to choose the price and production to maximize profits, given the wage that is specified in the contract.<sup>7</sup> Thus, to analyze the model I start with the firm's pricing and employment decision.

### *Pricing*

Production occurs under constant returns to scale with labor as the only input:  $q_i = \theta_i \ell$ , where  $\theta_i$  denotes firm-specific productivity. The demand curve for firm  $i$  is

$$q_i = \kappa^\eta \left( \frac{p_i}{p} \right)^\eta \frac{mz_i}{p}, \quad \eta < -1, \quad (1)$$

where  $p$  is the aggregate price level and  $\eta$  is the price elasticity.<sup>8</sup> The price and sales (production) of firm  $i$  are denoted  $p_i$  and  $q_i$ . The main difference

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<sup>6</sup>See e.g. Hall (1998).

<sup>7</sup>The analysis follows Gottfries & Westermark (1998).

<sup>8</sup> $\kappa$  is a normalization included in order to simplify the analysis.  $\kappa$  is defined below.



from the model developed by Gottfries (1992) is that there are two sources of uncertainty, an aggregate and a idiosyncratic part that show up multiplicatively in the production function and in (1). The real profit of firm  $i$  is

$$\Pi_i = \left( \frac{pq_i}{mz_i} \right)^{\frac{1}{\eta}} \frac{q_i}{\kappa} - \frac{w_i q_i}{p \theta_i}. \quad (2)$$

The wage of insiders is denoted,  $w_i$ .<sup>9</sup> The entrepreneur who owns the firm is risk averse and has a concave utility function  $\Psi(\Pi)$ .<sup>10</sup> Maximization of (2) generates the familiar mark-up pricing rule:

$$p_i = \frac{w_i}{\theta_i \kappa} \quad (3)$$

where  $\kappa = \left(1 + \frac{1}{\eta}\right)$ . When prices are set in this way, labor demand and profit are given by

$$\ell(w_i, m, z_i) = \left( \frac{w_i}{p\theta_i} \right)^{\eta} \frac{mz_i}{p\theta_i}, \quad (4)$$

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<sup>9</sup>The distinction between insiders and outsiders will be made clear in the next subsection.

<sup>10</sup>It is often assumed that firms are risk neutral. If company owners hold well diversified portfolios, fluctuations in the wealth of one company should have little impact on investors' financial state. Bewley (1999) argues that risk neutrality probably is invalid since even large firms sacrifice future earnings to obtain cash when in financial distress. Moreover, risk management is an important function in business.

and

$$\Pi_i(w_i, m, z_i) = A \left( \frac{w_i}{p\theta_i} \right)^{1+\eta} \frac{mz_i}{p}, \quad (5)$$

where  $A = -\frac{1}{1+\eta} > 0$ .<sup>11</sup>

### *The Optimal State-Contingent Wage Contract*

A worker can be in two states, employed or unemployed. The worker is an insider if he was employed by a firm at the start of the period and an outsider if he was unemployed. Insiders could be organized in a union that bargains with the firm, but we may also think of the contract as being chosen by the firm. I assume that wages of insiders and outsiders who are hired must be equal.<sup>12</sup> Insiders who are laid off receive unemployment compensation,  $b$ , which is assumed to be exogenous. Let the utility obtained by an insider in firm  $i$  be an increasing and concave function of the real wage,  $U\left(\frac{w_i}{p}\right)$ .<sup>13</sup>

I do not specify the exact bargaining situation. Such a specification is not necessary since I am not concerned with the determinants of the level of the wage (or employment). I do assume that the resulting contract is Pareto-optimal from

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<sup>11</sup>There is, according to Blanchard & Fischer (1989) p. 464, substantial evidence that firms, given wages, react to shifts in demand mostly by increasing quantities rather than by increasing prices.

<sup>12</sup>See Gottfries & Sjöström (2000) for a discussion on such a constraint.

<sup>13</sup> $U' > 0$ ,  $U'' < 0$ . Where  $U'$  and  $U''$  denote first- and second-order derivatives with respect to real wage.

the contracting parties' point of view. The design of a Pareto-optimal contract proceeds by maximizing one of the contracting party's expected utility subject to the other party receiving a reservation utility level. Which party's utility level is taken as a constraint does not matter in the analysis. Let  $\bar{U}$  denote the workers' ex ante reservation utility level. To show that there can be an equilibrium with nominal wage contracts Gottfries (1992) analyses the optimal contract for an individual firm, assuming that all unions have contracts with a fixed nominal wage,  $w^*$ . I use the same approach which implies that equation (3) can be rewritten as  $p = \frac{w^*}{\theta\kappa}$ . Aggregate productivity is denoted,  $\theta$ , and is assumed to be constant. Hence, the equilibrium will be a coordinated equilibrium.<sup>14</sup> For a wage contract,  $w_i(m)$ , to be Pareto-optimal it must solve the following maximization problem

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<sup>14</sup>Gottfries (1992) explains this by noting that indexation or nonindexation are social customs or norms that are persistent once they have been established.

$$\max_{w_i(m)} \int_X \int_M \Psi(\Pi_i) f(m, x_i) dm dx_i \quad (6)$$

subject to

$$\int_X \int_M \left[ \varphi(w_i, m, x_i) U\left(\frac{w_i(m)}{p}\right) + (1 - \varphi(w_i, m, x_i)) U(b) \right] f(m, x_i) dm dx_i \geq \bar{U} \quad (7)$$

where  $\varphi(w_i, m, x_i) = \min\left[\frac{\ell(w_i, m, z_i)}{n}, 1\right]$  indicates whether the insiders face a risk of being laid off or not. Hence, work or nonwork assignments are drawn by lot.<sup>15</sup> We see that the utility of outsiders,  $U(b)$ , are only a concern to the union if some of its current members face a risk of being laid off, i.e. if demand is low enough to generate a level of employment that falls short of the number of insiders.

I let the utility functions of the entrepreneur and the worker be of the constant relative risk aversion class

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<sup>15</sup>This assumption is done in order to keep things straight and to rule out the alternative that the length of time worked depends on market conditions.

$$\Psi(\Pi_i) = \frac{(\Pi_i)^{1+\gamma}}{1+\gamma}, \quad (8)$$

and

$$U\left(\frac{w_i}{p}\right) = \frac{\left(\frac{w_i}{p}\right)^{1+\rho}}{1+\rho}, \quad (9)$$

respectively.<sup>16</sup> The relative risk aversion of the entrepreneur and the worker are denoted  $\gamma \leq -1$  and  $\rho < -1$ . Setting up the Lagrangean function, using (8) and (9), and differentiating yields the first order condition for  $w_i(m)$ ,  $m \in M$  :

$$\begin{aligned} & \int_X \left\{ \frac{(1+\eta)}{w_i(m)} \left( A \left( \frac{w_i(m)}{\theta_i p} \right)^{1+\eta} \frac{m z_i}{p} \right)^{1+\gamma} \right\} h(x_i) dx_i \\ & + \phi \int_X \left\{ \varphi(w_i, m, x_i) \frac{1}{p} \left( \frac{w_i(m)}{p} \right)^\rho \right\} h(x_i) dx_i \\ & + \phi \int_X \left\{ I(w_i, m, x_i) \left( \frac{\eta}{w_i(m)} \left( \frac{w_i(m)}{\theta_i p} \right)^\eta \frac{m z_i}{p n \theta_i} \right) \left[ \frac{\left( \frac{w_i(m)}{p} \right)^{1+\rho}}{1+\rho} - \frac{(b)^{1+\rho}}{1+\rho} \right] \right\} h(x_i) dx_i = 0, \end{aligned} \quad (10)$$

where we define the indicator function  $I(w_i, m, x_i) = 0$  if  $\frac{\ell(w_i, m, z_i)}{n} \geq 1$ , and

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<sup>16</sup>  $\lim_{\gamma \rightarrow -1} \frac{(\Pi_i)^{1+\gamma} - 1}{1+\gamma} = \ln(\Pi_i)$ , by l'Hôpital's rule, so  $\Psi(\Pi_i) = \ln(\Pi_i)$  when  $\gamma = -1$  and  $U\left(\frac{w_i}{p}\right) = \ln\left(\frac{\kappa \theta w_i}{w^*}\right)$  when  $\rho = -1$ .

1 otherwise.<sup>17</sup> The Lagrange multiplier,  $\phi$ , is a weight that corresponds to the relative bargaining power of the parties.

The first term shows the effect of a marginal increase in the wage on the utility of the entrepreneur. The second and third term shows the marginal utility for the worker. The second term shows the effect of a marginal change in the wage on the workers utility given that he gets to keep his job. The last term shows the marginal effect of a change in the wage on the probability for a worker to be unemployed multiplied with the loss in utility that job loss is associated with. Note that a marginal increase in the wage increases the workers' probability of being laid off. Furthermore, from this condition it is easy to see the effects of insurance, or more specifically that the optimal wage contract is independent of the realization of the aggregate demand shock,  $m$ , when entrepreneurs have logarithmic utility functions and when  $I(w_i, m, x_i) = 0$ .

However, the contract will in general be state contingent. Thus the question is not whether a state contingent contract is optimal but how large is the gain of a complicated state contingent contract compared with a simple contract with a fixed wage.

Further analysis of the optimal wage contract requires the use of numerical methods. This is due to the inclusion of the idiosyncratic shock which adds some complexity to the analysis.

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<sup>17</sup>Since  $m$  and  $x_i$  are independent we can write  $f(m, x_i) = g(m)h(x_i)$ . This implies that we can divide the first order condition by  $g(m)$ .

### *The Gain from Indexation*

In this section I compare the state contingent contract with a contract that stipulates a fixed nominal wage. The best we can do, in general, is to compare the indirect expected utility that the contracts give rise to. It is however more convenient to have monetary measures of the change in utility. I define the gain from indexation,  $c$ , as the amount of money that has to be deducted from the optimal state contingent wage and unemployment compensation in order to make the indirect expected utility of the firm and the worker under this contract equivalent to a contract with a constant nominal wage.<sup>18</sup> Hence, the gain from indexation is measured as the decrease in income that would give the same decrease in the indirect expected utility for the firm and the worker,  $\Omega^{index}$ , (defined below) as the introduction of a fixed nominal wage.<sup>19</sup> This is done as follows: First, I calculate the optimal constant wage,  $\bar{w}_i$ , i.e. solve the following first order condition

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<sup>18</sup> $c$  can also be thought of as the required cost of indexation, i.e. cost that is required to prevent indexation.

<sup>19</sup>An equivalent way of defining the gain from indexation would be to add  $c$  to the fixed wage. This does not change the results.

$$\begin{aligned}
& \int_X \int_M \left\{ \frac{(1+\eta)}{\bar{w}_i} \left( A \left( \frac{\bar{w}_i}{\theta_i p} \right)^{1+\eta} \frac{m z_i}{p} \right)^{1+\gamma} \right\} f(m, x_i) dm dx_i \\
& + \phi \int_X \int_M \left\{ \varphi(w_i, m, x_i) \frac{1}{p} \left( \frac{\bar{w}_i}{p} \right)^\rho \right\} f(m, x_i) dm dx_i \\
& + \phi \int_X \int_M \left\{ I(w_i, m, x_i) \left( \frac{\eta}{\bar{w}_i} \left( \frac{\bar{w}_i}{\theta_i p} \right)^\eta \frac{m z_i}{p m \theta_i} \right) \left[ \frac{\left( \frac{\bar{w}_i}{p} \right)^{1+\rho}}{1+\rho} - \frac{(b)^{1+\rho}}{1+\rho} \right] \right\} f(m, x_i) dm dx_i = 0.
\end{aligned} \tag{11}$$

Second, I calculate the indirect expected utility for the firm and the worker with optimal constant wage by evaluating the following objective function

$$\begin{aligned}
\Omega^{fix} &= \int_X \int_M \left\{ \frac{\left( A \left( \frac{\bar{w}_i^o}{\theta_i p} \right)^{1+\eta} \frac{m z_i}{p} \right)^{1+\gamma}}{1+\gamma} \right\} f(m, x_i) dm dx_i \\
& + \phi \int_X \int_M \left[ \varphi(w_i, m, x_i) \frac{\left( \frac{\bar{w}_i^o}{p} \right)^{1+\rho}}{1+\rho} + (1 - \varphi(w_i, m, x_i)) \frac{(b)^{1+\rho}}{1+\rho} \right] f(m, x_i) dm dx_i.
\end{aligned} \tag{12}$$

where  $\bar{w}_i^o$  is the optimal constant wage. Third, I do the same as in the first stage but this time I solve for the state contingent (indexed) wage, i.e. solve equation (10). Fourth, I calculate the indirect expected utility with the optimal state contingent wage,  $w_i^o(m)$ , by evaluating the following objective function



$$\Omega^{index} = \int_M \left\{ \int_X \left\{ \frac{\left( A \left( \frac{w_i^o(m)}{\theta_i p} \right)^{1+\eta} \frac{mz_i}{p} \right)^{1+\gamma}}{1+\gamma} \right\} h(x_i) dx_i \right\} g(m) dm \quad (13)$$

$$+ \phi \int_M \left\{ \varphi(w_i, m, x_i) \frac{\left( \frac{w_i^o(m)}{p} - c \right)^{1+\rho}}{1+\rho} + (1 - \varphi(w_i, m, x_i)) \frac{(b-c)^{1+\rho}}{1+\rho} \right\} g(m) dm.$$

where  $\varphi(w_i, m, x_i) = \min \left[ \int_X \left\{ \left( \frac{w_i^o(m)}{\theta_i p} \right)^\eta \frac{mz_i}{np\theta_i} \right\} h(x_i) dx_i, 1 \right]$ . The last step is to set  $c$  so as to make  $\Omega^{fix} = \Omega^{index}$ . Hence, the gain from indexation,  $c$ , is the gain that the worker has to give up to be equally well off with a state contingent wage as with a fixed wage.<sup>20</sup> A constant nominal wage is thus an equilibrium if, when all other firms hold their prices fixed, the maximum gain to a worker from a state-contingent wage is less than the cost of such a contract.

This argument is very similar to the one put forward by Akerlof & Yellen (1985) and Mankiw (1985), namely that inertia in the wage-price behavior by firms may not be very costly. In Akerlof & Yellen (1985) this behavior is said to be near-rational. Near-rational behavior is, according to Akerlof & Yellen (1985), behavior that is perhaps suboptimal but that nevertheless imposes very small individual losses on its practitioners relative to the consequences of their first-best policy.

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<sup>20</sup>The gain from indexation is assumed to affect the worker since it is more intuitive to express the gain from indexation as a percentage of the wage rather than as a percentage of the profit.

### 3 Numerical Analysis

The parameter values are set as follows. The number of employed workers in the previous period,  $\ell_{-1}$ , is normalized to 1. Akerlof, Rose & Yellen (1988) report monthly quit rates for the United States of about 2 percent. Similar figures for the manufacturing sector in Sweden and United States have been reported by Holmlund (1984).<sup>21</sup> I set the quit rate,  $s$ , to 0.2. This is reasonable since we interpret a contract period in this model to be about a year. Hence, the firm enters the current period with 0.8 workers employed.

The relative risk aversion of the firm,  $\gamma$ , and the worker,  $\rho$ , are difficult to assess. Common measures for individuals, include 2–3 of Friend & Blume (1975) and 1–10 of Haubrich (1994).<sup>22</sup> In view of this, and since entrepreneurs probably are less risk averse than workers, in the baseline case, assume that  $\gamma$  equals  $-1$  and that  $\rho$  equals  $-2$ .

If the price elasticity,  $\eta$ , is set to  $-2$ , we get a mark-up factor of 2. This may

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<sup>21</sup>Akerlof et al. (1988) report quit rates for the period 1948-1991 while Holmlund (1984) only covers 1971-1975.

<sup>22</sup>Note that measures of relative risk aversion exceeding 25 also have been reported (such as the 29 of Kandel & Stambaugh (1991)). Relative risk aversion equal to 25 implies, according to Romer (1996) (p. 332), that individuals prefer a 17 percent reduction in consumption with certainty to a one-in-two chance of a 20 percent reduction. This suggests that risk aversion is much lower than this. As an example, that draws on Carlson (1998), of how much of a favourable gamble a risk-averse worker (or entrepreneur) will take, suppose the worker is confronted with the following situation. The worker can participate in a bet and either win  $x$  with probability  $\varepsilon$  or lose  $x$  with probability  $1 - \varepsilon$ . We can determine the size of the bet that the worker will undertake by choosing  $x$  to maximize expected utility:  $\varepsilon U(w + x) + (1 - \varepsilon) U(w - x)$ . The solution with the CRRA utility function is:  $w/x = (1 + r^{1/\rho}) / (1 - r^{1/\rho})$  where  $r = (1 - \varepsilon) / \varepsilon$ . If  $\varepsilon = 0.51$  and  $\rho = -3$  then  $w/x = 150$  which implies that the worker is willing to risk 2/3 of one per cent of the available wage. Romer (1996) (p. 335) views a coefficient of 4 as being on the high end of values that are plausible.

seem a bit high, but is well within the range (1.5–3) which, according to Andersen (1994), holds for most industries in the United states. Moreover, Rotemberg & Woodford (1995) argue that there is great uncertainty about actual markups in U.S. industry.

Unemployment compensation,  $b$ , is set to 0.6. Benefit rates varies quite a lot between countries. Blanchard & Wolfers (1999) report replacement rates from 11 percent for Italy to 90 percent for Denmark. The level chosen here is supposed to capture an American level (50 percent) somewhere between the two extreme cases. I have set unemployment compensation slightly higher than 0.5 because individuals generally have several possible ways to smooth variation in earnings that arises from unemployment. Moreover, unemployment spells are on average shorter than a year which we also have to take into account.

Aggregate productivity,  $\theta$ , is set equal to 1. The aggregate and idiosyncratic shocks,  $m$  and  $x_i$ , are assumed to be uncorrelated, normally distributed with mean equal to 1. The literature on job creation and job destruction gives a hint on the standard deviation of the idiosyncratic shock. Figure 2 depicts the standard deviation of plant-level growth rates in employment, standardized by firm size, for Swedish manufacturing firms between 1972 and 1996.<sup>23</sup> Davis &

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<sup>23</sup>The standard deviation is calculated as follows. Let  $\ell_{ist}$  denote the number of workers at employer  $i$  in sector  $s$  at time  $t$ .  $S_t$  denotes the set of employers with positive employment in  $t$  or in  $t - 1$ . The size of an establishment at time  $t$  is measured as the simple average of its employment in  $t - 1$  and  $t$ ,  $Z_{ist} = \frac{1}{2}(\ell_{ist} + \ell_{is,t-1})$ .  $Z_{st} = \sum_{i \in S_t} Z_{ist}$  denotes the size of sector  $s$  in period  $t$ . The time- $t$  growth rate for employer  $i$  can be written  $g_{ist} = \frac{\ell_{ist} - \ell_{is,t-1}}{Z_{ist}}$ . These growth rates lie on the closed interval  $[-2, 2]$ . The endpoints correspond to exit and entry. The

Haltiwanger (1999) (p. 100) report a standard deviation of 0.36 for 1978 and 0.41 for 1982 for the United States. These measures are somewhat higher than what is shown in figure 2, but are not standardized by plant size. In order to assess the importance of the size weighting I have calculated growth rates in employment for Swedish manufacturing firms without standardizing by plant size. The standard deviation is in this case 0.42 for 1978 and 0.41 for 1982, with a mean of 0.46 for the period 1972 – 1996. In view of this I have chosen a standard deviation of the idiosyncratic shocks  $\sigma_{x_i}$ , to equal 0.2.

The standard deviation of the aggregate demand shock,  $\sigma_m$ , is set to 0.05.<sup>24</sup> Ramey & Ramey (1995) report that the standard deviation of the growth rate in GDP for the period 1960 to 1985 in the U.S. is 0.0259. According to Davis et al. (1997) (p. 19), the standard deviation of net employment growth in the U.S. manufacturing industry is 0.048. Hence, 0.05 is fairly well in line with these observations. Table 1 summarizes the parameter values.

Table 1. Baseline Parameter Values

$\ell_{-1}$	$s$	$\gamma$	$\rho$	$\eta$	$b$	$\theta$	$\sigma_{x_i}$	$\sigma_m$
1	0.2	-1	-2	-2	0.6	1	0.2	0.05

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sectoral reallocation can be written as  $r_{st} = \sum_{i \in S_t} \left( \frac{Z_{ist}}{Z_{st}} \right) |g_{ist}|$ . The idiosyncratic growth rates are defined as  $\tilde{g}_{ist} = g_{ist} - r_{st}$ . The size weighted standard deviation is finally calculated as  $\sigma_{\tilde{g}_{ist}} = \sqrt{\sum_{i \in S_t} \left( \frac{Z_{ist}}{Z_{st}} \right) \left( \tilde{g}_{ist} - \bar{\tilde{g}}_{ist} \right)^2}$ . See e.g. Davis & Haltiwanger (1999) for a more detailed description of these measures.

<sup>24</sup>Gottfries (1992) uses the same value.

In order to clarify the logic of the model, we first consider the case where the firm is only subject to aggregate demand shocks.

### *Aggregate Demand Shocks*

This case is similar to Gottfries (1992) and will serve as a baseline case which we can refer to and compare with when we introduce idiosyncratic shocks. The analysis here is different in that I allow for states where the aggregate demand is so low that there may be layoffs. The first order condition is given by

$$\forall m \in M : \quad \frac{(1+\eta)}{w_i(m)} \left( A \left( \frac{w_i(m)}{\theta_i p} \right)^{1+\eta} \frac{mz_i}{p} \right)^{1+\gamma} + \phi \varphi(w_i, m, x_i) \frac{1}{p} \left( \frac{w_i(m)}{p} \right)^\rho \quad (14)$$

$$+ \phi I(w_i, m, x_i) \left( \frac{\eta}{w_i(m)} \left( \frac{w_i(m)}{\theta_i p} \right)^\eta \frac{mz_i}{pn\theta_i} \right) \left[ \frac{\left( \frac{w_i(m)}{p} \right)^{1+\rho}}{1+\rho} - \frac{(b)^{1+\rho}}{1+\rho} \right] = 0.$$

By varying the weight  $\phi$ , we describe the set of optimal contracts. Which one is chosen depends on the bargaining power of the worker and the firm. The bargaining power will depend on all the parameters in the model. I have throughout the analysis set  $\phi$  so as to mimic a fictive steady state where the expected value of the number of currently employed workers equals 1,  $E[\ell] = 1$ , so the previous employed insiders corresponds to 80 percent of expected employment. This way the model mimics a quit rate of 20 percent.

Figure 3 depicts the optimal state contingent wage contract, employment and

profit as functions of the aggregate demand shock.<sup>25</sup> We confirm the result in Gottfries (1992) that the optimal nominal wage is independent of the demand shock when  $\gamma = -1$ , and if the state is favourable. Workers prefer a constant nominal wage to one that varies with demand as long as prices do not vary with demand. The assumptions of constant returns and constant elasticity are crucial to this result. This case is similar to the standard insurance result that risk averse people are completely insured when premiums are actuarially fair<sup>26</sup>. Moreover, we see that the demand shock must be sufficiently limited for this to hold (above 0.8). In less favourable states ( $m < 0.8$ ) the worker has to weigh a higher wage against a higher probability of being laid off. To remain employed in less favourable times, workers agree to sign a contract where the wages decrease. In the interval (0.5 – 0.8) this decrease is set exactly so that all insiders remain employed.<sup>27</sup> The increase in marginal wage for a worker is higher in favourable states because a marginal increase in the wage does not affect the probability of being laid off in these states.

One should notice that these results hinge on the assumed level of risk aversion for the firm. If the firm is more risk averse, the wage should depend on the aggregate demand shock, so that the worker will absorb some of the risk.

Indexation is, in this case, not associated with any gain ( $c = 0$ ), i.e. the

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<sup>25</sup>Price,  $p$ , is set equal to 1. This is only a normalization and does not affect the results. See the appendix for the technical details of solving the non-linear first order condition.

<sup>26</sup>See Rosen (1985).

<sup>27</sup>If  $\gamma = -1$  we have that  $w_i = \left(\frac{np}{m}\right)^{\frac{1}{\eta}} p$ , which gives  $\frac{\ell(w_i, m, 1)}{n} = 1$ .

worker does not gain anything from making his wage contingent on aggregate demand. The gain from indexation is identical to Gottfries (1992) and is probably sufficiently small to support an equilibrium with nominal wage contracts. A price level independent of demand together with a high degree of job security (states where  $m < 0.8$  are very unlikely) makes insiders prefer a fixed nominal wage to a more complicated wage structure, i.e. a wage that is indexed to demand. Firms may also prefer a fixed nominal wage if they are not very risk averse.

#### *Aggregate and Firm-Specific Demand Shocks*

With both aggregate and firm-specific demand shocks we are back with the original first order condition (10). Figure 4 depicts the optimal wage contract, employment and profit with firm-specific shocks,  $\sigma_{z_i} = 0.2$ .<sup>28</sup>

The most striking difference between the nominal wage contracts with  $\sigma_{z_i} = 0.2$  and those with  $\sigma_{z_i} = 0$  is that the nominal wage is no longer independent of  $m$  around  $E[m]$ . Adding another source of uncertainty that cannot be written into the contract naturally makes the workers worry about being laid off even if the aggregate shocks are relatively favourable. Facing this extra source of uncertainty, the firm and the worker agree on a contract that makes the nominal wage dependent on the aggregate demand shock. Aggregate demand has to be approximately greater than 1.7 for the nominal wage to be constant.

Employment is different in that it varies more smoothly with demand and

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<sup>28</sup>In this subsection  $\sigma_{\theta_i}$  is set equal to 0.

does not level out for intermediate levels of aggregate demand.

The gain from indexation is in this case considerably higher compared with the case where  $\sigma_{z_i} = 0$ . The gain from indexation,  $c$ , is 0.015 which corresponds to 1.5 percent of the wage. It is difficult to assess if this increase still is sufficiently small to support an equilibrium with nominal wage contracts.

In order to clarify the logic of this result it is convenient to consider a situation where the firm-specific demand shocks can take only two values, either a low level,  $z_i^l$ , or a high level,  $z_i^h$ . Figure 5 depicts the optimal state contingent wage contract and the wage contracts that would be optimal if the firm-specific shocks were known at the time the contract was written. The dashed-dotted line depicts the optimal wage with a low firm-specific demand shock,  $z_i^l = 0.8$ , and the dashed line depicts the wage with a high firm-specific shock,  $z_i^h = 1.2$ . Uncertainty about the outcome of the firm-specific shock, and hence also about future employment, results in a smooth wage between the two cases. The same tendency to smooth the wage is evident in figure 4. Thus, the optimal wage increases for all levels of aggregate demand.

To gain further insights into the forces at work it is instructive to depict the ratio of  $\Omega^{index}$  and  $\Omega^{fix}$  for every  $m \in M$ . Figure 6 shows that the objective function is lower when the wage is constant. Obviously, a constant wage increases the probability of being laid off and the consequence is that, for every  $m \in M$ ,  $\frac{\Omega^{index}}{\Omega^{fix}} > 1$ . For intermediate levels of aggregate demand ( $0.8 < m < 1.2$ ) the ratio is closer to one. This is the relevant interval since the shocks lie within this



interval more than 95 percent of the time ( $\sigma_m = 0.05$ ).

### *Aggregate Demand and Firm-Specific Productivity Shocks*

It is easy to see from the first order condition (10), that firm-specific demand and supply shocks give exactly the same gain from indexation if the price elasticity is equal to  $-2$ . Consequently, in this particular case the analysis from the previous subsection applies for supply shocks as well. Compared with the effects of demand shocks, supply shocks generally interact with the price elasticity, which makes the analysis slightly more involved. For low levels of  $\eta$  variations in  $\theta_i$  bring about high variability in production. Therefore indexation is more attractive the lower is the price elasticity.

Figure 7 depicts the optimal wage contract, employment and profit when  $\sigma_{\theta_i} = 0.2$  and  $\eta = -2.1$ .<sup>29</sup> For these parameter values the decrease in income that would give the same loss in indirect expected utility as the introduction of a constant wage is 1.81 percent.<sup>30</sup>

## 4 Sensitivity Analysis

In this section I will take a closer look at the gain from indexation for a range of parameter values. I begin by generalizing the preferences of the worker and the

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<sup>29</sup>In this subsection  $\sigma_{z_i}$  is set equal to 0.

<sup>30</sup>The corresponding cost of indexation with firm-specific demand shocks and a price elasticity equal to 2.1 is approximately 0.004 percentage points greater than the baseline case. Hence, the resulting cost of indexation is approximately equal to the cost reported in table 1.

entrepreneur by allowing for varying degrees of risk aversion. A natural question is to what extent these results in turn are sensitive to changes in the rest of the parameters. Hence, I continue by changing one parameter at a time while keeping the rest at their baseline values.

### *Risk Aversion*

Table 2 shows the gain from indexation for  $\rho \in \{-2, -3, -4, -5\}$  and for  $\gamma \in \{-1, -2, -3\}$ . The gain from indexation to demand increases with the risk aversion of the worker. This contradicts Gottfries (1992), who shows that the gain from indexation decreases with the risk aversion of the worker. The difference is due to the risk of being laid off, which is disregarded in Gottfries (1992). An increase in the risk aversion of the worker decreases the utility of being laid off. This can be seen by studying the last term in equation (10). This decrease naturally makes the workers worry more about the possibility of being laid off. The workers will, consequently, agree to make the wage more sensitive to changes in aggregate demand in order to reduce layoffs in bad states. Hence, the gain from indexation will be higher if the workers become more risk averse.

The more risk averse the firm is the less willing is the firm to provide insurance against wage fluctuations. Hence, the gain from indexation increases with  $\gamma$ . The gain from indexation is all in all relatively high, ranging from 1.5 to 3.6 percent of the wage.

### *Standard Deviation of the Firm-Specific Demand Shocks*

Table 3 shows the gain from indexation for the same values of relative risk aversion as table 2 but with only aggregate demand shocks. The size of the gain from indexation is now more in line with the values reported by Gottfries (1992).<sup>31</sup> The direction of the change in the gain from indexation is qualitatively different from table 2. The gain from indexation decreases with the risk aversion of the worker but increases with the risk aversion of the firm.

The idiosyncratic standard deviation of of plant-level growth rates in employment, depicted in figure 2, is probably to a fairly large extent driven by plants that enter or exit. This is evident from the shape of the distribution of plant-level growth rates in employment.<sup>32</sup> In order to focus more on ongoing firms I have computed the gain from indexation for a lower idiosyncratic standard deviation. Table 4 depicts the gain when  $\sigma_{z_i} = 0.1$ . The pattern from Table 2 is evident also in Table 4, i.e. the gain from indexation increases with the risk aversion of both the worker and the firm. The gain is however much lower, ranging from 0.1 to 0.3 percent of the wage. Clearly, the degree of firm-specific uncertainty must be relatively high for a constant wage to be much worse than a state-contingent wage.

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<sup>31</sup>Gottfries (1992) shows that the gain is less than 0.1 percent of the wage when the risk aversion of the firm is below  $-6$ .

<sup>32</sup>See e.g. Davis et al. (1997).

### *Price Elasticity*

Table 5 displays the gain from indexation when the price elasticity of demand,  $\eta$ , is equal to  $-3$ . This generalization increases the gain from indexation slightly. It also makes the gain less sensitive to changes in the relative risk aversion of the firm. The intuition is that a higher price elasticity makes employment, the employment probability,  $\varphi$ , and profit more sensitive to changes in the wage. Hence, changes in the wage becomes relatively more costly and the gain from indexation increases consequently. The optimal state contingent contract is depicted in figure 8.

### *Quit Rate*

A decrease in the quit rate,  $s$ , (increase in  $n$ ) affects the employment probability,  $\varphi$ , directly. This generalization is displayed in table 6. If the quit rate is small then a smaller part of adjustments of the labor force can be made by variations in hiring. Hence, variation in employment affects the insiders more when the quit rate is low. Consequently, the gain from indexation increases when the quit rate decreases. Figure 9 depicts the corresponding wage contract, employment and profit. It is similar to figure 4. The relative bargaining power is smaller which indicates that the risk of being laid off has increased.<sup>33</sup>

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<sup>33</sup>If the risk of being laid off is substantial, workers would agree to lower their wages and thus increase production. Employment must however fulfil the steady state condition  $E[\ell] = 1$  which in turn implies a lower  $\phi$ .

### *Unemployment Compensation*

Table 7 displays the gain from indexation when unemployment benefit,  $b$ , is equal to 0.8. If the cost of unemployment is lower one should expect a lower gain from indexation. This is, indeed, the case. The gain from indexation is reduced substantially compared with the baseline case in table 2. The difference is especially palpable for high degrees of risk aversion. The gain from indexation, when the risk of being laid off is low, seems to be more sensitive to changes in the risk aversion of the firm than of the risk aversion of the worker. Figure 10 shows why the gain from indexation is lower for higher levels of unemployment benefits. The reason for a higher wage in less favourable states is simply that the outside option is not as bad as with a lower  $b$ . One problem with assigning a value to unemployment benefits is whether to rely on the momentary (dis)utility of job loss or whether to take dynamic aspects into account. The model is clearly not dynamic, but if we want to capture some form of discounted utility of job loss we should assign a slightly higher value than what the replacement rates indicate. Unemployment benefit equal to 0.8 should, in view of this, be more appropriate.<sup>34</sup>

### *Standard Deviation of the Aggregate Demand Shocks*

I will end the sensitivity analysis of demand shocks by assigning a higher standard deviation to the aggregate demand shocks. The intuition behind this generalization is equivalent to assigning a lower quit rate,  $s$ . If the aggregate

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<sup>34</sup>If the expected duration of unemployment is one third of a year we would have  $b = \frac{1}{3} \cdot \text{replacement rate} + \frac{2}{3}w_i = \frac{1}{3}0.5 + \frac{2}{3} = \frac{5}{6} = 0.833$

demand shocks are sufficiently limited all of the employment adjustments can be made by variations in hiring. Hence, insiders experience a higher degree of job security and the gain from indexation is consequently lower. Table 8 depicts the gain from indexation when  $\sigma_m = 0.1$ .

### *Variance Decomposition*

In this subsection I will increase the aggregate uncertainty to the level that corresponds to the uncertainty that equals the total uncertainty in the baseline case. This is done in order to investigate whether the increase in the gain from indexation,  $c$ , only follows from the fact that the overall variance in the economy has increased when we introduced firm-specific uncertainty. The overall uncertainty in the baseline case stems from two sources; firm-specific uncertainty,  $\sigma_{x_i}$ , equal to 0.2 and aggregate uncertainty,  $\sigma_m$ , equal to 0.05. The total variance is given by  $\sigma_{tot}^2 = \sigma_{x_i}^2 + \sigma_m^2 + cov(x_i, m)$  which equals 0.0625 since the shocks are independent. Table 9 depicts the gain from indexation when  $\sigma_m = 0.25$  and  $\sigma_{x_i} = 0$ . The gain is far greater than what was the case in table 2. The difference is due to the fact that it is very costly to abstain from indexation when it is possible to be completely insured against it. Thus, it is very unlikely that a contract that stipulates a fixed nominal wage is an equilibrium if the total uncertainty is as great as specified above, and when it is possible to completely insure against it.

As shown above, the gain from indexation is substantially lower when we

cannot make contracts contingent on firm-specific shocks.

#### *Risk Aversion - Firm-Specific Productivity Shocks*

Table 10 depicts the gain from indexation for different degrees of risk aversion for the firm and the worker with firm-specific productivity shocks,  $\sigma_{\theta_i} = 0.2$ . The gain exhibit the same general characteristics as the gain in table 2, but is about 20 percent higher, ranging from 1.81 to 4.2 percent of the wage.

## 5 Summary and Concluding Remarks

The common view of business cycles is that expansions and contractions in economic activity are driven by positive and negative shocks that affect all or most of the firms symmetrically at the same time. The result of these aggregate shocks is widespread fluctuations in employment and production. This has also been the prevailing view in the implicit contract theory of real wages and employment formalized by Azariadis (1975) and Baily (1974) and extended by Gottfries (1992). The basic insight underlying this theory is that firms, who are assumed to be less risk averse than workers, may be in a position to insure the workers against employment fluctuations by stabilizing the wage. Hence, these studies have tried to explain wage rigidity in the face of employment fluctuations caused by aggregate shocks.

The assumption that aggregate shocks is the main determinant of employment fluctuations seems hard to reconcile with the recent literature on job creation and

job destruction. Microeconomic evidence from most OECD countries shows that job creation and job destruction occur simultaneously at all phases of the business cycle and that a large part of establishments' employment experiences seems to be explained by idiosyncratic or firm-specific sources of uncertainty.

In this paper we take this criticism seriously by addressing the neglected issue of how firm-specific shocks affect the gain from writing state contingent wage contract. The very nature of firm-specific shocks seems to be such that it is very hard to make wages or employment contingent on them. Hence, I assume that these firm-specific sources of uncertainty cannot be written into the contract, due to different transactions costs.

By numerically solving an insider-outsider model developed by Gottfries (1992) I first show that the introduction of firm-specific uncertainty increases the gain from indexation considerably (from 0 to 1.5 percent of the wage). The increase is more pronounced for firm-specific supply shocks. It is not evident that the gain from indexation is small enough to support an equilibrium with a constant nominal wage. The second result is that nominal wage contracts should be more prevalent, when layoff is not so costly for the worker, e.g. due to high unemployment benefits or short duration of unemployment spells.

One caveat with the analysis put forward in this paper that ought to be mentioned is that when contracts are incomplete the contracting parties may introduce other forms of contracts that can be used as substitutes for complete contracts. One way of doing this is to introduce the possibility of renegotiation



as new information becomes available. At law, any contract may be renegotiated provided both parties agree. If it is possible to make the contract completely contingent on the state of the world, which is the case if  $\sigma_{x_i} = 0$ , there is no economic rationale for any ex post renegotiation because no new information comes in. The introduction of firm-specific shocks that cannot be written into the contract makes the contract incomplete and vulnerable to renegotiation. Hence, it would be interesting to explore the effects of renegotiation on the gain from indexation when firm's employment experiences can be explained by aggregate and firm-specific uncertainty. This extension is however left for future research.

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## 6 Appendix

### 6.1 Numerical Procedure

There exists a wide range of methods for solving nonlinear equations like (10). The numerical task is to find, for each  $m \in M$ , the zero of (10).<sup>35</sup> To do this I choose the secant method. In essence the secant method reduces a nonlinear problem to a sequence of linear problems. Formally the secant method is a simple iteration which proceeds as follows. Start by guessing a wage  $w_k$ . Second, construct the linear approximation to  $\Lambda$  (equation 10) at  $w_k$ . This yields the function  $g(w) \equiv \Lambda(w_k) + \frac{\Lambda(w_k) - \Lambda(w_{k-1})}{(w_k - w_{k-1})} (w_{k+1} - w_k)$ . The functions  $g(w)$  and  $\Lambda(w)$  are tangent at  $w_k$ . This means that we now, instead of solving for a zero of  $\Lambda$ , can solve for a zero of  $g$ . Set  $g$  equal to 0 and solve for  $w_{k+1}$ , to find our new guess of  $w$ . This results in the iteration

$$w_{k+1} = w_k - \frac{\Lambda(w_k)(w_k - w_{k-1})}{\Lambda(w_k) - \Lambda(w_{k-1})} \quad (15)$$

Continue this iteration until (15) holds approximately up to some accuracy parameter. One difficulty in this procedure is that we for every guess of  $w$  have to numerically evaluate the integral in (10). We will not go through the details of the theory behind numerical integration (quadrature) routines, see Judd (1998)

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<sup>35</sup>If  $f : R^n \rightarrow R^n$ , then a zero of  $f$  is any  $w$  such that  $f(w) = 0$ , and a fixed point of  $f$  is any  $w$  such that  $f(w) = w$ .

for an exposition. Here we just note that GAUSS (and other similar computer programs) has a selection of routines which allow us to evaluate the integral in (10). I used the routine INTQUAD1 (and INTQUAD2 for double integrals) in GAUSS which performs the following approximation

$$\int_b^a \Lambda(w_k) f(z_i) dz_i \approx \sum_j^o \Lambda(w_k) \omega_j f(z_{ij}), \quad (16)$$

where  $\omega_j$  and  $z_{ij}$  are Gauss-Legendre weights and nodes. The order of integration was set to 40.<sup>36</sup> The integral is evaluated between  $a = 5\sigma_{z_i}^2 + \bar{z}_i$  and  $b = -5\sigma_{z_i}^2 + \bar{z}_i$ , where  $\sigma_{z_i}^2$  and  $\bar{z}_i$  is the variance and the mean of the idiosyncratic demand shock. The idiosyncratic demand shocks are assumed to be normally distributed.

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<sup>36</sup>The results does not significantly change if I instead use 24 or 32 as the order of integration.

Figure 1 Sequence of Events

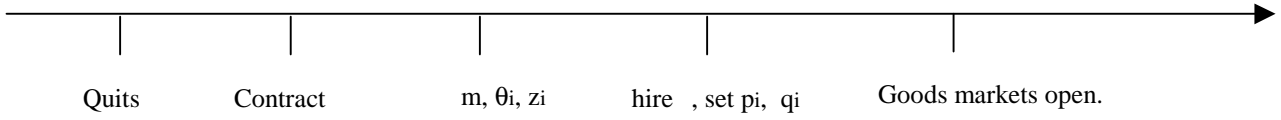


Figure 2 Standard deviation of idiosyncratic growth rates in employment, standardized by plant size. Source: Andersson (1999)

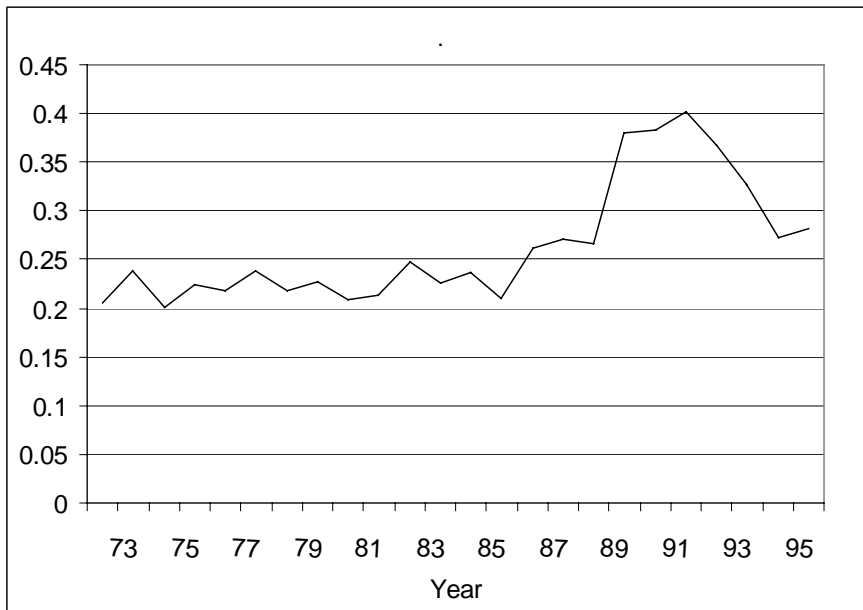




Figure 3 Indexed wage contract, employment and profit. Only aggregate shocks.

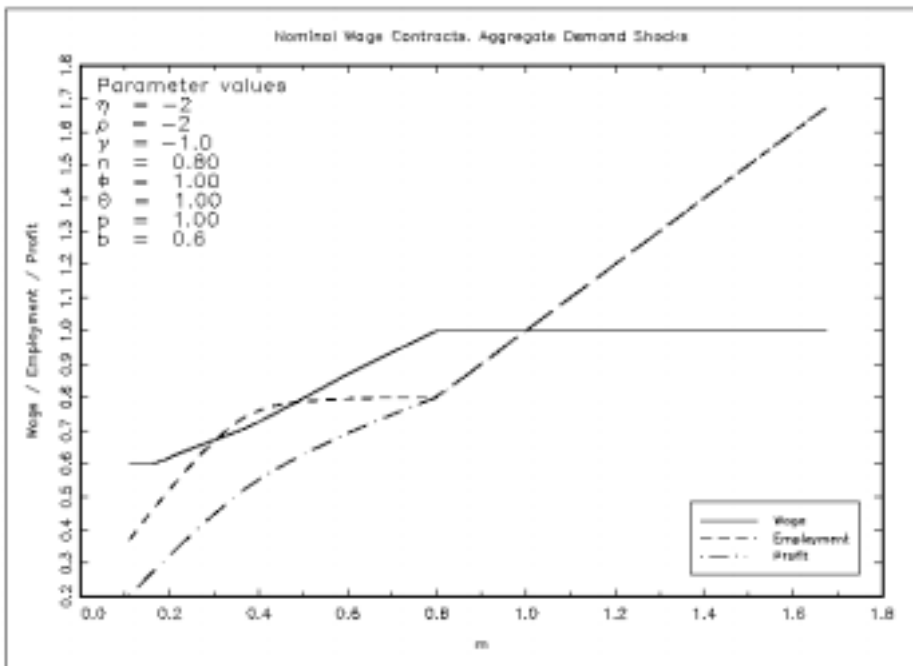


Figure 4 Indexed wage contract, employment and profit. Aggregate and firm-specific demand shocks.

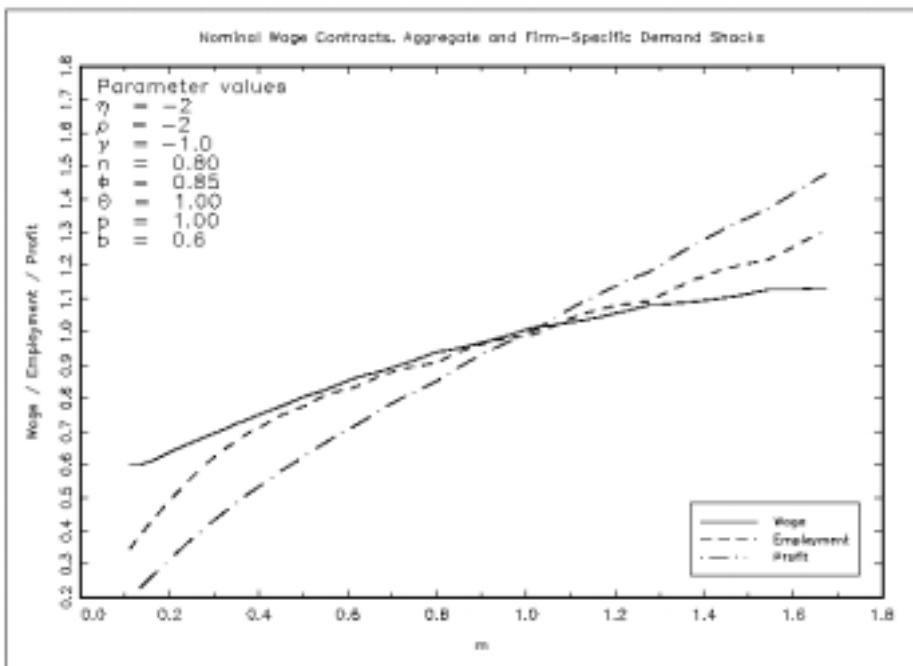


Figure 5 Firm-specific shocks can only take two values 0.8 and 1.2.

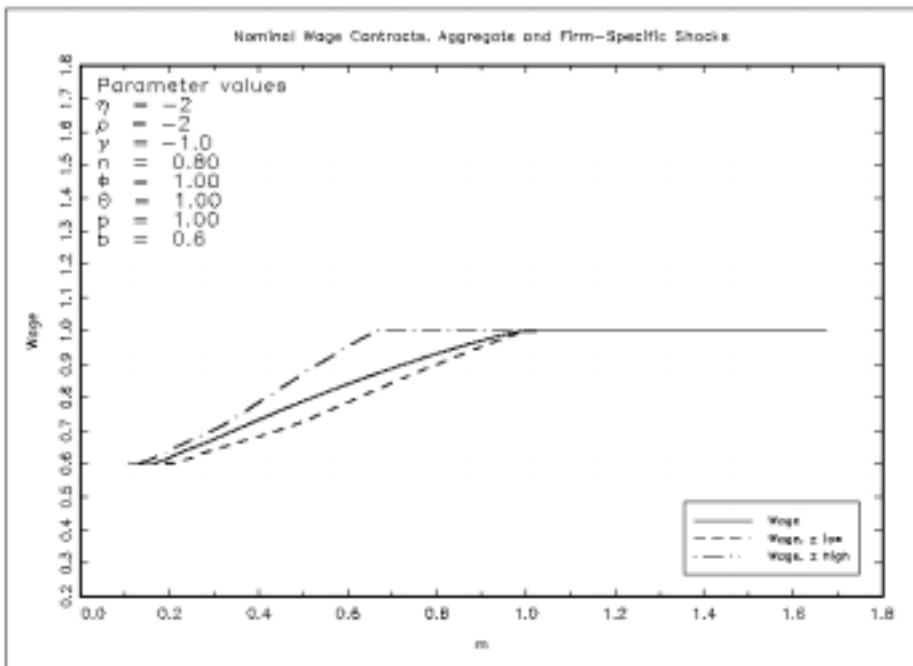


Figure 6 Ratio of indirect expected utility under a indexed and a fixed wage (contingent on aggregate demand)

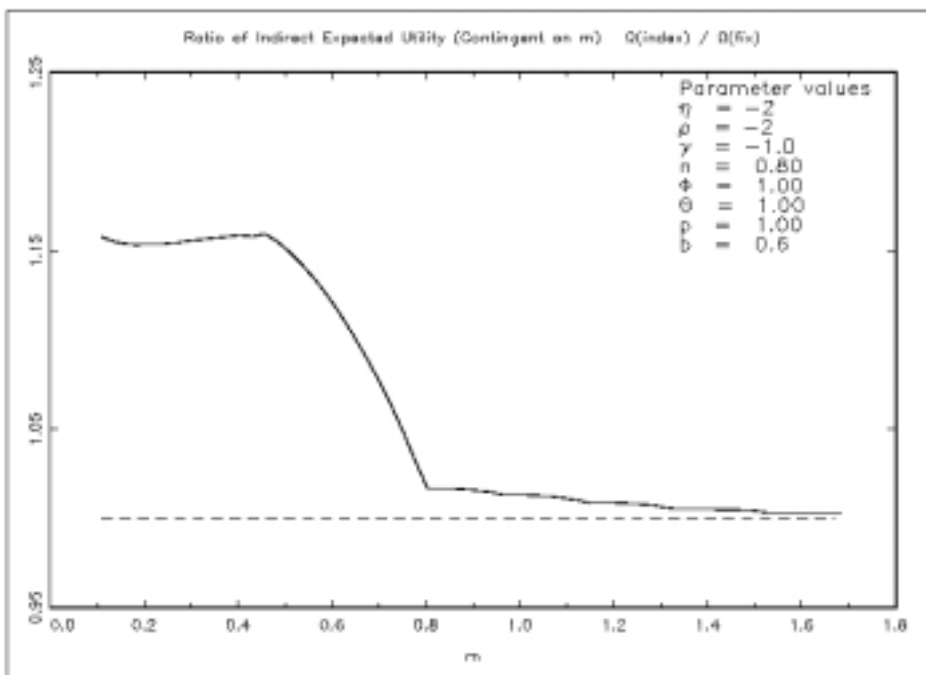


Figure 7 Indexed wage contract, employment and profit. Aggregate demand and firm-specific productivity shocks.

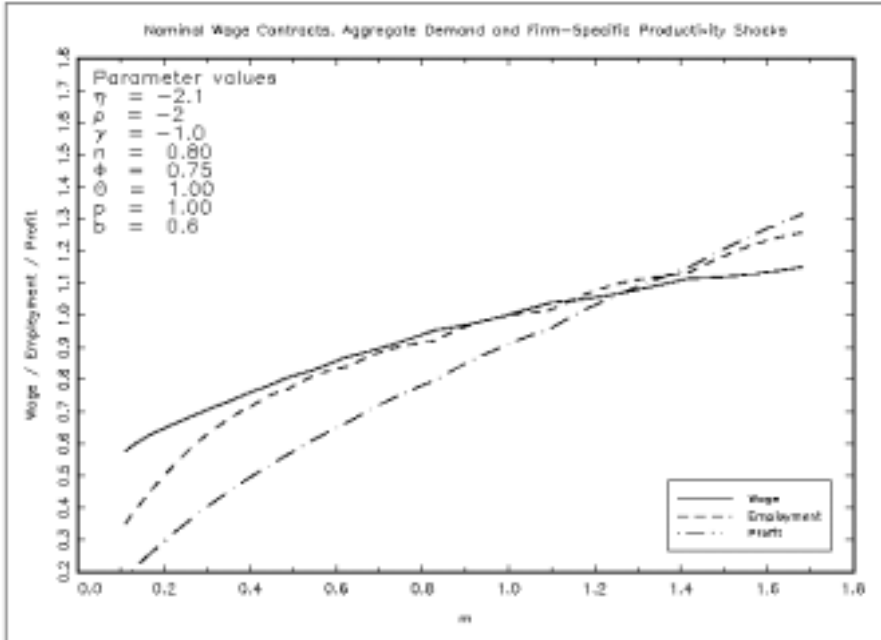


Figure 8 Indexed wage contract, employment and profit. Aggregate and firm-specific demand shocks.  $\eta = -3$ .

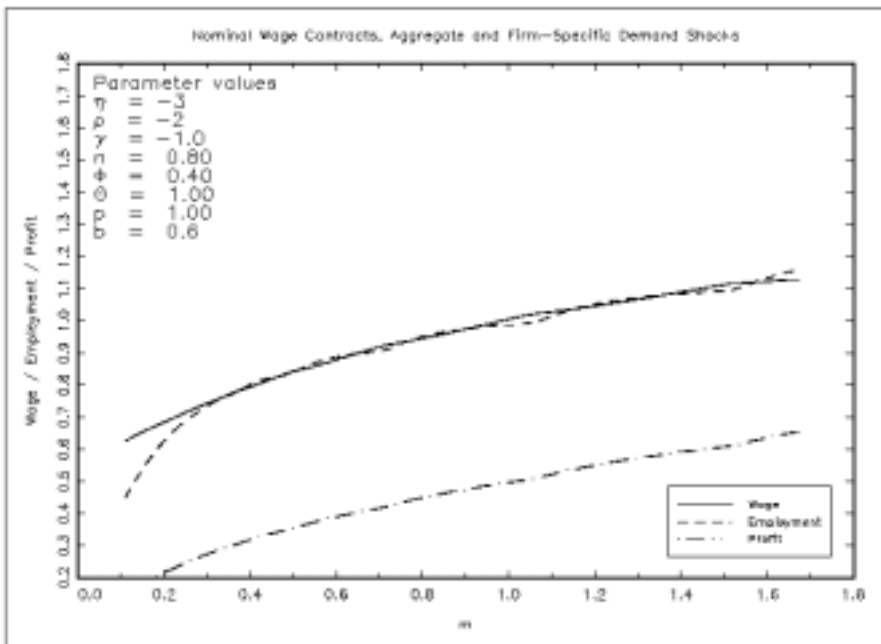


Figure 9 Indexed wage contract, employment and profit. Aggregate and firm-specific demand shocks.  $n = 0.9$ .

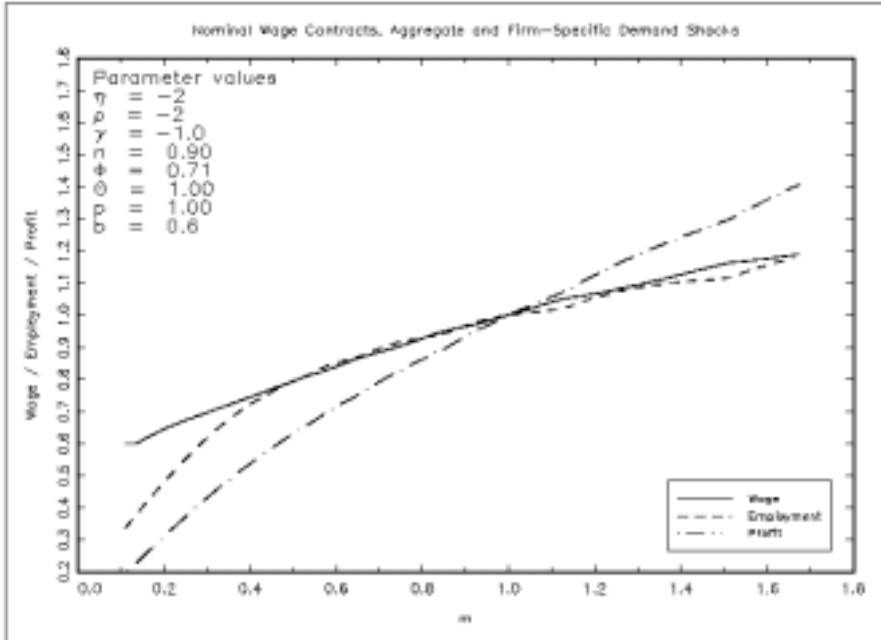


Figure 10 Indexed wage contract, employment and profit. Aggregate and firm-specific demand shocks.  $b = 0.8$ .

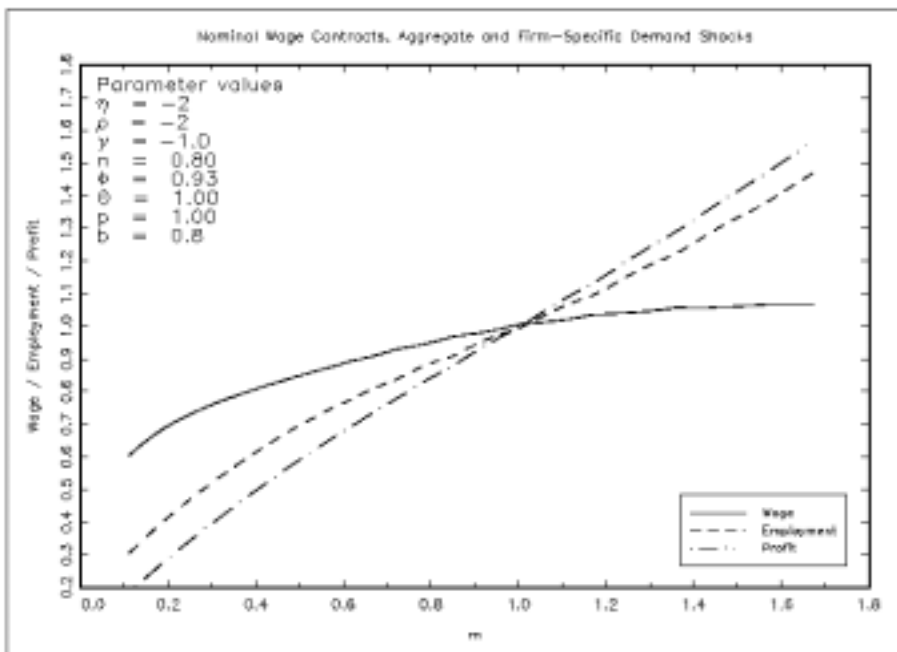


Table 2

## Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.015	0.019	0.026	0.034
-2	0.016	0.020	0.026	0.035
-3	...	0.021	0.027	0.036

Note - The table shows the cost that would give the same loss in expected utility as the introduction of a constant nominal wage. The standard deviation of the aggregate demand shock ( $\sigma_m$ ) is 5 percent. I assume that  $\rho \leq \gamma$ .

Table 3

 $\sigma_z = 0$ 

## Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0	0	0	0
-2	0.00060	0.00042	0.00031	0.00025
-3	...	0.00127	0.00101	0.00084

Note - See note to table 1.

Table 4

 $\sigma_z = 0.10$ 

## Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.00116	0.00152	0.00207	0.00300
-2	0.00182	0.00200	0.00245	0.00320
-3	...	0.00282	0.00320	0.00380

Note - See note to table 1.

Table 5

$\eta = -3$

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.015	0.020	0.026	0.035
-2	0.016	0.020	0.027	0.036
-3	...	0.021	0.027	0.036

Note - See note to table 1.

Table 6

$n = 0.9$

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.0297	0.0385	0.0501	0.0650
-2	0.0301	0.0387	0.0502	0.0650
-3	...	0.0391	0.0504	0.0651

Note - See note to table 1.

Table 7

$b = 0.8$

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.0055	0.0061	0.0069	0.0078
-2	0.0063	0.0067	0.0073	0.0081
-3	...	0.0075	0.0080	0.0087

Note - See note to table 1.

Table 8

 $\sigma_m = 0.1, \sigma_z = 0.2$ 

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.018	0.023	0.030	0.041
-2	0.020	0.025	0.032	0.042
-3	...	0.028	0.034	0.043

Note - See note to table 1. (valid except for  $\sigma_m = 0.05$ )

Table 9

 $\sigma_m = 0.25, \sigma_z = 0$ 

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.226	0.161	0.151	0.166
-2	0.298	0.208	0.186	0.192
-3	...	0.324	0.273	0.258

Note - See note to table 1. (valid except for  $\sigma_m = 0.05$ )

Table 10

 $\sigma_\theta = 0.2, \sigma_z = 0, \eta = 2.1$ 

Gain from indexation ( c )

$\gamma$	$\rho$			
	-2	-3	-4	-5
-1	0.0181	0.0237	0.0313	0.0417
-2	0.0185	0.0240	0.0316	0.0418
-3	...	0.0245	0.0319	0.0420

Note - See note to table 1.