WorkSim, an agent-based model to study labor markets

Gérard Ballot[1] Jean-Daniel Kant [2]

(1) Université Panthéon Assas - TEPP-CNRS, Paris- CRED

(2) Université Pierre et Marie Curie - CNRS, Paris - LIP6

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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

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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
- Richiardi (2004, 2006)
  - 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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Related ABM for labor markets (2)

- Barlet et al. (2009) simulated the French labor market for year 2006.
  - 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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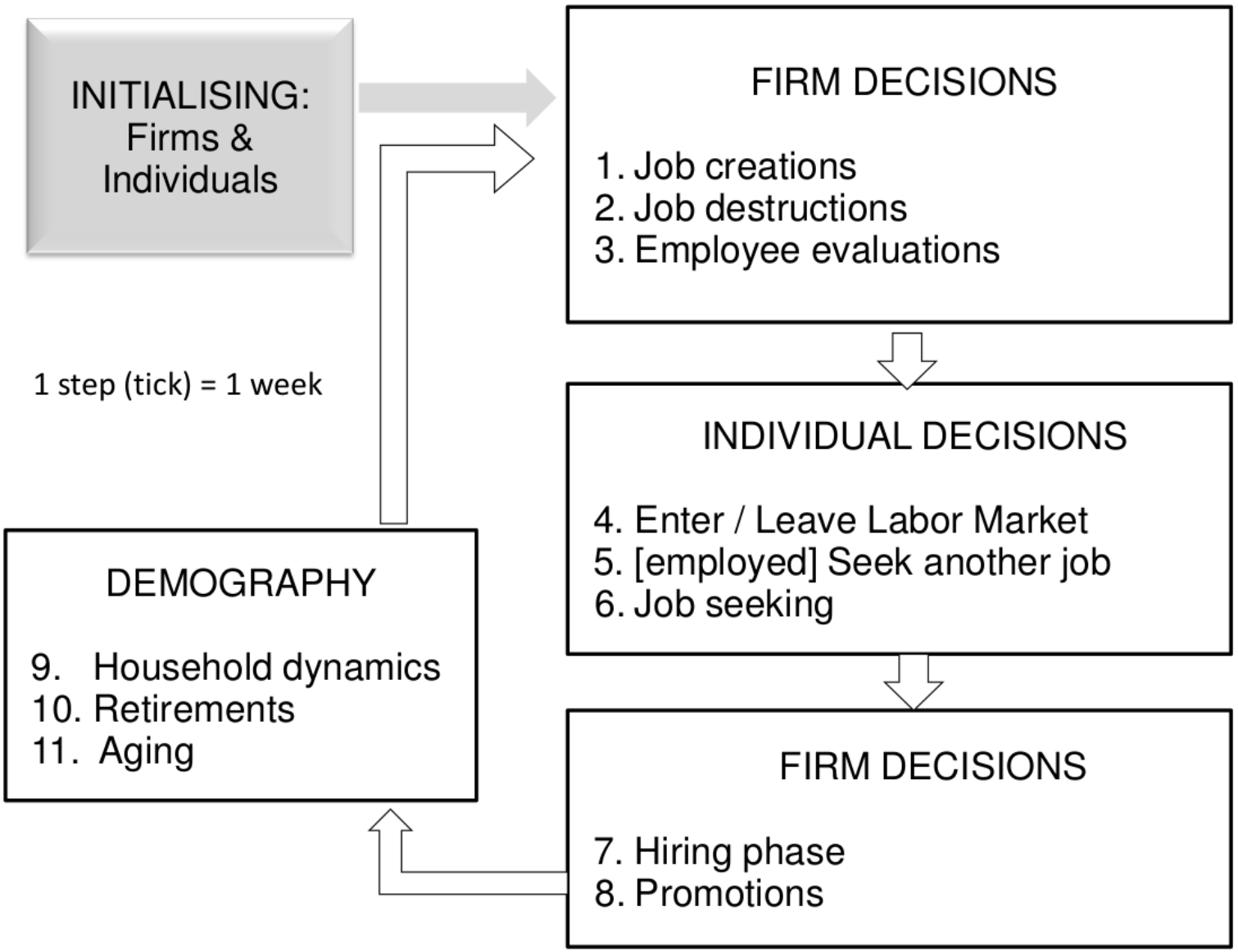
3. WorkSim : a (quick) tour

Simulation Cycle

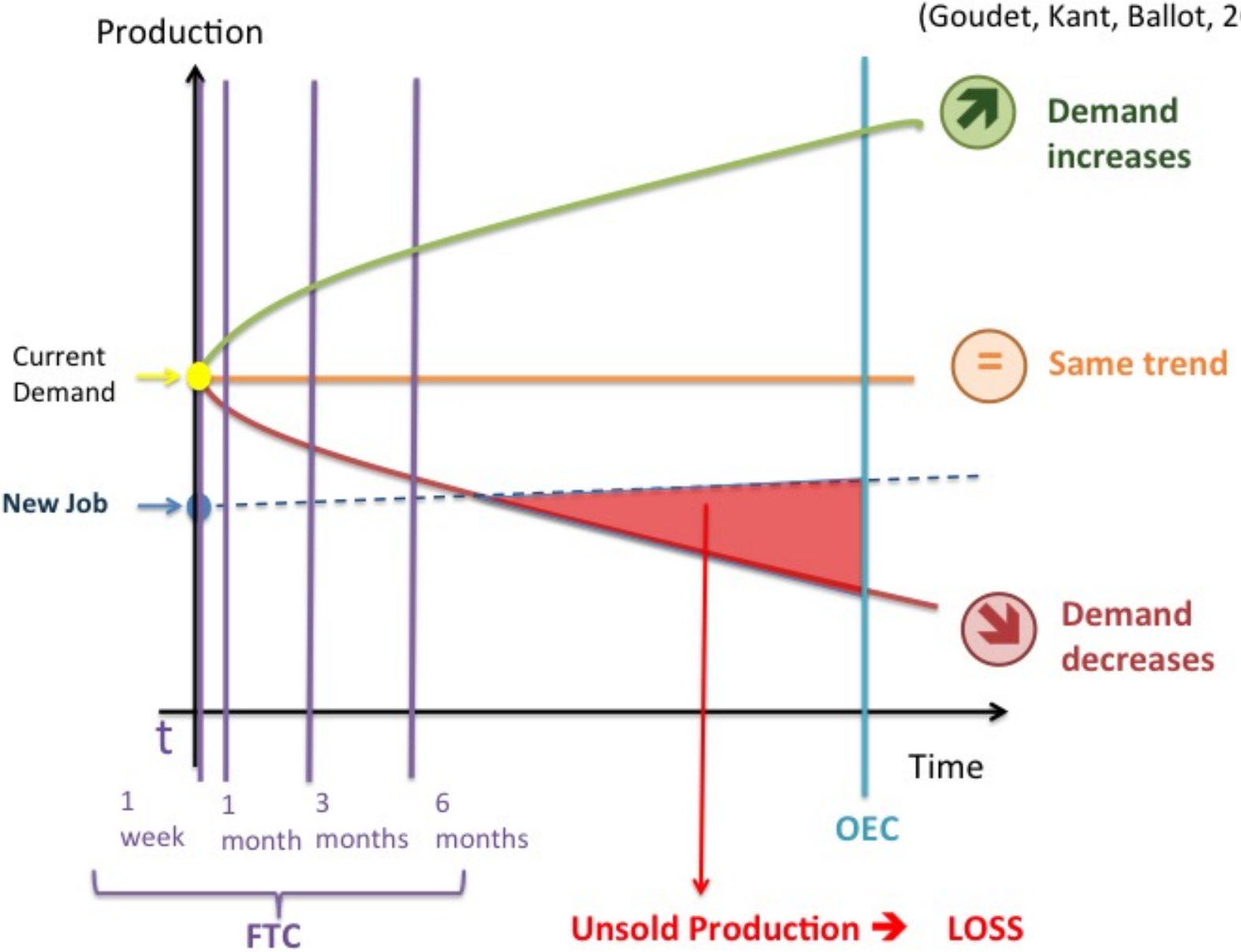


Firms' decisions: job creations

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



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):
  $\boldsymbol{U = (Income + Amenity + Stability)^{1-\alpha}(Free\ Time)^{\alpha}}$
  - $\alpha \in [0, 1]$ encodes the preference for free time. It depends on age, number of children in household and their age (for women)

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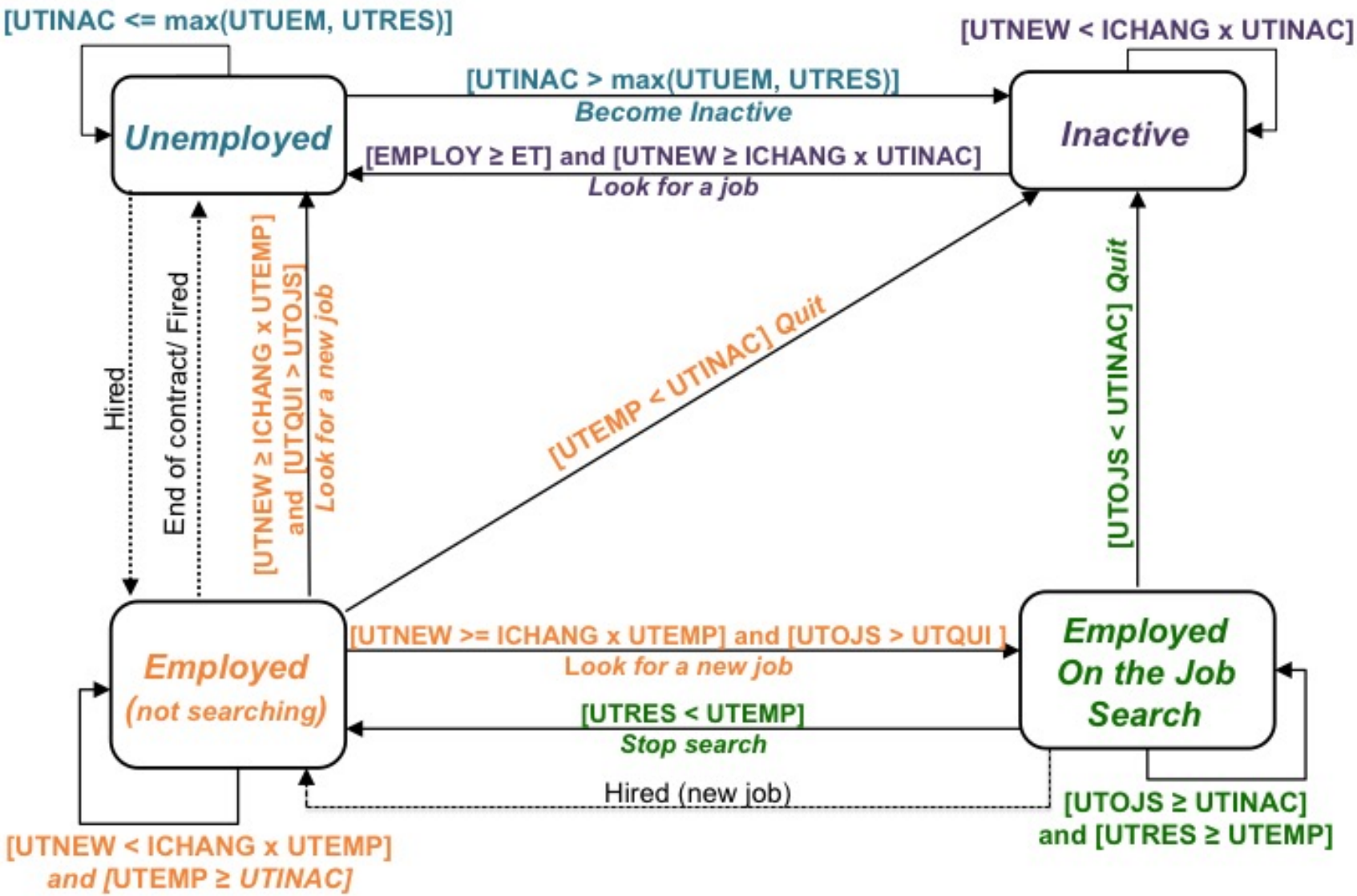
Individual state changes: overview



Learning: key reservation levels for the matching process

- **Hiring Norm**

$$HNorm_{j,p,q,t=crea} = (\phi^{per}_{Avg} + N_1 \times (\phi^{per}_{Max} - \phi^{per}_{Min})) \frac{N(d_c)}{H(TIGH_{q,t=crea})}$$

- **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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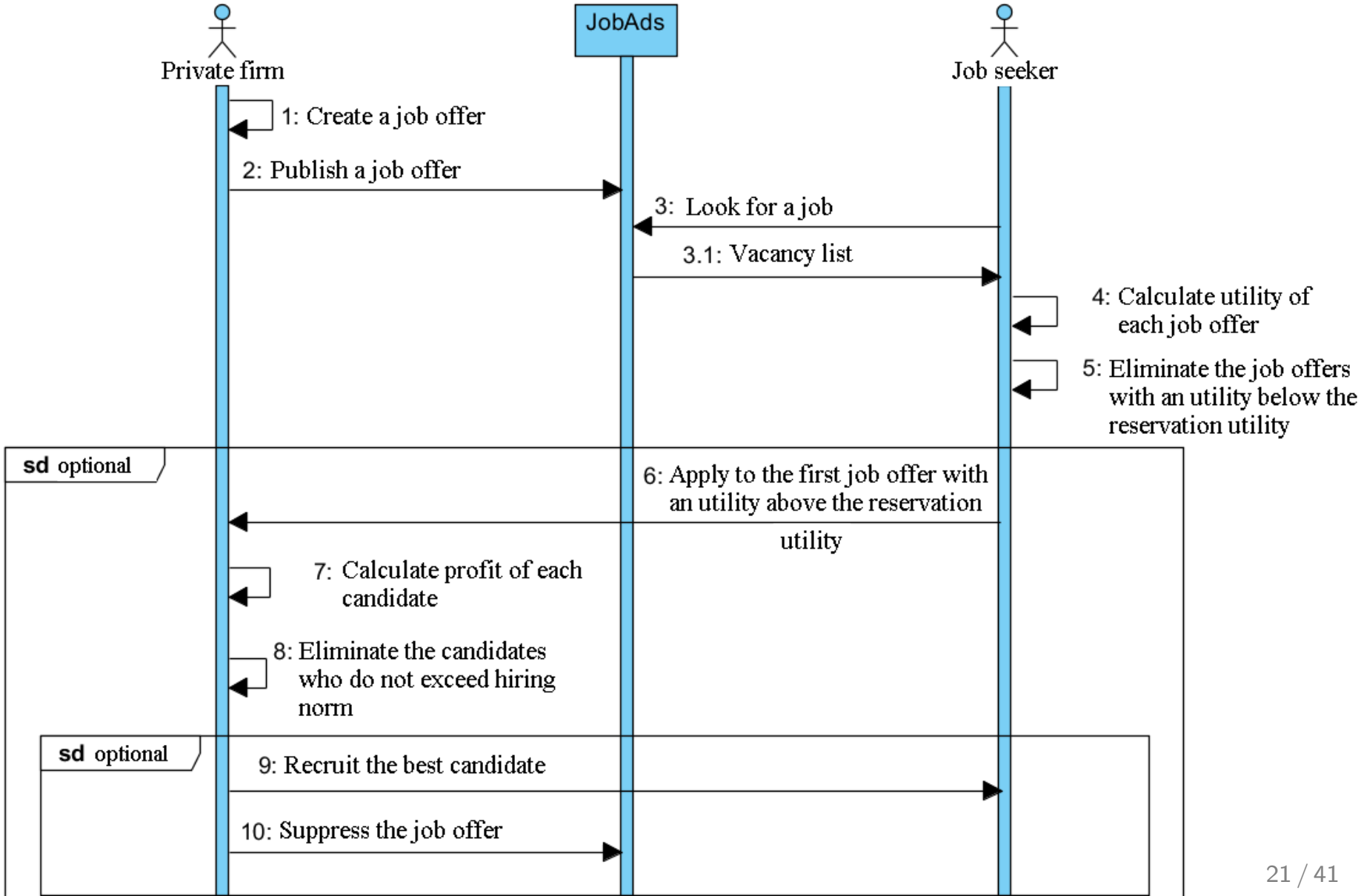
Matching **process** : overview



4. Simulation results

Calibration (1/2)

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
  - $fit = \sum_k w_k.(SimOutput_k - Target_k)^2$
- **60 parameters** to calibrate
- **63 targets** : unemployment rates, activity rates, salaries, job flows, FTC, long-term unemployment, ...

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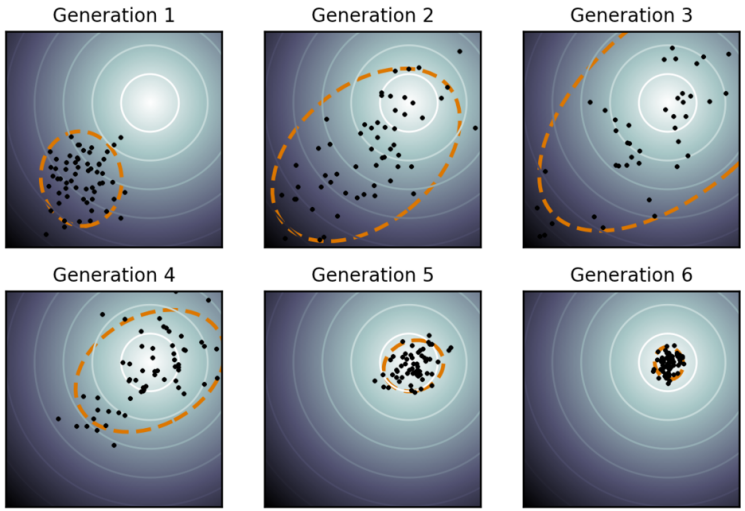
Calibration (2/2)

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)

Calibration (2/2)

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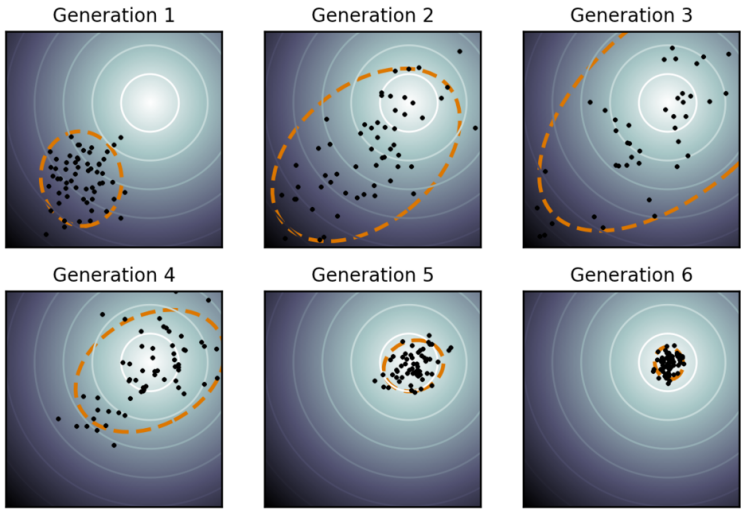

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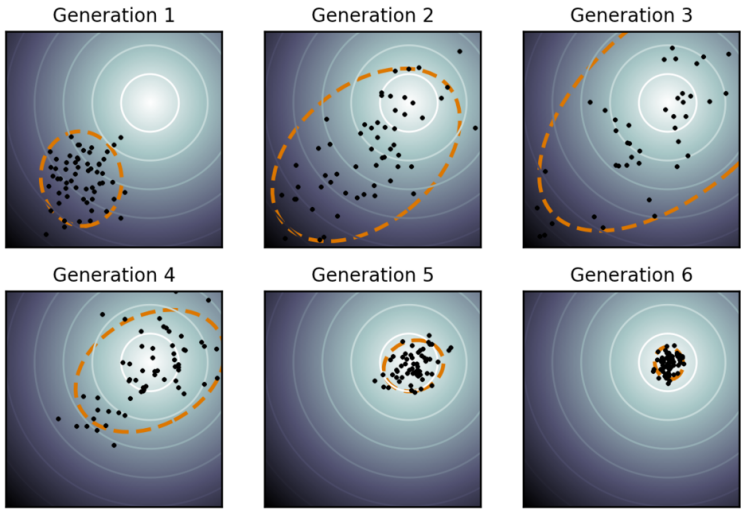

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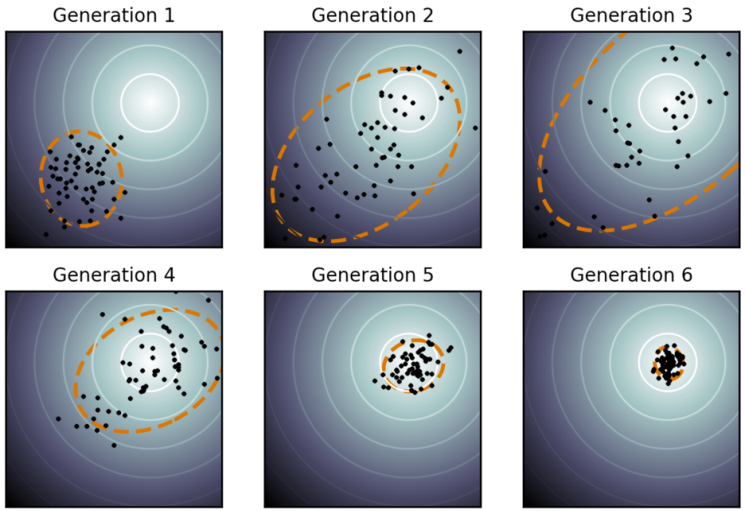

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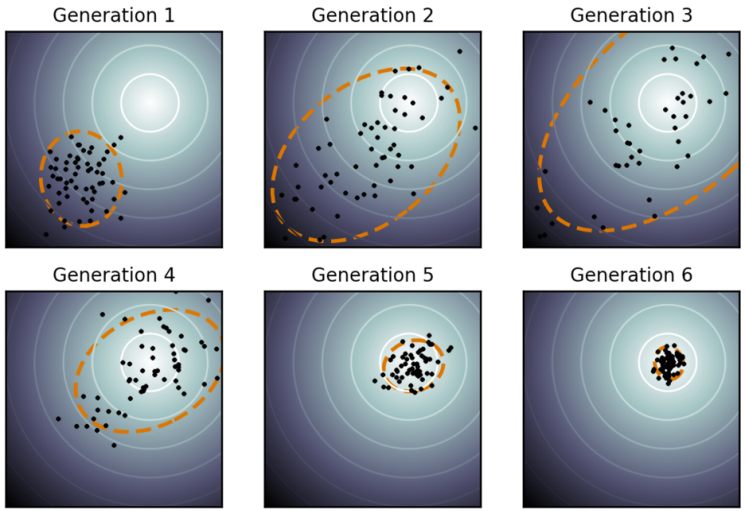

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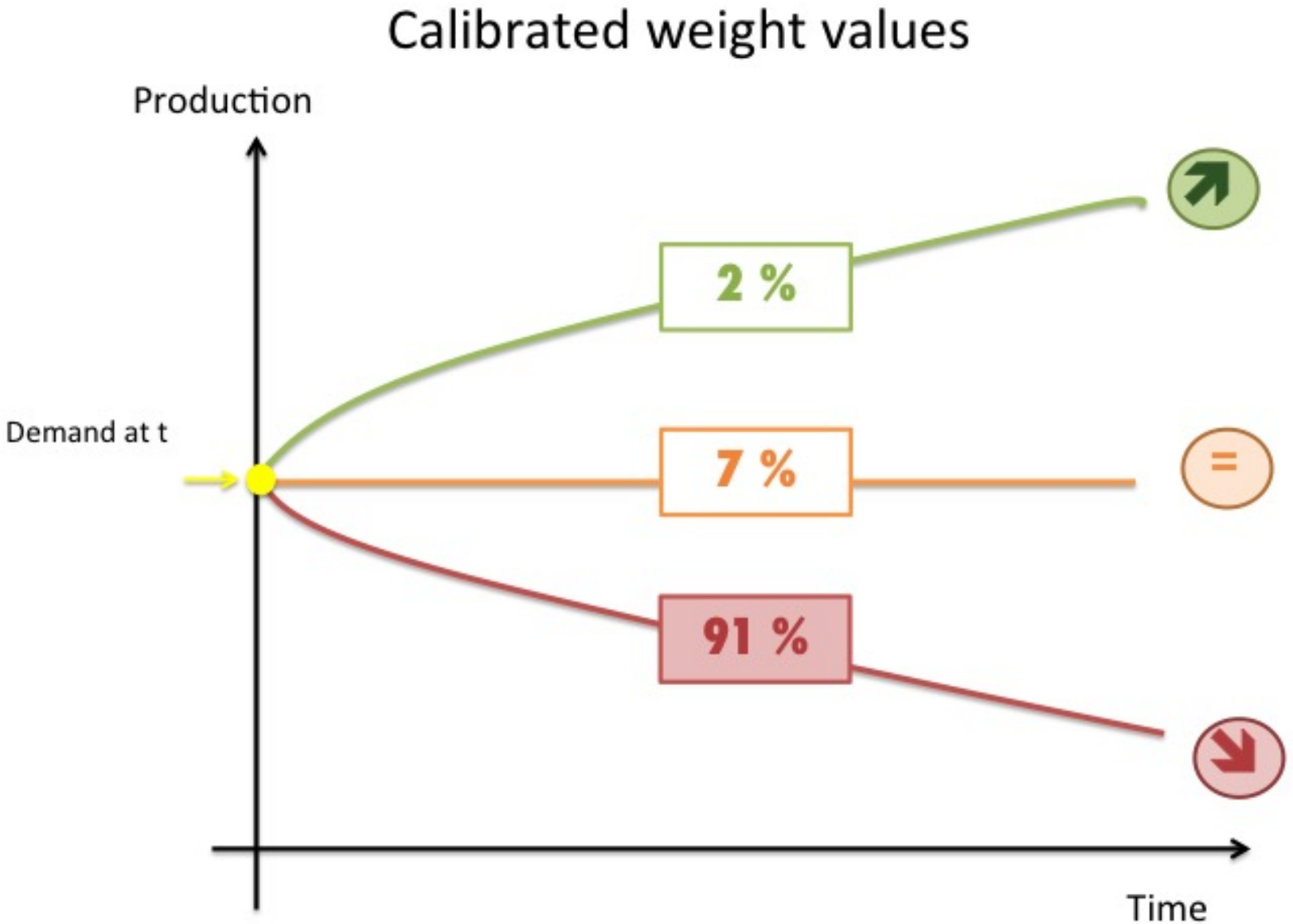

Assessment of 6 labor public policies

	Δ UEMP (pts)	Comments
Contrat de Génération	-0.38 *(yo.)*, -0.03 *(sen.)*	*windfall* (90%) *and crowding-out*
FTC Removal	$+2.61$ (2 yo), $+0.42$ (4 yo)	↑ segmentat ↑ & LTU
Renew FTC twice	$+0.25$,-1.4 *LTU*	↑ *turnover* ($+7.08$)
↓ *Charges* 1.6 SMIC	-0.72	+233 K jobs
↓ *Charges* 1.2 SMIC	-0.95	+ 298 K jobs, ↓ costs
↓ Firing costs	$0 \rightarrow \simeq 0$, $x50 \rightarrow +1$	insensitive
X legal justification	-1.89, -9.71 (yo.), $+1.48$ (sen.) -2.7 LTU, $+726$ K EMP	econ. fire x 60 pr(loose job) +65%

Labor Policies : FTC Removal

- 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
- Suppressing FTC then does not end segmentation effects.

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Labor Policies : Changing the severance pay (1/2)

- Legal severance pay schedule is multiplied by a factor of 0 to 50.
- Unemployment rises only by 1 point when the severance pay is multiplied by 50
- FTC hires increase and substitute to OEC hires which decline.
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- If the severance pay is suppressed, the hoarding costs remain and unemployment does not decline below 9.5 %

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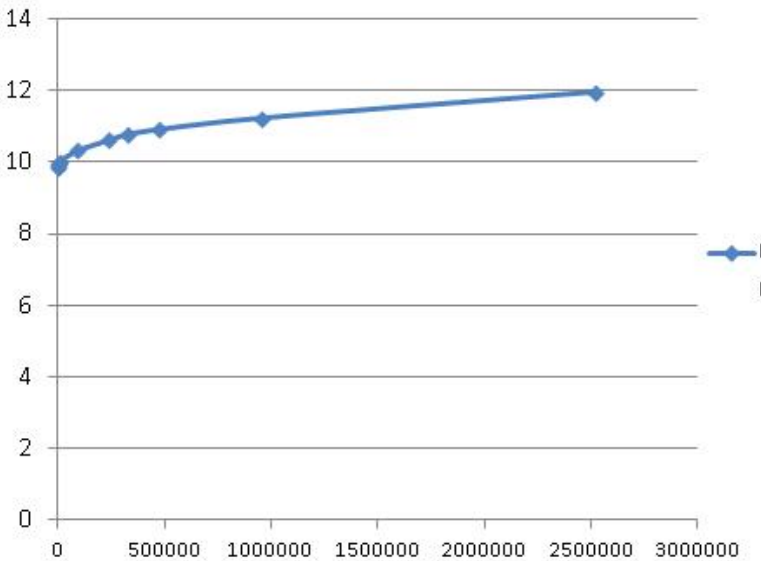

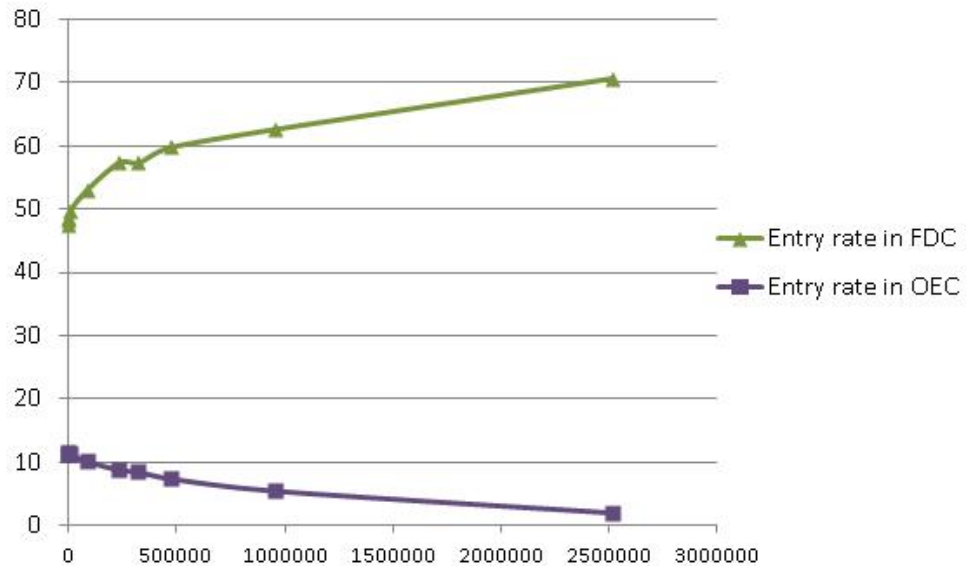

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- This experiment aims principally to show that the model provides results similar to the literature on a topic for which it has not been specifically designed.
- A survey by Ourliac and Nouveau (2012) states that the reduction of charges for salaries 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 %.

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El Khomri Law

- New labor law project introduced in February and adopted on July 21, 2016
- labor Minister Myriam El Khomri $\Rightarrow$ "El Khomri Law"
- 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

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- A vivid debate among economists, with 2 sides : pro (Tirole, Blanchard, Aghion, Cahuc,...) vs. anti (Piketty, Ashkenazy, Cohen,...)

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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

Firm Size	**Period (quarters)**
< 11	1
[11,50 [	2
[50, 300 [	3
≥ 300	4

ELK Law : Change the nature of the FLM

FTC-OEC substitution

- $\downarrow$ share of FTCs : 77% $\rightarrow$ 30%
- The OEC becomes the dominant hiring contract (23% $\rightarrow$ 70% of hires)
- Proportion of FTCs in ongoing contracts falls from 8% to 2.3%
  - $\downarrow$ Mean duration (renewal not included) : 3.6 $\rightarrow$ 1.9 weeks
- **Economic dismissal rate** $\Uparrow$: 0.6% $\rightarrow$ 19% ($\times$30)
- OECs become shorter and more precarious
  - probability to loose one's OEC within a year $\Uparrow$ 8.17% $\rightarrow$ 13.13% (+ 60 %)

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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.

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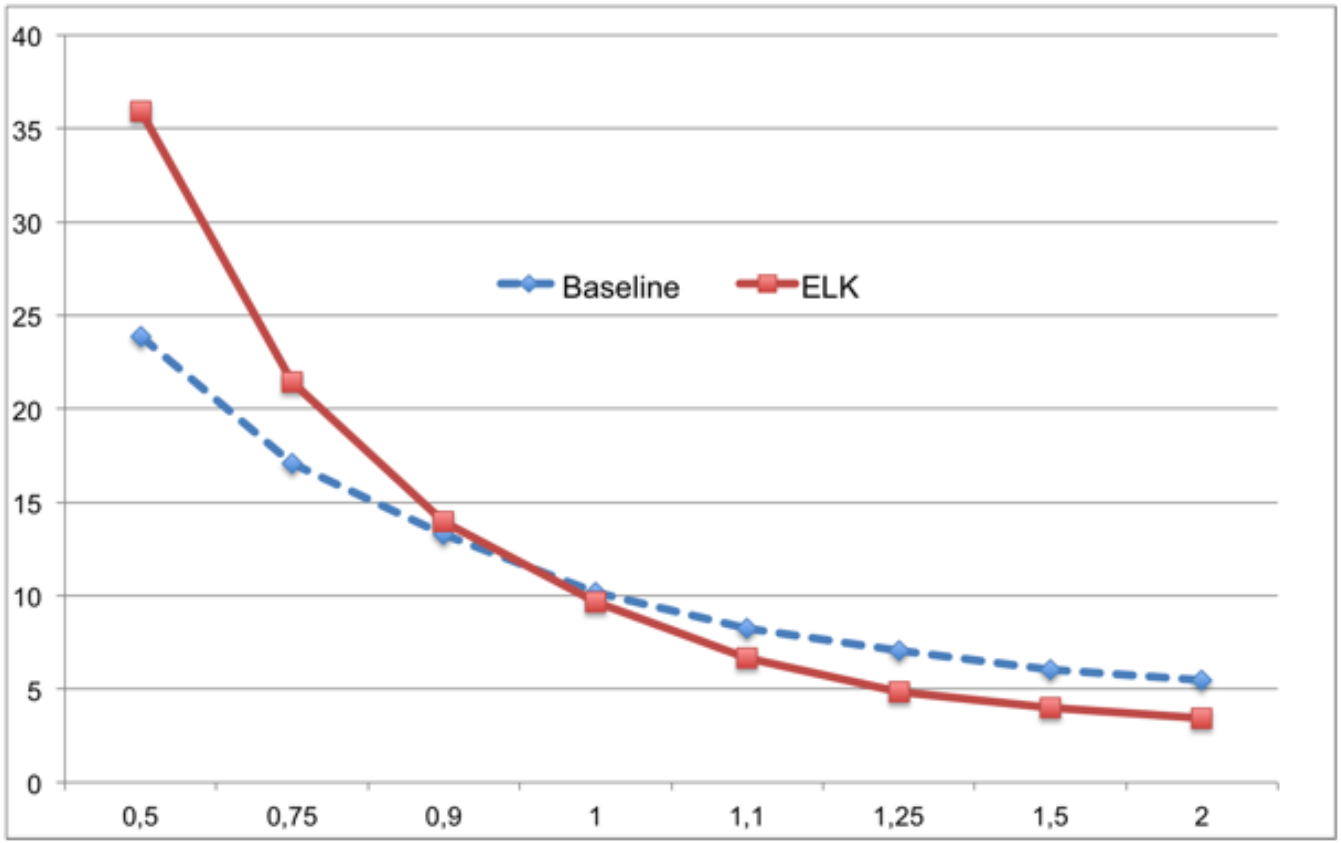
Adjustment to aggregate demand



- When demand $\uparrow$: more hire in OECs, and unemployment $\downarrow$ (-2 pts)
- When demand $\downarrow$: more economic dismissals, and unemployment $\Uparrow$ (between 4 and 12 pts)

5. Discussion and perspectives

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- 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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- **Shift from one type of flexibility** (hires in short FTC) **to another** (short and more precarious OEC)
- **Asymetric response** to demand shocks

Future Work

- **Extend** the model : temporary employment agencies, social networks, training over the career, task based jobs, unions ...
- Plug into a **Macroeconomic** framework
- **Cohort analysis** (classification of individual trajectories)
- Link with **econometrics**
  - to improve the agents' micro-foundation and enhance the **validation** process.

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Perspectives

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- **NumJobs : Impact of digital and AI to employment**
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