Zero-Sum Thinking in Search Equilibrium

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Abstract

I study a search equilibrium model of a labor market with zero-sum thinking workers. Under the assumption of wage rigidity and two-sided lack of commitment, match surplus is endogenously determined by firms and workers' strategies. Zero-sum thinking is modeled as a biased perception of how match surplus is determined. In particular, zero-sum thinking workers perceive surplus as exogenous and behave as if any gain for the firm comes at a loss for them, and vice versa. I show that zero-sum thinking implies both a bias on the job destruction rate and on the job finding probability. As a result, zero-sum thinking workers quit the job prematurely, decreasing firms value and the job finding rate in the economy. The economy exhibits higher unemployment, lower aggregate surplus, and a redistribution of value from firms to workers compared to a rational expectations benchmark. These inefficiencies are further amplified in response to an inflationary shock.

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1 Introduction

This paper explores the implications of zero-sum thinking in labor market. Zero-sum thinking is defined as the subjective belief that, independently of the actual nature of the game, the gains of one party inevitably come as the losses of other parties. Rozycka-Tran et al. 2015 define it as a "*general belief system about the antagonistic nature of social relations*", based on the assumption that a finite amount of goods exists in the world. The concept was first proposed by the anthropologist George Foster to describe the "*image of limited good*" shared by individuals in many small-scale societies he had studied. Zero-sum thinking is essentially a misperception of the nature of the game played, and as such, it is a widespread bias of human behavior shown to be relevant in multiple economic and political contexts. Recently, Chinoy et al. (2024) showed how zero-sum thinking correlates with political preferences about redistribution, affirmative action, and immigration policies. Carvalho et al. (2023) study how zero-sum thinking gives rise to demotivating beliefs that reduce aggregate welfare. Finally, Ali et al. (2025) build a political economy model to show how zero-sum thinking can arise as an equilibrium outcome in elections.

While zero-sum thinking has been increasingly studied in economics in recent years, the macroeconomic implications of zero-sum thinking are yet to be explored. In general, zero-sum thinking depict social relationships as inherently conflictual and distort people's understanding of surplus sharing. As such it is especially relevant when it comes to negotiations or bargaining games (Carnevale and Pruitt, 1992), for example in the labor market. In particular, I propose a search and matching labor market model with zero-sum thinking workers that wrongly perceive the nature of the bargaining game, this influences the bargaining outcome and changes their optimal strategies.

As a labor market model with a departure from rational expectation assumption, this paper also speaks to the recent literature on behavioral macroeconomics (Gabaix 2019, 2020). In the search and matching literature (Pissarides 1985, Mortensen and Pissarides 1994 or Shimer 2005) it is standard to assume that workers have perfect information and rational expectations. To my knowledge, Menzio (2022) is one of the few paper introducing behavioral insights into a general equilibrium search and matching model. Assuming that workers' have *stubborn beliefs* about aggregate productivity he rationalize some recent findings about the expected job-finding probability not changing in response to new individual nor aggregate information (Mueller, Spinnewjin and Topa, 2019). In Menzio's model workers believe that all the fundamentals of the economy are constant over time. While their beliefs are correct on average, stubbornness leads to a biased perception of how the job-finding probability responds to the duration of unemployment or to business cycle conditions. A similar result derives from the assumption of zero-sum thinking. While zero-sum thinking is modeled as a biased perception of the bargaining game, it still give rise to a similar form of stubbornness when it comes to expectations about job-finding and job destruction probabilities. In labor market models in the style of Pissarides (1985) the surplus is exogenously determined by the fundamentals of the economy, therefore the bargaining game is by definition a zero-sum game. On the other hand, in recent models like Blanco et al. (2025) and Afrouzi et al. (2025) the surplus is endogenously determined by workers' and firms' optimal strategies. This non-zero sum nature of the bargaining game results from two crucial assumptions: *two-sided lack of commitment to stay in the match* and *nominal wage rigidity.* A job is destroyed as soon as the value of the staying in the match becomes negative either for the firm or the worker. Workers' will voluntarily quit the match if the wage is too low relative to their productivity; while the firm will layoff the worker if the wage is too high relative to its productivity. In this non-zero sum setting a change in the bargained wage has two effects: a *sharing effect* (it changes the division of surplus between firm and worker) and a *level effect* (it changes the overall level of surplus). For example, for a given level of productivity, an increase in the bargained wage redistributes surplus from the firm to the worker (sharing effect). But, for *too high* wages the firm will eventually layoff the worker, destroying the job and the surplus of the match (level effect). The same happens for lower wages with the worker quitting the match. While they play the bargaining game, zero-sum thinking workers do not internalize the *level effect* on surplus but only take into account the *sharing effect*. That is, they behave as if the game was zero-sum and the surplus was exogenously determined, independent from the bargained wage. Workers will therefore interpret any of their losses (gain) as an equal gain (loss) for the firm. This conflictual misperception of the game modifies the negotiation outcome and also the optimal behavior of both workers and firm, leading to an inefficiently high destruction rate, low job finding probability and high unemployment. As a result, zero-sum thinking reduces aggregate surplus. All this inefficiencies are amplified as the economy responds to an aggregate inflationary shock.

2 The Model

I propose a simple search-and-matching model that combines elements from Menzio (2022) and Afrouzi et al. (2024), and introduces zero-sum thinking as a bias in workers' perceptions. Following Menzio (2022), biased workers form expectations and make decisions based on their subjective model of the world, rather than the objective one. In line with Afrouzi et al. (2024), the model's structure gives rise to a non-zero-sum bargaining environment, in which the surplus is endogenously determined by firms and workers' strategies.

2.1 Environment

Time is discrete. The labor market is populated by a measure one of workers and a positive measure of firms. Workers and firms discount future values at a factor $\beta \in (0, 1)$. When employed, the worker gets a nominal wage $\hat{w}$ and produces y_t units of output. In the economy there is one good with exogenous price P_t. The price of the good grows at a constant rate π. I define the real wage at time t as $w_t = \frac{\hat{w}}{P_t}$. Workers' specific productivity y follows a stochastic AR(1) process with state dependent drift $\mu(E)$, where E defines if the worker is unemployed or unemployed. When a worker with productivity y_t is unemployed it receives a real income of $b \cdot y_t$. Job search is frictional and directed, both on firm and worker sides.

Unemployed workers search for vacant positions and firms search for new workers. Firms post wage-specific vacancies for workers with productivity y_t at a cost of $k \cdot y_t$. At any point in time the outcome of the search is given by the constant return to scale matching function $M(u, v)$, where u is the number of unemployed workers and v is the number of vacant positions. We define the labor market tightness as the number $\theta \equiv v/u$, that is the number of vacancies per unemployed worker. An unemployed worker meets a vacancy with probability $p(\theta) \equiv \frac{M(u,v)}{u} = M(1, \theta)$, a strictly increasing and concave function with $p(0) = 0$ and $p(\infty) = 1$. Similarly, a vacancy meets an unemployed worker with probability $q(\theta) \equiv \frac{M(u,v)}{v} = M(\frac{1}{\theta}, 1) = \frac{p(\theta)}{\theta}$, a strictly decreasing function with $q(0) = 1$ and $q(\infty) = 0$. Given that firms post productivity specific vacancies, we can define $\theta_t(y)$ as the tightness of the sub-market with productivity y at time t. This implies that the probabilities defined above are also productivity specific.

Once in a match, wage renegotiation is subject to two nominal frictions: workers and firms can renegotiate the wage at time t with exogenous probability λ, and upon bargain workers pay a fixed cost χ in utility terms. The outcome of the negotiation is the result of a Nash Bargain where I define the bargaining power of worker and firm respectively as γ and γ. As I am going to show, zero-sum thinking workers have a biased perception of their value both from employment and unemployment, therefore the outcome of the bargaining process will be influenced by the presence of the bias.

Neither the firm nor the worker is committed to staying in the match. At any point in time, given the worker's wage and productivity, either party can unilaterally choose to leave the match. As a result, the probability of destruction of the match will be endogenously determined by the optimal choices of firm and worker, being therefore a function both of real wages and productivity. For example, given a certain level of productivity, a sufficiently high real wage induces the firm to terminate the match, while a sufficiently low real wage leads the worker to voluntarily quit. Accordingly, as the real wage deviates significantly from the productivity level, the job destruction probability approaches one. Both worker and firm's value from staying in the match are influenced by the job destruction probability: when the probability goes to one the value of staying in the match goes to zero for both parties. Defining the surplus of the match as the sum of the values of both parties we get that the surplus will tend to zero for extreme values of the bargained wage. Given that the surplus is endogenously determined, matched workers and firms are playing a non-zero sum game. However, zero-sum thinking workers do not take into account the actual nature of the game but behave as if any variation of their value was equal to an opposite variation of firm's value. From their perspective, the surplus is exogenously determined and independent from the wage: changing the bargaining outcome only affect the share of the surplus but not its level.

Finally I define the timing of the model as follows: (i) the worker's idiosyncratic productivity is realized; (ii) firms and workers engage in wage renegotiation; (iii) matches are either dissolved or continued; (iv) unemployed workers transition into employment; and (v) all agents receive their respective incomes (wages, production output, unemployment benefits).

2.2 Equilibrium

I start by defining the value functions that characterize firms and workers' optimal choices and the bargaining process. Zero-sum thinking workers form expectations about the economy by solving a subjective version of the model. The bias alter their perception of the economy and of the equilibrium variables. I denote with $\delta_t(w, y)$ the probability that a match with real wage w and productivity y is destroyed at time t. As I will show, assuming that workers have a zero-sum thinking bias implies that they have a bias on the destruction rate. In particular, the perceived job destruction probability $\hat{\delta}_t(y)$ is independent of the wage w_t and it is exogenously determined by workers' productivity. From their misperception of the destruction rate will follow a general misperception of equilibrium values. I denote with $U(y)$ and $V(y)$ respectively the actual value of an unemployed worker and of a vacant position with productivity y, and with $\hat{U}(y)$ and $\hat{V}(y)$ the same values as perceived by a zero-sum thinking worker. Similarly, I use $E(w,y)$ and $J(w,y)$ respectively for the value of an employed worker and the value of a firm in a match with wage w and productivity y. As before, I will use $\hat{E}(w,y)$ and $\hat{J}(w,y)$ to denote the perceived values. I also denote by $\theta(y)$ the actual market tightness in the sub-market with productivity y and by $\hat{\theta}(y)$ the perceived tightness in the same sub-market.

I use $w^*(y)$ for the outcome of the bargaining process, $w_e(y)$ for the entry wage and $w(y)$ for the current wage of the worker, all in a match with productivity y. I will use the notation $w_{t+1} \equiv \frac{w_t}{1+\pi}$ to denote the real wage eroded by inflation.

At any point in time workers and firms within the match can negotiate a new wage with probability λ. Given this exogenous parameter and the renegotiation wage w^*, I define the bargaining hazard function $\lambda(w,y) = \lambda \cdot \mathbb{I}_{w<w^*}$, that is the rate at which positive renegotiation happen in a match with real wage w and productivity y.

2.2.1 Actual Values and Equilibrium Variables

The actual values of workers' employment and unemployment and firms' job and vacancy are respectively given by the following Bellman equations.

$$\begin{aligned} E_t(w_t,y_t) = w_t + \beta\,\mathbb{E}_y\Big[&\lambda(w_{t+1},y_{t+1})\big((1-\delta(w^*(y_{t+1}),y_{t+1}))\,(E_{t+1}(w^*(y_{t+1}),y_{t+1})-\chi) \\ &+ \delta(w^*(y_{t+1}),y_{t+1})\;U_{t+1}(y_{t+1})\big) \\ &+ (1-\lambda(w_{t+1},y_{t+1}))\big((1-\delta(w_{t+1},y_{t+1})\big)\,E_{t+1}(w_{t+1},y_{t+1}) \\ &+ \delta(w_{t+1},y_{t+1})\,U_{t+1}(y_{t+1})\big)\Big] \end{aligned} \tag{1}$$

When employed at time t workers are payed a real wage w_t by the firm. In the following period, with probability $\lambda(w_{t+1},y_{t+1})$ they renegotiate and get a wage w^* that depends on their productivity at that time. When they renegotiate they also incur in a fixed cost χ. With probability $1-\lambda(w_{t+1},y_{t+1})$ they do not renegotiate and their real wage is eroded by inflation. In both scenarios with probability $1-\delta$ the match survives and they get their value from employment, while with probability δ the match is destroyed and they become unemployed. The probability δ depends both on wage and productivity.

$$U_t(y_t) = b(y) + \beta\,\mathbb{E}_y\Big[p(\theta_{t+1}(y_{t+1})\,E_{t+1}(w_e(y_{t+1}), y_{t+1}) + \big(1 - p(\theta_{t+1}(y_{t+1}))\big)\,U_{t+1}(y_{t+1})\Big] \quad (2)$$

When unemployed at time t workers enjoy their leisure from unemployment $b(y) = b \cdot y$. In the future, with probability $p(\theta)$ they will find a job and become employed with the entry wage w_e, while with probability $1 - p(\theta)$ they will stay unemployed.

$$\begin{aligned} J_t(w_t, y_t) = y_t - w_t + \beta\,\mathbb{E}_y\Big[&\lambda(w_{t+1}, y_{t+1})\big((1 - \delta(w^*(y_{t+1}), y_{t+1}))\,J_{t+1}(w^*(y_{t+1}), y_{t+1}) \\ &+ \delta(w^*(y_{t+1}), y_{t+1}))V_{t+1}(y_{t+1})\big) \\ &+ (1 - \lambda(w_{t+1}, y_{t+1}))\big((1 - \delta(w_{t+1}, y_{t+1})\big)\,J_{t+1}(w_{t+1}, y_{t+1}) \\ &+ \delta(w(y_{t+1}), y_{t+1}))V_{t+1}(y_{t+1})\big)\Big] \end{aligned} \quad (3)$$

Upon matching, firms at time t get a real income y_t and pay the real wage w_t to workers. Again, in the future, with probability $\lambda(w_{t+1}, y_{t+1})$ the wage is renegotiated and with probability $1 - \lambda(w_{t+1}, y_{t+1})$ the wage is eroded by inflation. In both cases the match survives and firms continue to get value from it with probability $1 - \delta$, otherwise the match is destroyed and the firm becomes vacant.

$$V_t(y_t) = -k(y_t) + q(\theta_t(y_t))J_t(w_e(y_t), y_t) \quad (4)$$

Finally the value of a vacant firm is equal to the cost $k(y) = k \cdot y$ incurred to open a vacancy in the sub-market with productivity y, plus the expected value from filling the vacancy (the probability of meeting a worker times the job value at the entry wage w_e).

Firms posts vacancies in the sub-market y until the marginal cost from opening a new vacancy is equal to the expected value of the match. Therefore, in equilibrium the value of a vacant firm is zero ($V_t(y) = 0$) for all sub-markets and the equilibrium market tightness is pinned down by the free entry condition:

$$k_t(y_t) = q(\theta_t(y_t))J_t(w_e(y_t), y_t) \tag{5}$$

2.2.2 Stopping Time Game and Endogenous Job Destruction

By assumption both firms and workers do not commit to stay in the match. Therefore, at any point in time they play a game to optimally choose whether or not they want to dissolve the match. I denote with $\mathbb{W}_J(y)$ the set of wages where, in a match with productivity y, the firm chooses to continue the match. I call $w_u(y)$ the highest value in $\mathbb{W}_J(y)$, for which $J(w_u(y), y) = 0$. Similarly, I denote with $\mathbb{W}_W(y)$ the set of wages where, in a match with productivity y, the worker chooses to continue the match. And I call $w_l(y)$ the lowest value in $\mathbb{W}_W(y)$, for which $\hat{E}(w_u(y), y) = \hat{U}(y)$. Note that zero-sum thinking workers take their quitting decision based on their perceived value, not the actual one. Therefore while their biased choices are adding an inefficiency to the economy, their behavior is still optimal relative to their perception of the world. Finally, for a given productivity level y we can define the continuation set of the match as the intersection of the two sets defined above $\mathbb{W}_J(y) \cap \mathbb{W}_W(y)$. This implies that the continuation set of a match with productivity y is the interval (($w_l(y)$,$w_u(y)$)), where both $w_l(y)$ and $w_u(y)$ are respectively the result of workers' and firms' optimal strategies.

The above strategies endogenously determine the probability of job (match) destruction $\delta(w, y)$. At any point in time, a match with with productivity y can be destroyed exogenously with probability $\bar{\delta}(y)$, or endogenously by the choice of firm and worker. Given the optimal strategies, we can therefore define the probability of job destruction as follows:

$$\delta(w, y) = \begin{cases} 1 & \text{if } w \leq w_l(y) \\ \bar{\delta}(y) & \text{if } w_l(y) < w < w_u(y) \\ 1 & \text{if } w \geq w_u(y) \end{cases} \tag{6}$$

2.2.3 Perceived Values and Equilibrium Variables

Similarly to Section 2.2.1. , I define the values of employment, unemployment and firm as perceived by the zero-sum thinking worker.

$$\begin{aligned}\hat{E}_t(w_t, y_t) = w_t + \beta\,\mathbb{E}_y\Big[&\lambda(w_{t+1}, y_{t+1})\big((1-\hat{\delta}(y_{t+1}))\,(\hat{E}_{t+1}(w^*(y_{t+1}), y_{t+1}) - \chi)\\ &+ \hat{\delta}(y_{t+1})\;\hat{U}_{t+1}(y_{t+1})\big)\\ &+ (1-\lambda(w_{t+1}, y_{t+1}))\big((1-\hat{\delta}(y_{t+1})\big)\,\hat{E}_{t+1}(w_{t+1}, y_{t+1})\\ &+ \hat{\delta}(y_{t+1})\,\hat{U}_{t+1}(y_{t+1})\big)\Big]\end{aligned} \tag{7}$$

$$\hat{U}_t(y_t) = b(y) + \beta\,\mathbb{E}_y\Big[p(\hat{\theta}_{t+1}(y_{t+1})\,\hat{E}_{t+1}(w_e(y_{t+1}), y_{t+1}) + \big(1 - p(\hat{\theta}_{t+1}(y_{t+1}))\big)\,\hat{U}_{t+1}(y_{t+1})\Big] \tag{8}$$

$$\begin{aligned}\hat{J}_t(w_t, y_t) = y_t - w_t + \beta\,\mathbb{E}_y\Big[&\lambda(w_{t+1}, y_{t+1})\big((1-\hat{\delta}(y_{t+1}))\,\hat{J}_{t+1}(w^*(y_{t+1}), y_{t+1})\\ &+ (1-\lambda(w_{t+1}, y_{t+1}))\big((1-\hat{\delta}(y_{t+1})\big)\,\hat{J}_{t+1}(w_{t+1}, y_{t+1})\Big]\end{aligned} \tag{9}$$

While the structure of the function is the same of before, zero-sum thinking workers have a biased perception of the job-destruction and job-finding probability. This misperception of the transition between employment and unemployment affect their perception of workers' and firms' value.

Workers form expectation about market tightness $\hat{\theta}$, and the job-finding probability $p(\hat{\theta})$, by solving the perceived free entry condition:

$$k_t(y_t) = q(\hat{\theta}_t(y_t))\hat{J}_t(w_e(y_t), y_t) \tag{10}$$

2.2.4 Zero-Sum Thinking

I now show why zero-sum thinking implies a bias on the destruction rate. By definition thinking in zero-sum terms means that for a given level of worker's productivity the perceived surplus is flat (independent from the wage). Therefore, any increase in the bargained wage leads to a gain in value for the worker that is exactly equal to the loss of the firm (the two variations always sum to zero). I define the actual surplus of the match as the sum of firms' workers' net value:

$$S(w, y) = J(w, y) + E(w, y) - U(y) \tag{11}$$

Using the definitions from Section 2.2.1, and rearranging the terms I can write the equation of the actual surplus at time t.

$$\begin{aligned} S_t(w_t, y_t) = y_t - b(y_t) + \beta\, \mathbb{E}_y \big[&\lambda(w_{t+1}, y_{t+1})(1 - \delta(w^*, y_{t+1}))S_{t+1}(w^*, y_{t+1}) \\ &+ (1 - \lambda(w_{t+1}, y_{t+1}))(1 - \delta(w_{t+1}, y_{t+1}))S_{t+1}(w_{t+1}, y_{t+1}) \big] \end{aligned} \tag{12}$$

At time t the surplus is given by the net product of the match $y_t - b_t$, plus the discounted value in the future. At time $t+1$ workers and firms renegotiate with probability $\lambda(w_{t+1}, y_{t+1})$ and the match is destroyed with probability δ. When the match is destroyed firms' continuation value is zero and workers' continuation value is unemployment, therefore the continuation value in terms of match surplus is zero.

In this model there is a one to one mapping between the perception of a surplus independent from the wage (zero-sum thinking) and the perception of the job-destruction probability independent from the wage. We define the perceived surplus as:

$$\hat{S}(y) = \hat{J}(w, y) + \hat{E}(w, y) - \hat{U}(y) \tag{13}$$

Now using (13) in (12) and guessing that $\hat{\delta}$ is independent from w we get:

$$\hat{S}_t(y_t) = y_t - b(y_t) + \beta\, \mathbb{E}_y \big[(1 - \hat{\delta}(y_{t+1}))\hat{S}_{t+1}(y_{t+1}) \big] \tag{14}$$

[1]

[1] Under zero-sum thinking the bargain hazard is irrelevant for the determination of the perceived surplus.

While it is true that zero-sum thinking implies a misperception of the job-destruction rate and vice versa, not any misperception of the job-finding rate allows me to clearly study the effect of zero-sum thinking. For example, lets suppose I simply assume that the perceived job-finding rate is equal to the exogenous rate $\bar{\delta}$. In a similar scenario the workers are not only thinking in zero-sum terms, but they are also systematically underestimating the aggregate job destruction probability in the economy, something that should not be directly related to zero-sum thinking. Moreover, as it is clear from Figure 1, workers in the US on average estimate correctly the aggregate job destruction probability (separation rate) at steady state. To isolate the effect of zero-sum thinking from any other form of misperception of the job destruction rate I assume that, at steady state, workers are on aggregate correct about their perception of the job destruction rate. Using the distribution at the beginning of each period (right after the realization of workers' productivity) we can calculate the aggregate separation rate for workers with productivity y as follows:

$$\Delta_{ss}(y) \equiv \int_w [\lambda\delta(w^*(y), y) + (1-\lambda)\delta(w(y), y)] \cdot \mu_{ss}(w|y)dw$$

Where I define with $\mu_{ss}(w|y)$ the share of employed workers with wage w and productivity y at steady state.

While the perceived aggregate separation rate for workers with productivity y is:

$$\hat{\Delta}_{ss}(y) \equiv \int_w [\lambda\hat{\delta}(y) + (1-\lambda)\hat{\delta}(y)] \cdot \mu_{ss}(w|y)dw = \hat{\delta}(y)$$

I assume not only that the perceptions of workers are correct on aggregate for the entire economy, but also that they are correct on aggregate for each productivity type. In this way I can attribute any heterogeneity in workers' behavior to the interaction between zero-sum thinking and workers' productivity. Therefore we finally get:

$$\hat{\Delta}_{ss}(y) = \Delta_{ss}(y) \implies$$

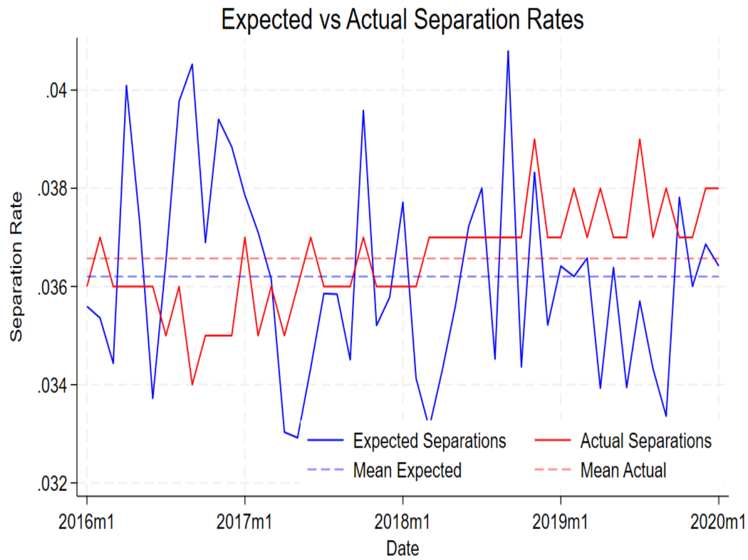

Figure 1: Expected vs Actual Separation Rates. The aggregate expected separation rate is constructed using data from the nationally representative Survey of Consumer Expectations of the New York Fed, based both on questions about voluntary quits and layoffs probability. The actual separation rate is calculated using data from the Bureau of Labor Statistics. I am considering the years before February 2020 to isolate the steady state feature of the labor market.

$$\implies \hat{\delta}(y) = \int_w [\lambda\delta(w^*(y), y) + (1-\lambda)\delta(w(y), y)] \cdot \mu_{ss}(w|y)dw \tag{15}$$

Knowing the entire distribution of employed workers in the economy, zero-sum thinking workers form their expectation about the match-specific destruction probability by solving the model and calculating the aggregate separation rate. However, the distribution itself is determined by the perception of zero-sum thinking workers about the destruction rate in the economy. Therefore, workers will find the fixed-point of this problem in order to form their expectations consistently. While this leads to an on-average correct expectation, they still do not internalize the effect that the bargained wage has on the match-specific destruction probability and therefore on the surplus level.

2.2.5 Wage Determination

When zero-sum thinking workers' are unemployed and search for a job, the entry wage is the result of a sub-market choice where they trade off the perceived benefit of finding a job quickly with the perceived value of finding a job that pays more. Therefore the entry wage is the solution to the following maximization problem:

$$w_e(y) = \arg\max_{w_e}\{p(\hat{\theta}(w_e, y)) \cdot [\hat{E}(w_e, y) - \hat{U}(y)]\} \tag{16}$$

I assume that the firm knows about the bias of the worker and therefore knows its subjective valuation; therefore there is no private information in the game. Moreover, the firm has no possibility of informing the worker about the true values. Under this assumptions, when workers and firms are already in a match, the new renegotiation wage is the Nash bargaining solution:

$$w^*(y) = \arg\max_{w^*}[J(w^*, y)^{1-\gamma} \cdot (\hat{E}(w^*, y) - \hat{U}(y))^{\gamma}] \tag{17}$$

Where the firm maximize its actual value J while the worker maximize its perceived value $\hat{E}(w^*, y) - \hat{U}(y))$. Both are weighted by the respective bargaining power.

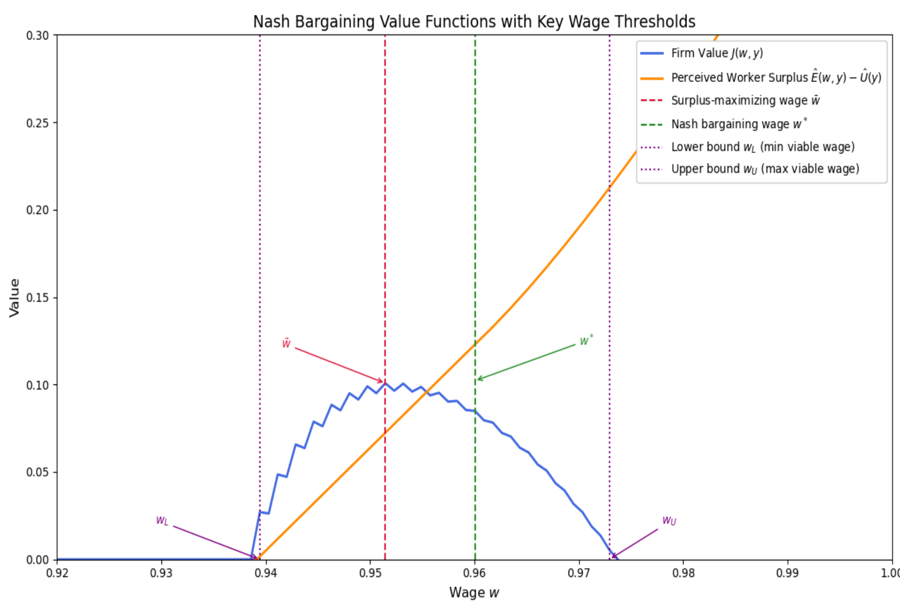

Figure 2: Nash Bargaining Value Functions.

To better describe what is happening during the bargaining and why there is not bilateral incentive to deviate from w^* I am plotting in Figure 2 the value functions used to find the Nash Bargaining solution (I am assuming equal bargaining power). As it is clear from the plot, as long as w^* is higher than $\bar{w}$, there is no possible deviation from the equilibrium. The firm would like to offer a lower wage but knows that the worker has no incentive to accept it. The same is true for the worker that would prefer an higher wage, but the firm would never accept such deviation. The only area where both would agree to deviate for an higher wage is between w_l and $\bar{w}$. Even though the plotted w^* is the result of assuming a specific $\gamma = 0.5$, it is clear that for any value of γ the Nash Bargain solution will never be below $\bar{w}$. Therefore, the w^* defined above will always be the equilibrium solution of the bargaining.

2.2.6 Equilibrium Definition

I can now define the equilibrium for the economy with zero-sum thinking workers. It will be useful to compare the Zero-Sum Thinking equilibrium with the Rational Expectation equilibrium where workers do not have any bias and form their expectations correctly. Therefore I define both the ZST and the RE equilibrium.

ZST Equilibrium. *A Zero-Sum Thinking (ZST) equilibrium is given by actual and perceived value functions* $\{S, E, U, J, V, \hat{S}, \hat{E}, \hat{U}, \hat{J}\}$*, actual and expected market tightness* $\{\theta,\hat{\theta}\}$*, wages* $\{w_l,w_u,w^*,w_e\}$ *and perceived destruction rate* $\hat{\delta}$ *such that:*

1. *The values* $\{S, E, U, J, V, \hat{S}, \hat{E}, \hat{U}, \hat{J}\}$ *satisfy conditions (1)-(4),(7)-(9) and (11)-(14);*

2. θ *and* $\hat{\theta}$ *satisfy respectively conditions (5) and (10);*

3. $w_e(y)$ *and* $w^*(y)$ *satisfy respectively conditions (16) and (17);*

4. w_l *and* w_u *are optimally chosen;*

5. $\hat{\delta}$ *satisfy condition (15).*

RE Equilibrium. *A Rational Expectation (RE) equilibrium is given by value functions* $\{S, E, U, J, V\}$*, expected market tightness* $\{\theta\}$ *and wages*$\{w_l,w_u,w^*,w_e\}$ *such that:*

1. *The values* $\{S, E, U, J, V\}$ *satisfy conditions (1)-(4) and (11)-(12);*

2. *θ satisfies condition (5);*

3. *$w_e(y)$ and $w^*(y)$ satisfy respectively conditions*

$$w_e(y) = \arg\max_{w_e}\{p(\theta(w_e, y)) \cdot [E(w_e, y) - U(y)]\}$$

and

$$w^*(y) = \arg\max_{w^*}[J(w^*, y)^{1-\gamma} \cdot (E(w^*, y) - U(y))^{\gamma}] \; ;$$

4. *w_l and w_u are optimally chosen.*

3 Quantifying the Model

In this section, I first calibrate the parameters of the RE model. Then, under those parameter values, I compare the RE model with the ZST one. I discuss the core differences between the two at steady state. Next, I briefly describe how both models respond to a one-time, unexpected inflationary shock, highlighting how ZST affects welfare losses from inflation.

3.1 Calibration

I calibrate the model using the simulated method of moments approach. I follow Afrouzi et al. (2024) in the choice of targeted moments. Table 1 shows the values for all the parameters of the model and the chosen targeted moments. The time period is one month. I set the monthly discount factor β to 0.995, consistent with the choice of Afrouzi et al. (2024) and an annual discount rate of 6% (Hall, 2017). The mean of the AR(1) productivity process is normalized to 1. Following Afrouzi et al. (2024), the standard deviation is set to 0.04, and the drift terms for employed and unemployed workers are set to 0.002 and -0.006, respectively. To approximate the Brownian motion assumed in their continuous-time model, I set the autoregressive parameter ρ of the AR(1) process to 0.99. The elasticity of the matching function is set to 0.5, standard value from Petrongolo and Pissarides (2001). The bargaining power parameter is set to 0.5, which is standard in the literature. The Calvo parameter λ is set to 0.076 to match the value chosen in Afrouzi et al. (2024) for the probability of positive adjustment. I set the values of the exogenous destruction rate $\bar{\delta}(y)$ using the same function $\bar{\delta}(y) = \delta_0 + \delta_1 \exp(\delta_2 y)$ and parameters of Afrouzi et al. (2024). I set the trend inflation parameter π equal to 0.0017 to match an annual trend inflation of 2%. Finally, I calibrate k and b to match respectively the average job-finding probability and the average separation rate in the US between January 2016 and January 2020.

Table 1: Model Parameters and Targeted Moments

Parameter	**Description**	**Value**	**Target/Moment**
β	Discount factor	0.995	Afrouzi et al.
ρ	AR(1) persistence	0.99	Afrouzi et al.
σ_z	Prod. shock std. dev.	0.04	Afrouzi et al.
γ_e, γ_u	Employed/unemp. drift	0.002, -0.006	Afrouzi et al.
α	Matching elasticity	0.5	Standard
τ	Bargaining power	0.5	Standard
λ	Calvo parameter	0.076	Afrouzi et al.
$\delta_0, \delta_1, \delta_2$	Separation rate params	0.006, 0.023, -2.11	Afrouzi et al.
$\bar{\pi}$	Trend inflation	0.0017	2% annual
K	Vacancy cost	0.10185	Avg. Job-finding rate
B	Unemp. Income	0.9304	Avg. Separation rate

3.2 Steady State

Using the parameters values discussed above, I solve both the RE model and the ZST model in steady state. Figure 3 shows, on the left, firms and workers' actual values from the match in the ZST model. In red it is highlighted the actual surplus. All values are plotted as a function of the wage markdown $w - y$. Both firms and workers' actual value are non-monotonic in the continuation set, they both tend to zero for extreme wage markdowns and reach the maximum inside the continuation region. This happens because the variation of wage markdown influences the value functions both directly and indirectly (through the destruction probability). Let us consider an increase in the wage markdown: the direct effect is positive for workers' value (they are paid more) and negative for firms' value (they have to pay more), while the indirect effect is negative for both (as we approach the upper boundary, the likelihood that the match will be endogenously destroyed by the firm increases). A similar mechanism is at work for a decrease in wage markdowns. As a result, the actual surplus of the match is also a non-monotonic function of the wage markdown. Again Figure 3, on the right, shows the values as perceived by zero-sum thinking workers. Firms and workers' perceived value are, respectively, monotonically decreasing and increasing in the wage markdown. Any variation in the perceived value of one party is exactly compensated by an opposite variation in the perceived value of the other. Therefore, the perceived surplus is flat and independent of the wage.

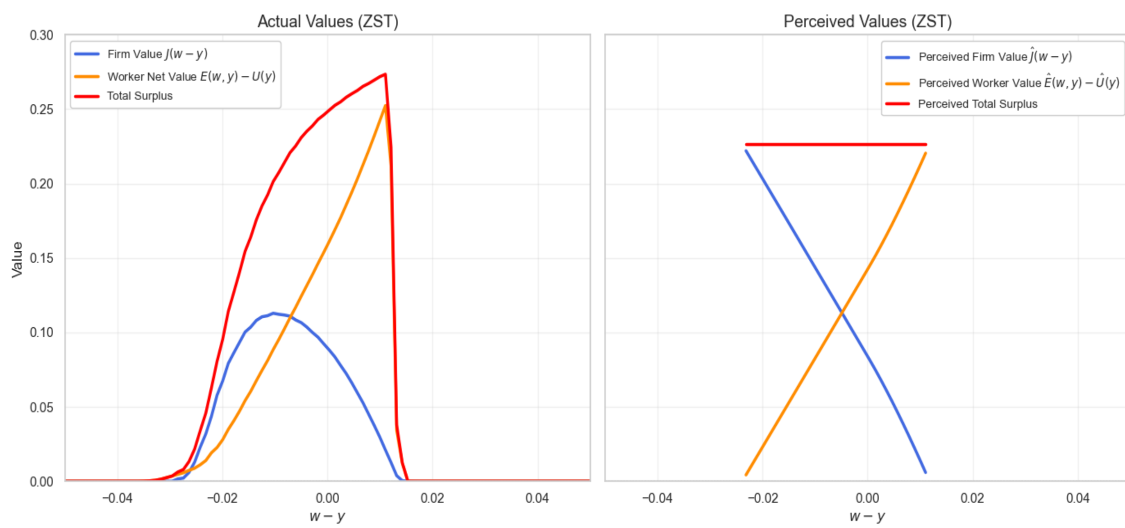

Figure 3: Actual and Perceived Values in the ZST model.

It is important to briefly discuss the effect of the bias on the quitting strategy of zero-sum thinking workers. Both firms and workers' actual value functions change their concavity inside the continuation region. In particular, they become convex as they get closer to the boundary resulting from their stopping strategy. This is again due to the endogenous destruction probability going to one for extreme values. As the wage markdown approach the boundary, the value becomes much more sensitive to variations in $w-y$. For example, for very low wage markdowns, both workers' and firms' values increase sharply as $w-y$ goes up because the endogenous destruction probability falls. However, this second-order effect is completely ignored by the zero-sum thinking worker. The implication is that the perceived workers' value from the match reaches 0 faster than the actual one, and as a result zero-sum thinking workers quit the match inefficiently early. This too high quitting rate negatively impacts the value of the firm, that internalizes the higher separation probability of the match and decides to layoff the worker earlier than in the RE model.

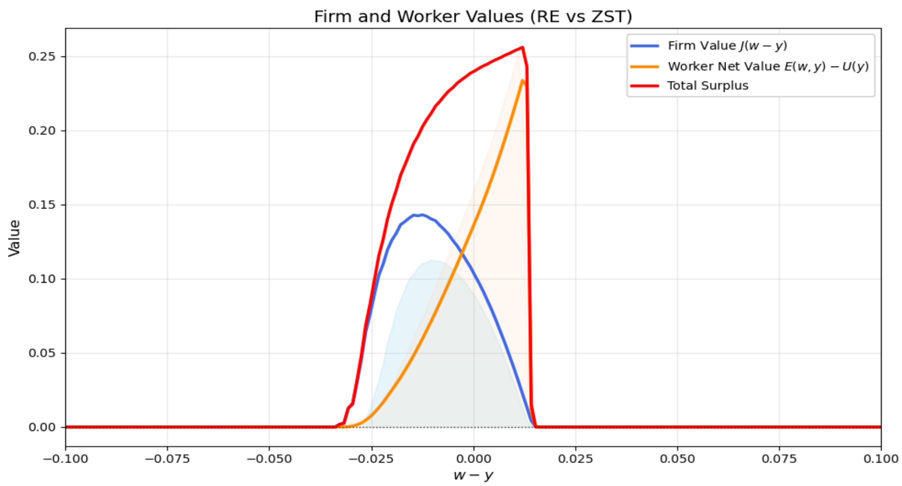

Figure 4: Actual Values in RE and ZST model.

The overall effect is represented in Figure 4, where I plot both actual values in the RE (line) and in the ZST (area) economy. The higher quitting rate in the ZST economy reduces the value of the firms in the match. The higher separation rate and the lower firms' value negatively affect the probability of finding a job, and therefore the value of unemployment. Reducing the outside option's value, this has a positive effect on workers' net value from staying in the match, relative to the RE model. The ZST economy has therefore a stricter continuation set and, for the matches that survive, a redistribution of the surplus from firms towards workers. However, the overall increase in workers' value do not compensate for the decrease in firms' value, leading to a lower surplus for all the productivity levels (Figure 5). The negative effect on average surplus seems to be decreasing in productivity and correlated with the redistribution effect. At the lowest productivity level workers' value is higher than firms' value, and the distance between ZST and RE surplus reaches its maximum.

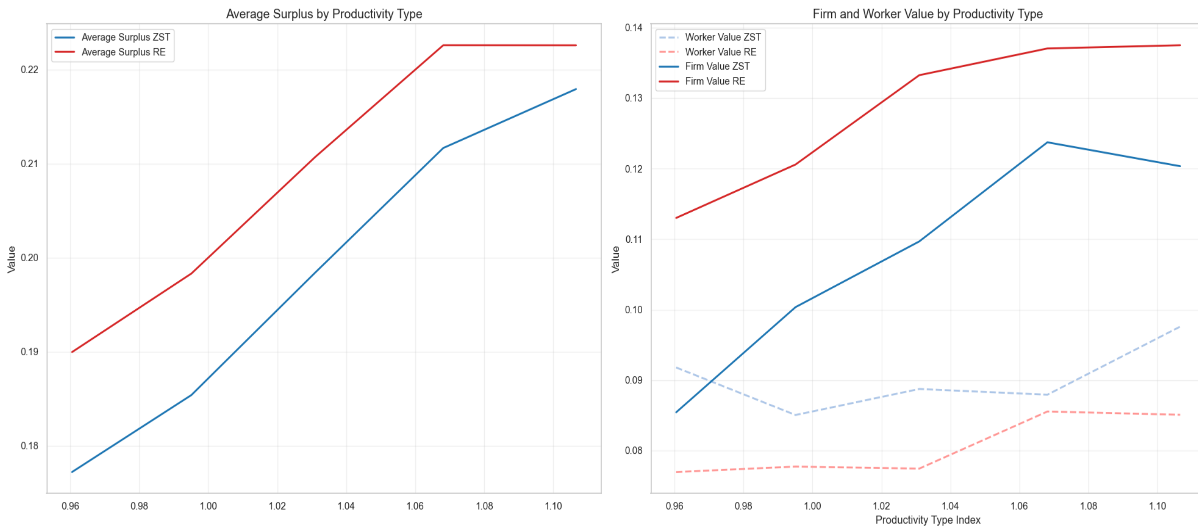

Figure 5: Actual Surplus and Surplus Sharing by Productivity Type.

Figure 6 shows the equilibrium boundaries and the renegotiation wage for each productivity level. As we can see, the ZST economy has on average stricter continuation sets relative to the RE one, while there is no difference in terms of renegotiation wage despite the lower match surplus. ZST therefore operates on the one hand on the stopping time game (leading workers to quit the match inefficiently early) and on the other hand on the bargaining game (increasing the share of surplus obtained by workers), changing the outcome of both.

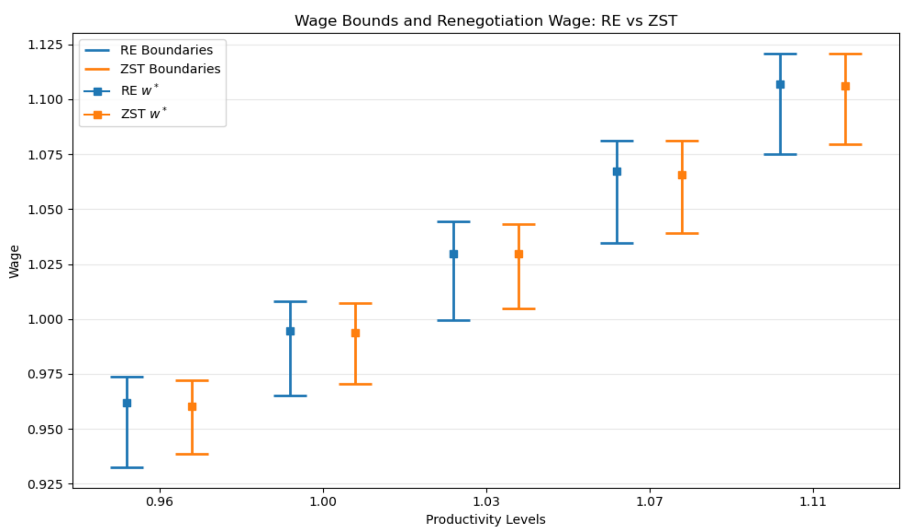

Figure 6: Policy Functions and Renegotiation Wage by Productivity Type.

Zero-sum thinking workers form expectations about labor market variables by solving the model from their biased perspective. Workers' expectations about the destruction rate and job finding probability are correct on aggregate. Aggregate expectations of the separation rate are correct by assumption (section 2.2.4), and we see from Figure 7 that they are also correct for each productivity type. On the other hand, the fact that workers perception of the job finding rate are correct on average emerges as a result of the model. Moreover, expectations about the job finding rate appear to be "stubborn" as in Menzio (2022): they underreact both to private information (there is almost no variation across productivity types) and to aggregate information (as I will show later, they do not respond to aggregate nominal shocks). The stubbornness of the perceived job finding probability is consistent with recent empirical findings from Mueller, Spinnewijn and Topa (2021). They find that "*job seekers with a high underlying job finding rate tend to be over-pessimistic, whereas job seekers with a low job finding rate are overoptimistic*". A similar result comes from my model: workers with low actual job finding probability tend to overstate their possibility of finding a job, while the opposite is true for workers with a high job finding probability.

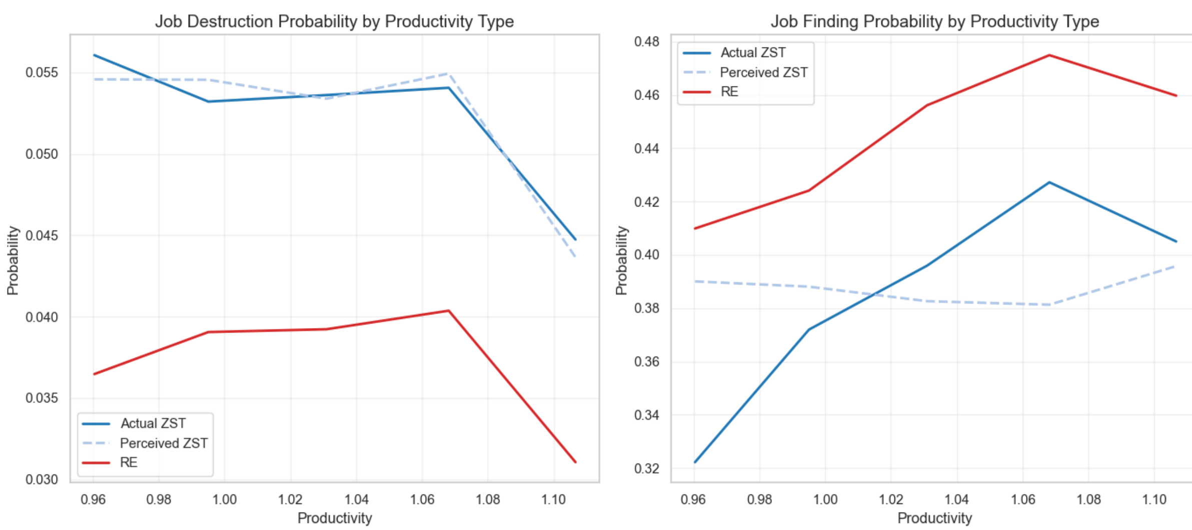

Figure 7: Job Destruction and Job Finding Probability by Productivity Type.

Relative to the RE model, the ZST economy presents an higher actual job destruction rate for all the productivity levels. On the other hand, the actual job finding probability is always lower. This implies that relative to the RE, in the ZST model more workers lose their job in any period (either by quitting or layoff) and less workers find a new one. Higher out-flows and lower in-flows generates higher aggregate unemployment (Figure 7). As low productivity workers overstate their job-finding probability, they also overvalue their outside option while are matched with a firm and quit the job more often than the other workers. However, the actual job finding probability is lower for low productivity workers. As a result, not only zero-sum thinking increases overall unemployment in the economy, but the effect is even stronger for low productive workers as we see from Figure 8.

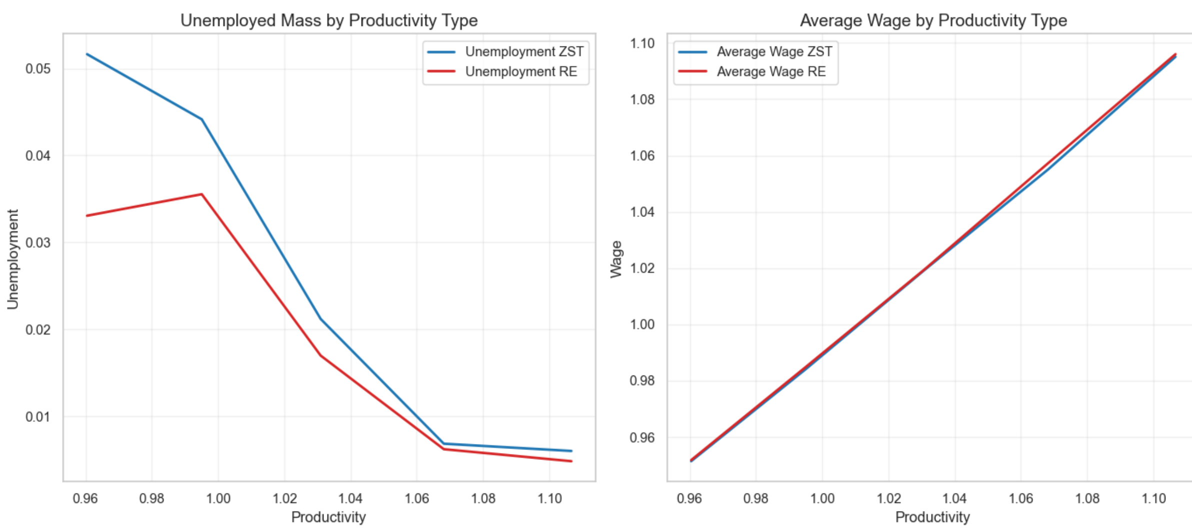

Figure 8: Unemployment Mass and Average Wage by Productivity Type.

3.3 Response to a Temporary Shock to Inflation

I now look at the response of the economy to a one time, unexpected, inflationary shock. I plot the impulse response functions of unemployment, average wage, job finding probability and separation rate both for the ZST and the RE economy. Monthly trend inflation is shocked by a factor of 10 at time 0 and then goes back to steady state value. All the responses are plotted in deviation from SS.

As inflation hits, the distribution of wages moves to the left and many workers pass the lower boundary, causing an increase in the separation rate (Figure 9) due to workers quitting their jobs. This effect is stronger in the ZST economy due to the misperception

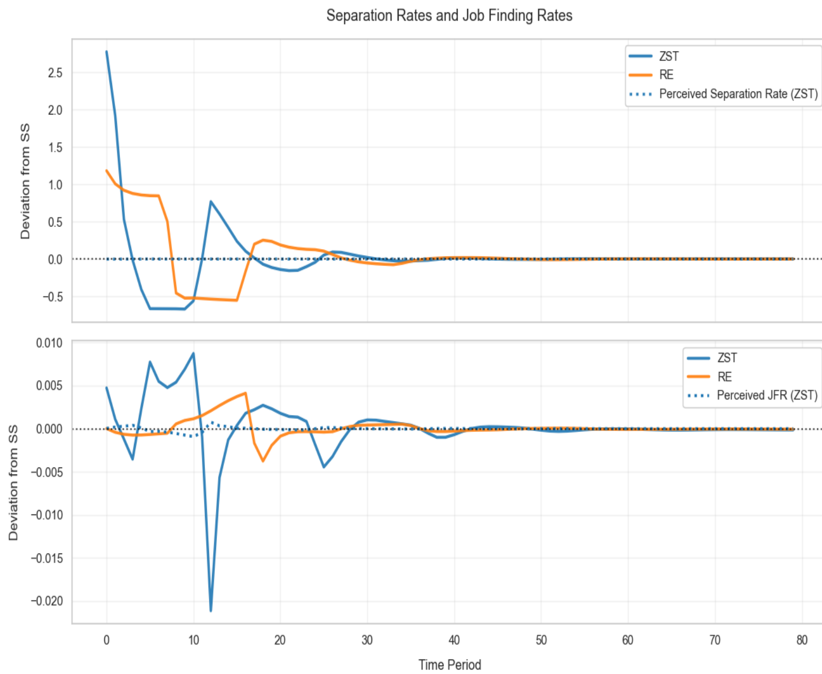

Figure 9: Separation Rate and Job Finind Probability Response to Inflation.

discussed above that leads to stricter boundaries and premature quitting. On impact the actual separation rate therefore responds more in the ZST relative to the RE model. In both economies, the rise in the separation rate is not compensated by a comparable increase in the job finding probability, as a result the unemployment rate increases (Figure 10); with an higher response in the ZST economy. For the matches that survives, most of the workers do not have the possibility of renegotiate and their wage is eroded by inflation. However, there is no significant difference in the response of average wages between the two models. Consistently with the previous discussion, the perceive job finding probability is stubborn even with respect to aggregate (nominal) shocks (Figure 9). As inflation goes back to steady state, unemployed workers gradually find new jobs, the unemployment rate decline going below its initial level, as firms lay off fewer workers. This process continues with up and downs until the economy reaches again the steady state equilibrium. A similar process is followed by the separation rate, job finding probability and average wages.

At steady state I have described how ZST have both a redistribution effect of value towards workers and a destruction effect of overall value in the economy. A similar mechanism is at work as the economy responds to the inflationary shock (Figure 11). Both workers and firms value drops, but compared with the RE benchmark, firms' value is going down more while workers' value is responding less. Therefore even dynamically we observe a redistribution effect similar to the one described above. On the other hand, average surplus in the ZST economy is responding more to inflation relative to the RE economy. Again, the overall welfare effect of ZST is negative.

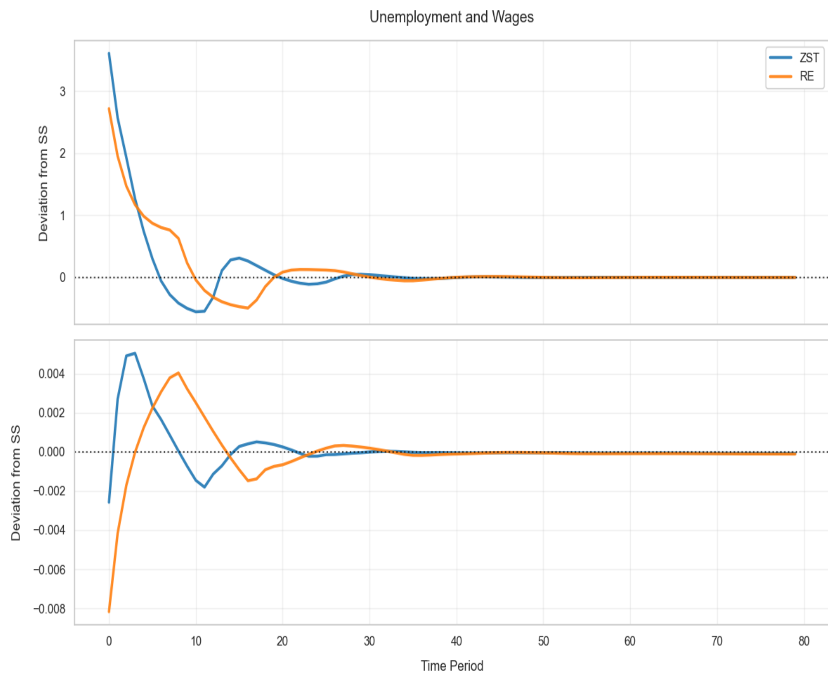

Figure 10: Unemployment Rate and Average Wage Response to Inflation.

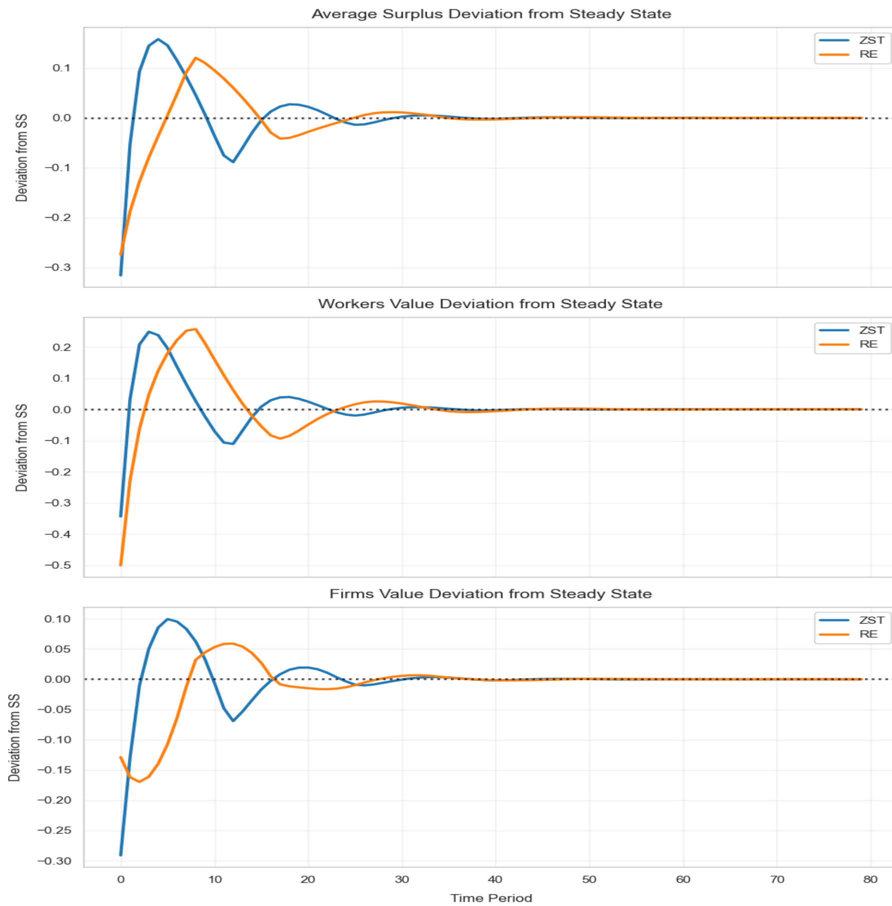

Figure 11: Average Surplus, Worker and Firm's Value Response to Inflation.

4 Conclusions

In this paper, I developed a search theoretic model with zero-sum thinking workers. I have modeled zero-sum thinking as a misperception of how surplus is determined in a match. In particular, zero-sum thinking workers take surplus as given and exogenously determined by their idiosyncratic productivity. Therefore, zero-sum thinking workers behave as if any gain for the firm comes at a loss for them, and vice versa. This has several implication for equilibrium outcome. Zero-sum thinking bias influence workers' optimal quitting strategies and modifies the bargaining outcome. In particular, relative to a benchmark model where workers have rational expectations, the ZST economy has an higher separation rate, lower job finding probability and an higher unemployment rate. There is also a redistribution of aggregate value from firms towards the workers. However, aggregate surplus in the economy is lower than in the RE model. Therefore, consistently with the psychological literature, zero-sum thinking increases conflict between the parties (in this case workers and firms) and destroys value in the economy.

The conflictual nature of zero-sum thinking is amplified as the economy is hit by an unexpected inflationary shock. On impact, inflation rises separation and unemployment more in the ZST model than in the RE benchmark. The distributionary effects described for steady state are again present in the dynamic response to inflation. As inflation hits, average surplus decreases more in the zero-sum thinking economy.

An additional result of the model is about the perceived job finding probability. Zero-sum thinking workers have stubborn beliefs about their job finding probability: their expectations underreact both to individual and aggregate new informations. This is consistent with a recent literature about workers' biased expectations about job finding probability (Menzio 2022 and Mueller, Spinnewjin and Topa 2019).

For future work, I first plan to study a version of the model with both zero-sum thinking and rational expectation workers. Moreover, it may be equivalently interesting and potentially insightful to study a labor market with zero-sum thinking firms.

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