Ambiguity and Labour Contracts under the *New Normal*

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This Version: 27 March 2022

Abstract

This paper provides a theoretical model on how ambiguity sharing labour contracts emerge under the *New Normal*. We suppose there exist two possible states of nature/events, the *normal* state and an unknown state or *New Normal*, the latter associated with extra costs to be incurred in the economy to adapt to it. We analyse the model considering alternatively linear and nonlinear wage contracts, under two distinct scenarios: (1) a single employer, and (2) competing employers. Our results suggest that in the single employer scenario, both the employer and their employees prefer linear over non-linear labour contracts; whereas the equilibrium labour contracts that emerge are nonlinear in the competing employers scenario.

JEL Codes: D81, J41, J65

Keywords: ambiguity, adaptation ability, labour contracts, matching, *New Normal*

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1 Introduction

The World Health Organisation declared the COVID-19 outbreak was an emergency of international concern on 31st January 2020, and full national lockdown announcements were made in many countries to control the outbreak and spread of COVID-19. There have been four rounds of lockdown in Auckland, New Zealand, since the start of the pandemic. At Alert Level 3 and 4, public facilities are closed, and people are asked to stay home and work from home. Some people lost their jobs because the negative demand shock heavily affected some service sectors, such as restaurants, with businesses having to reduce the number of their employees to lower their operating costs. According to Statistics NZ (2021), the unemployment rate increased from 4.2% pre-lockdown (March 2020) to a peak of 5.3% months after experiencing repeated lockdowns (September, 2020). This is in line with what is to be expected when entering into a national lockdown, in New Zealand, and world-wide: the shocks to both supply and demand imposed on the economy are responsible for a rapid increase in the unemployment rate.[1] Our interest is to try and understand what might be driving the way in which workers and businesses adjust to such shocks, also depending on the workers' and firms' characteristics, as well as on the type of available labour contracts. In this context, risk and ambiguity sharing labour contracts can ensure a smooth consumption for employees.

This research aims to find labour contracts where ambiguity plays a role in offering/accepting labour contracts under the *New Normal*. Under the *New Normal*, the employees have some extra costs to adapt to the new environment. This can come in many forms and in a variety of essential workers sectors, as well as others that kept functioning in the midst of the tighter lockdown measures. Think, for instance, about the extra hours spent learning to use a new software while working from home (e.g. to host Zoom meetings as opposed to face-to-face ones); or adapting to offer online shopping platforms, as well as distribution channels to organise delivery 'up to the door'.[2] In our

[1] According to Tatsiramos and Van Ours (2014), for instance, during a recession, there is an increase in layoffs, especially with increased unemployment among experienced and higher educated workers.

[2] Adapting to new ways of reaching customers became widespread during the pandemic, e.g., as customers relied ever more on online grocery shopping, with 'click & collect' or 'home delivery' options, depending on the various alert levels in place; online shopping affected many other products, including electronics and pharmaceuticals. It is very well known that online platforms such as Amazon offering online

model, an employee's ambiguity attitude and their ability to adapt to the new, unknown environment, will affect their perceived wage, thereby also determining whether they will likely accept or reject a labour contract, specifying a given nominal wage. We aim to focus on two main research questions:

(i) How do agents make labour contract decisions in the presence of such uncertainty?

(ii) Could employers offer different labour contracts to attract employees with different ambiguity attitudes and adaptation abilities?

1.1 Related Literature

1.1.1 The Unemployment Insurance (UI) system, and risk and ambiguity sharing under uncertainty

The unemployment insurance (UI) system was designed to provide smooth consumption while providing incentives for employees to be in employment (Hansen and Imrohoroğlu, 1992; Gruber, 1997; Fredriksson and Holmlund, 2006a). Gruber (1997) shows that the consumption fall upon unemployment would be over three times larger without the UI system. This provides support for the notion that the UI system provides a method for employers and employees to share risk and ambiguity. However, some scholars argue that the UI system might have negative effects on labour markets. The unemployment insurance system may encourage layoffs and moral hazard (Feldstein, 1976, 1978; Topel, 1983; Anderson and Meyer, 2000; Fath et al., 2005; Fredriksson and Holmlund, 2006a,b; Blanchard and Tirole, 2008; Tatsiramos and Van Ours, 2014). Because of asymmetric information, employees may search less intensely for a new job when they

shopping with home delivery, media streaming and cloud-based web-services boomed during the pandemic having to meet the increasing demand by consumers 'grounded' at home. Continuing with the example of Amazon and their flourishing online shopping and home delivery services in particular, it needs to be stressed that such business model was also accompanied by increased criticisms over pay and work conditions during the pandemic: Employers had to spend extra hours working in very demanding shifts involving the use of personal protective equipment (PPE) to meet the surge in demand for online shopping, generating pressures to adjust their wages upwards. See also "Amazon's Profit Tripled in First Quarter" by Karen Weise in *The New York Times*, Published 29 April 2021, Updated 29 July 2021.

are unemployed, and the UI system may raise wage pressure (Fredriksson and Holmlund, 2006a) for employers, thus, leading to a high unemployment rate (Baily, 1977). Feldstein (1976) uses a theoretical model, finding the UI system may increase unemployment rates, which seems to support that the UI system encourages layoffs. However, when assuming the firm size is endogenous, Burdett and Wright (1989) find that the UI system helps firms be larger and hire more employees. This finding is inconsistent with the results from Feldstein (1976). Rebollo-Sanz (2012) uses data from Spain between 2005 and 2008, suggesting that the UI system has negative impacts on the employment duration and the level of the impact depends on the type of the employers and employees: the UI system has more effects on the unemployment rate of workers with loose attachment to the labour market such as females and temporary workers.

Some research provides instruments to deal with the problem that the UI system may encourage unemployment, focussing on the design of an optimal UI system. Baily (1977), Topel (1983) and Blanchard and Tirole (2008) suggest partially "experience rated" payroll taxes on individual employers. Fredriksson and Holmlund (2006a,b) review three instruments: the duration of the benefit payment, monitoring, and workfare. They suggest that while these three instruments, a decreasing unemployment benefits for the duration of unemployment, monitoring and workfare, might help to encourage employees to search jobs, they have limited power to speed up job finding. Furthermore, there is little known about the relative efficiency of these instruments. A tax on unemployment entry and self-insurance via precautionary saving might reduce unemployment rates, but little research shows whether these can be a substitute for the UI system. Moreover, research on the optimal UI system design does not consider ambiguity which may affect people's decision-making in labour markets.

We propose an *ambiguity sharing labour contract model* under the *New Normal*. Differently from the public UI system, and the share-tenancy contracts, which allow the rent paid to depend on the level of harvest and to enable the tenant to share risks with the landlord (Newbery, 1977), our model assumes the bonus [3] paid to the employees in

[3] An example of the nonlinear contract scheme is the NZD500 bonus paid to the nurses and midwives in Zealand for every night shift they worked for, which followed hospitals' experience of severe staff shortages during the 2022 Omicron outbreak. The bonuses were paid to compensate nurses and midwives for the extra work they needed to put in to adjust to the adverse conditions due to COVID-19. See "Covid 19

the 'bad' scenario to also rely on the employer's ambiguity aversion.

1.1.2 Expected utility for decision–making under ambiguity

The sure-thing principle (STP), which suggests that uncertainty should not change a person's choice between two acts if that uncertainty does not affect their preferences over these two acts, dates back to Savage (1954). Under the STP, a person's preference does not change regardless of whether an event occurs or not. However, Ellsberg (1961) shows that individuals often violate the sure-thing principle and subjective expected utility (SEU) (Savage, 1954, 1972). In a two-urn two-colour scenario and a one-urn three-colour scenario experiment, this study shows that a person prefers to bet in situations for which they know specific odds, rather than in situations for which the odds are ambiguous. Ellsberg (1961) suggests that ambiguity aversion affects people's decision-making under uncertainty, and specifically under ambiguity. Besides, Smith (1961) also claimed that people's belief might be affected by what odds they would like to bet on, and he suggested the probabilities adjusted by Bayes' Theorem rather than the subjective probabilities should be considered when dealing with people's decision-making problems. These studies led to more research on decision-making models which extend SEU by adding ambiguity aversion into them.

There are many models which allow ambiguity to play a role in a person's decision-making: the MaxMin expected utility model (MaxMin EU) (Wald, 1949; Gilboa and Schmeidler, 1989, 1993), the Choquet expected utility model (CEU) (Gilboa, 1987; Schmeidler, 1989), and the α-MaxMin expected utility model (α-MaxMin EU) (Hurwicz, 1951; Cohen et al., 2000; Ghirardato et al., 2004; Hey et al., 2010; Gul and Pesendorfer, 2015; Grant et al., 2019). The MaxMin EU model posits that a person maximises the worst-case expected utility when making decisions under uncertainty; whereas the α-MaxMin EU model adds a weight, α, and suggests that people calculate a weighted average of the best and worse cases when dealing with decision-making problems under uncertainty. This study selects the α-MaxMin EU model because research from Hey et al.

Omicron outbreak: Auckland numbers peak, cases expected to climb for the rest of country" appeared in the *New Zealand Herald*, on 18 March 2022. https://www.nzherald.co.nz/front-page-top-stories/news/article.cfm?c_id=698&objectid=12511678&ref=rss.

(2010); Gul and Pesendorfer (2015) suggest it to have a better performance for decision-making problems using experimental data.

2 The Model

2.1 Model Setup

We describe our labour market using a modified Hotelling model (Hotelling, 1929, 1990). Suppose there exist two possible states of nature/events, the *normal* state (e.g., the familiar state, pre-pandemic; or the *back to normal* state), and an unknown, challenging state or *New Normal* (e.g., a wave of infections leading to a – or yet another – lockdown). The *New Normal* state is such that extra costs are to be incurred in the economy to adapt to it.

Assumption 1. *There exists a continuum of potential employees, i, the mass of which is normalised to one, and an employer contracting over labour.*

Assumption 2. *Two parameters, $\alpha_i \in [0,1]$ and $\beta_i \in [0,1]$, capture each idiosyncratic employee i's relative degrees of ambiguity aversion and adaptation ability to the New Normal, respectively.*

For simplicity, we assume $\alpha \overset{iid}{\sim} U[0,1]$ and $\beta \overset{iid}{\sim} U[0,1]$ and independence of an employee i's ambiguity attitude and adaptability. These parameters summarise the characteristics of an employee i in the economy: the bigger their α_i, the more pessimistic that employee is; the bigger their β_i, the less their adaptability. We denote with the probability distribution functions of α and β by $f(\alpha)$ and $g(\beta)$, and their cumulative distribution functions by $F(\alpha)$ and $G(\beta)$.

Assumption 3. *$\alpha \overset{iid}{\sim} U[0,1]$ and $\beta \overset{iid}{\sim} U[0,1]$. $f(\alpha|\beta) = f(\alpha)$, $g(\beta|\alpha) = g(\beta)$.*

Consequently, there are four types of employees in the labour market, that can be distinguished along these two (α and β) dimensions. Those can also be depicted using four different regions, as in figure 1.

- A: ambiguity loving & low adaptability (small α_i & large β_i);
- B: ambiguity loving & high adaptability (both small α_i & β_i);
- C: ambiguity averse & low adaptability (both large α_i & β_i); and
- D: ambiguity averse & high adaptability (large α_i & small β_i).

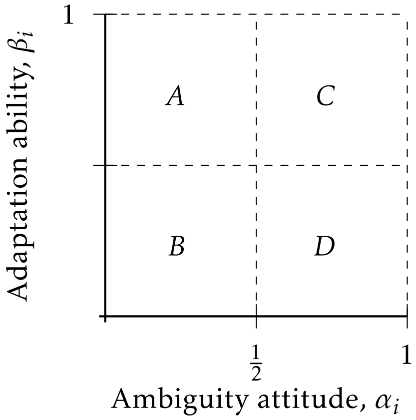

Figure 1: Four types of employees

Assumption 4. *Employees know their types, but the employer only knows the distributions of the employees' types.*

Assumption 5. *The employer offers a uniform base wage denoted by $w_i = w \geq 0$, and a bonus, $\Delta \geq 0$, as an extra monetary compensation to be only paid under the 'new normal'.*

If they reject a labour contract, an employee maintains their outside option ('reservation' wage), labelled w_r. As per assumption 5, depending on which state of nature will materialise, if accepting a contract offer the employee receives w in the 'good state' (e.g., prior to the pandemic), whereas the employee receives $(1-\beta_i)\cdot(w+\Delta)$ in the 'bad' state (under the *new normal*). Following the $\alpha - MaxMin$ EU rule, an employee i places a weight of $1-\alpha_i$ on the best case scenario of receiving w, and α_i on the worst case scenario of receiving $(1-\beta_i)\cdot(w+\Delta)$.

Therefore, we can identify an $\widetilde{\alpha}$–$\widetilde{\beta}$ employee's type that is indifferent between accepting and rejecting a contract as follows:

$$\widetilde{w} = (1-\widetilde{\alpha})\cdot w + \widetilde{\alpha}\cdot(1-\widetilde{\beta})\cdot(w+\Delta) = w_r$$

or

$$\widetilde{\alpha} = \frac{w - w_r}{\widetilde{\beta} \cdot (w + \Delta) - \Delta}$$
$$\widetilde{\beta} = \frac{w - w_r + \widetilde{\alpha}\Delta}{\widetilde{\alpha} \cdot (w + \Delta)} \tag{1}$$

Denote the conditional expected wage for agents willing to accept the contract by $E[\widetilde{w}|\alpha \leq \tilde{\alpha}, \beta \leq \tilde{\beta}]$. Given this, and the independence assumptions over the two distributions $f(\alpha)$ and $g(\beta)$, such conditional expected wage can be derived as follows:

$$E[\widetilde{w}|\alpha \leq \tilde{\alpha}, \beta \leq \tilde{\beta}] = \frac{\int_0^{\widetilde{\beta}} \int_0^{\widetilde{\alpha}} [(1-\alpha) \cdot w + \alpha \cdot (1-\beta) \cdot (w + \Delta)] f(\alpha) g(\beta) d\alpha d\beta}{\int_0^{\widetilde{\beta}} \int_0^{\widetilde{\alpha}} f(\alpha) g(\beta) d\alpha d\beta} \tag{2}$$

Given Assumptions 1–3 the mass of agents who accept the contract equals $F(\widetilde{\alpha}) \cdot G(\widetilde{\beta}) = \widetilde{\alpha} \cdot \widetilde{\beta}$; conversely, the mass of agents who reject the contract is, simply, $1 - F(\widetilde{\alpha}) \cdot G(\widetilde{\beta}) = 1 - \widetilde{\alpha} \cdot \widetilde{\beta}$.

Assumption 6. *Consider an employer's production function to be $Y(L) = L$, where L is L–abour and such that $L = F(\widetilde{\alpha}) \cdot G(\widetilde{\beta}) = \widetilde{\alpha} \cdot \widetilde{\beta}$. Further assume that each unit of output is sold in the economy at a fixed price P.*

Assumption 7. *Consider an employer's ambiguity aversion, denoted by $\hat{\alpha}$, to follow the same i.i.d. distribution as those of employees, i.e., $f(\hat{\alpha}) \sim U(0,1)$.*

These are simplifying assumptions that allow us to concentrate on production that is solely labour-driven, while also abstracting from the potential market power that the employer could possess on the final product market. Further, they allow us to concentrate on the employer opportunity to select the labour contract that is most advantageous to them, given the interplay between their own ambiguity aversion and employees' behaviour under the uncertainty described thus far, i.e., given employees' expected types in terms of both their idiosyncratic ambiguity aversion and adaptation ability, and the mass that the employer is able to attract to them.

Next, we analyse the model considering alternatively linear and nonlinear wage contracts, under two distinct scenarios: (1) a single employer, and (2) competing employers.

2.2 Analysis: Single Employer Scenario

2.2.1 Linear wage contracts

In this case, the labour contract is linear, which means that the employer offers a fixed wage, regardless of whether the employer faces the 'good' or the 'bad' state (i.e., $\Delta = 0$). This leads to a mass of employees attracted by this labour contract equal to

$$\widetilde{\alpha} \cdot \widetilde{\beta} = \frac{w - w_r}{w} \tag{3}$$

And, therefore, for an employer's profit equal to:

$$\Pi = (\frac{w - w_r}{w}) \cdot P - (w - w_r) \tag{4}$$

Using Eq. (4), we can derive the first order condition for the employer's profit-maximisation problem,

$$\frac{\mathrm{d}\Pi}{\mathrm{d}w} = \frac{w_r \cdot P}{w^2} - 1 = 0$$

Therefore, the optimal values for the wage, mass of employees and profits obtained in equilibrium are as follows:

- $w^* = (w_r \cdot P)^{\frac{1}{2}}$
- $\widetilde{\alpha}^* \cdot \widetilde{\beta}^* = 1 - (\frac{w_r}{P})^{\frac{1}{2}}$
- $\Pi^* = w_r + P$

where $w_r < P$.

Lemma 1. *A single employer offering linear labour contracts, leads to the optimal base wage of* $w^* = (w_r \cdot P)^{\frac{1}{2}}$*, a mass of employees equal to* $\widetilde{\alpha}^* \cdot \widetilde{\beta}^* = 1 - (\frac{w_r}{P})^{\frac{1}{2}}$ *and optimal profit in the amount of* $\Pi^* = w_r + P$*.*

2.2.2 Nonlinear wage contracts

Now, assume that an employer offers a nonlinear labour contract, such that employees would gain a wage spread equals to Δ to offset the extra cost of having to adjust to the 'bad' state. Adding a subscript 'n' to signify 'nonlinear contracts', the conditional expected wage for agents willing to accept the contract now equals

$$E[\widetilde{w}_n | \alpha \leq \tilde{\alpha_n}, \beta \leq \tilde{\beta_n}] = \frac{\int_0^{\widetilde{\beta_n}} \int_0^{\widetilde{\alpha_n}} [(1-\alpha) \cdot w_n + \alpha \cdot (1-\beta) \cdot (w_n + \Delta)] f(\alpha) g(\beta) d\alpha d\beta}{\int_0^{\widetilde{\beta_n}} \int_0^{\widetilde{\alpha_n}} f(\alpha) g(\beta) d\alpha d\beta} \tag{5}$$

Given our assumptions, we can rewrite the employer's profit as follows:

$$\Pi_n = F(\widetilde{\alpha}_n) \cdot G(\widetilde{\beta}_n) \cdot P - F(\widetilde{\alpha}_n) \cdot G(\widetilde{\beta}_n) \cdot [(1-\hat{\alpha}) \cdot w_n + \hat{\alpha} \cdot (w_n + \Delta)]$$

By substituting the value of $\tilde{\alpha_n} \cdot \tilde{\beta_n}$ into this profit, we obtain:

$$\Pi = \frac{w_n - w_r + \widetilde{\alpha_n}\Delta}{w_n + \Delta} \cdot (P - w_n - \hat{\alpha}\Delta) \tag{6}$$

Eq. (6) can be used to derive the first order conditions for the employer's profit-maximisation problem. Those provide us with a system of equations to solve for the optimal w_n and Δ, which characterises the optimal nonlinear contract that would be offered to employees.

$$\frac{\partial \Pi_n}{\partial w_n} = \frac{[(w_n + \Delta) - (w_n - w_r + \widetilde{\alpha}_n \Delta)](P - w_n - \hat{\alpha}\Delta)}{(w_n + \Delta)^2} - \frac{w_n - w_r + \widetilde{\alpha}_n \Delta}{w_n + \Delta} = 0$$

$$\frac{\partial \Pi_n}{\partial \Delta} = \frac{[\widetilde{\alpha}_n (w_n + \Delta) - (w_n - w_r + \widetilde{\alpha}_n \Delta)](P - w_n - \hat{\alpha}\Delta)}{(w_n + \Delta)^2} - \frac{w_n - w_r + \widetilde{\alpha}_n \Delta}{w_n + \Delta} \cdot \hat{\alpha} = 0$$

Solving for this system of equations leads to the following optimal values:

$$\begin{aligned}
\Delta^* &= \frac{(1-\widetilde{\alpha}_n)^2 \cdot P - (1-\hat{\alpha})^2 \cdot w_r}{(\widetilde{\alpha}_n - \hat{\alpha})(1-\hat{\alpha})(1-\widetilde{\alpha}_n)}, \\
{w_n}^* &= \frac{\widetilde{\alpha}_n(1-\hat{\alpha})w_r}{(\widetilde{\alpha}_n - \hat{\alpha})(1-\widetilde{\alpha}_n)} - \frac{\hat{\alpha}(1-\widetilde{\alpha}_n)\cdot P}{(\widetilde{\alpha}_n - \hat{\alpha})(1-\hat{\alpha})}, \\
{\Pi_n}^* &= \frac{\widetilde{\alpha}_n - \hat{\alpha}}{1-\hat{\alpha}} \cdot (P - \frac{1-\hat{\alpha}}{1-\widetilde{\alpha}_n} \cdot w_r), \\
\tilde{\alpha}_n^* \cdot \tilde{\beta}_n^* &= \frac{\widetilde{\alpha}_n - \hat{\alpha}}{1-\hat{\alpha}},
\end{aligned}$$

where $\frac{\hat{\alpha}}{\widetilde{\alpha}_n}(\frac{1-\widetilde{\alpha}_n}{1-\hat{\alpha}})^2 < \frac{w_r}{P} < (\frac{1-\widetilde{\alpha}_n}{1-\hat{\alpha}})^2$ and $\hat{\alpha} < \widetilde{\alpha}_n$

Lemma 2. *A single employer offering nonlinear labour contracts, leads to the optimal base wage of* ${w_n}^* = \frac{1-\widetilde{\alpha}_n}{1-\hat{\alpha}} \cdot P - \widetilde{\alpha}_n \cdot \Delta$, *a mass of employees of* $\widetilde{\alpha}_n^* \cdot \tilde{\beta}_n^* = \frac{\widetilde{\alpha}_n - \hat{\alpha}}{1-\hat{\alpha}}$, *and optimal profit in the amount of* ${\Pi_n}^* = \frac{\widetilde{\alpha}_n - \hat{\alpha}}{1-\hat{\alpha}} \cdot (P - \frac{1-\hat{\alpha}}{1-\widetilde{\alpha}_n} \cdot w_r)$.

2.2.3 Optimal labour contracts for the single employer scenario

Comparing the profit that an employer can secure offering either labour contracts, one can demonstrate that linear labour contracts are always preferred, even for an ambiguity loving employer. This is so because, although an employer might have appeared to be more generous when offering nonlinear wage contracts, since such contracts would provide for larger bonuses, they also involve lower base wages, ultimately leading to fewer agents employed in equilibrium, as well as lower profits than linear wage contracts.

Proposition 1. *A single employer prefers offering linear over non-linear labour contracts.*

To summarise, both the employer and their employees prefer linear over non-linear labour contracts: the employer obtains a higher profit and the base wage is higher than under non-linear labour contracts. Fewer agents would be employed even if they were promised positive a bonus when facing the prospects of a 'bad' scenario.

Table 1: Summary of results for the single employer scenario

	Linear Contract	**Nonlinear Contract**	**Comparison**
w^*	$(w_r \cdot P)^{\frac{1}{2}}$	$\frac{\tilde{\alpha}_n(1-\hat{\alpha})w_r}{(\tilde{\alpha}_n-\hat{\alpha})(1-\tilde{\alpha}_n)} - \frac{\hat{\alpha}(1-\tilde{\alpha}_n)\cdot P}{(\tilde{\alpha}_n-\hat{\alpha})(1-\hat{\alpha})}$	${w_n}^* < w^*$
Δ^*	NA	$\frac{(1-\tilde{\alpha}_n)^2\cdot P-(1-\hat{\alpha})^2\cdot w_r}{(\tilde{\alpha}_n-\hat{\alpha})(1-\hat{\alpha})(1-\tilde{\alpha}_n)}$	$\frac{\mathrm{d}\Delta}{\mathrm{d}w_n} < 0$
$\tilde{\alpha}^*\tilde{\beta}^*$	$1-(\frac{w_r}{P})^{\frac{1}{2}}$	$\frac{\tilde{\alpha}_n-\hat{\alpha}}{1-\hat{\alpha}}$	$\tilde{\alpha}_n^* \cdot \tilde{\beta}_n^* < \tilde{\alpha}^*\tilde{\beta}^*$
Π^*	$w_r + P$	$\frac{\tilde{\alpha}_n-\hat{\alpha}}{1-\hat{\alpha}} \cdot (P - \frac{1-\hat{\alpha}}{1-\tilde{\alpha}_n} \cdot w_r)$	${\Pi_n}^* < \Pi^*$
Restrictions	$w_r < w^* < P$	$\frac{\hat{\alpha}}{\tilde{\alpha}_n}(\frac{1-\tilde{\alpha}_n}{1-\hat{\alpha}})^2 < \frac{w_r}{P} < (\frac{1-\tilde{\alpha}_n}{1-\hat{\alpha}})^2$ and $\hat{\alpha} < \tilde{\alpha}_n$	NA

2.3 Analysis: Competing Employers Scenario

Now, let us consider the scenario with two employers competing for employees in the labour market. Let us distinguish employer a and employer b, and look at whether they compete for employees offering either a linear or a nonlinear labour contract, mapping the analysis provided for the situation with a single employer. We will use subscripts 'a' and 'b' to refer to the strategic variables set by each of these employers, so that, for instance, the base wages they offer would be w_a and w_b, respectively. Once more, we assume these employers not to have any market power in the output market and to take the price in the final product market as given. Furthermore, assume they are competing perfectly over the labour market, so that they end up making no profits.

Furthermore, employees extract all rents from competing employers offering their labour contracts, such that the indifferent employee's type would be just indifferent to work for either employer, so long that the following condition holds:

$$\widetilde{w_a} = (1-\tilde{\alpha}_{ab}) \cdot w_a + \tilde{\alpha}_{ab} \cdot (1-\tilde{\beta}_{ab}) \cdot (w_a + \Delta_a) = (1-\tilde{\alpha}_{ab}) \cdot w_b + \tilde{\alpha}_{ab} \cdot (1-\tilde{\beta}_{ab}) \cdot (w_b + \Delta_b) = \widetilde{w_b}$$

This implies that in equilibrium there exists symmetry in the offered labour contracts across employers.

2.3.1 Linear wage contracts

In the competition case with linear labour contracts, $\Delta_a = \Delta_b = 0$. Therefore, the two employers need to offer the same base wage in equilibrium, so that $w_a^* = w_b^* = w^*$.

Given the perfectly competitive assumption in the final product market, we also know that $w^* = P$.

Next, consider that the perceived expected wage for an employee to be indifferent between accepting to work for either employer, should guarantee the following condition to hold

$$\widetilde{w^*} = (1 - \tilde{\alpha}_{ab}) \cdot w^* + \tilde{\alpha}_{ab} \cdot (1 - \tilde{\beta}_{ab}) \cdot w^* = P$$

Or, substituting $w^* = P$ in it:

$$\widetilde{w^*} = (1 - \tilde{\alpha}_{ab}) \cdot P + \tilde{\alpha}_{ab} \cdot (1 - \tilde{\beta}_{ab}) \cdot P = P$$

This condition is satisfied if and only if

$$\widetilde{\alpha^*_{ab}} \cdot \widetilde{\beta^*_{ab}} = 0,$$

which implies that no agent will accept a linear contract offered by competing employers.

Lemma 3. *Competing employers offering linear labour contracts, lead to the optimal base wage of $w_a^* = w_b^* = w^* = P$ and optimal profit in the amount of $\Pi_a^* = \Pi_b^* = \Pi^* = 0$, and no agent will accept a linear contract.*

2.3.2 Nonlinear wage contracts

This brings us to the analysis of the alternative, non-linear labour contracts we explored in the single employer scenario. In this analysis, we restrict each employer's ambiguity aversion to satisfy the following assumption:

Assumption 8. *The two competing employers share a common ambiguity aversion, $\hat{\alpha}_n$, which follows the same i.i.d. distribution as those of employees, i.e., $f(\hat{\alpha}_n) \sim U(0,1)$.*

Under nonlinear labour contracts, each employer obtains the following profit, so long as they offer the same perceived wage to prospective employees, thereby equally sharing the mass of employed workers among themselves:

$$\Pi_{an} = \frac{1}{2}(\tilde{\alpha}_{abn} \cdot \tilde{\beta}_{abn}) \cdot (P - w_{an} - \hat{\alpha}_n \Delta_a)$$

$$\Pi_{bn} = \frac{1}{2}(\tilde{\alpha}_{abn} \cdot \tilde{\beta}_{abn}) \cdot (P - w_{bn} - \hat{\alpha}_n \Delta_b)$$

Once more, our perfectly competitive market assumption demands that $P - w^*_{an} - \hat{\alpha}_n \Delta^*_a = 0 = P - w^*_{bn} - \hat{\alpha}_n \Delta^*_b$. Put differently:

$$P = w^*_{an} + \hat{\alpha}_n \Delta^*_a = w^*_{bn} + \hat{\alpha}_n \Delta^*_b \tag{7}$$

Recall that:

$$\widetilde{w}_{an} = (1 - \tilde{\alpha}_{abn}) \cdot w_{an} + \tilde{\alpha}_{abn} \cdot (1 - \tilde{\beta}_{abn}) \cdot (w_{an} + \Delta_a) = P$$

$$\widetilde{w}_{bn} = (1 - \tilde{\alpha}_{abn}) \cdot w_{bn} + \tilde{\alpha}_{abn} \cdot (1 - \tilde{\beta}_{abn}) \cdot (w_{bn} + \Delta_b) = P$$

Given the above, we can obtain the following conditions:

$$(1 - \tilde{\alpha}_{abn}) \cdot w_{an} + \tilde{\alpha}_{abn} \cdot (1 - \tilde{\beta}_{abn}) \cdot (w_{an} + \Delta^*_a) = P = w_{an} + \hat{\alpha}_n \Delta_a$$

$$\tilde{\alpha}_{abn}\tilde{\beta}_{abn} = \frac{(\tilde{\alpha}_{abn} - \hat{\alpha}_n)\Delta_a}{(w_{an} + \Delta_a)}$$

If $\tilde{\alpha}_{abn} > \hat{\alpha}_n$, then $\tilde{\alpha}^*_{abn}\tilde{\beta}^*_{abn} > 0$. Therefore, this implies that in equilibrium if the employees are more ambiguity averse than competing employers, a positive mass of employees will accept the nonlinear contract, whereas no agent will accept a linear contract offered by competing employers.

Lemma 4. *Competing employers offering linear labour contracts, lead to the optimal base wage of $w^* = P - \hat{\alpha}_n \Delta_a = P - \hat{\alpha}_n \Delta_b$, a mass of employees of $\tilde{\alpha}^*_{abn}\tilde{\beta}^*_{abn} = \frac{(\tilde{\alpha}_{abn} - \hat{\alpha}_n)\Delta_a}{(w_a + \Delta_a)}$, and optimal profit in the amount of $\Pi^* = 0$.*

2.3.3 Optimal labour contracts for the competing employers scenario

With competing employers, the equilibrium labour contracts that emerge are nonlinear: both linear and nonlinear contracts lead employers to break even (therefore to be indifferent between offering either type of contracts), but employees are strictly better off when accepting nonlinear contracts from competing employers.

Table 2: Summary of results for the competing employers scenario

	Linear Contract	**Nonlinear Contract**	**Comparison**
w^*	${w_a}^* = {w_b}^* = P$	$w_{an}^* = P - \hat{\alpha}_n \Delta_a^* = P - \hat{\alpha}_n \Delta_b^* = w_{bn}^*$	${w_a}^* = {w_b}^* > {w_{an}}^* = {w_{bn}}^*$
$\tilde{\alpha}^* \tilde{\beta}^*$	0	$\frac{(\tilde{\alpha}_{abn} - \hat{\alpha}_n)\Delta_a}{(w_a + \Delta_a)}$	$\tilde{\alpha}_{abn}^* \cdot \tilde{\beta}_{abn}^* > \tilde{\alpha}_{ab}^* \tilde{\beta}_{ab}^* = 0$
Π^*	0	0	$no - difference$
Restrictions	NA	$\tilde{\alpha}_{abn} > \hat{\alpha}_n$	NA

Proposition 2. *With competing employers, no agent accepts linear labour contracts.*

To summarise, employees prefer nonlinear over linear labour contracts, while competing employers are indifferent between them: employers break even, employees capture all rents, and although employees' perceived wages are the same across labour contracts, the mass of employees increases in equilibrium under nonlinear contracts (becoming strictly positive).

3 Conclusion and Further Research

We explore theoretically how ambiguity sharing labour contracts may emerge under the *New Normal*. We describe our labour market using a modified Hotelling model (Hotelling, 1929, 1990). We suppose there exist two possible states of nature/events, the normal state and an unknown bad state or *New Normal*. The *New Normal* state is such that extra costs are to be incurred in the economy to adapt to it. In our model, an employee's ambiguity attitude and their ability to adapt to the *New Normal* will affect their perceived wage, thereby also determining whether they will likely accept or reject a labour contract, specifying a given nominal wage. We analyse the model considering alternatively linear and nonlinear wage contracts, under two distinct scenarios: (1) a single employer, and (2) competing employers.

Our model tells us that: (1) In the single employer scenario, both the employer and their employees prefer linear over non-linear labour contracts: the employer obtains a higher profit and the expected wage is higher than under non-linear labour contracts; although an employer might have appeared to be more generous when offering nonlinear wage contracts, since such contracts would provide for larger bonuses, they also involve lower base wages, ultimately leading to fewer agents employed in equilibrium. (2) In the competing employers scenario, the equilibrium labour contracts that emerge are nonlinear: both linear and nonlinear contracts lead employers to break even (therefore to be indifferent between offering either type of contracts), but employees are strictly better off when accepting nonlinear contracts from competing employers.

With our work, we contribute to filling the gap in the study of how ambiguity sharing labour contracts emerge under the *New Normal*. Understanding how ambiguity aversion affects agents' decisions on accepting or rejecting a labour contract can help us to find which information might be relevant to consider in the formation and use of labour contracts. Furthermore, we add to the literature by analysing the implications of the design of the unemployment insurance system, thereby providing alternative explanations for labour sharing contracts under the *New Normal*.

We aimed to explore theoretically how ambiguity sharing labour contracts may emerge under the *New Normal*. We assumed that each unit of output were sold in economy at a fixed price P, which allowed us to abstract from the potential market power that the employer could possess on the final product market. In reality, under the *New Normal*, such as during a pandemic that we concentrated on as a motivation for our study, the final prices of products and services available in the economy are likely to increase (due to rationing, eventually). For those businesses that are operating at various alert levels during a pandemic, there will be pressures along the supply chain to maintain their inventories and to be able to reach customers in the final market. These adjustments are likely to put extra pressures on employees who will have to adopt strategies to adjust to the new ways of delivering their services and assist in selling products, in challenging times, as opposed to when it is 'business as usual'. Therefore, whilst it is reasonable to assume that the prices of good and services in the economy remain fixed in the short run, it is equally plausible that prices would raise due to the disruptions in the supply chains and related shortages that some sectors might experience, as a result of a prolonged pandemic, for instance. Further research could consider relaxing this assumption, as well as explore how alternative ambiguity sharing labour contracts could emerge in the long run, when other market conditions are allowed to change too.

References

Anderson, P. M. and Meyer, B. D. (2000). The effects of the unemployment insurance payroll tax on wages, employment, claims and denials. *Journal of Public Economics*, 78(1-2):81–106.

Baily, M. N. (1977). On the theory of layoffs and unemployment. *Econometrica: Journal of the Econometric Society*, 45(5):1043–1063.

Blanchard, O. J. and Tirole, J. (2008). The joint design of unemployment insurance and employment protection: A first pass. *Journal of the European Economic Association*, 6(1):45–77.

Burdett, K. and Wright, R. (1989). Optimal firm size, taxes, and unemployment. *Journal of Public Economics*, 39(3):275–287.

Cohen, M., Gilboa, I., Jaffray, J.-Y., and Schmeidler, D. i. (2000). An experimental study of updating ambiguous beliefs. *Risk, Decision and Policy*, 5(2):123–133.

Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *The Quarterly Journal of Economics*, 75(4):643–669.

Fath, J., Fuest, C., et al. (2005). Risk aversion does not justify the introduction of mandatory unemployment ins urance in the shirking model. Technical report.

Feldstein, M. (1976). Temporary layoffs in the theory of unemployment. *Journal of Political Economy*, 84(5):937–957.

Feldstein, M. (1978). The effect of unemployment insurance on temporary layoff unemployment. *The American Economic Review*, 68(5):834–846.

Fredriksson, P. and Holmlund, B. (2006a). Improving incentives in unemployment insurance: A review of recent research. *Journal of Economic Surveys*, 20(3):357–386.

Fredriksson, P. and Holmlund, B. (2006b). Optimal unemployment insurance design: Time limits, monitoring, or workfare? *International Tax and Public Finance*, 13(5):565–585.

Ghirardato, P., Maccheroni, F., and Marinacci, M. (2004). Differentiating ambiguity and ambiguity attitude. *Journal of Economic Theory*, 118(2):133–173.

Gilboa, I. (1987). Expected utility with purely subjective non-additive probabilities. *Journal of Mathematical Economics*, 16(1):65–88.

Gilboa, I. and Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. *Journal of Mathematical Economics*, 18(2):141–153.

Gilboa, I. and Schmeidler, D. (1993). Updating ambiguous beliefs. *Journal of Economic Theory*, 59(1):33–49.

Grant, S., Rich, P., and Stecher, J. D. (2019). Worst-and best-case expected utility and ordinal metautility. *Available at SSRN 3369078*.

Gruber, J. (1997). The consumption smoothing benefits of unemployment insurance. *The American Economic Review*, 87(1):192–205.

Gul, F. and Pesendorfer, W. (2015). Hurwicz expected utility and subjective sources. *Journal of Economic Theory*, 159(Part A):465–488.

Hansen, G. D. and Imrohoroğlu, A. (1992). The role of unemployment insurance in an economy with liquidity constraints a nd moral hazard. *Journal of Political Economy*, 100(1):118–142.

Hey, J. D., Lotito, G., and Maffioletti, A. (2010). The descriptive and predictive adequacy of theories of decision making under uncertainty/ambiguity. *Journal of Risk and Uncertainty*, 41(2):81–111.

Hotelling, H. (1929). Stability in competition. *The Economic Journal*, 39(153):41–57.

Hotelling, H. (1990). Stability in competition. In *The Collected Economics Articles of Harold Hotelling*, pages 50–63. Springer.

Hurwicz, L. (1951). Some specification problems and applications to econometric models. *Econometrica*, 19(3):343–344.

Newbery, D. M. G. (1977). Risk sharing, sharecropping and uncertain labour markets. *The Review of Economic Studies*, 44(3):585–594.

Rebollo-Sanz, Y. (2012). Unemployment insurance and job turnover in spain. *Labour Economics*, 19(3):403–426.

Savage, L. J. (1954). The foundations of statistics, jon wiley and sons. *Inc.: New York, Chapman Hall Ltd., London.*

Savage, L. J. (1972). *The foundations of statistics*. Courier Corporation.

Schmeidler, D. (1989). Subjective probability and expected utility without additivity. *Econometrica: Journal of the Econometric Society*, 57(3):571–587.

Smith, C. A. (1961). Consistency in statistical inference and decision. *Journal of the Royal Statistical Society: Series B (Methodological)*, 23(1):1–25.

Tatsiramos, K. and Van Ours, J. C. (2014). Labor market effects of unemployment insurance design. *Journal of Economic Surveys*, 28(2):284–311.

Topel, R. H. (1983). On layoffs and unemployment insurance. *The American Economic Review*, 73(4):541–559.

Wald, A. (1949). Statistical decision functions. *The Annals of Mathematical Statistics*, 20(2):165–205.