

An Agent-Based Model of Work-from-Home Bargaining in Labour Market Matching

Narrative Documentation for CoMSES Library

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Model summary

This document describes a computational model of work-from-home bargaining in labour market matching. The model is written as a brand-new model description for submission to the CoMSES Library. It follows an ODD-style structure and includes equations, pseudocode, submodels, assumptions, and a text-based flow diagram.

Contents

1	Overview	4
2	Purpose	4
3	Model Scope	5
4	Entities, State Variables and Scales	5
4.1	Entities	5
4.2	Workers	5
4.3	Firms	6
4.4	Job Advertisements	6
4.5	Job Board	6
4.6	Economy and Environment	7
4.7	Temporal Scale	7
5	Process Overview and Scheduling	7
6	Flow Diagram	8
7	Design Concepts	9

7.1	Basic Principles	9
7.2	Emergence	10
7.3	Adaptation	10
7.4	Objectives	10
7.5	Learning	10
7.6	Sensing	10
7.7	Interaction	11
7.8	Stochasticity	11
7.9	Observation	11
8	Initialisation	11
8.1	Worker Initialisation	11
8.2	Firm Initialisation	12
8.3	Job Board Initialisation	12
8.4	Statistics Initialisation	12
9	Input Data	12
10	Submodels	12
10.1	Wage Offer Submodel	13
10.2	Work-from-Home Match Submodel	13
10.3	Worker Utility Submodel	13
10.4	Worker Application Submodel	14
10.5	Firm Applicant Evaluation Submodel	14
10.6	Worker Offer Decision Submodel	15
10.7	Employment Status Update Submodel	15
10.8	Vacancy Carry-Over Submodel	15
10.9	Firm Strategy Adaptation Submodel	16
10.10	Worker Expectation Adjustment Submodel	16
10.11	Worker Experience Update Submodel	17
10.12	Statistics Submodel	17
11	Detailed Pseudocode	18
12	Model Outputs	20

12.1 Cycle-Level Outputs	20
12.2 Final Outputs	20
12.3 Monte Carlo Outputs	20
13 Key Assumptions	20
13.1 Workers are heterogeneous	20
13.2 Firms are heterogeneous	20
13.3 Workers evaluate both wage and WFH	20
13.4 Firms adapt based on hiring success	21
13.5 Employed workers are more selective	21
13.6 Unemployed workers may adjust expectations	21
13.7 The model is exploratory	21
14 Interpretation of Bargaining	21
15 Verification and Debugging Logic	21
15.1 Job Advertisement Consistency	21
15.2 Hiring Log Consistency	22
15.3 Vacancy Carry-Over Consistency	22
15.4 Worker Expectation Adjustment Consistency	22
15.5 Reproducibility	22
16 Validation Approach	22
17 Sensitivity Analysis	22
18 Limitations	23
19 Possible Experiments	23
19.1 Baseline Experiment	23
19.2 High WFH Preference Experiment	23
19.3 Low WFH Preference Experiment	23
19.4 Firm Size Comparison	23
19.5 Wage-Only Comparison	23
19.6 Monte Carlo Experiment	24

1 Overview

This agent-based model examines how work-from-home preferences affect labour market matching between workers and firms. The model represents a simplified labour market, inspired by the IT sector, in which firms advertise jobs and workers decide whether to apply for and accept offers. The central mechanism is a bargaining-like interaction between workers and firms over wages and work-from-home arrangements.

The model should not be understood as a literal negotiation model where each worker and firm exchange offers in a formal bargaining protocol. Instead, bargaining is represented indirectly through repeated decision-making. Firms adapt their wage offers and work-from-home strategies depending on whether they succeed in hiring workers. Workers decide whether job offers are acceptable depending on their wage expectations, current employment status, work-from-home preferences, and experience. Over repeated cycles, this creates a decentralised bargaining process in which firms and workers adjust to each other.

The model is designed as an exploratory computational model. Its purpose is not to predict a specific real labour market directly. Rather, it is intended to examine how individual-level rules can generate aggregate labour market outcomes such as unemployment, unfilled vacancies, firm hiring success, wage adjustment, worker utility, and the emergence of preferred work-from-home strategies.

The model includes heterogeneous firms and heterogeneous workers. Firms differ by size, and firm size affects their hiring behaviour and ability to adjust recruitment strategies. Workers differ by experience, wage expectations, employment status, and preference for work-from-home arrangements. The model therefore allows the labour market to be studied as a matching process shaped by both employer strategy and worker preference.

2 Purpose

The purpose of the model is to study how work-from-home preferences influence labour market matching.

In particular, the model asks how the interaction between worker preferences and firm recruitment strategies can affect unemployment, unfilled vacancies, hiring success by firm size, wage multiplier evolution, adoption of work-from-home strategies, worker utility, differences in outcomes between employed and unemployed workers, differences in outcomes between workers with different experience levels, and the ability of different firm sizes to attract workers.

The model is useful because work-from-home is not treated simply as a fixed employment condition. Instead, it is treated as part of the matching process. Firms may use work-from-home arrangements as part of their recruitment strategy, while workers may treat work-from-home as part of the value of a job offer.

This means that a job offer is not evaluated only by wage. A worker may accept a lower wage if the work-from-home arrangement is closer to their preference, or may reject a higher wage if the work-from-home conditions are unattractive. Similarly, a firm may increase wages, change work-from-home arrangements, or continue with an existing strategy depending on whether previous hiring attempts succeeded.

3 Model Scope

The model represents a stylised labour market. It is not intended to include every feature of a real labour market.

The model focuses on workers, firms, job advertisements, job applications, job offers, wage expectations, work-from-home preferences, firm recruitment strategies, and repeated hiring cycles.

The model does not attempt to fully represent formal employment law, firm-level accounting in full detail, macroeconomic shocks, trade unions, household constraints, commuting geography, detailed skill taxonomies, formal contract negotiation, or long-term career planning.

The model deliberately keeps the labour market simplified so that the effect of work-from-home preferences on labour market matching can be studied more clearly.

4 Entities, State Variables and Scales

4.1 Entities

The main entities in the model are workers, firms, job advertisements, the job board, the economy or simulation environment, and the statistics and logging system.

4.2 Workers

Workers represent individuals who may be employed or unemployed. Each worker has attributes that influence job search, applications, and acceptance decisions.

Variable	Description
worker_id	Unique identifier for the worker.
employment_status	Whether the worker is employed or unemployed.
current_wage	Wage currently earned by the worker if employed.
expected_wage	Minimum wage the worker expects from a job offer.
experience	Worker experience level.
wfh_preference	Preferred level of work-from-home.
initial_wfh_preference	Original WFH preference at the start of the simulation.
applications_sent	Jobs the worker has applied to in the current cycle.
offers_received	Offers received by the worker in the current cycle.
accepted_offer	Whether the worker accepted an offer in the current cycle.
utility	Utility associated with accepted or evaluated offers.
strategy_memory	Information used by the worker to adapt search expectations.

Workers do not all behave in exactly the same way. Their behaviour depends on their current status. Employed workers are more selective because they already have a job. Unemployed workers are more likely to reduce expectations if they fail to receive suitable offers.

4.3 Firms

Firms represent employers that may advertise vacancies and attempt to hire workers. Firms differ by size. The model includes micro, small, medium, and large firms.

Variable	Description
firm_id	Unique identifier for the firm.
firm_size	Micro, small, medium, or large.
workers	Current employees.
vacancies	Number of vacancies available.
wage_multiplier	Multiplier applied to the industry wage.
wfh_offer	Work-from-home arrangement offered by the firm.
job_ads	Current job advertisements created by the firm.
applications_received	Applications received in the current cycle.
offers_sent	Offers sent to workers.
filled_positions	Vacancies successfully filled.
unfilled_positions	Vacancies not filled by the end of the cycle.
learning_memory	Record of past recruitment strategy performance.
hiring_success	Whether the firm succeeded in filling vacancies.

Firms use wage and work-from-home arrangements as recruitment strategies. They observe whether a strategy worked by checking whether vacancies were filled. If hiring fails, firms may adjust their strategy in later cycles.

4.4 Job Advertisements

A job advertisement is a temporary object linking a firm to a vacancy. A job advertisement contains the information workers use to decide whether to apply.

Variable	Description
job_id	Unique identifier for the job advertisement.
firm_id	Firm that created the advertisement.
offered_wage	Wage offered for the job.
wage_multiplier	Firm wage multiplier used to calculate the offered wage.
wfh_offer	Work-from-home arrangement offered.
required_experience	Experience requirement, if used.
status	Open, filled, or carried over.
cycle_created	Simulation cycle in which the job was created.

Job advertisements are important because they allow the model to track which specific positions were filled and which remained unfilled.

4.5 Job Board

The job board is the market interface between firms and workers. Firms submit job advertisements to the job board. Workers search the job board and decide which jobs to apply for.

The job board does not make decisions by itself. It stores job advertisements and allows matching interactions to take place.

4.6 Economy and Environment

The economy controls the simulation cycle. It creates firms and workers, runs the sequence of events, and coordinates the interaction between agents.

The economy also records aggregate outcomes such as unemployment rate, vacancies, wage strategies, and work-from-home adoption.

4.7 Temporal Scale

The model runs in discrete cycles. Each cycle represents one round of labour market activity.

A cycle includes firms updating strategy, firms creating job advertisements, workers searching for jobs, workers applying, firms evaluating applications, firms sending offers, workers accepting or rejecting offers, employment states being updated, expectations and strategies being updated, and statistics being recorded.

The model can be run for a chosen number of cycles. Monte Carlo runs can be used to repeat the simulation under different random seeds.

5 Process Overview and Scheduling

The model runs as a repeated sequence of labour market cycles.

Cycle scheduling

```
Initialise economy  
Initialise firms  
Initialise workers  
Initialise job board  
Initialise statistics
```

For each simulation cycle:

1. Reset temporary cycle variables
2. Firms review previous hiring outcomes
3. Firms adapt wage and WFH strategies
4. Firms create job advertisements
5. Job advertisements are published on the job board
6. Workers search available job advertisements
7. Workers decide which jobs to apply for
8. Firms receive applications
9. Firms evaluate applicants
10. Firms send offers to selected workers
11. Workers evaluate offers
12. Workers accept or reject offers
13. Filled vacancies are removed from the job board
14. Unfilled vacancies may be carried over
15. Workers without suitable offers may adjust expectations
16. Worker experience and age-related variables are updated where relevant
17. Firm and worker outcomes are logged
18. Aggregate statistics are recorded

```
End simulation  
Generate final outputs
```

The sequence is important because firms must advertise before workers can apply, firms must receive applications before offers can be made, and workers must make final decisions before vacancies can be marked as filled or unfilled.

6 Flow Diagram

The following text-based flow diagram summarises the main process.

Simulation flow diagram

```

Start simulation
|
v
Initialise firms, workers, job board and statistics
|
v
Start cycle t
|
v
Firms review previous hiring success
|
v
Firms adapt wage and WFH strategies
|
v
Firms create vacancies and job advertisements
|
v
Job board publishes available jobs
|
v
Workers search and apply for jobs
|
v
Firms evaluate applications and send offers
|
v
Workers evaluate wage and WFH conditions
|
v
Workers accept or reject offers
|
v
Update employment, vacancies and strategies
|
v
Record statistics
|
v
More cycles? ---- yes ----> Next cycle
|
no
v
Generate final outputs and logs

```

7 Design Concepts

7.1 Basic Principles

The model is based on the idea that labour market outcomes can emerge from repeated local interactions between workers and firms.

Workers do not observe a perfect labour market. They only respond to the job advertisements available to them in a given cycle. Firms also do not know in advance which strategy will guarantee successful recruitment. They experiment with wages and work-from-home arrangements and learn from whether vacancies are filled.

The central idea is that work-from-home can act as a non-wage job attribute. This means that workers may evaluate jobs using a combination of wage and work-from-home conditions, rather than wage alone.

7.2 Emergence

Aggregate outcomes emerge from individual decisions.

The model allows outcomes such as unemployment, unfilled vacancies, and dominant work-from-home strategies to emerge from the interaction between worker expectations and firm recruitment strategies.

For example, if many workers strongly prefer work-from-home and firms do not offer it, vacancies may remain unfilled even if firms are offering acceptable wages. Alternatively, firms that offer more attractive work-from-home arrangements may be able to hire workers without always needing to increase wages.

7.3 Adaptation

Both workers and firms adapt.

Firms adapt by reviewing hiring success. If a firm fails to fill vacancies, it may change its wage multiplier or work-from-home offer. If a firm succeeds, it may continue with the same strategy.

Workers adapt by adjusting expectations when they repeatedly fail to receive suitable offers. This is especially important for unemployed workers, who may lower wage expectations over time. Employed workers remain more selective because they already have a current job.

7.4 Objectives

Workers aim to obtain acceptable employment. Their decision is based on the utility of a job offer, which depends on wage and work-from-home match.

Firms aim to fill vacancies. Their behaviour is evaluated through hiring success. A firm does not necessarily maximise profit in a full accounting sense at every step. Instead, it uses adaptive rules to improve recruitment success over repeated cycles.

7.5 Learning

Learning is represented through simple adaptive memory.

Firms record whether previous strategies were successful. Strategies associated with successful hiring are more likely to be retained. Strategies associated with failed hiring may be modified.

Workers also respond to their own job search outcomes. If a worker receives no suitable offers, the worker may adjust expectations at the end of the cycle.

7.6 Sensing

Workers can sense available job advertisements through the job board. They can observe the wage and work-from-home conditions attached to those advertisements.

Firms can sense applications received from workers. They can observe worker characteristics relevant to hiring, such as experience.

The model does not assume that all agents have perfect information about the whole labour market.

7.7 Interaction

The main interaction is between workers and firms through the job board.

The interaction has four stages. Firms advertise jobs. Workers apply. Firms send offers. Workers accept or reject offers.

This creates the bargaining-like structure of the model. Firms adjust what they offer, and workers decide whether offers are good enough.

7.8 Stochasticity

Randomness may enter the model in several places, including initial worker characteristics, initial firm strategies, vacancy creation, job application choices, firm strategy exploration, selection among alternative strategies, and Monte Carlo seed variation.

Random seeds can be used to make simulation runs reproducible.

7.9 Observation

The model records both individual-level and aggregate outcomes.

Typical observed outputs include unemployment rate, employment rate, number of vacancies, number of unfilled vacancies, firm hiring success, wage multiplier by firm size, work-from-home offer by firm size, worker utility, worker wage expectation satisfaction, strategy adoption rates, and outcomes by worker experience level.

8 Initialisation

At the beginning of a simulation, the economy is created and populated with firms and workers.

8.1 Worker Initialisation

Workers are created with heterogeneous characteristics. These may include employment status, experience, current wage, expected wage, work-from-home preference, initial work-from-home preference, and job search behaviour.

Workers may begin the simulation as employed or unemployed. This allows the model to distinguish between workers who already have a job and workers who are actively seeking employment.

8.2 Firm Initialisation

Firms are created with different sizes. The model distinguishes between micro firms, small firms, medium firms, and large firms.

Firm size matters because firms of different sizes may not behave in exactly the same way. Larger firms may have more vacancies and more stable recruitment strategies. Smaller firms may have fewer vacancies and may be more cautious when hiring.

Each firm is given initial strategy values such as wage multiplier, work-from-home offer, number of vacancies, existing workers, and learning memory.

8.3 Job Board Initialisation

The job board starts empty. It is populated during each cycle when firms create job advertisements.

8.4 Statistics Initialisation

The statistics system is initialised before the first cycle. It records values during the simulation and produces outputs at the end.

9 Input Data

The model can be run as a self-contained simulation with synthetic initial conditions. In that case, the main input data are parameter values chosen by the modeller.

Parameter	Description
number_of_cycles	Number of cycles to run.
number_of_workers	Number of worker agents.
number_of_firms	Number of firm agents.
firm_size_distribution	Distribution of micro, small, medium, and large firms.
industry_wage	Baseline wage used to calculate offers.
initial_wage_multiplier_range	Range of possible starting wage multipliers.
wfh_preference_distribution	Distribution of worker WFH preferences.
wfh_offer_options	Work-from-home arrangements firms can offer.
experience_distribution	Distribution of worker experience.
random_seed	Seed used for reproducibility.

The model can also be extended to use empirical calibration, but this is not necessary for the basic model. The current model is best understood as an exploratory simulation.

10 Submodels

This section describes the main behavioural submodels.

10.1 Wage Offer Submodel

Firms calculate wage offers using a wage multiplier applied to an industry wage.

The basic wage equation is:

$$w_{j,t} = \bar{w} \times m_{j,t}$$

where $w_{j,t}$ is the wage offered by firm j at cycle t , $\bar{w}$ is the baseline industry wage, and $m_{j,t}$ is the wage multiplier used by firm j at cycle t .

A firm with a wage multiplier above 1 offers more than the baseline industry wage. A firm with a wage multiplier below 1 offers less than the baseline industry wage.

10.2 Work-from-Home Match Submodel

Workers have a preferred level of work-from-home. Firms offer a level of work-from-home. The closer the offer is to the worker preference, the better the match.

A simple work-from-home match score can be represented as:

$$S_{ij,t} = 1 - \frac{|P_i - R_{j,t}|}{R_{\max}}$$

where $S_{ij,t}$ is the WFH match score between worker i and firm j at cycle t , P_i is the WFH preference of worker i , $R_{j,t}$ is the WFH arrangement offered by firm j , and $R_{\max}$ is the maximum possible distance between WFH preference levels.

A value closer to 1 means the firm offer is close to the worker preference. A value closer to 0 means the offer is far from the worker preference.

10.3 Worker Utility Submodel

Workers evaluate job offers using a utility function that combines wage and WFH match.

A general form is:

$$U_{ij,t} = \alpha_i W_{ij,t} + \beta_i S_{ij,t}$$

where $U_{ij,t}$ is the utility worker i receives from firm j 's offer at cycle t , $W_{ij,t}$ is the wage attractiveness of the offer, $S_{ij,t}$ is the WFH match score, α_i is the weight worker i gives to wage, and β_i is the weight worker i gives to WFH match.

The wage attractiveness component can be represented as:

$$W_{ij,t} = \frac{w_{j,t}}{E_{i,t}}$$

where $w_{j,t}$ is the wage offered by firm j , and $E_{i,t}$ is the expected wage of worker i at cycle t .

If the offered wage is higher than the worker's expected wage, the wage attractiveness score increases.

10.4 Worker Application Submodel

Workers search the job board and decide which jobs to apply for.

A worker is more likely to apply to a job if the offered wage is close to or above the worker's expected wage, the work-from-home arrangement is close to the worker's preference, the worker meets the experience expectations of the firm, and the worker is unemployed or the job is sufficiently better than the current job.

Worker application rule

```
For each worker:
  Observe available job advertisements

  For each job advertisement:
    Calculate wage attractiveness
    Calculate WFH match
    Calculate expected utility

    If expected utility is acceptable:
      Add job to application list

  Send applications to selected firms
```

For employed workers, the model can impose a higher acceptance threshold. For example, an employed worker may only consider a job attractive if it improves their current situation sufficiently. This reflects the assumption that employed workers do not move jobs unless the new offer is clearly better.

10.5 Firm Applicant Evaluation Submodel

Firms evaluate applications after workers apply.

A firm may rank applicants based on experience and suitability.

Firm evaluation rule

```
For each firm:
  Receive applications for each open job advertisement

  For each job advertisement:
    Rank applicants by suitability
    Select preferred applicant
    Send job offer
```

Suitability may depend on worker experience, employment status, or other worker attributes included in the model. The current emphasis is on the matching process rather than complex human resource decision-making.

10.6 Worker Offer Decision Submodel

Workers may receive one or more offers. They evaluate offers and accept the best acceptable one.

Worker offer decision rule

```

For each worker:
  Collect offers received in the current cycle

  If no offers received:
    Mark worker as having no suitable offer
    Continue to expectation adjustment stage

  If offers received:
    Calculate utility for each offer
    Select offer with highest utility

    If selected offer meets acceptance threshold:
      Accept selected offer
      Reject other offers
      Update employment status
      Update current wage
      Update employer
    Else:
      Reject all offers

```

This rule means that a worker does not automatically accept any offer. The offer must be good enough relative to the worker's expectations and current position.

10.7 Employment Status Update Submodel

When a worker accepts an offer, the worker becomes employed by the firm, the firm fills the vacancy, the job advertisement is marked as filled, the filled job is removed from the job board, the worker's current wage is updated, and the worker's employment status is updated.

If a worker rejects all offers, the worker remains in their current state. An employed worker stays with the current employer. An unemployed worker remains unemployed.

10.8 Vacancy Carry-Over Submodel

If a job advertisement is not filled, it may be carried over into the next cycle.

This represents recruitment difficulty. It also allows failed hiring attempts to affect future firm strategy.

Vacancy carry-over rule

```

For each job advertisement:
  If job is filled:
    Remove job from active job board
  Else:
    Mark job as unfilled
    Allow firm to carry vacancy forward

```

This mechanism is important because it prevents the model from treating every cycle as completely independent. Unfilled jobs are part of the pressure that firms respond to.

10.9 Firm Strategy Adaptation Submodel

Firms adapt their recruitment strategy based on hiring success.

Firm strategy adaptation rule

```

For each firm:
  Review whether vacancies were filled

  If hiring was successful:
    Record current strategy as successful
    Continue or reinforce current strategy

  If hiring was unsuccessful:
    Record current strategy as unsuccessful
    Adjust wage multiplier and/or WFH offer
    Explore alternative recruitment strategy

```

The strategy can include increasing the wage multiplier, reducing the wage multiplier if hiring is easy, increasing WFH offer, reducing WFH offer, keeping the same strategy, or selecting a strategy based on previous success.

This creates the bargaining-like process from the firm side. Firms respond to worker behaviour by changing what they offer.

10.10 Worker Expectation Adjustment Submodel

Workers may adjust expectations if they fail to receive suitable offers.

The expectation adjustment takes place at the end of the cycle. This is important because workers should not lower expectations after every individual rejection. Instead, they evaluate the outcome of the whole cycle.

Worker expectation adjustment rule

```

For each worker:
  If worker received no suitable offer during the cycle:
    If worker is unemployed:
      Lower expected wage within defined limits
    If worker is employed:
      Keep expected wage at or above current wage threshold
  Else:
    Keep or update expectations based on accepted offer

```

This prevents excessive adjustment within a single cycle and makes expectation change more realistic.

For employed workers, expected wages should not fall below a reasonable threshold based on current wage. This reflects the idea that an employed worker should not accept a worse job unless there is another reason to do so.

10.11 Worker Experience Update Submodel

Worker experience can be updated over time. Experience may affect job applications and firm selection.

Worker experience update rule

```

For each worker:
  If employed:
    Increase experience according to the model rule
  If unemployed:
    Experience may remain constant or change more slowly

```

Experience is useful because it allows the model to examine whether outcomes differ between workers at different experience levels.

10.12 Statistics Submodel

At the end of each cycle, the model records outcomes.

The unemployment rate can be calculated as:

$$UR_t = \frac{N_t^{unemployed}}{N_t^{workers}}$$

where UR_t is the unemployment rate at cycle t , $N_t^{unemployed}$ is the number of unemployed workers at cycle t , and $N_t^{workers}$ is the total number of workers.

The vacancy fill rate can be calculated as:

$$FR_t = \frac{V_t^{filled}}{V_t^{created}}$$

where FR_t is the fill rate at cycle t , V_t^{filled} is the number of vacancies filled, and $V_t^{created}$ is the number of vacancies created or active.

Average wage multiplier by firm size can be calculated as:

$$\bar{m}_{s,t} = \frac{1}{N_s} \sum_{j \in s} m_{j,t}$$

where $\bar{m}_{s,t}$ is the average wage multiplier for firm size group s , N_s is the number of firms in size group s , and $m_{j,t}$ is the wage multiplier of firm j .

Work-from-home adoption by firm size can be calculated as:

$$A_{s,t}(r) = \frac{N_{s,t}(R=r)}{N_s}$$

where $A_{s,t}(r)$ is the adoption rate of WFH strategy r for firm size group s , $N_{s,t}(R=r)$ is the number of firms of size s offering WFH strategy r , and N_s is the total number of firms in size group s .

11 Detailed Pseudocode

The following pseudocode gives a more complete view of the simulation.

```

FUNCTION run_simulation(number_of_cycles, random_seed):

    Set random seed

    economy = create_economy()
    firms = create_firms()
    workers = create_workers()
    job_board = create_job_board()
    statistics = create_statistics()

    FOR cycle in 1 to number_of_cycles:

        Reset worker applications
        Reset worker offers
        Reset firm applications
        Reset temporary cycle logs

        FOR each firm in firms:
            firm.review_previous_hiring_result()
            firm.update_strategy_if_needed()

        FOR each firm in firms:
            vacancies = firm.calculate_vacancies()
            job_ads = firm.create_job_ads(vacancies)
            job_board.add(job_ads)

```

```

FOR each worker in workers:
    available_jobs = job_board.get_open_jobs()
    selected_jobs = worker.choose_jobs_to_apply_for(available_jobs)

    FOR each job in selected_jobs:
        firm = job.get_firm()
        firm.receive_application(worker, job)

FOR each firm in firms:
    FOR each open job advertisement:
        applicants = firm.get_applicants(job)
        selected_worker = firm.evaluate_applicants(applicants)

        IF selected_worker exists:
            firm.send_offer(selected_worker, job)

FOR each worker in workers:
    offers = worker.get_offers()

    IF offers exist:
        best_offer = worker.select_best_offer(offers)

        IF worker.accepts(best_offer):
            worker.accept_offer(best_offer)
            best_offer.firm.mark_position_filled(best_offer.job_id)
            job_board.mark_job_as_filled(best_offer.job_id)

        ELSE:
            worker.reject_all_offers()

    ELSE:
        worker.record_no_offer()

FOR each job in job_board:
    IF job is filled:
        job_board.remove(job)
    ELSE:
        job.mark_as_unfilled_or_carried_over()

FOR each worker in workers:
    worker.adjust_expectations_if_no_suitable_offer()
    worker.update_experience_if_required()

FOR each firm in firms:
    firm.calculate_hiring_success()
    firm.update_learning_memory()

statistics.record_cycle_results(
    workers,
    firms,
    job_board,
    cycle
)

statistics.generate_final_outputs()
RETURN statistics

```

12 Model Outputs

The model produces outputs at both cycle level and final simulation level.

12.1 Cycle-Level Outputs

Cycle-level outputs may include number of employed workers, number of unemployed workers, unemployment rate, number of vacancies created, number of vacancies filled, number of unfilled vacancies, wage multiplier by firm, WFH offer by firm, applications sent, offers made, offers accepted, worker utility, and firm hiring success.

12.2 Final Outputs

Final outputs may include final unemployment rate, average firm wage multiplier, wage multiplier by firm size, WFH strategy adoption by firm size, worker utility distribution, wage expectation satisfaction, hiring success by firm size, preferred strategies by worker experience, and number and proportion of unfilled vacancies.

12.3 Monte Carlo Outputs

When the model is run many times with different random seeds, Monte Carlo outputs may include mean outcome across runs, variation across runs, confidence intervals or distribution summaries, comparison of firm size outcomes, comparison of worker experience outcomes, and robustness of strategy adoption patterns.

Monte Carlo simulation is useful because a single run may be affected by randomness. Repeated runs allow the modeller to see whether observed patterns are stable.

13 Key Assumptions

13.1 Workers are heterogeneous

Workers differ in experience, wage expectations, employment status, and WFH preferences. This is important because the same job offer may be attractive to one worker but unattractive to another.

13.2 Firms are heterogeneous

Firms differ by size. Firm size affects hiring behaviour and the ability to attract workers.

13.3 Workers evaluate both wage and WFH

Workers do not evaluate job offers using wage alone. WFH arrangements are part of the perceived value of the offer.

13.4 Firms adapt based on hiring success

Firms do not know the best recruitment strategy in advance. They learn from whether they fill vacancies.

13.5 Employed workers are more selective

An employed worker already has a job, so a new offer must normally improve their current situation. This creates a difference between employed and unemployed job search behaviour.

13.6 Unemployed workers may adjust expectations

Unemployed workers who fail to receive suitable offers may reduce expectations over time. This reflects pressure from unemployment.

13.7 The model is exploratory

The model is not intended to forecast an actual labour market. It is designed to explore possible mechanisms and patterns.

14 Interpretation of Bargaining

The word bargaining is used in a broad behavioural sense.

The model does not include a formal bargaining game with alternating offers, reservation wages, or negotiated contracts. Instead, bargaining is represented by repeated adjustment.

Firms change wage and WFH offers after observing hiring success or failure. Workers accept, reject, or ignore offers depending on expectations and preferences. Firms respond to worker behaviour in later cycles. Workers respond to their own success or failure in the labour market.

This creates a decentralised bargaining process. The negotiated outcome is not produced by a single meeting between one worker and one firm. It emerges over time through repeated labour market interactions.

15 Verification and Debugging Logic

Several checks are important for verifying the model.

15.1 Job Advertisement Consistency

Each job advertisement should have a unique job identifier. When a worker accepts an offer, the corresponding job advertisement should be marked as filled and removed from the active job board.

This prevents the same vacancy from being counted as both filled and unfilled.

15.2 Hiring Log Consistency

The number of filled positions reported by a firm should match the number of accepted offers linked to that firm's job advertisements.

15.3 Vacancy Carry-Over Consistency

Only genuinely unfilled vacancies should be carried over into the next cycle. Filled jobs should not appear as unfilled in later cycles.

15.4 Worker Expectation Adjustment Consistency

Workers should adjust expectations only once at the end of a cycle if they received no suitable offers. They should not reduce expectations repeatedly after each individual rejection.

15.5 Reproducibility

When a random seed is provided, the simulation should produce the same results for the same parameter configuration.

16 Validation Approach

The model is mainly theoretical and exploratory, so validation should focus on whether the behaviour of the model is plausible and whether it is useful for examining the research question.

Possible validation steps include checking that individual agent behaviour matches the intended assumptions, checking that unemployment and vacancies respond sensibly to changes in wages and WFH offers, running sensitivity analysis on key parameters, comparing results across multiple random seeds, examining whether firm-size differences are plausible, and comparing model mechanisms with labour market theory and work-from-home literature.

The model should be interpreted as an analytical tool rather than a forecasting instrument.

17 Sensitivity Analysis

The model can be tested under different parameter settings.

Useful sensitivity tests include changing the distribution of worker WFH preferences, the baseline industry wage, the strength of WFH in the utility function, the strength of wage in the utility function, the number of firms, the number of workers, firm size distribution, vacancy creation rates, the willingness of firms to adjust wage multipliers, the willingness of firms to adjust WFH offers, the speed at which unemployed workers lower expectations, and the selectiveness of employed workers.

Sensitivity analysis helps identify which assumptions drive the main results.

18 Limitations

The model has several limitations.

First, it simplifies the labour market. Real labour markets include many additional factors such as commuting distance, household responsibilities, detailed skill requirements, contract types, organisational culture, and legal constraints.

Second, the model treats work-from-home as a simplified job attribute. In reality, work-from-home arrangements can vary in many ways, including hybrid schedules, informal flexibility, full remote work, and role-specific restrictions.

Third, firm behaviour is adaptive rather than fully optimising. Firms learn from success and failure, but they do not solve a complete profit maximisation problem in every cycle.

Fourth, worker preferences are simplified. Workers evaluate wage and work-from-home arrangements, but the model does not include all possible motivations for job search.

Finally, the model is not calibrated to predict a specific labour market. It is best used for exploring mechanisms and comparing scenarios.

19 Possible Experiments

19.1 Baseline Experiment

Run the model with a balanced distribution of WFH preferences and observe unemployment, vacancies, wage multipliers, and WFH strategy adoption.

19.2 High WFH Preference Experiment

Increase the proportion of workers who strongly prefer WFH and observe whether firms shift towards more remote or hybrid offers.

19.3 Low WFH Preference Experiment

Reduce worker preference for WFH and observe whether wage becomes the dominant recruitment strategy.

19.4 Firm Size Comparison

Compare micro, small, medium, and large firms to examine whether some firms are better able to adapt to worker preferences.

19.5 Wage-Only Comparison

Run a version where WFH preferences are inactive and compare only outcomes that remain meaningful across scenarios, such as employment rate and average wage multiplier.

19.6 Monte Carlo Experiment

Repeat the model many times with different random seeds to test whether the main patterns are stable.