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# The Synergy between ABM and Labor Market Dynamics

## How do they get along?

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# Presentation Overview

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# Objectives and motivation

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Objective: to trace the use and applicability of agent-based modelling (ABM) in the field of labor market. Previous paper: [Neugard and Richiardi, 2018].

Distinctive approach:

- 1 **methodological path** - we follow a computer science-based perspective
- 2 **economic perspective**- the labor market related topics in which this methodology demonstrates its applicability

⇒ This study differentiates from the existing literature in that it is meant to serve as a *guideline* for future works in implementing agent-based models in this field.

# An agent-based model is...

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- a computerized simulation
- consisting of decision makers (**agents**) that interact with one another in a certain environment

**SCOPE:** to study an overall, complex system comprising a large number of interacting agents

- emergent *outcome* is generated from the whole system

# When ABM proves its worth?

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- complexity

*"The whole is not equal to the sum of the parts."*

Vicsek (2002): the emergent properties generated in such a setup are qualitatively different from those that govern the behavior of individual units that form the system.

- space: agents' positions are not fixed
- population heterogeneity: agents' behavior is complex (learning)
- interactions: their topology matters and is complex (e.g. social networks)

# A formal definition

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## Definition

An **agent based model** is a system that *“consists of a number of agents, which interact with one another, typically by exchanging messages through some computer network infrastructure.”* [Woolridge, 2002][page 19].

# ABM's building blocks

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## Agents

that possess a set of attributes, a learning style and an algorithm for decision making

## Interactions

among agents (e.g. worker-firm or worker-worker) or between agents and the environment

## Environment

the place/space where the agents interact

# What is different from traditional economics?

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## The **neoclassical economic models**:

### **PROs**

- 1 computational advantages
- 2 tractability and mathematically solvable equations
- 3 assumptions: rationality, homogeneity, and the existence of equilibrium

### **CONs**

they show a simplified version of the reality and are not capable of reproducing all the features of the real world

**Agent-based modeling:** a more realistic setup.

- test whether the existence of some particularities of the system leads to **equilibrium** (equilibrium not imposed a priori) (Ballot& Mandel& Vignes, 2014).
- use a **bottom-up approach** which allows the aggregate phenomena to emerge from the model



# What is different from traditional economics?

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ABM deviates from the traditional economic approaches as it makes use of three distinctive elements (Wall & Leitner, 2020):

- agents are considered to have **bounded rationality**
- they evolve as a result of an **adaptive learning process**
- they are **heterogenous** in terms of their beliefs, preferences, cognitive capabilities, social network or behavioral rules of decision

# Some limits and challenges

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- too much flexibility?
- difficulties in generalizing the results
- computational challenges

a computational  
feasible model

**OR**

a model that better  
approximates the reality

- they sometimes require a non-negligible amount of time to generate results and advanced programming skills
- robustness can be overcome only by multiple runs of the model (with different parameters or initial conditions) (Axtell, 2000)

# ABM and Labor market dynamics

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Agent-based modeling (ABM) uses features that allow for a more realistic and detailed description of the labor market setup.



ABM - for studying the complexity of labor market dynamics, as a continuously evolving and adaptive system

# I. Methodological view

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we split the analysis on the components of an ABM

- agents
- interactions
- environment

and investigate to what extent the economic considerations are transposed into model simulations.

# 1. The AGENT

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## Definition

The **agent** is a *computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives.*  
[Woolridge, 2002][page 15].

- 1 agent's endowments
- 2 the learning process
- 3 decision making algorithm

Two types of agents are of particular interest for the labor market setup:

- workers
- firms

# The AGENT: a. Agent's endowments

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- the agents have *heterogenous* features and characteristics (education level, work-site history, abilities and cognitive capabilities)
- differentiate between:
  - **internal endowment** (age, skills, etc.)
  - **objective information** (a job offer, minimum wage, etc.)
  - **subjective features** (conservative view or entrepreneurial spirit, more or less risk averse, preference for leisure in the detriment of wage)

# The AGENT: a. Agent's endowments

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- the degree of **heterogeneity** varies:
  - workers are skill-homogenous (Fagiolo et al., 2004), (Tassier&Menczer, 2008);
  - differentiate by means of entrepreneurial attitude and productivity (Richiardi, 2006);
  - specific on-the-job skills (Dawid et al., 2009 and 2012);
  - individual productivity levels (Lewkovicz & Kant, 2008)

# The AGENT: b. The learning process

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## Definition

How an agent improves its performance over time.

- prisoner's dilemma game approaches (Tesfatsion, 1998); (Pingle & Tesfatsion, 2004);
- adaptive behaviour (Tesfatsion, 2001), (Axtell, 2002), (Richiardi, 2006), (Fagiolo et al., 2004);
- endogenously determined and related to the social network (Dawid et al., 2014); (Gemkov & Neugart, 2011)



# The AGENT: c. Decision making algorithm

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Agents are independent and their actions within the system are not governed by an aggregate rule.

- *random associations*
- most of the models leave the decision making process *to the workers or firms*
  - hiring: firm's skill requirements (Baruffini, 2013);
  - firms -rank the applicants according to their skills, while job seekers classify possible employers based on the reservation wage (Dawid et al., 2009);
  - agent dynamics are considered to be firm-specific (Lopez et al., 2015))

## 2. INTERACTIONS

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The **job searching mechanism**: the matching process between employers and employees

- aggregate matching function
- local selection mechanism (Tassier & Menczer, 2001); (Tefatsion, 1998 and 2002)
- rule-based modeling: evolutionary fitness selection mechanism (Boudreau, 2010) and based on referral hiring (Gemkov & Neugart, 2011)
- **The Labor Flow Network approach** (Lopez et al., 2015); (Axtel et al., 2019); (Tong et al., 2017)

# 3. The ENVIRONMENT

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## Definition

= a set of rules, norms that define the modeling setup

Two different approaches:

- 1 a spatial representation  
or
- 2 a network structure

Technically, it is modeled similar to an agent: a policy maker agent; the government; a central bank; a statistical office; a public sector, etc.

## II. Applied research topics

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- 1 Labor market stylized facts
- 2 Unemployment and labor market policies
- 3 Social networks and referral hiring

# 1. Labor market stylized facts

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- three labor market stylized facts:

- the *Beveridge curve* (Guerrero&Lopez, 2017; Kuhn&Hillmann, 2016)
- the *Wage curve* (Richiardi, 2006)
- *OKUN's law* (Richiardi, 2006)

-the study of *firm size distribution* and *firm growth* (Axtell, 2001; Axtell 2006; Perline et al., 2006) - statistical oriented analysis; motivated by policy implications associated with firms' sizes

## 2. Unemployment and labor market policies

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- the roots of unemployment as originating in the behavior of labor market players (Lewkovicz & Kant, 2008), (Lewkovicz et al., 2009), (Goudet et al., 2016)
- the labor market as an endogenously evolving institution (*ARTEMIS* (Ballot, 2002) and *WorkSim* (Lewkovicz et al., 2009), (Goudet et al., 2016), (Kant et al., 2020))
- the role of labor institutions on a country's economic performance (unemployment benefits (Bergman, 1990), (Ricetti et al., 2013), (Pingle & Tesfatsion, 2004))

### 3. Social networks and referral hiring

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**Social networks** - influence labor market outcomes.

**Referral hiring** - correlated to the spread of labor market inequalities:

- wage dispersion is positively correlated with the density of social ties (Montgomery, 1991);
- reduction in inequality when there is less referral hiring, making unemployment more evenly distributed across the market (Gemkov & Neugart, 2011);
- wage and employment gaps between gender and racial groups can be explained by the job network structure in the presence of social homophily (Buhai & Van der Leij, 2020WP)

# An example

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Model	LaborSim	WorkSim
<b>General purpose</b>	pedagogical tool for analysing labor dynamics and conducting policy experiments, online computational framework that allows users to simulate realistic labor dynamics and perform computational experiments about economic shocks and policy interventions.	tool for experimenting labor market policies, including changes in the labor law in France
<b>Model innovation</b>	LaborSim models each worker and each firm individually and accounts for the complex structure of their interactions;	Individuals' decisions respect the cognitive limitations of human subjects (bounded rationality), information is available but limited in quantity. Companies' decisions for job creation are endogenous and they use limited rationality.
<b>Economic issues addressed</b>	policies that target specific firms in the network	policies on the labor market: generation contract, reduction of charges, elimination of fixed-term contracts, labor law, etc
<b>Agents</b>	workers, firms	individuals and companies
<b>Institutional framework</b>	a frictionless network	main elements of labor law (CDD and CDI labor contracts, termination indemnities, etc.); and 3 modules: the State (recruiting civil servants), Job Ads (a job center-type site that lists jobs), and a statistical institute (data dissemination)
<b>Algorithm/ steps</b>	<ol style="list-style-type: none"> <li>1. firm innovations;</li> <li>2. worker: job search (if unemployed) and application submission;</li> <li>3. worker: each employed worker becomes unemployed with a firm-specific probability;</li> <li>4. firm: hiring</li> </ol> <p>Constraints: job seekers can only apply to one firm per period, and firms do not discriminate between workers local job searching; job search is restricted by labor market network structure (constraint: a worker can only search for jobs among those firms that are linked to their last employer)</p>	<p>Firm decisions: 1. job creation; 2. job destruction; 3. employee evaluation;</p> <p>Individual decisions: 4. enter/leave labor market; 5. seek another job (if employed); 6. job seeking;</p> <p>Firm decisions: 7. hiring phase; 8. promotions;</p> <p>Demography: 9. household dynamics; 10. Retirements; 11. aging</p>
<b>Job searching process</b>		sequential double search framework; matching emerges from bilateral meetings on a decentralized labor market (both sides select and can prefer no match other than a poor one)
<b>Data and calibration</b>	theoretical simulation	French labor market simulation (2014); numerous INSEE data available: demographics and economics; reproduces the labor market on a scale currently varying between 1/2000 and 1/1400 (from 20,000 to 30,000 agents); the parameters are calibrated automatically (using a powerful optimization algorithm, CMA-ES)
<b>Output parameters</b>	network structure parameters (number of firms and workers), unemployment rate and unemployment volatility in dynamics, the Beveridge curve	reproduces French labor market stylized facts: flow, segmentation of the labor market, long-term unemployment, etc.,
<b>Programming language</b>	JavaScript	
<b>Data</b>	yes	no



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- 1 Choose the economic research topic and formulate the hypotheses
- 2 Design and equip the model
- 3 Model parametrization and calibration
- 4 Model execution
- 5 Data gathering
- 6 Model evaluation and comparison

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# The End

Questions? Comments?