1. Introduction

2. Theoretical framework

3. WorkSim

4. Results

5. Discussion

WorkSim, an agent-based model to study labor markets

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1. Introduction
WorkSim: an agent-based model of the French labor market

- Novel tool of analysis for labor markets
- Theory: endogenous choice of contract types
- Method: 1. Agent-based Computational Economics
- Method: 2. Calibration on a large number of targets (63)
- Results: an anatomy of the French labor market
- Experiments in labor market policies
WorkSim: an agent-based model of the French labor market

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Related ABM for labor markets

- **Pioneers**: Bergmann (1974) Eliasson (1977) macro ABM
- **ARTEMIS**, the ancestor of WorkSim (Ballot, 1981, 2002)
  - first ABM of the labor market with gross flows, institutional framework (incl. temporary help firm), and firing costs
  - generates segmentation, espec. for the young workers
  - matching process between workers and firms with on-the-job search, entrepreneurial decisions and endogenous wage determination.
  - Reproduce a number of stylized facts (e.g. negatively sloped wage curve)
- **Neugart (2008)**: ABM with sector-specific skill requirements, firms are hit by asymmetric shocks, human capital investments. No matching function. Used for labor policy evaluation.
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  - matching process between workers and firms with on-the-job search, entrepreneurial decisions and endogenous wage determination.
  - Reproduce a number of stylized facts (e.g. negatively sloped wage curve)
- They distinguish individuals and jobs but not firms.
- Labor demand side, with creations and destructions of jobs based on a desired margin.
- Aggregate Matching function.
- Calibrated through an indirect inference method (20 targets).
WorkSim: Agents and institutions

- **Heterogeneous** agents along several dimensions:
  - individuals’ side: age, gender, household, talent, human capital accumulated, status (employed, unemployed, inactive, retired)
  - firms’s side: firm size, different occupations, jobs with Open Ended Contracts (OEC) and Fixed Term Contracts (FTC)
  - Modeling of some **institutions** and specifically labor law on contracts
  - detailed modeling of the endogenous choice between OEC and FTC contracts
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Two types of contracts

Open Ended Contract (OEC) – "CDI"

- 87% of employees in 2014
- Undetermined duration, More attractive for job seekers
- Probationary period (2-4 months)
- Firing costs: delay for economic dismissals, advance notice, severance pay, litigation costs

Fixed Term Contract (FTC) – "CDD"

- 9% of employees in 2014 – 80% of the hires
- Maximum duration 18 months, renewable once (2014)
- Small probationary period (< 4 weeks)
- Job risk allowance at the end of the contract (10% of total gross salary)
- Grace period to be respected by the employer between 2 FTC
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2. Theoretical framework
Extensions of search approach

- Extension of the search approach along several axes:
  - 1. Matching by bilateral meetings (workers search with a reservation utility, employers select with a reservation expected profit). No aggregate matching function
  - 2. Firms are multi-jobs and allocate their demand rise between contracts
  - 3. All decisions take into account anticipated search and other costs
  - 4. Decisions are taken under bounded rationality (H. Simon) in this complex environment
- BUT agents learn individually (expected firing costs, expected duration of an OEC...)
- Outcomes: Job gross flows and workers’ gross flows emerge from these micro-level interactions. Consistent stock-flow accounts.
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Shocks on firms’ individual demand and anticipations

- Partial equilibrium model: aggregate demand is exogenous and stable, and price fixed (small economy).
- Each firm can be viewed as offering its variety of a good to consumers who have fluctuating preferences.
- Stochastic shocks on firm’s demand share, not productivity shocks on individual jobs: a yearly trend and weekly random walk.
- Each firm forms anticipations with several scenarios which are weighted with possible loss aversion (more below).
- The computation of the expected profits of each type of contract for a given job creation leads to choose either an OEC or a FTC.
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Substitutions between OEC and FTC

3 substitution factors

1. termination costs
   - for OEC, severance pay and litigation costs, hoarding costs, advance notice costs
   - for FTC, job risk allowance, grace period, some hoarding costs.

2. duration related factors: training and productivity
   - amortization of training costs less costly on OEC
   - productivity increase during expected spell duration larger for OEC.

3. uncertainty factor
   - the higher the volatility of demand, the more jobs created are FTC
   - The higher the aversion to loss, the more FTC
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Complementarities between OEC and FTC

2 complementarity factors

1. screening role of FTC before hiring on OEC: some FTC are a stepping stone to OEC, because workers without credentials would never be directly hired on OEC.

2. A special buffer role of FTC: the higher the present labor share of FTC, the less risky the hire of new OEC, since FTC can be terminated instead.
Individuals, imperfect information, productivity and wages

- **3 types of **Human Capital** (general, occupational, job specific)**
  - Each job has minimum requirements in human capitals. The employer observes the human capitals credentials, and must pay for the training of a worker he hires up to requirements, if needed
  - A worker receives wage based on the hourly base wage posted for the job plus a return on her/his human capitals
  - Hiring wages are influenced by the tension on the labor market
  - The employer does not know the true productivity of a worker, since he does not observe her/his talent
  - After hiring, he learns progressively but never perfectly
  - The hired worker learns the amenity (conditions of work) of the job immediately after hire
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3. WorkSim: a (quick) tour
Simulation Cycle

INITIALISING: Firms & Individuals

1 step (tick) = 1 week

FIRM DECISIONS
1. Job creations
2. Job destructions
3. Employee evaluations

INDIVIDUAL DECISIONS
4. Enter / Leave Labor Market
5. [employed] Seek another job
6. Job seeking

FIRM DECISIONS
7. Hiring phase
8. Promotions

DEMOGRAPHY
9. Household dynamics
10. Retirements
11. Aging

Simulation cycle
Firms’ decisions: job creations

Job creation issues

- Is the current demand sufficient?
- How to anticipate its fluctuations?
- Which type of contract is the most suitable?
Demand anticipation: 3 scenarios

- **Demand increases**
- **Same trend**
- **Demand decreases**

Production

Current Demand

New Job

1 week
1 month
3 months
6 months

OEC

Unsold Production ➔ LOSS

(Goudet, Kant, Ballot, 2015)
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Individual decisions

State Machine

- 6 possible states: inactive, unemployed, employed, employed and seeking a new job, student or retired
- Transitions between these states can be caused by individual choices, external events or a sequence of multiple decisions

Satisficing Heuristics

- Each individual uses a utility function, to decide whether s/he should stay in her/his current state or move to another one
- Generic utility function (Cobb-Douglas function):
  $$U = (Income + Amenity + Stability)^{1-\alpha}(Free\ Time)^\alpha$$
  - $\alpha \in [0,1]$ encodes the preference for free time. It depends on age, number of children in household and their age (for women)
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Individual state changes: overview

The diagram illustrates the transitions between different states:

- **Unemployed**
  - Transition to Inactive: $[\text{UTINAC} \leq \max(\text{UTUEM}, \text{UTRES})]$
  - Transition to Employed: $[\text{EMPLOY} \geq \text{ET}]$ and $[\text{UTNEW} \geq \text{ICHANG} \times \text{UTINAC}]$

- **Inactive**
  - Transition to Unemployed: $[\text{UTINAC} > \max(\text{UTUEM}, \text{UTRES})]$
  - Transition to Employed: $[\text{UTNEW} < \text{ICHANG} \times \text{UTINAC}]$

- **Employed (not searching)**
  - Transition to Employed On the Job Search: $[\text{UTNEW} = \text{ICHANG} \times \text{UTEMP}]$ and $[\text{UTOJS} > \text{UTQUI}]$
  - Transition to Unemployed: $[\text{UTRES} < \text{UTEMP}]$

- **Employed On the Job Search**
  - Transition to Employed: $[\text{UTOJS} = \text{UTINAC}]$ and $[\text{UTOJS} \geq \text{UTINAC}]$

- **End of contract/Fired**
  - Transition to Unemployed: $[\text{UTNEW} \geq \text{ICHANG} \times \text{UTEMP}]$ and $[\text{UTOJS} > \text{UTQUI}]$

- **Quit**
  - Transition to Unemployed: $[\text{UTOJS} < \text{UTINAC}]$

- **Look for a job**
  - Transition to Unemployed: $[\text{EMPLOY} \geq \text{ET}]$ and $[\text{UTNEW} \geq \text{ICHANG} \times \text{UTINAC}]$

- **Stop search**
  - Transition to Employed: $[\text{UTRES} < \text{UTEMP}]$

- **Hired (new job)**
  - Transition to Employed: $[\text{UTNEW} < \text{ICHANG} \times \text{UTEMP}]$ and $[\text{UTOJS} \geq \text{UTINAC}]$

- **[UTINAC] Quit**

The diagram uses logical expressions to define the conditions for each transition.
Learning: key reservation levels for the matching process

- **Hiring Norm**

\[
HNorm_{j,p,q,t=\text{ crea}} = \left( \phi_{\text{Avg}} + N_1 \times (\phi_{\text{Max}} - \phi_{\text{Min}}) \right) \frac{N(d_c)}{H(TIGH_{q,t=\text{ crea}})}
\]

- **Reservation utility**

\[
UTRES_{i,t} = UTRES_{i,t-1} \times (1 - Ru_3) \\
+ Ru_4 \times (UTUEM_{i,t} - UTUEM_{i,t-1})
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\]
Matching process: overview

1. Create a job offer
2. Publish a job offer
3. Look for a job
   - 3.1: Vacancy list

4. Calculate utility of each job offer
5. Eliminate the job offers with an utility below the reservation utility

6. Apply to the first job offer with an utility above the reservation utility

7. Calculate profit of each candidate
8. Eliminate the candidates who do not exceed hiring norm

9. Recruit the best candidate
10. Suppress the job offer
4. Simulation results
Scaling

- 20,000 agents: 18,300 individuals and 1,700 firms (Reduction factor 1/2300)

The Calibration problem

- A set of parameters and a set of desired outputs (targets)
- Minimize fitness function
  \[ \text{fit} = \sum_k w_k (\text{SimOutput}_k - \text{Target}_k)^2 \]
- 60 parameters to calibrate
- 63 targets: unemployment rates, activity rates, salaries, job flows, FTC, long-term unemployment, ...
Calibration (1/2)

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The Calibration problem

- A set of parameters and a set of desired outputs (targets)
- Minimize fitness function
  \[ fit = \sum_k w_k \cdot (SimOutput_k - Target_k)^2 \]
- 60 parameters to calibrate
- 63 targets: unemployment rates, activity rates, salaries, job flows, FTC, long-term unemployment, ...
Calibration (2/2)

**CMA-ES optimization**  (Hansen and Ostermeier, 2001)

- Covariance Matrix Adaptation Evolution Strategy

1 iteration = 4 years (102 + 102 ticks) - 48 replications

- Convergence stop: no improvement for 500 iterations

- Computational cost: 100,000 simulations - 2 days on 48-cores computer grid

- *median error* = 7.9%
  - *Mean standard-deviation* on the 63 outputs: 6.9% (relative)
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![Generation 1](image1) ![Generation 2](image2) ![Generation 3](image3)

- Generation 4
- Generation 5
- Generation 6

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Loss Aversion

Calibrated weight values

Production

Demand at t

Time

2%

7%

91%
Assessment of 6 labor public policies

<table>
<thead>
<tr>
<th>Policy</th>
<th>Δ UEMP (pts)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrat de Génération</td>
<td>−0.38 (yo.), −0.03 (sen.)</td>
<td>windfall (90%) and crowding-out</td>
</tr>
<tr>
<td>FTC Removal</td>
<td>+2.61 (2 yo), +0.42 (4 yo)</td>
<td>↑ segmentat &amp; LTU</td>
</tr>
<tr>
<td>Renew FTC twice</td>
<td>+0.25 , −1.4 LTU</td>
<td>↑ turnover (+7.08)</td>
</tr>
<tr>
<td>Charges 1.6 SMIC</td>
<td>−0.72</td>
<td>+233 K jobs</td>
</tr>
<tr>
<td>Charges 1.2 SMIC</td>
<td>−0.95</td>
<td>+ 298 K jobs, ↓ costs</td>
</tr>
<tr>
<td>Firing costs</td>
<td>0 → ≃ 0, x50 → +1</td>
<td>insensitive</td>
</tr>
<tr>
<td>X legal justification</td>
<td>−1.89, −9.71 (yo.), +1.48 (sen.)</td>
<td>econ. fire x 60 pr(loose job) +65%</td>
</tr>
</tbody>
</table>

|                           | −2.7 LTU, +726 K EMP                     |
|                           |                                           |
No new FTC contract can be signed except customary contracts (limited to 1% of employment)

- Unemployment increases by 1.1 point, then decreases to the baseline
- However the long term unemployment rises by 24 points
- Employment loses permanently 290,000 jobs.
- the equivalent number of unemployed have become discouraged by the difficulty of finding an OEC and the activity rate falls by 1 point. Human capital starts to fall - with irreversible effects
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Unemployment rises only by 1 point when the severance pay is multiplied by 50.

FTC hires increase and substitute to OEC hires which decline.

This substitution is also found in the econometric literature: Hijzen et al. (2017), Tejada (2017).

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- New labor law project introduced in February and adopted on July 21, 2016
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  - Contains many articles: hierarchy of standards, duration of work, training, youth aid,...

Article 30: Economic Dismissals

- Facilitate Economic Dismissals
- Making labor market more flexible to induce employers to hire on OEC
A new labor law in France (1/2)

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ELK Law Implementation

**Article 30** Economic dismissals will be allowed in case of a decline either in firm’s demand or its turnover computed over a certain period, which depends on the firm’s size.

<table>
<thead>
<tr>
<th>Firm Size</th>
<th>Period (quarters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 11</td>
<td>1</td>
</tr>
<tr>
<td>[11, 50]</td>
<td>2</td>
</tr>
<tr>
<td>[50, 300]</td>
<td>3</td>
</tr>
<tr>
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</tr>
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**FTC-OEC substitution**

- ↓ share of FTCs : 77% → 30%
- The OEC becomes the dominant hiring contract (23% → 70% of hires)
- Proportion of FTCs in ongoing contracts falls from 8% to 2.3%
  - ↓ Mean duration (renewal not included) : 3.6 → 1.9 weeks
- **Economic dismissal rate** ↑ : 0.6% → 19% (×30)
- OECs become shorter and more precarious
  - probability to loose one’s OEC within a year ↑
  - 8.17% → 13.13% (+ 60 %)
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ELK Law: Impact on Employment

**Age group substitution**

- After 4 years, no impact on global employment
- Favourable to the young (15-24), ↓ unemployment (-148,000, -5 pts)
- Not significant for the middle-age class (25-49)
- Unfavourable to the Seniors (50-65): ↑ unemployment (+101,000, +1.4 points), ↓ employment (-121,000).

⇒ Young were much more often in FTCs and benefit from their fall

⇒ Most of seniors are in OECs and face more dismissals. Moreover, youngers are often preferred to seniors because their net profitability is higher and training can be better amortized.

Firm’s mean profit ↑: +16%
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Adjustment to aggregate demand

- When demand ↑: more hire in OECs, and unemployment ↓ (-2 pts)
- When demand ↓: more economic dismissals, and unemployment ↑ (between 4 and 12 pts)
5. Discussion and perspectives
Summary: Contributions of WorkSim

- **Most comprehensive ABM of the French labour Market**
- Theoretical contributions to the choice between labour contracts
- Calibrated on a large number of targets
- Analyzes the anatomy of the French Labor Market
- Anticipations (with several scenarios) matter
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- Plug into a **Macroeconomic** framework
- **Cohort analysis** (classification of individual trajectories)
- Link with **econometrics**
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  - WorkSim code is modular, institutions is an independent component with an interface to the simulator

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- A survey by Ourliac and Nouveau (2012) states that the reduction of charges for salaries below 1.6 SMIC has generated a gain between 200,000 and 400,000 jobs.
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- The decrease in unemployment is 0.72 points.
- Several studies recommend a concentration of the reduction on lower wages.
- Experiments with WorkSim show that setting the ceiling at 1.2 SMIC raises the gain to 298,000 while decreasing the gross cost by created job by 22%.
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Labor Policies: Reduction of charges

- This experiment aims principally to show that the model provides results similar to the literature on a topic for which it has not been specifically designed.
- A survey by Ourliac and Nouveau (2012) states that the reduction of charges for salaries below 1.6 SMIC has generated a gain between 200,000 and 400,000 jobs.
- WorkSim finds a gain of 233,000 jobs (compared to a simulation with charges).
- The decrease in unemployment is 0.72 points.
- Several studies recommend a concentration of the reduction on lower wages.
- Experiments with WorkSim show that a setting the ceiling at 1.2 SMIC raises the gain to 298,000 while decreasing the gross cost by created job by 22%.