

**AN EVOLUTIONARY MODEL OF
INDUSTRY DYNAMICS AND FIRMS
INSTITUTIONAL BEHAVIOR WITH
JOB SEARCH, BARGAINING AND
MATCHING**

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An evolutionary model of industry dynamics and firms' institutional behavior with job search, bargaining and matching

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April 18, 2007

Abstract

This paper proposes an evolutionary model that captures the main dynamics of a world where heterogeneous firms and workers interact and co-evolve. Within a micro-meso perspective, the model focuses on the influence of firms' "institutional settings" on industry dynamics, formalizing these settings as firms' labor choices. Benefiting from insights offered by mainstream labor economics, we introduce the dynamic processes of job search, bargaining and matching in an evolutionary framework.

The results of a computer simulation model show that in a stable environment there is an initial clear improvement in the average fitness of the population of incumbent firms, which then evolves around an evolutionary stationary threshold. The consideration of endogenous matching and bargaining processes in the labor market results in important

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frictions. Furthermore, the simulation results show an increasing wage inequality between the two types of workers considered in the model.

We also consider the effect of both positive and negative demand shocks. The turbulence in the industry increases (decreases) after the negative (positive) demand shock. As expected, the negative demand shock causes a decrease in the number of vacancies and, consequently, the unemployment rates increase considerably. Following the positive demand shock, on the other hand, the firms slightly increase the number of vacancies, so the behavior in terms of unemployment rates is better than in the model without shocks.

Keywords: evolutionary, firm behavior, job search, bargaining and matching, micro-foundations, industrial dynamics

JEL-Codes: B52, D21, L2, J2, J3, O12

1 Introduction

Understanding economic growth and business cycles involves analyzing employment fluctuations as response to shocks in an uncertain environment (e.g. Andersen (1999)). Firms go through processes of reorganization associated with several factors, such as technological constraints, market fluctuations, and manpower mobility. Within this analytical frame, the economy's adjustment costs, as well as its structure at the micro level, are of relevance. The timing and pattern of employment adjustment, including hiring and firing decisions adopted by employers, are mediated by adjustment costs (e.g. Hamermesh (1993), Hamermesh and Pfann (1996), Abowd and Kramarz (2003)).

Neoclassical economics has been offering important insights concerning labor dynamics. Nevertheless, such contributions seem very stylized, in the sense that they usually do not focus on firms' diversity and they do not deal with industry dynamics. Most neoclassical labor literature assumes a standard approach based on the idea of hyper-rational firms and workers. The most common perspective considers the representative agent hypothesis as a tool to deal with the aggregation of heterogeneous behaviors. In addition, macroeconomic dynamics is usually interpreted under equilibrium conditions. Hence, the mainstream research seems very rigid in what concerns economic agents. In addition, it does not usually deal with the evolution of industries. Even reference models of labor mobility and job matching (for a survey see, for example, Mortensen and Pissarides (1999)) usually ignore the interdependencies between industry dynamics and labor market forces.

Evolutionary economics offers a much more realistic setting as it conceives the observed co-evolution between aggregate variables, such as the employment and the output, as resulting from far-from-equilibrium interactions between heterogeneous agents. Therefore, even when some equilibrium relationship takes place between aggregate variables, for example inflows and outflows from unemployment, the economy might systematically depart from it and show some disequilibrium trajectory (Fagiolo *et al.* (2004)).

In an evolutionary world, workers and firms interact directly, and their behaviors are influenced by the choices made in the past by both themselves and other agents. Such interaction networks, materialized in matching rules in the labor market, are endogenous and may change in time (Fagiolo *et al.* (2004)). The interaction occurs both in the labor and product markets, and firms' survival depends on firms' labor choices, such as hiring and firing policies and wage-setting decisions. In fact, changes in the industry structure and worker mobility influence each other. For example, Dunne *et al.* (1989) show that industries' dynamics are associated with the creation and destruction of jobs. Moreover, Haveman (1995) stresses that industry turbulence influences the labor market not only directly, through the movement of individuals employed in established firms to new ones, and of individuals allocated to exiting organizations to surviving ones, but also indirectly, through the vacancy chains associated to the founding and exiting processes of firms.

However, evolutionary economics usually does not focus on such topics, with most models of evolutionary industrial dynamics just emphasizing the technological and/or financial determinants of the evolution of industries (see e.g. Dosi *et al.* (1997), Sutton (1997)). Therefore, mainstream contributions, particularly in what concerns job search, matching and bargaining processes, are important to fulfill our main motivation: bring labor market dynamics into the evolutionist framework. In this framework, the economy is a complex and evolving system, agents are bounded rational and heterogeneous in almost all their attributes, there are open-ended search spaces and novelty is endogenous (for example, Nelson and Winter (1982), Dosi (1988), Andersen (1994), Nelson (1995), Nelson and Winter (2002)).

In this paper, we explicitly introduce labor market dynamics in a model that explores the implications of firms' behavior in their industry. The matching process that emerges from the interaction between firms and workers in the labor market is crucial to understanding employment and output growth dynamics. These topics are extensively treated by the neoclassical approach, while few formal contribu-

tions exist within the evolutionary literature. One important exception is Fagiolo *et al.* (2004), who offer a model close to both the "Agent-Based Computational Economics" (ACE) approach (Tesfatsion (1997), Epstein and Axtell (1996)) and self-organization models of labor markets (Lesourne (1992)).

The model we propose in this paper adopts a setting similar to the one proposed by Fagiolo *et al.* (2004) in what concerns the job search, matching and bargaining mechanisms. However, our model includes two distinct types of labor, the routine and the non-routine workers, while Fagiolo *et al.* (2004) only consider homogeneous labor. Furthermore, we focus on the idea of firms as heterogeneous organizations, with distinct "institutional settings",¹ which evolve over time building the firms' own "social capital",² and in how such choices interact with the evolving industrial process. In such a framework, our modeling exercise tries to capture the important dynamics of an evolutionary world where heterogeneous individuals, firms and workers, interact and co-evolve.

Our model selects labor organizational choices as the substantial nature of firms' "institutional settings", and is based on the specificity of labor amongst the firms' inputs since it carries imprinted relations and constitutes the core of the firms' routines (Stinchcombe (1965)). We assume that workers have distinct attributes. Certain workers (the non-routine) are more able to learn, organize people and tasks, make decisions and adapt to changing environments. These qualities may be associated with the worker's level of general education, which develops his/her analytical skills and abstract reasoning capabilities, and stimulates the ability to learn. However, they may also be associated with unobservable features such as attitude, confidence, the ability to organize and adaptability.

The remainder of the paper is structured as follows. Section 2 details the formal evolutionary model. In Section 3, the simulation exercise is presented and the results are discussed. Finally, in Section 4 we present some concluding remarks.

¹We adopt the definition of "institution" proposed by Rutherford (1994) (p. 182): "regularity of behavior or a rule that is generally accepted by members of a social group, that specifies behavior in specific situation, and that is either self-policed or policed by external authority. It is important to distinguish between general social rules (sometimes called the institutional environment) and particular organizational forms (sometimes called institutional arrangements). Although organizations can also be thought of as sets of rules, the rules apply only internally. Organizations have constitutions, are collective actors and are also subject to social rules."

²Despite the huge amount of research associated to the term "social capital", its definition remains vague (Durlauf and Fafchamps (2004)). The concept of "social capital" we adopt here corresponds to a broad interpretation embracing all the relations that influence personal interaction. Within the core of the paper, such relations occur within the firm as an organization.

2 Model set-up

2.1 The level of the micro agents: firms and workers

2.1.1 Some initial considerations

We consider that each firm in a certain industry is associated with one specific "institutional setting" that can be more or less close to the industry's institutional frame.³ The survival likelihood for each firm i depends on its ability to hire the suitable workers for its "institutional set" and on its ability to react to environmental change (which are connected with the transparency of the institutional environment). The "fitness" of each firm must be defined as a function of these abilities.⁴

In our framework, firms cannot fully understand the complexity of the economic system. Information is incomplete, in particular with regard to the future economic development (imperfect foresight). We base our study on the concept of bounded rationality (Simon (1955), Simon (1956), March and Simon (1958)), which appears in opposition to the neoclassical traditional assumption of fully rational agents. The bounded rationality program incorporates all the constraints on human knowledge and human computation, which are responsible for distinct behaviors of real actors when compared with the predictions made by the neoclassical economic theory.⁵ Furthermore, Simon (1956) introduces the idea that decision making is influenced not only by information processing capabilities, but also by the environment. Following Simon's contributions on human rationality and decision-making, we assume that firms make decisions based on adaptive expectations, with decisions being revised periodically, since their strategies are likely to be inconsistent.

In our model, the actors of the economic system are workers and firms. They are held together by two markets: an output market and a labor market. A single good is produced in the industry and there is no difference between the output of the firms in quality terms. The good is sold and bought in the output market that

³The modeling effort at the micro level developed here was inspired in the model of organizational culture presented in Carrillo and Gromb (2002). This paper intends to show that an organization is more productive if its agents "fit" in its culture and that organizations choose agents who are "good fits", but do so in an imperfect way and over time.

⁴Given a certain environment, fitness corresponds to the likely ability for an organization to survive.

⁵Simon sustains that the decision makers must simplify the decision actions, suggesting the "satisficing" concept as one possibility (Simon (1955)). A decision maker will maintain search until a good enough solution is found: "The player instead of seeking for a "best" move, needs only to look for a "good" move"(Simon (1955), p. 108).

takes place at the end of each period. Firms supply their maximum output, and the output price is determined so it clears the market.

In the labor market, we have \mathbf{L} workers of two distinct types. We have "routine-workers", $L^R \in \{1, \dots, \mathbf{L}^R\}$, that correspond to agents that do not have the ability to deal with activities involving innovative procedures, since they lack the minimum attributes required to deal with unexpected change. Their learning capability is of a learning-by-doing type. We will assume that these workers have attributes that make them "fit" into activities featured by routine or standard procedures. Additionally, we have "non-routine workers", $L^{NR} \in \{1, \dots, \mathbf{L}^{NR}\}$ and $\mathbf{L} = \mathbf{L}^R + \mathbf{L}^{NR}$. These agents have attributes that make them "fit" into activities where the reaction to unexpected change and learning-by-thinking are crucial. Therefore, the non-routine workers have a greater ability to perform activities involving problem-solving and complex tasks, being well suited to organizational forms that demand team work and job rotation.

Our categorization of workers is different from the one usually proposed in the literature as unskilled and skilled workers. The routine workers are individuals with severe difficulties in adapting to new situations, while the non-routine ones are highly flexible. Typically, the division of job levels appears as low and high skilled. The high skill jobs require professional or scientific skills at the level of high vocational or university education. The low skill jobs are associated with simple and routine tasks which mainly demand the use of hand-held tools and physical effort. In our division, the routine worker can have a higher degree of formal education and even so be unable to react to change. He/She can perform tasks that demand school training at a higher level but do not require flexibility in responses, being featured by monotony, repetitiveness and work constraints. Certainly, there is a high correlation between the capability of dealing with change and new situations and the degree of professional and scientific skills. In the skilled versus unskilled categorization, it is possible that high-skilled workers are more efficient than low-skilled ones on low-level jobs. In our typology, we assume this is not the case. A non-routine is less efficient than a routine worker if matched with a routinized set of tasks. This occurs because his or her attributes induce spending time looking for innovative procedures, which is a non profitable behavior within a routinized and inert activity. The level at which firms and production processes call for these types of workers is expected to vary across industries and occupations.

2.1.2 Baseline configuration

We consider an industry (*Ind*) composed by a certain number of firms N_t in each discrete time period t , with $t = 0, 1, 2, \dots$. Firms are assumed to produce the same homogeneous good, with one production factor, labor, with two distinct types of workers. In each period, a firm i produces X_{it} units of the homogeneous good whose price is $p_t > 0$.

The industry is characterized by an exogenous institutional environment represented by the variable $IInd$. Each firm i in the industry is featured by a specific "institutional frame" represented by the variable I_i . The "institutional fitness" of the firm is measured by $|I_{it} - IInd_t|$.

The firm decides on the following set of variables in each period of time

$$Firm_{it}(L_{it}^R, L_{it}^{NR}, w_{it}^R, w_{it}^{NR}, v_{it}^R, v_{it}^{NR}), \quad (1)$$

where:

- L_{it}^R corresponds to the number of workers associated with routine activities employed by the firm;
- L_{it}^{NR} corresponds to number of workers associated with non-routine activities employed by the firm;
- w_{it}^R and w_{it}^{NR} correspond to the contractual wages that firms offer, in each period of time, to routine and non-routine workers, respectively, as the result of an endogenous matching and bargaining process;
- v_{it}^R and v_{it}^{NR} corresponds to the number of job openings defined by each firm in t for routine and non-routine workers, respectively.

The firm's output level X_{it} is a function of technological progress A_{it} , and of the number of workers L_{it}^R and L_{it}^{NR} :

$$X_{it} = f(A_{it}, L_{it}^R, L_{it}^{NR}). \quad (2)$$

We assume a Cobb-Douglas production function with constant returns to scale associated with routine labor and non-routine labor,

$$X_{it} = A_{it}(L_{it}^R)^{\beta_1}(L_{it}^{NR})^{\beta_2} \quad (3)$$

where $\beta_1 + \beta_2 = 1$, $\beta_1 > 0$ and $\beta_2 > 0$, and A_{it} corresponds to the total factor productivity of the technique employed by the firms in each period t . Dividing by L_{it} , we obtain the firm's product efficiency per unit of labor, x_{it} ,

$$\begin{aligned}\frac{X_{it}}{L_{it}} &= A_{it} \frac{(L_{it}^R)^{\beta_1} (L_{it}^{NR})^{\beta_2}}{L_{it}} \\ x_{it} &= A_{it} \left(\frac{L_{it}^R}{L_{it}} \right)^{\beta_1} \left(\frac{L_{it}^{NR}}{L_{it}} \right)^{\beta_2} \\ x_{it} &= A_{it} l_{it}^{\beta_1} \alpha_{it}^{\beta_2}\end{aligned}\tag{4}$$

where l_{it} represents the stock of routine workers per unit of total labor and α_{it} corresponds to the ratio $\frac{L_{it}^{NR}}{L_{it}}$ (that is, the relative importance of non-routine workers).

We consider a simple framework in which the "institutional set" of each firm is represented by α_{it} and by an ex-ante unobservable variable ψ_{it} that sums up factors that determine this set, but which are not controlled by the firm. More precisely, in each period of time t , the α_{it} variable results from the stock of "social capital" measured as the value of the variable in time $t-1$, the investment made in time t by the firm to improve its own "fitness" in the institutional environment (the rearrangement of the proportion of workers through matching and bargaining processes, hiring and firing decisions), represented by $\Delta\alpha_{it}$, and from an unobservable random variable, ψ_{it} . Formally, we have:

$$I_{it} = \alpha_{it-1} + \Delta\alpha_{it} + \psi_{it}.\tag{5}$$

The firm may choose more rigid or more flexible "institutional sets". In the first case, the firm prefers more L_i^R workers. In the second case, the L_i^{NR} workers are crucial. The variable α_i represents the firm's institutional options, which are made by boundedly rational agents in a context of uncertainty. Each firm faces a trade-off when choosing the "satisficing" share of workers: a very low α means low wage costs but low possibilities to adjust, while a very high α corresponds to high possibilities to adapt, but also to high wage costs that may not be compensated by the adjustment benefit.

The short-run profit function, π_{it} , of each firm i is

$$\pi_{it} = X_{it}p_t - c_{it}\tag{6}$$

where c_{it} is the cost function.

The costs of the firm depend on the workers wages (w_R and w_{NR}) and on the "mix" of workers (α_{it}). They also depend on a "transaction cost", associated with the workers competencies, which is defined as $\tau_{it} = \mathfrak{S}(|I_i - Ind_1|)$. If the firm has a proportion of labor competencies close to the one that features its environment, this means a lower "transaction cost". Otherwise, this cost rises since the firm will have, for example, to subcontract thinking workers able to react to unexpected situations or deal with innovative procedures in industries featured by flexible "institutional sets". On the other hand, a firm within an industry characterized by a rigid "institutional set" also faces high transaction costs if it has a very flexible "social capital". As a matter of fact, this firm has more costs, not only in the form of wages, since $w_{NR} > w_R$, but also as costs of constant search for new possibilities in a very inert environment. Formally, the cost function, c_{it} , is defined as:

$$c_{it} = c(w_R, w_{NR}, \alpha_{it}, \tau_{it}). \quad (7)$$

Firms employ labor in one period contracts, so wages are paid after one period of employment. As previously mentioned, the model considers distinct remunerations for each type of workers. For the L^R the wage is w_R , and for the L^{NR} the wage is w_{NR} , with $w_{NR} > w_R$. Therefore, on one hand, we have workers that earn less, representing lower costs to firms, but that are incapable of adjusting themselves. Therefore, firms with a high proportion of these workers are much more likely to die when facing an unexpected and significant environmental change than those with higher proportion of L^{NR} workers. On the other hand, the non-routine workers receive a higher wage, meaning a higher cost for the firm, but are flexible and able to quickly adjust to changes. They are crucial for the firm to react to such changes, avoiding bankruptcy or even allowing firm's growth.

The wages emerge from the interaction between firms and workers. They correspond to contractual wages offered by firms to workers, being the result of a matching and a bargaining process. The wages can be different for each worker, and we assume that each worker supplies only one unit of labor.

Similarly to Fagiolo *et al.* (2004), we adopt the following assumptions concerning wages and jobs:

- Each firm i has a satisfying wage it wants to offer at time t to any routine (non-routine) worker, w_{it}^{sR} (w_{it}^{sNR});

- Each routine (non-routine) worker $j^R \in \{1, \dots, \mathbf{L}^R\}$ ($j^{NR} \in \{1, \dots, \mathbf{L}^{NR}\}$) has a satisficing wage, w_{jt}^{sR} (w_{jt}^{sNR}), which he/she wants to obtain from firms at time t ;
- Any worker j will only accept contractual wages if they are equal or greater to his/her reservation wage (denoted as w_{jt}^{RR} and w_{jt}^{RNR} for routine and non-routine workers, respectively);
- Jobs last only one period and therefore workers must search for a new job in each period;
- Job openings, v_{it} , correspond to labor demand and, at the same time, to ex-ante vacancies or new job positions;
- The ex-post vacancies correspond to the number of unfilled job openings;
- Workers can be unemployed;
- Firms might not assure their labor demand.

2.1.3 Job openings, job search, job matching and bargaining procedures

Job openings Each firm creates, in the beginning of period t , a queue of job openings for each type of worker, $queue_{it}^R$ and $queue_{it}^{NR}$.⁶ In each time period, the firms decide on how many job vacancies to open for routine workers (v_{it}^R) and non-routine workers (v_{it}^{NR}). In terms of firms' decisions about how many vacancies to open in each time period, we consider a behavioral scenario featured by some path-dependency. We define the process in formal terms similarly to Fagiolo *et al.* (2004).

The total number of job openings (for both types of workers) in period t by firm i depends on the value of vacancies in $t-1$ (path-dependency), and on the evolution of the firm's profit. If profits in t are higher or equal to profits in the previous period the firm increases the number of total vacancies. Otherwise, it decreases it:

$$v_{it} = \begin{cases} v_{it-1}(1 + |F|) & \text{if } \frac{\Delta\Pi_{it-1}}{\Pi_{it-1}} \geq 0 \\ v_{it-1}(1 - |F|) & \text{if } \frac{\Delta\Pi_{it-1}}{\Pi_{it-1}} < 0 \end{cases} \quad (8)$$

⁶Thurow (1975) proposes the notion of job queues, where workers are ranked according to their trainability, as measured by their background features. In our model we also use the concept of job queue but the only hierarchy that exists between workers is their arrival rate at the queue.

where F is an independent and identically distributed (i.i.d.) random variable, with a normal distribution featured by a zero mean and a $\sigma_v^2 > 0$ variance. The variance σ_v^2 offers a measure of the way firms react to the profits growth rate, enlarging or shrinking their current queue size. A higher variance means a higher sensitivity to the signals of the market.

While in Fagiolo *et al.* (2004) labor is homogeneous, in our model labor is heterogeneous, and so the process of job openings is associated to changes in each firm's relative importance of non-routine workers, i.e. $\alpha_{it} = \frac{L_{it}^{NR}}{L_{it}}$. The total number of job openings will then be split into two queues, one for each type of worker, according to the value of α_{it} :

$$v_{it}^{NR} = \alpha_{it}v_{it} \text{ and } v_{it}^R = (1 - \alpha_{it})v_{it}. \quad (9)$$

We assume that firms always open at least one job vacancy for each type of worker in each time period.

Job search In Fagiolo *et al.* (2004) two job search procedures are considered. The first scenario assumes no search inertia. This means that each worker j randomly visits one firm i in the market. If the chosen firm still has available places in the queue, the worker gets in and asks for its satisficing wage w_{jt-1}^s . In the second scenario, the authors introduce some stickiness, conceived as loyalty, in firm visiting. If a certain worker j was employed in firm i in period $t - 1$, he/she starts by visiting firm i . If this firm still has available places in the queue, the worker gets in and asks for w_{jt-1}^s . If not, the worker uses the random value defined in the no search scenario to select among the remaining $N_t - 1$ firms. In both scenarios, a worker can only enter one queue, and stays unemployed if he/she chooses a firm that has already filled all available slots in its queue.

In our model, we use a similar approach but always with search inertia, since we recognize the existence of important transaction costs associated with the process of job search, not only for firms, but also for workers (although they are not explicitly defined in our model), which are certainly more significant than just loyalty considerations. Beyond contractual reasons, firms prefer workers already familiar with their structures, technologies and methods. A similar preference is experienced by workers. These preferences reveal the need to reduce transaction costs and uncertainty (e.g. Nickell (1986), Teixeira (2004)).

Moreover, we consider two types of workers. Each of these workers searches for a

job opening for its particular type. For simplicity, we assume that workers may not apply to job openings that do not correspond to their particular type. For example, a non-routine worker cannot search for a routine job opening position, and a routine worker cannot search for a non-routine vacancy.

Job matching and bargaining After workers queue up, the process of job matching and bargaining takes place. As in Fagiolo *et al.* (2004), we assume that firms start exploring workers wage demands to match them with their offers. At each time period t , firm i observes the workers in its two queues. Let $0 < m_{it}^{NR} \leq v_{it}^{NR}$ and $0 < m_{it}^R \leq v_{it}^R$ denote the number of workers in the non-routine and routine queues, respectively. The firm then computes the average wage \bar{w}_{it} demanded by workers in both queues. Formally:

$$\bar{w}_{it}^{NR} = \frac{1}{m_{it}^{NR}} \sum_{j=1}^{m_{it}^{NR}} w_{jt-1}^{sNR} \quad (10)$$

and

$$\bar{w}_{it}^R = \frac{1}{m_{it}^R} \sum_{j=1}^{m_{it}^R} w_{jt-1}^{sR}. \quad (11)$$

The firm then sets the contractual wages for period t as a linear combination of the average wages, \bar{w}_{it}^{NR} and \bar{w}_{it}^R , and the satisficing wages, w_{it-1}^{sNR} and w_{it-1}^{sR} . Thus:

$$w_{it}^{NR} = \beta w_{it-1}^{sNR} + (1 - \beta) \bar{w}_{it}^{NR} \quad (12)$$

and

$$w_{it}^R = \gamma w_{it-1}^{sR} + (1 - \gamma) \bar{w}_{it}^R \quad (13)$$

where $\beta, \gamma \in [0, 1]$ and $\beta < \gamma$. As in Fagiolo *et al.* (2004) we define the institutional parameters β and γ to govern the firm's strength in wage bargaining. The power of the firms in the wage setting process increases with the value of β and γ . Assuming $\beta < \gamma$ means that firms have more power in the setting of the wages for the routine workers than for the non-routine.⁷

⁷This assumption is based on empirical evidence. As Howell and Wolff (1991) and Gregg and Wadsworth (1995) show for the US and the UK workplaces, respectively, occupations requiring high cognitive and interactive skills have grown faster than those demanding low skills. At the same time, there has been an increasing inequality in what concerns the earnings of low and high skilled workers. This evolution may reflect the reduction in the role of unions and centralized negotiating processes (e.g. Acemoglu *et al.* (2001)). Another possible explanation for this increasing inequality

Following this procedure, each firm sets the contractual wage that it is willing to offer to workers in the queues. However, any worker will only accept the job position if the contractual wage is equal or larger than his/her reservation wage.

After this matching and bargaining process, the updating of the satisficing wage values, for both firms and workers, takes place, within a bounded rationality frame. We consider that when a routine (non-routine) worker j accepts a job position, he/she changes the satisficing wage to the new earned wage, i.e., $w_{jt-1}^{sR} = w_{it}^R$ ($w_{jt-1}^{sNR} = w_{it}^{NR}$). In addition, each firm i which has filled at least a job vacancy in each queue will replace its satisficing wages, $w_{it-1}^{sR} = w_{it}^R$ and $w_{it-1}^{sNR} = w_{it}^{NR}$.

Fagiolo *et al.* (2004) additionally consider the possibility that surviving firms and workers may wish to revise their satisficing wages according to their perceptions about the result of the economy's dynamic. In line, we assume that each firm has a fixed desired ratio of filled to opened job positions for each type of work:

$$\begin{aligned}\rho_i^R &\in [0, 1] \\ \rho_i^{NR} &\in [0, 1]\end{aligned}$$

The above ratios are then compared to the current effective ratios:

$$\begin{aligned}r_{it}^R &= \frac{L_{it}^R}{v_{it}^R} \\ r_{it}^{NR} &= \frac{L_{it}^{NR}}{v_{it}^{NR}}\end{aligned}$$

Indeed, if the firm has hired too few workers, as compared with the number of job positions it has decided to open, it will be willing to increase the wages offered to workers. Otherwise, it might want to decrease them. A simple rule is adopted to give a formal meaning to this behavior. For routine workers, we have:

$$w_{it}^{sR} = \begin{cases} w_{it-1}^{sR}(1 + |Y|) & \text{if } r_{it}^R < \rho_i^R \\ w_{it-1}^{sR}(1 - |Y|) & \text{if } r_{it}^R \geq \rho_i^R \end{cases} \quad (14)$$

where Y is an i.i.d. random variable with a standard normal distribution and $w_{it-1}^{sR} = w_{it}^R$ if the firm has hired at least one routine worker. Similarly, for the non-routine

may be the higher importance of tacitly acquired firm-specific skills. Workers that have specific attributes are in a better position to negotiate for relatively higher wages than those who do not have them (Howell and Wolff (1991)).

workers:

$$w_{it}^{sNR} = \begin{cases} w_{it-1}^{sNR}(1 + |Y|) & \text{if } r_{it}^{NR} < \rho_i^{NR} \\ w_{it-1}^{sNR}(1 - |Y|) & \text{if } r_{it}^{NR} \geq \rho_i^{NR} \end{cases} \quad (15)$$

where $w_{it-1}^{sNR} = w_{it}^{NR}$ if the firm has hired at least one non-routine worker.

Given the number of both types of workers hired by each firm, the model then computes each firm's production, the price and profits. Each firm's ex-post vacancies, \tilde{v}_{it}^R and \tilde{v}_{it}^{NR} , are defined as:

$$\tilde{v}_{it}^R = v_{it}^R - L_{it}^R \quad (16)$$

and

$$\tilde{v}_{it}^{NR} = v_{it}^{NR} - L_{it}^{NR}. \quad (17)$$

In what concerns the updating of the workers' satisficing wages, we assume that any worker that remains unemployed after the matching and bargaining process might want to reduce his or her satisficing wage, without violating the threshold imposed by the reservation wage. Otherwise, he/she might want to ask for a higher wage in the next bargaining round. In formal terms, we have:

$$w_{jt}^{sR} = \begin{cases} \max \{w_j^{RR}, w_{jt-1}^{sR}(1 - |Y|)\} & \text{if } j^R \text{ unemployed} \\ w_{jt-1}^{sR}(1 + |Y|) & \text{if } j^R \text{ employed} \end{cases} \quad (18)$$

and

$$w_{jt}^{sNR} = \begin{cases} \max \{w_j^{RNR}, w_{jt-1}^{sNR}(1 - |Y|)\} & \text{if } j^{NR} \text{ unemployed} \\ w_{jt-1}^{sNR}(1 + |Y|) & \text{if } j^{NR} \text{ employed} \end{cases} \quad (19)$$

where Y is an i.i.d. random variable with a standard normal distribution and $w_{it-1}^{sR} = w_{it}^R$ and $w_{it-1}^{sNR} = w_{it}^{NR}$ if j^R and j^{NR} have just been hired.

2.1.4 Technological progress

Concerning labor productivity dynamics, we analyse two technological scenarios. The first considers an equal technological level for all firms, that is $A_{it} = A_t \forall i$,

where $A_t = A_{t-1}e^g$ and g is the exogenous rate of technological progress. The second scenario assumes the presence of firm-specific technological progress. We consider that the industry has an exogenous technological trajectory A_h , defined as $A_{ht} = A_{ht-1}e^g$, which corresponds to the maximum value that the firms within the industry can achieve. We associate with each firm a measure of technological efficiency, μ_{it} , $0 < \mu_{it} \leq 1$, such that the technological progress for each one is represented as:

$$A_{it} = A_{ht}\mu_{it} \quad (20)$$

and

$$\mu_{it} = \text{function}(\text{fitness}_{it}, \alpha_{it}). \quad (21)$$

Each firm's efficiency measure increases with the firm's fitness and with the relative importance of each firm's innovative non-routine workers.

2.2 Industry level

The aggregate output of the industry is computed at each time period as the sum of the output of all the firms in the industry at that time:

$$\mathbf{X}_t = \sum_{i=1}^{N_t} X_{it}. \quad (22)$$

We assume that the short-term equilibrium price results from the confrontation of the total supply with a constant price-elasticity demand function

$$p_t = \frac{\mathbf{D}_t}{(\mathbf{X}_t)^{1/\eta}} \quad (23)$$

where η is the demand price elasticity and $\mathbf{D}_t > 0$ is the exogenous demand.

The number of firms operating in the industry in each time period t , N_t , is constant, since we assume that the firms that leave the market are automatically replaced by an equal number of firms with characteristics close to the average of the attributes of the surviving firms in that period.

2.3 Labor market

As mentioned earlier, workers might be unemployed. In aggregate terms, the number of unemployed workers of each type is equal to

$$U_t^R = \mathbf{L}^R - \sum_{i=1}^{N_t} L_{it}^R \quad (24)$$

and

$$U_t^{NR} = \mathbf{L}^{NR} - \sum_{i=1}^{N_t} L_{it}^{NR}. \quad (25)$$

The aggregate values of routine vacancies and non-routine vacancies are:

$$V_t^R = \sum_{i=1}^{N_t} v_{it}^R \quad (26)$$

and

$$V_t^{NR} = \sum_{i=1}^{N_t} v_{it}^{NR}. \quad (27)$$

In Figure 1, we present the structural scheme of the proposed model.

3 Simulation exercise

3.1 Details on the computational model and simulation trials

The computational model was built in Lsd (the "Laboratory for Simulation Development"), a free-use language for simulation models written by Marco Valente (see, for example, Valente (1998), Valente and Andersen (2002)).

The simulation model executes the following steps:

1. Given the initial position of the institutional set of firms and the institutional environment in the industry at $t = 0$, we solve for the output and profits of firms, and the market price.
2. Firms decide to maintain or to change its institutional set in the next period, according to the evolution of their profits and their market shares. This deci-

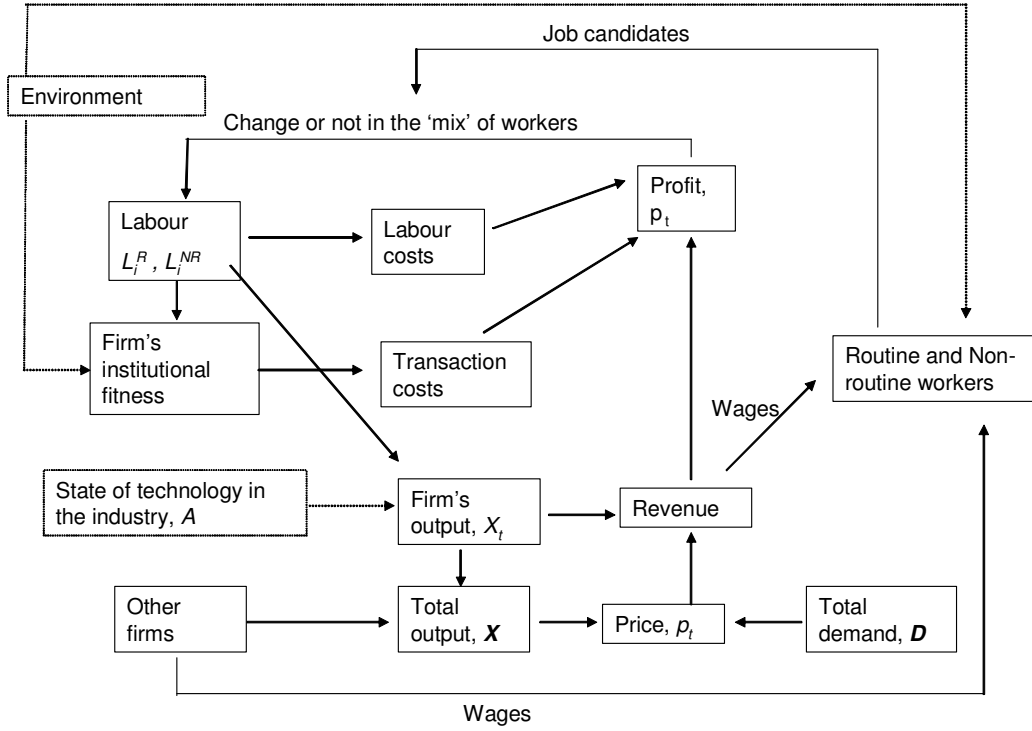


Figure 1: Structural Diagram of the Model

sion is materialized in the mix of its workers. If the profits in $t + 1$ are higher than in t and the market share in $t + 1$ is higher than in t , the firm does not change its mix of workers. Otherwise, the firm changes the mix.

3. After the decision to maintain or change the mix of workers, job search, matching and bargaining takes place:
 - (a) The firms decide how many vacancies for each type of worker they want to open in period $t + 1$. Each firm opens at least one posting of each type.
 - (b) Routine (non-routine) workers search for a firm posting at least one job opening of the routine (non-routine) type and queue up.
 - (c) The process of job matching and bargaining takes place: firms look in their queues and start bargaining with workers who have queued up (if any) for both types of jobs to decide whether to hire or not.

4. After hiring, production takes place. Aggregate demand is exogenous and the aggregate supply is obtained by simply aggregating the individual supplies.
5. After a certain number of runs, firms undergo a selection process. We established that firms that accumulate negative or nil profits during the last five time steps leave the market. Each exiting firm is replaced by a new firm with initial features close to the average characteristics of the surviving firms at that time period. This procedure allows us to keep an invariant number of firms in the economy at each t .
6. Firms and workers update their satisficing wages.
7. Technological progress takes place. As mentioned before, we consider equal technological progress and firm-specific technological progress scenarios.

The simulation requires us to set initial values for several variables and for all the parameters. Our calibration work was guided by some available empirical literature on labor markets and on internal firm organization, for example Davis *et al.* (1996), Lorenz and Valeyre (2004) and Bartelsman and Doms (2000). In the Appendix, we present a synthesis of the chosen initial values and the possible combinations defined for some relevant parameters.

The simulation model consists of one industry composed by 10 firms. The industry is characterized by its "institutional set", α_t , which is an exogenous variable, only partially observable by the firms. For simulation purposes, we consider that α , while approximated by the relative importance of routine and non-routine workers in the employment structure behind the industry, is equal to 0.5.⁸ Since we do not introduce the determinants of the labor supply in our model, we keep α constant,

⁸Lorenz and Valeyre (2004), in a study based on the 3rd European Survey on Working Conditions in the 15 member states of the EU in 2000, offer one of the first systematic comparison of the adoption of new organization forms across Europe. The paper stresses the idea that phenomena of globalization and intensified international competition are conducting to a restructuring of management practices in most European countries, as a way to achieve greater flexibility and cooperation at the workplace. They conclude that two types of organizational forms, the "Learning Model" and the "Lean Model", which correspond to organizational forms where variables measuring autonomy, task complexity, learning and problem-solving are over-represented, account for respectively 39% and 28% of the employees. At the same time, the two other classes of the proposed typology, the "Taylorist Model" and the "Traditional Model", both associated with minimal learning dynamics, low complexity and low autonomy, account for, respectively, 14% and 19% of the employees. Since the study is developed to the economy as a whole, and our model only concerns manufacturing, the value of 50% associated to non-routine sets of tasks seems a reasonable feature for the exogenous industrial environment.

as it corresponds to structural, institutional characteristics remarkably stable over time. In fact, the characteristics associated with skills and education employment structures are likely to present a high degree of inertia (see Baron *et al.* (1996)). Therefore, the model considers that firms are able to change their "institutional sets", but maintains the global, exogenous "institutional frame" stable.

In period $t = 0$ we have each firm's mix of workers, α_{i0} and profits, π_{i0} . We construct the initial configuration according to the chosen parameters and scenarios. In addition, the initial values of each firm's institutional set, α_{i0} , were drawn from a uniform distribution in the $]0, 1[$ interval. We also set initial values for the distinct types of workers and the technology of each firm (see the Appendix) to implement the model.

The simulation exercise has two main sets: one that considers equal technological progress for all firms (EqualTP), and another that assumes idiosyncratic technological behaviors (FirmSpecificTP). Moreover, the study considers two stages: one that assumes a completely stable exogenous environment, and another that considers two distinct exogenous demand shocks after a certain number of time runs (a reduction and an increase of around 30%).

3.2 Simulation results

3.2.1 Stable exogenous environment

In the stable environment configuration, in both the EqualTP and the FirmSpecificTP sets, the industry observes an initial strong shake-out period, with most firms leaving after 5 time steps (see Table 1). As a consequence, there is a clear improvement in the average fitness of the population of incumbent firms. Afterwards, the entry and exit of firms leads to a slow but regular improvement of that variable in the EqualTP set, and to a more irregular path in the FirmSpecificTP set. In the first set, we have two initial surviving firms at $T=50$, firm 1 ($\alpha_{i0} = 0.404$) and firm 5 ($\alpha_{i0} = 0.512$), while in the second set we have only one, firm 7 ($\alpha_{i0} = 0.659$).⁹ This result is not surprising, since in the FirmSpecificTP set the technological progress rate depends not only on each firm's "institutional fitness", but also on each firm's relative importance of non-routine workers. When compared with firms 1 and 5, firm

⁹For different seeds we obtain, in average, the same type of results. For considerations about the processes and techniques associated to the validation and verification of simulation models see for example Sargent (1999).

Time steps	Number of initial firms in the market		Final average 'institutional gap' in industry (0.305 at T=0)		Inverse of the Herfindal Index		FirmsTurnover	
	EqualTP	Firm SpecificTP	EqualTP	Firm SpecificTP	EqualTP	Firm SpecificTP	EqualTP	Firm SpecificTP
T=10	2	2	0.058	0.086	9.7188	9.6769	0.80	0.80
T=50	2	1	0.104	0.088	9.2785	8.7661	0.30	0.42
T=100	0	0	0.067	0.115	9.5597	8.6355	0.27	0.41
T=250	0	0	0.070	0.101	9.1431	9.3079	0.28	0.40
T=500	0	0	0.060	0.125	9.1221	8.6624	0.39	0.38

Table 1: EqualTP Model vs. FirmSpecificTP Model

7 has a lower initial fit, but benefits from a higher relative number of non-routine workers.

The EqualTP scenario shows less turbulence, and has a less concentrated market structure, with the inverse Herfindhal index showing an almost minimal concentration (see Table 1). In addition, the turnover of firms,¹⁰ after the initial shake out, is higher for the FirmSpecificTP set. This is also not surprising, since in this set the firms have the same technological path, while in the FirmSpecificTP set the firms have distinct technological efficiencies.

Figures 2 and 3, which give the number of entries in each period, clearly show that the FirmSpecificTP set is more turbulent. The peak in period 5 provides additional evidence of the initial shake-out.

¹⁰The turnover of firms is the ratio between the total number of firms' exits (equal to the number of entries) and the number of time periods.

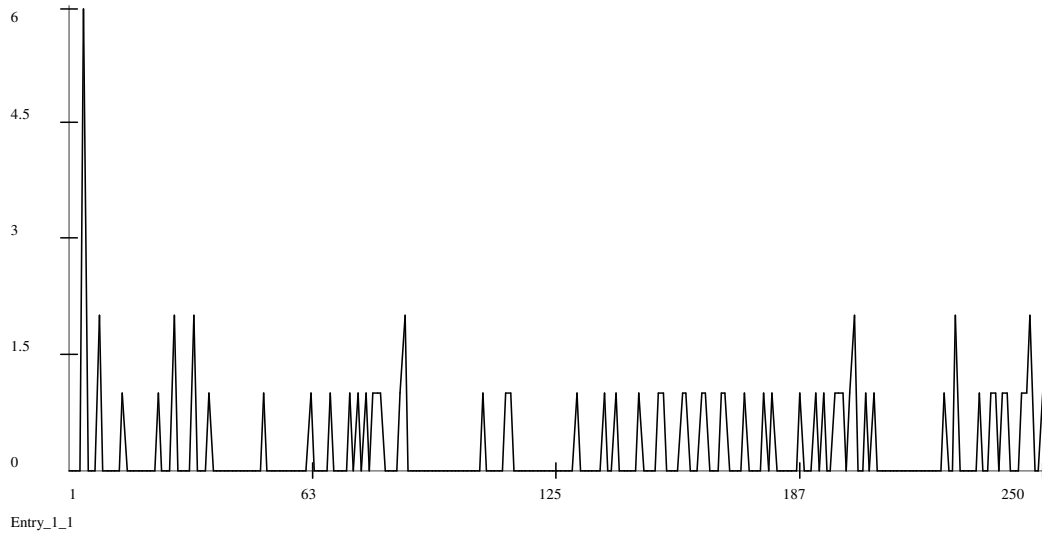


Figure 2: Entry of Firms EqualTP Model (T=250)

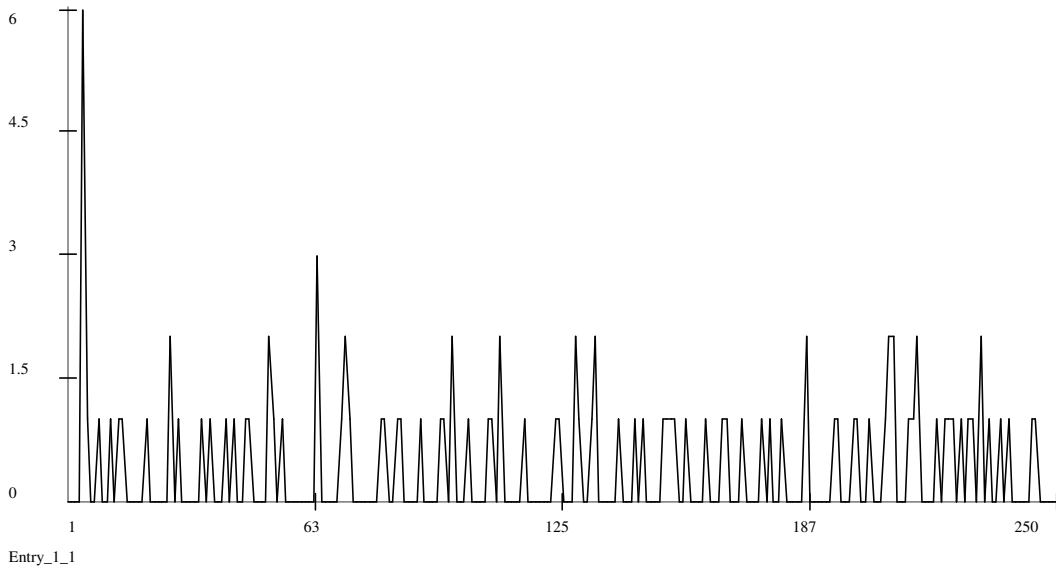


Figure 3: Entry of Firms FirmSpecificTP Model (T=250)

In terms of the co-evolution of the population of firms and the population of workers, both sets show that the introduction of matching and bargaining processes in the labor market results in important frictions, as shown by the existence of ex-post vacancies and unemployment. The EqualTP set is featured by a higher creation

of job vacancies and by a lower ability of the firms to fill them (in Figure 4, we present the evolution of the total vacancies in both sets). As a result, since in our model (*cf.* equations (14) and (15)) the wages offered by the firms depend on the ability to fill the ex-ante vacancies (the firm only increases the wage in the next period if it did not attain the desired ratio of vacancies in the last period), the wages for both types of workers increase more in the EqualTP set than in the FirmSpecificTP set. This is clearly shown in Figures 5 and 6, which give the evolution of the wages for the non-routine and the routine workers, respectively.

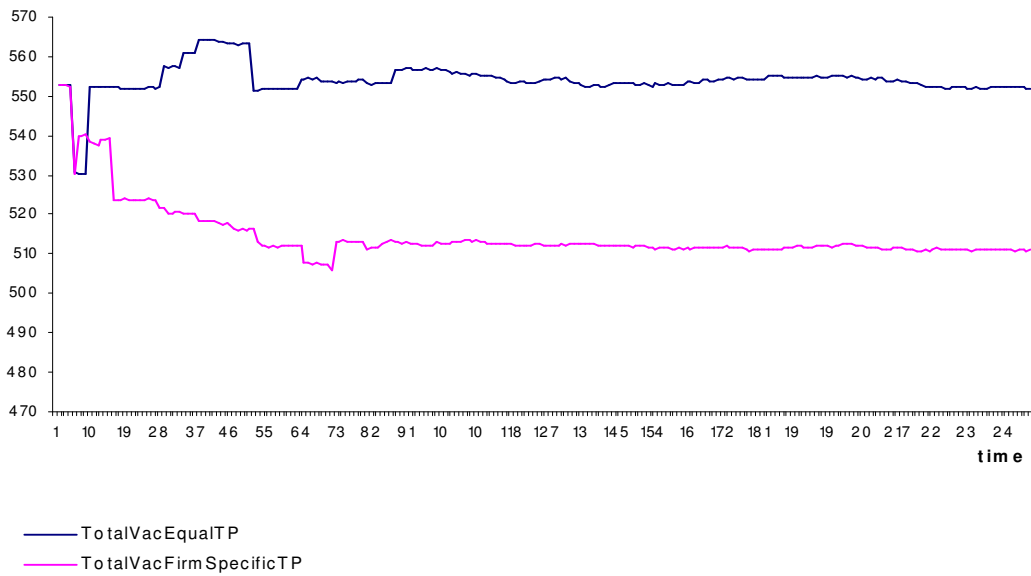


Figure 4: Total Vacancies EqualTP Model vs. FirmSpecificTP Model (T=250)

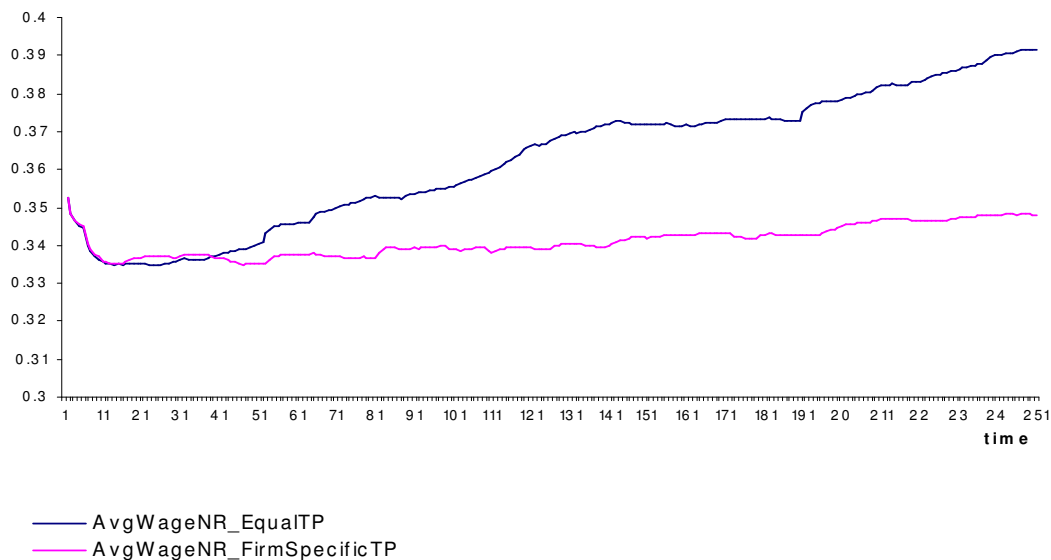


Figure 5: Average Wages NR EqualTP Model vs. FirmSpecificTP Model (T=250)

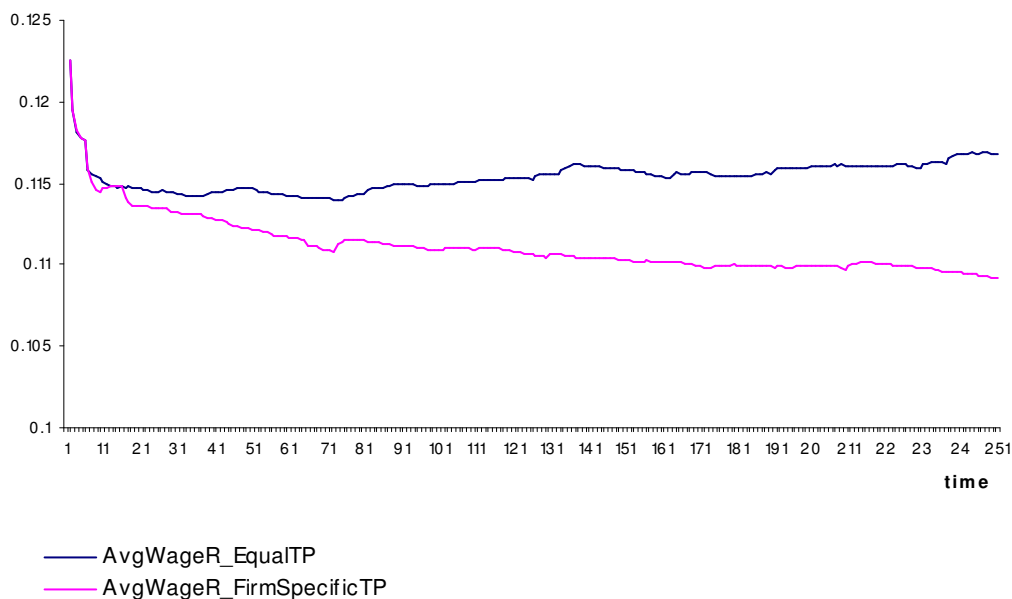


Figure 6: Average Wages R EqualTP Model vs. FirmSpecificTP Model (T=250)

In both sets, the average wage of the non-routine workers increases through time, while the average wage of the routine workers decreases in the FirmSpecific set and, after the initial shake out in the industry, slightly increases in the EqualTP configuration. We have not tried to match our typology of workers with empirical data. If

we roughly match the non-routine workers with skilled labor and the routine workers with unskilled labor, it is interesting to note the similarity between our computational results and empirical data. Indeed, several studies have found evidence of an increase in wage-income inequality over the last two decades in several advanced and developing countries (for example, Borjas and Ramey (1994), Freeman (1995), Richardson (1995), Gottschalk (1997), Jensen and Troske (1997), Johnson (1997), Wood (1998), Katz and Autor (1999)).

In Figure 7, we can see that our artificial economy indeed leads to an increasing inequality between both types of workers. This evolution must be understood within an industry where the non-routine workers are more productive per unit of output than the routine workers, and where the firms have less negotiable power in the bargaining with the non-routine workers.¹¹

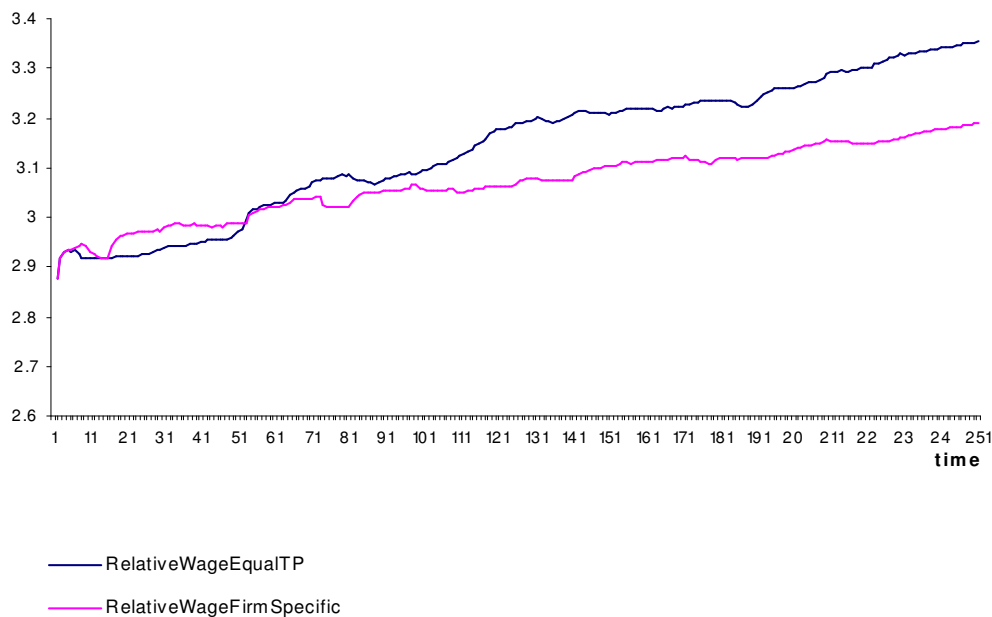


Figure 7: Relative Wage EqualTP Model vs FirmSpecificTP Model

Since the FirmSpecificTP set is more turbulent and firms create less vacancies for both types of workers, the unemployment rates are higher in this set (Figure 8).

¹¹Our economy has the same number of the two types of workers and there is no training investments. Also, we assume that a worker cannot join a queue that does not correspond to its type. In addition, we do not endogenize the labor supply in the model, so there are no actions that might contribute to alter the relative number of workers, such as education/training opportunities. Moreover, technological change is not "occupational"-biased in our model. This aspect could be an interesting research avenue to explore in the future.

In both configurations, the initial shake-out leads to a peak in the unemployment rates. As expected, unemployment has a similar influence on both types of workers, since the respective population is exogenous and constant, technological change is neutral and the wages are higher for the more productive workers.

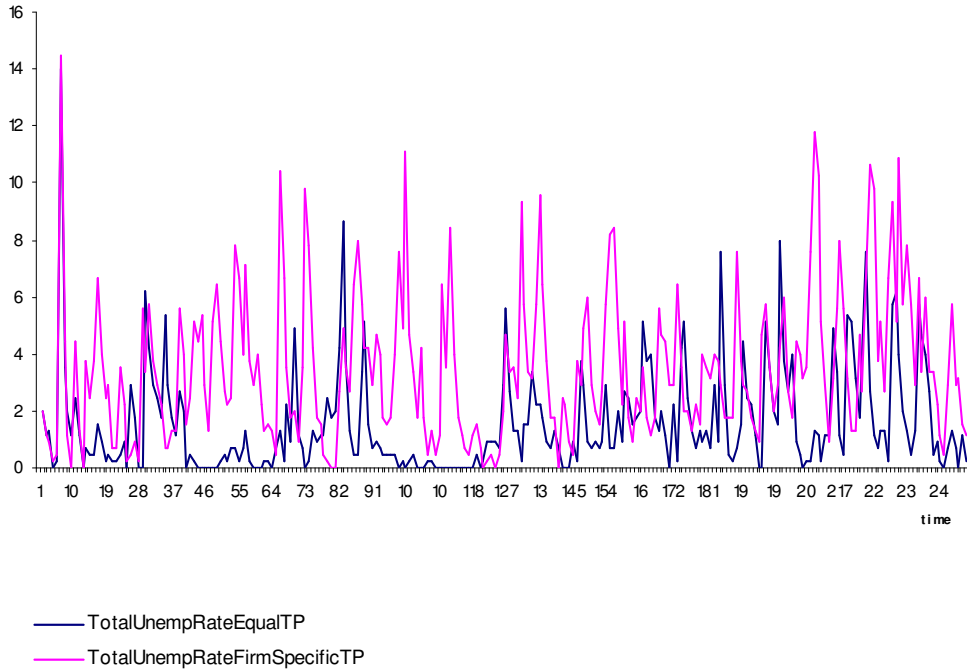


Figure 8: Total Unemployment Rate EqualTP Model vs. FirmSpecificTP Model (T=250)

Table 2 presents the average results for a simulation with 250 time steps ($T = 250$), for each configuration. The numbers in parentheses correspond to the variances. Note that the average wages paid to both types of workers, as well as the relative wage, are higher in the EqualTP configuration. This occurs because the average rates of occupancy of the vacancies (denoted as Avg_r_NR and Avg_r_R for the non-routine and routine workers, respectively) are higher in the FirmSpecificTP set, and so, according to our formal model, firms do not need to increase the wages so often in this configuration. The higher turbulence of the FirmSpecificTP set is associated with higher unemployment rates for both workers. In terms of the firms' "institutional gap", in both sets the average fitness of the incumbent firms is substantially improved with the industry initial shake out. The average fitness then evolves around a long run equilibrium threshold that may be called an evolutionary

Variables	EqualTP Model	FirmSpecific
Average Fitness	0.076 (0.001)	0.085 (0.001)
InverseHerfindhal	9.3182 (0.832)	9.3953 (0.622)
Avg_r_NR	0.781 (0.004)	0.814 (0.004)
Avg_r_R	0.783 (0.004)	0.820 (0.005)
TotalUnemploymentRate	1.57 (3.49)	3.52 (6.65)
UnemploymentRate_NR	1.52 (4.56)	3.30 (9.35)
UnemploymentRate_R	1.61 (5.25)	3.73 (11.57)
AverageWages_NR	0.363 (0.000)	0.314 (0.000)
AverageWages_R	0.115 (0.000)	0.111 (0.000)
RelativeWage	3.142 (0.012)	3.069 (0.005)

Table 2: Average Final Period Simulation Results (T=250)

stationary state. By evolutionary we mean that history matters, as the path trajectory of the variable shows since it reveals reversions and path dependency. In Figure 9, we present the time trajectories of the average fitness in each configuration set. In addition, Table 2 shows that, for T=250, the average fitness is quite good (0.076 for the EqualTP set and 0.085 for the FirmSpecificTP Model, with low variances).

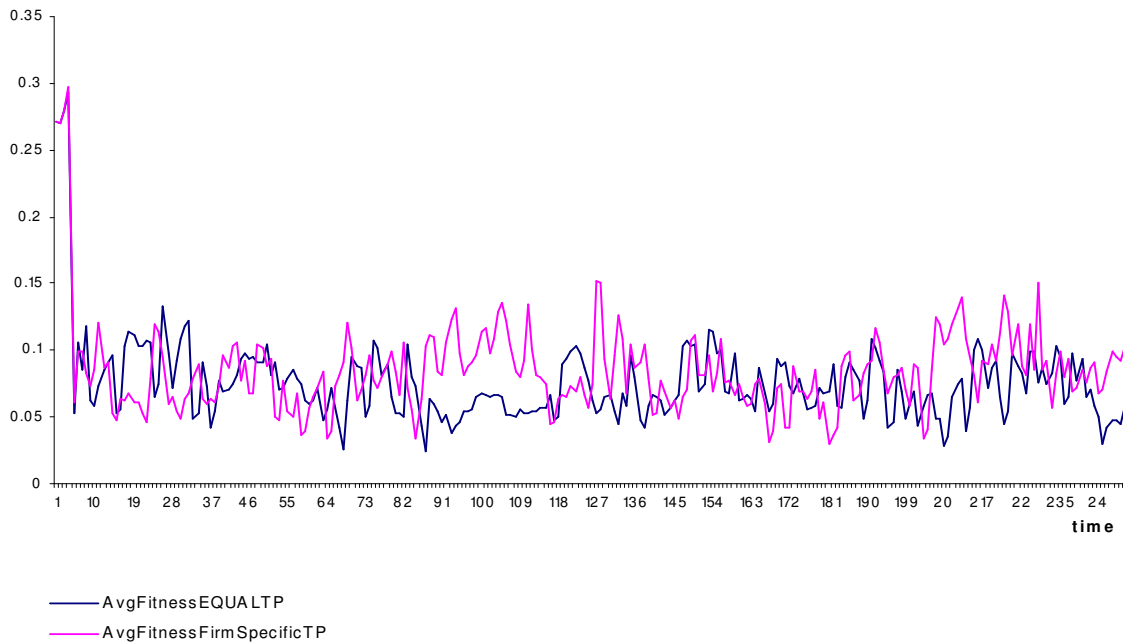


Figure 9: Average Fitness EqualTP Model vs FirmSpecificTP Model (T=250)

3.2.2 Demand shocks

Using the configuration that seems closer to economic reality, the FirmSpecificTP Model, we induce exogenous demand shocks and study their impact in the co-evolution of the industry and the labor market. We consider two types of shocks: a reduction and an increase in demand of around 30% that occurs at $T=125$. The impact is rather surprising in terms of job posts and wage evolution when compared with a standard neoclassical labor demand model. In fact, the existence of matching and bargaining processes means that the response of firms to a variation in demand is not automatically absorbed in terms of job places and wages, as it happens in the neoclassical standard models. Important differences associated with these shocks are also visible in the market structure, since they lead to an important process of exits and entries in the industry, and to a change in the concentration index. The adjustment in terms of "institutional gap" is similar before and after the shock. To understand this result, it is important to recall that the number of firms in the population is assumed constant and that, although some randomness exists, the entrant firms have features close to the average characteristics of the surviving firms.

Reduction in the demand An exogenous reduction in demand leads to a small improvement in the "institutional fitness" of the incumbent firms in comparison with the behavior of the economy without shocks (see Figure 10).

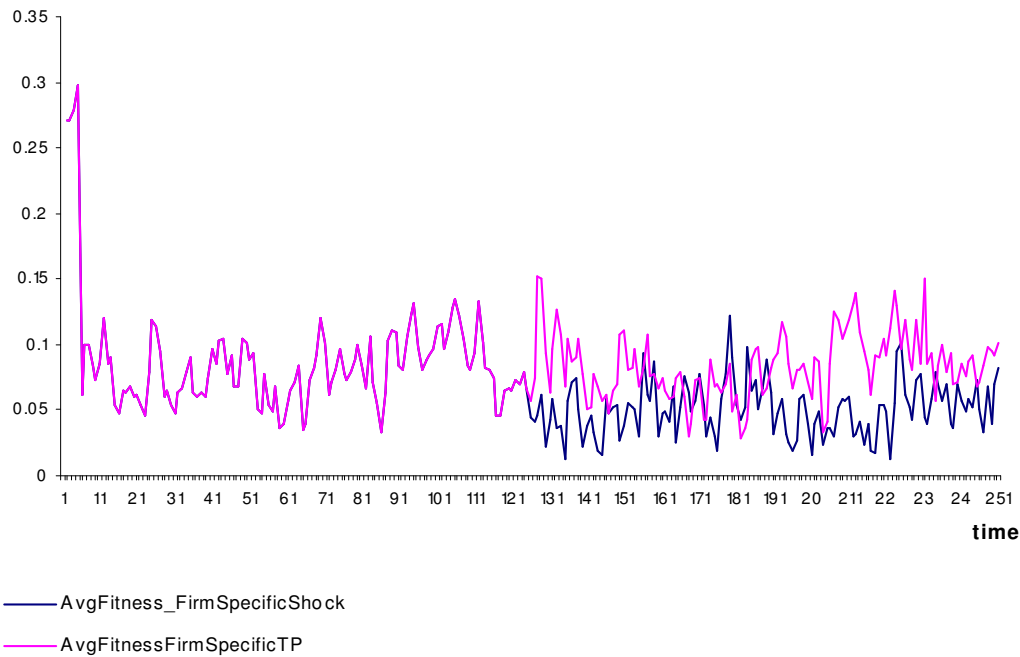


Figure 10: Average Fitness FirmSpecificTP Model With and Without a Reduction in Demand at $T=125$ ($T=250$)

This improvement in the institutional fit may be associated with a strong selection process that eliminates the less fit firms in a more restrictive environment. The turbulence in the industry increases strongly after the demand shock, as Figure 11 shows. Without the shock, the industry registers a turnover of firms around 0.4 for $T=250$. For the overall 250 time period, with the shock, this value increases to 0.96, whereas restricting the analysis only to the post shock period (after $T=125$) the turnover is 1.55. For a constant population of 10 firms, these values mean a significant increase in the industry's turbulence. As the literature mentions (for example Christensen and Rosenbloom (1995)), changes in demand represent a major variation in the environment in which firms operate, and may favor the entry of new firms rather than the success of established ones.

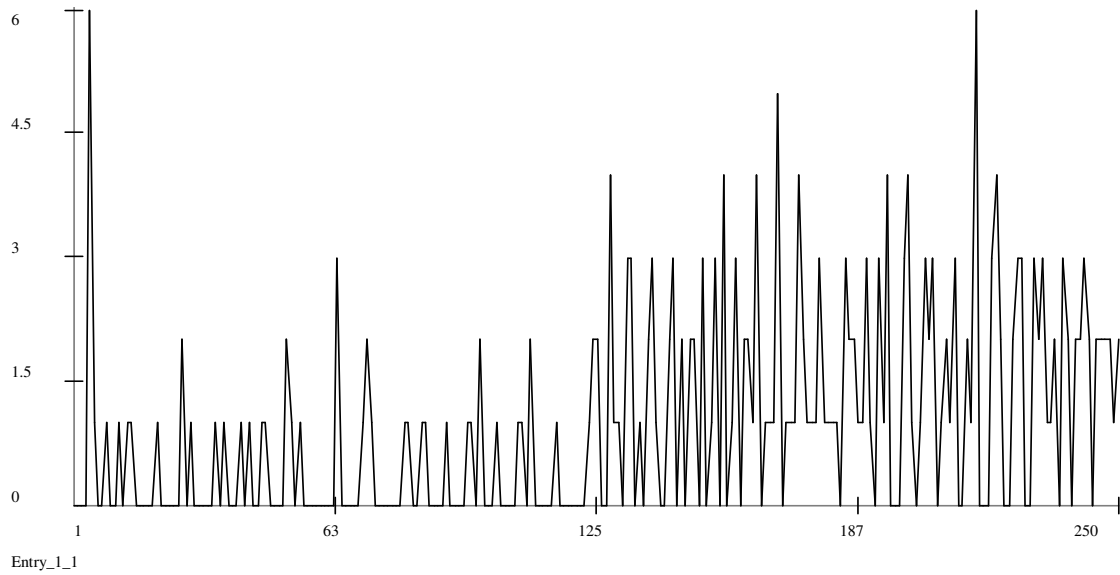


Figure 11: Entry of Firms FirmSpecificTP Model. Negative Demand Shock at $T=125$

As expected, the reduction in demand induces a decrease in the number of vacancies (Figure 12). Consequently, the unemployment rates substantially increase (Figure 13).

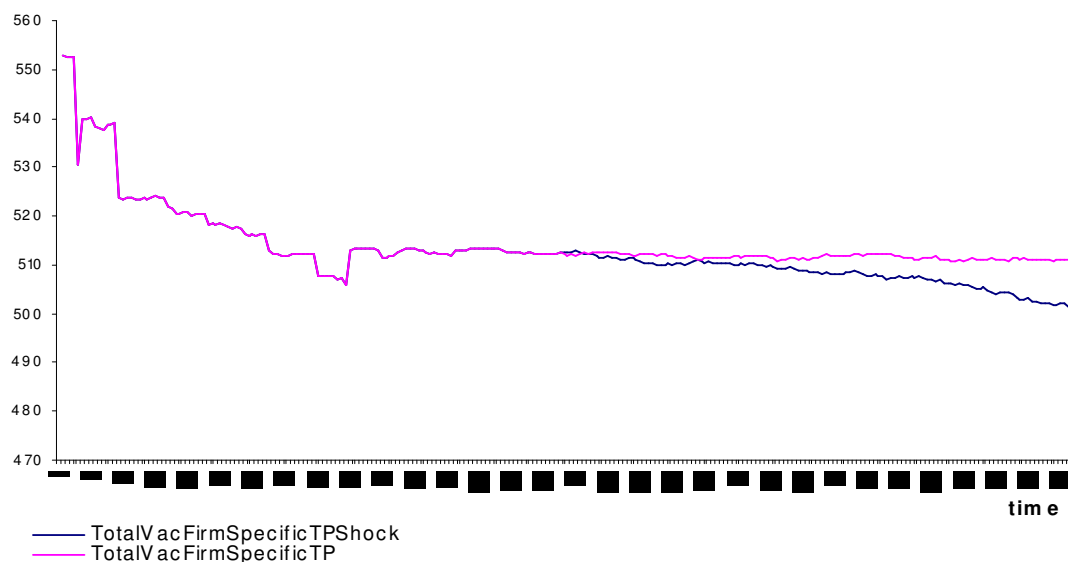


Figure 12: Total Vacancies FirmSpecificTP Model With and Without a Reduction in Demand at $T=125$

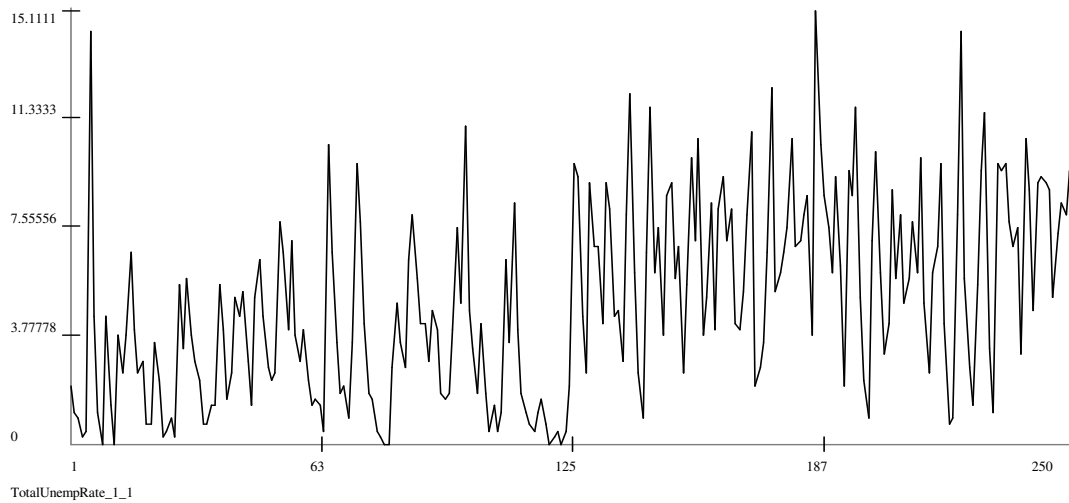


Figure 13: Total Unemployment Rate FirmSpecificTP Model. Negative Demand Shock at T=125

This increase in unemployment is accompanied by an increase in wages for both types of workers. This happens because the ability of the firms to fill their vacancies decreases after the shock. Therefore, since the range of firms that do not satisfy the desired ratio of filled vacancies increases (see Figure 14), the firms increase the wages. Consequently, we observe a small increase in wages, although the economy suffers a negative shock, as Figure 15 shows. This result is associated with the presence of frictions in the labor market, such as higher unemployment, ex-post vacancies and rising wages.

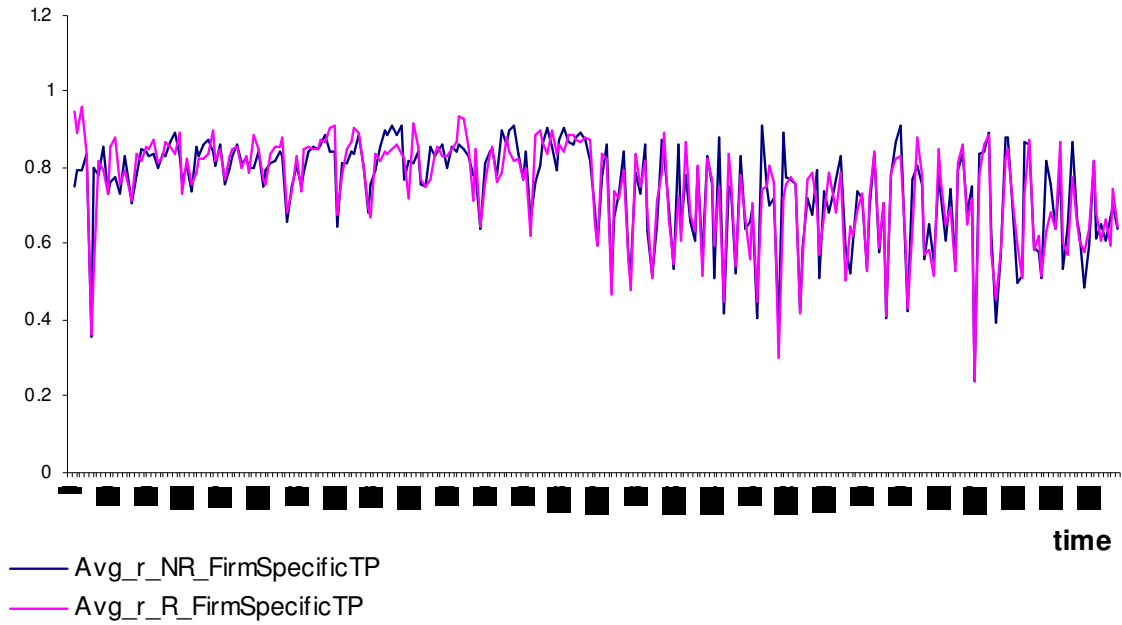


Figure 14: Average Effective Filled Vacancies Ratio (r) for NR Workers (r_{NR}) and for R Workers (r_R), FirmSpecificTP Model. Negative Demand Shock at $T=125$

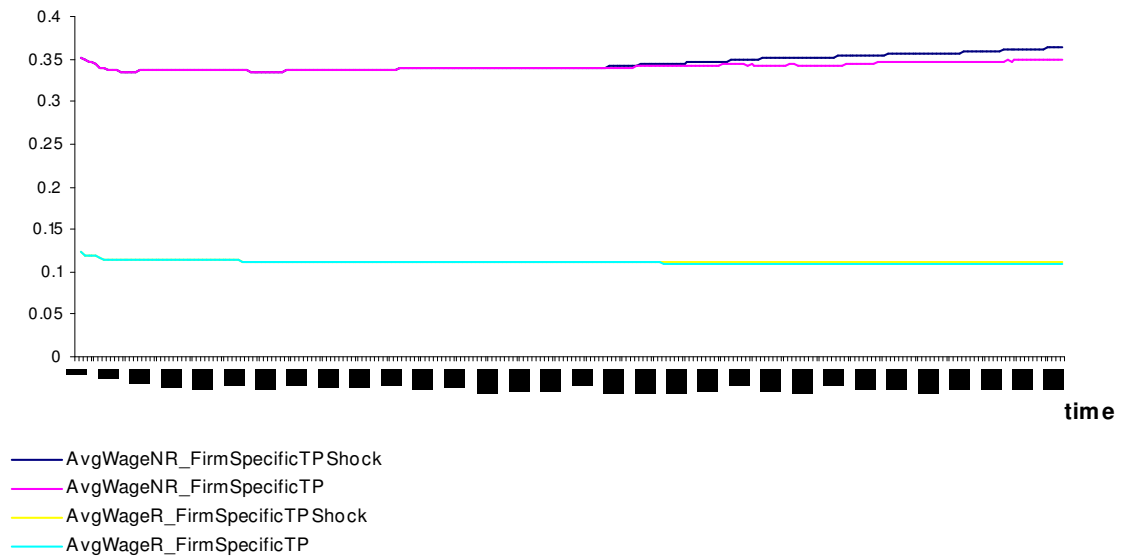


Figure 15: Average Wages for the Non Routine and for the Routine Workers FirmSpecificTP Model With and Without a Reduction in Demand at $T=125$.

In Table 3, we present a synthesis of results with the average of most relevant

Variables	FirmSpecific No Shocks	FirmSpecificIPModel Reduction Demand
Average Fitness	0.085 (0.001)	0.069 (0.001)
InverseHerfindhal	9.3953 (0.622)	10.7714 (8.613)
Avg_r_NR	0.814 (0.004)	0.749 (0.016)
Avg_r_R	0.820 (0.005)	0.749 (0.017)
TotalUnemploymentRate	3.52 (6.65)	4.93 (11.28)
UnemploymentRate_NR	3.30 (9.35)	4.81 (15.28)
UnemploymentRate_R	3.73 (11.57)	5.05 (15.04)
AverageWages_NR	0.314 (0.000)	0.345 (0.000)
AverageWages_R	0.111 (0.000)	0.112 (0.000)
RelativeWage	3.069 (0.005)	3.090 (0.009)

Table 3: Average Final Period Simulation Results (T=250). Negative Demand Shock at T=125

variables for the 250 time periods. The numbers in parentheses represent the variances. Note that the averages for the set with the demand shock correspond to the entire period, and not only to the post shock period. Therefore, the results appear smoother. For example, the average total unemployment rate for the period after the shock is 6.8%, while the value observed for the entire period is 4.9%. This rate of 6.8% results from unemployment rates of 6.95% and 6.7% for the routine and non-routine workers, respectively.

Increase in the demand We also consider the impact of an increase in the demand. Figure 16 gives the evolution of the average fitness of the incumbent firms. This average fitness deteriorates slightly after the shock. It seems that the increase in the demand allows less fit firms, that would otherwise leave the industry, to survive longer.

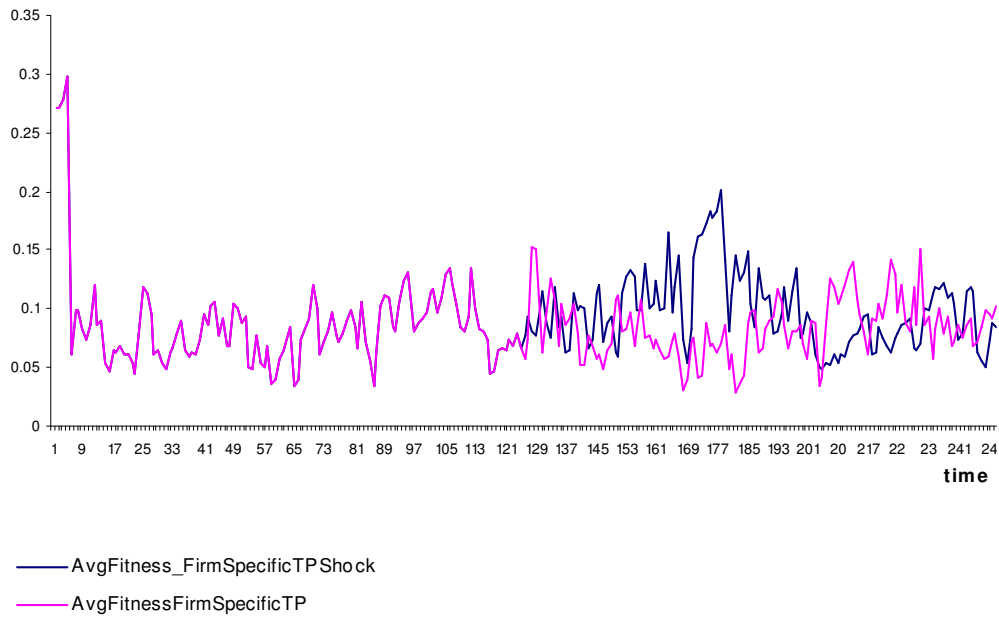


Figure 16: Average Fitness FirmSpecificTP Model With and Without an Increase in Demand at $T=125$

The turbulence in the market is smaller than in the configuration without shocks, as shown by the number of entries (Figure 17). In fact, the turnover of firms decreases substantially after the shock: the average turnover is 0.4 for the entire period without shocks, and only 0.29 for the entire period considering the shock (0.21 for the period after the shock only).

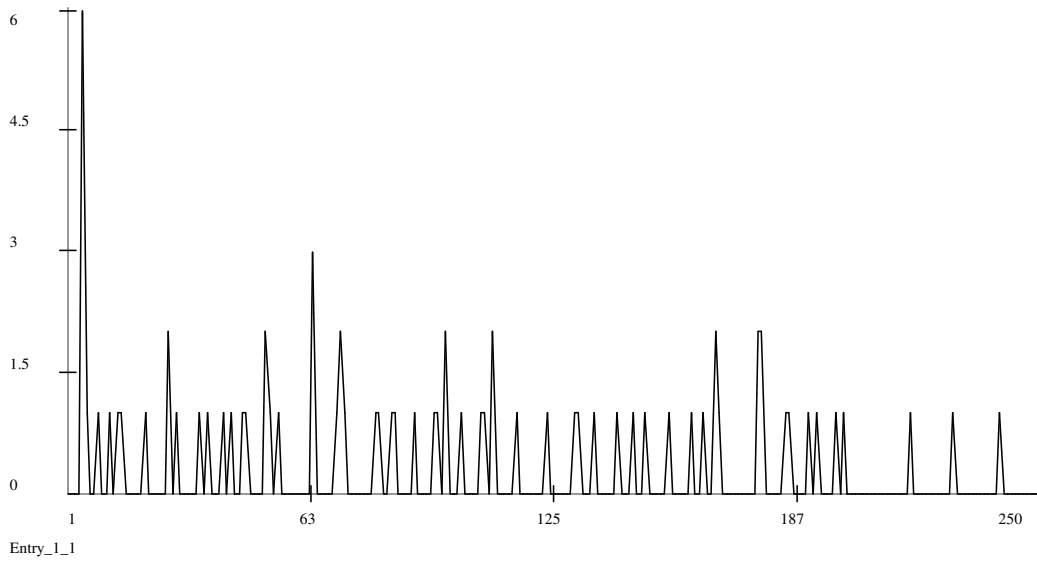


Figure 17: Entry of Firms FirmSpecificTP Model: Positive Demand Shock at $T=125$

In terms of labor market dynamics, the number of vacancies is slightly higher after the shock (see Figure 18). Therefore, the unemployment rates are somewhat lower than in the model with no shock, as shown in Figure 19.

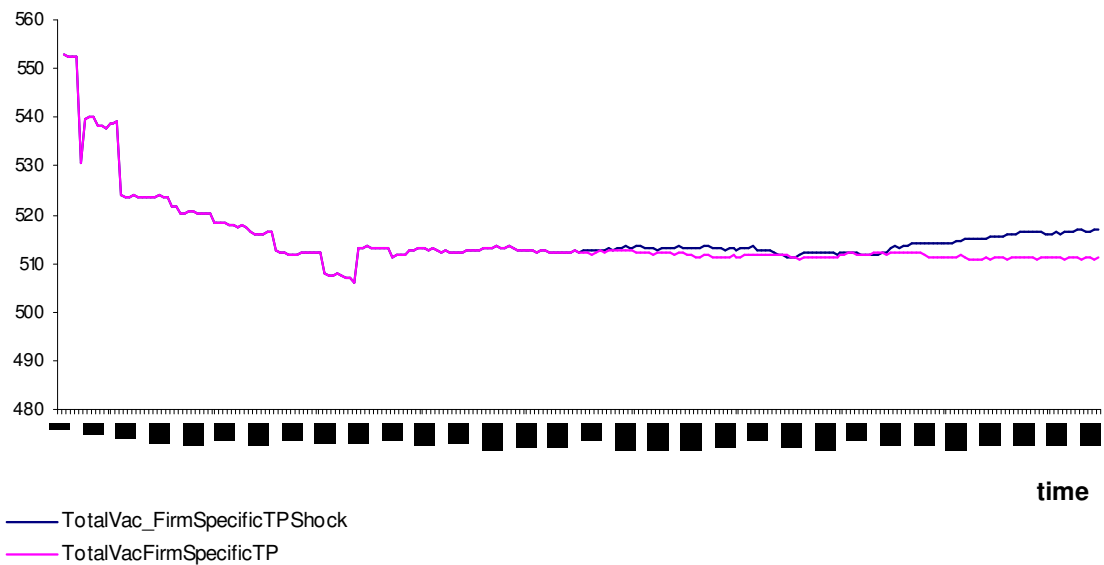


Figure 18: Total Vacancies FirmSpecificTP Model With and Without an Increase in Demand at $T=125$

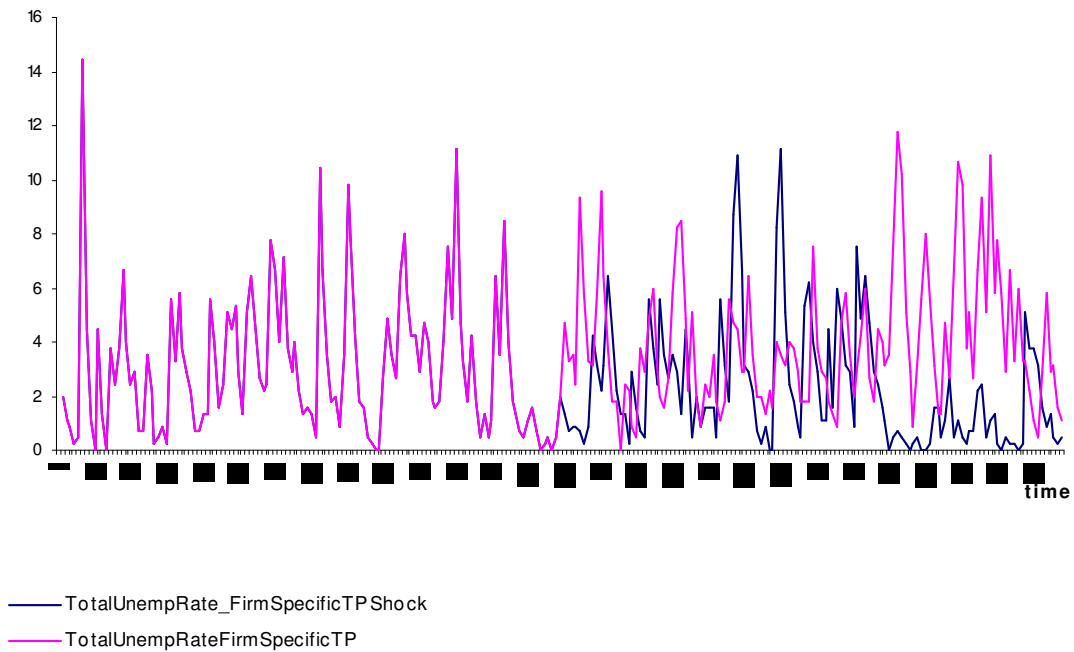


Figure 19: Total Unemployment Rate FirmSpecificTP Model With and Without an Increase in Demand at $T=125$

The increase in demand does not lead to an increase in wages. In fact, in our economy the adjustment of the labor demand is not automatic. Firms interact with workers through matching and bargaining processes where the bargaining power is split between the actors. Our simulation results show that, after the shock, the non-routine and the routine wages have a relatively stable behavior (Figure 20).

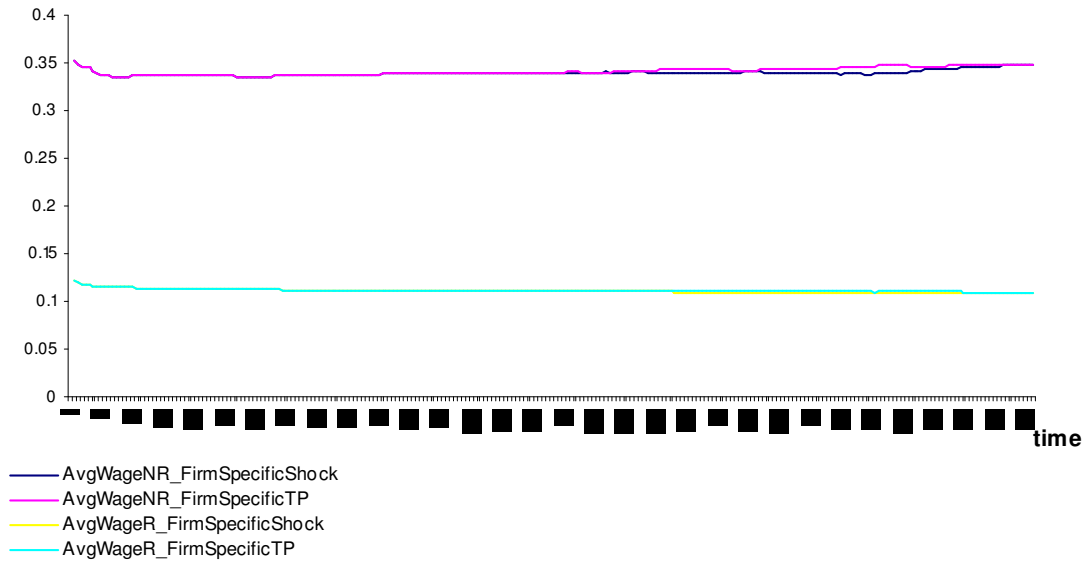


Figure 20: Average Wages for the Non Routine and for the Routine Workers FirmSpecificTP Model With and Without an Increase in Demand at T=125

The relative wage continues to increase after the shock, although at a slower pace, as seen in Figure 21. This can also be seen in Table 4, which presents the average final period simulation results for T=250. To understand the behavior of the wages, we must consider the ability of the firms to fill their vacancies. In order to do that, we must analyze the effective ratios of filled vacancies (r_{NR} and r_R), for the configurations with and without shocks.

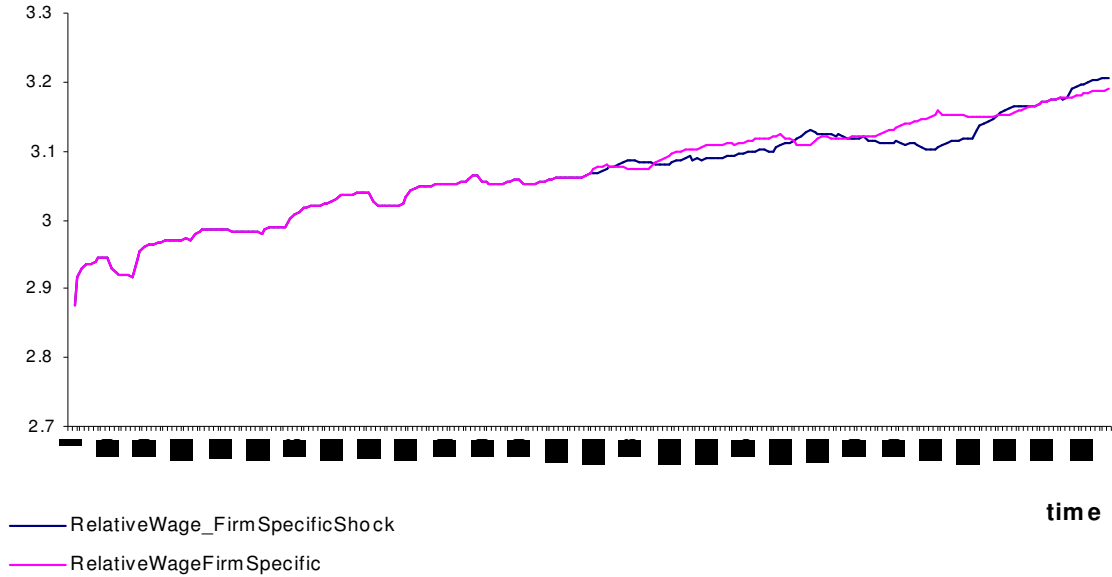


Figure 21: Relative Wage FirmSpecificTP Model With and Without an Increase in Demand at T=125

In Table 4, we can see that these two variables are somewhat improved when compared with the situation without shocks. This means that, in average, firms fill a larger proportion of their vacancies, so there are fewer ex-post vacancies. According to our model, this means that firms do not have to increase their wages in order to attract workers to their queues. Nevertheless, the wages of the non-routine workers increase more than in the set without shocks, while the wages of the routine workers have a very similar behavior in both sets (see Table 4).

In an expansion period, the firms' efforts to fulfill the increased demand mean they will pay relatively more to the non-routine workers, who not only are more productive, but also have a greater bargaining power. The average wage for the non-routine workers is 0.346 after the demand increase, and only 0.314 and 0.339 for the model with no shock, and the entire period in the model with a demand shock, respectively. For the routine workers, the average wage is 0.111 for all these three cases. The relative wage is higher for the post shock period (3.17), than for the entire period both with and without shocks (3.069 and 3.065, respectively).

Variables	FirmSpecific No Shocks	FirmSpecificTPModel Increase Demand
Average Fitness	0.085 (0.001)	0.092 (0.001)
InverseHerfindhal	9.3953 (0.622)	9.3425 (0.480)
Avg_r_NR	0.814 (0.004)	0.831 (0.004)
Avg_r_R	0.820 (0.005)	0.834 (0.005)
TotalUnemploymentRate	3.52 (6.65)	2.67 (6.17)
UnemploymentRate_NR	3.30 (9.35)	2.85 (10.83)
UnemploymentRate_R	3.73 (11.57)	2.50 (7.72)
AverageWages_NR	0.314 (0.000)	0.339 (0.000)
AverageWages_R	0.111 (0.000)	0.111 (0.000)
RelativeWage	3.069 (0.005)	3.065 (0.005)

Table 4: Average Final Period Simulation Results (T=250): Positive Demand Shock at T=125

4 Conclusion

In this paper, we proposed an evolutionary model where heterogeneous firms and workers interact and co-evolve. Within a micro-meso perspective, the model highlights the influence of firms' "institutional settings" on industry dynamics. These settings are formalized as firms' labor choices. The model includes an endogenous labor market and, benefiting from insights offered by mainstream labor economics, the dynamic processes of job search, bargaining and matching are introduced in an evolutionary framework.

The results obtained by means of computer simulation show that in a stable environment there is an initial clear improvement in the average fitness of the incumbent firms' population, which then evolves around an evolutionary stationary threshold. The introduction of endogenous matching and bargaining processes in the labor market leads to important frictions, as shown by the existence of ex-post vacancies and unemployment. Furthermore, there is an increasing wage inequality between the two types of workers considered in the model.

We also analysed the effect of both positive and negative demand shocks. The turbulence in the industry increases (decreases) after the negative (positive) demand shock. As expected, the negative demand shock causes a decrease in the number of vacancies and, consequently, the unemployment rates increase considerably. This raise in unemployment goes together with an increase in wages for both types of

workers, since the capability of the firms to fill their vacancies decreases after the shock. Following the positive demand shock, on the other hand, the firms slightly increase the number of vacancies, so the behavior in terms of unemployment rates is better than in the model without shocks.

We should keep in mind that these results were obtained for a specific model, within a computational simulation setting. Therefore, we must be aware of the limitations of this approach, and cautious in the interpretation of the results. In what concerns the theoretical frame, we could explore more realistic assumptions, namely regarding the duration of jobs and the wage setting mechanism itself. Moreover, we could endogenize the supply of both types of labor in the model, which would allow us to examine issues related to education, training and employment policies. Those issues will certainly encourage our future research.

5 Appendix - Object structure and initial configuration set

We assume that 225 workers of each type exist in the economy. A very small number is initially unemployed: 5 of the non-routine and 10 of the routine workers. The initial number of both types of workers allocated to each firm is randomly generated, and the initial total number of workers is equal for all firms. The desired ratio of filled vacancies is initially set, for all firms, at 0.9 for the non-routine and 0.85 for the routine workers. The initial total vacancies are generated so that the effective ratio of filled vacancies (r) is between 0.6 and 1.0, giving an average of 0.8.

Object Market	Object Industry	Object Firm	Object Labor	Object NR_Worker	Object R_Worker
Supply (0)	NumberFirms (P)	Firm_ID (P)	SumContWages (0)	NR_W_ID (P)	R_W_ID (P)
Demand (0)	HighestFirmID (P)	Quantity (1)	SumContWagesNR (0)	NR_W_SatWage (1)	R_W_SatWage (1)
Price (0)	AvgFitness (0)	Profits (4)	SumContWagesR (0)	NR_W_ResWage (P)	R_W_ResWage (P)
Matching (0)	Ah (1)	Costs (0)	NumberNR (P)	NR_W_ContWage (0)	R_W_ContWage (0)
	SumQuantity (0)	Fitness (0)	NumberR (P)	NR_W_FirmID (1)	R_W_FirmID (1)
	BargPower_NR (P)	AlphaFirm (1)	TotalW (P)		
	BargPower_R (P)	Beta1 (P)	TotalUnemp (0)		
	TotalVac (0)	Beta2 (P)	UnempNR (0)		
	TotalVac_NR (0)	A (1)	UnempR (0)		
	TotalVac_R (0)	F_Sat_Wage_NR (1)	TotalUnempRate (0)		
	Avg_r_NR (0)	F_Sat_Wage_R (1)	TotalUnempRateNR (0)		
	Avg_r_R (0)	F_Cont_Wage_NR (1)	TotalUnempRateR (0)		
	Alpha (P)	F_Cont_Wage_R (1)			
	Exit (0)	F_TotalVac (1)			
	Entry (0)	F_Vac_NR (0)			
	InvHerf (0)	F_Vac_R (0)			
		Ro_NR (P)			
		Ro_R (P)			
		r_NR (0)			
		r_R (0)			
		L (1)			
		LNR (1)			
		LR (1)			
		MShare (2)			
		RndAlphaFirm (0)			
		DesiredAlphaFirm (0)			
		A_Fit_Coeff (P)			
		A_LNR_Value			

* In parentheses we have the letter "P" when the respective label corresponds to a parameter in the model. Alternatively the labels that correspond to variables have in parentheses an integer that denotes the lagged time associated to each of them

Table 5: List of Variables and Parameters per Object

Market	NR_Worker			R_Worker		
Supply	59.75658		SatWage	0.36	SatWage	0.13
Demand	140		ResWage	0.3	ResWage	0.1
Price	2.342838					

Firms										
ID	1	2	3	4	5	6	7	8	9	10
AlphaFirm	0.404334	0.311681	0.814229	0.077761	0.512565	0.853656	0.658692	0.761495	0.068212	0.972433
estimated LNR	17.38636	13.40228	35.01185	3.343736	22.0403	36.70721	28.32376	32.74429	2.933133	41.81462
estimated LR	25.61364	29.59772	7.988153	39.65626	20.95971	6.292792	14.67624	10.25572	40.06687	1.185381
LNR	16	13	33	3	21	35	26	31	3	39
LR	27	30	11	40	22	9	17	13	40	6
L	43	43	44	43	43	44	43	44	43	45
TotalVac	56	44	51	49	68	71	44	64	57	49
r	0.767857	0.977273	0.862745	0.877551	0.632353	0.619718	0.977273	0.6875	0.754386	0.918367
A	0.350397	0.333349	0.310182	0.290308	0.365688	0.302927	0.338801	0.319885	0.288551	0.281072
Beta1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Beta2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Quantity	6.559248	5.569244	7.361969	1.894358	7.787375	7.054379	7.754616	7.640644	1.882893	6.251852
Mshare	0.109766	0.093199	0.123199	0.031701	0.130318	0.118052	0.12977	0.127863	0.031509	0.104622
BargPower_NR	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BargPower_R	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
SatWage_NR	0.352692	0.303248	0.351339	0.311379	0.311652	0.34988	0.352401	0.348272	0.32872	0.337105
SatWage_R	0.111502	0.118949	0.126541	0.115582	0.119546	0.107133	0.107874	0.122866	0.122601	0.127276
ContWage_NR	0.357077	0.337299	0.356536	0.340552	0.340661	0.355952	0.35696	0.355309	0.347488	0.350842
ContWage_R	0.118901	0.123369	0.127925	0.121349	0.123728	0.11628	0.116724	0.12572	0.125561	0.128366
WagesNR	5.713229	4.38489	11.76567	1.021655	7.153877	12.45832	9.28097	11.01457	1.042464	13.68284
WagesR	3.210332	3.701082	1.407171	4.853968	2.722007	1.046518	1.984315	1.634355	5.022424	0.770194
Fitness	0.095666	0.188319	0.314229	0.422239	0.012565	0.353656	0.158692	0.261495	0.431788	0.472433
Revenues	15.36726	13.04784	17.2479	4.438174	18.24456	16.52727	18.16781	17.90079	4.411313	14.64708
Costs	10.98038	12.13483	20.08588	14.95375	10.14603	21.28527	14.67716	18.40182	15.34832	25.08277
Profits	4.386878	0.913009	-2.83798	-10.5156	8.098528	-4.758	3.490648	-0.50102	-10.937	-10.4357

Table 6: Initial Values Configuration

References

- Abowd, J. and F. Kramarz (2003), “The costs of hiring and separations”, Working Paper 9543, CREST, INSEE.
- Acemoglu, D., P. Aghion and G. L. Violante (2001), “Deunionization, technical change and inequality”, Discussion paper, CEPR.
- Andersen, E. S. (1994), *Evolutionary Economics: Post-Schumpeterian Contributions*, London: Pinter Publishers.
- Andersen, E. S. (1999), “Multisectoral growth and national innovation systems”, *Nordic Journal of Political Economy*, vol. 25, pp. 33–52.
- Baron, J., M. Burton and M. Hannan (1996), “The road taken: origins and evo-

- lution of employment systems in emerging companies”, *Industrial and Corporate Change*, vol. 5, 2, pp. 239–275.
- Bartelsman, E. and M. Doms (2000), “Lessons from longitudinal microdata”, *Journal of Economic Literature*, vol. 38, pp. 569–594.
- Borjas, G. J. and V. A. Ramey (1994), “Time series evidence on the sources of trends in wage inequality”, *American Economic Review (Papers and Proceedings)*, vol. 84, 2, pp. 10–16.
- Carrillo, J. and D. Gromb (2002), “Cultural inertia and uniformity in organizations”, paper, CEPR.
- Christensen, C. and R. Rosenbloom (1995), “Explaining the attacker advantage”, *Research Policy*, vol. 23, 2, pp. 237–257.
- Davis, S. J., J. Haltiwanger and S. Schuh (1996), *Job Creation and Destruction*, Cambridge: MIT Press.
- Dosi, G. (1988), “The nature of the innovative process”, in *Technical Change and Economic Theory*, G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete, editors, London: Pinter Publishers, pp. 221–238.
- Dosi, G., F. Malerba, O. Marsili and L. Orsenigo (1997), “Industrial structures and dynamics: evidence, interpretations and puzzles”, *Industrial and Corporate Change*, vol. 6, 1, pp. 3–24.
- Dunne, T., M. J. Roberts and L. Samuelson (1989), “Plant turnover and gross employment flows in the U.S. manufacturing sector”, *Journal of Labor Economics*, vol. 7, pp. 48–71.
- Durlauf, S. and M. Fafchamps (2004), “Social capital”, WP Series 214, The Centre for the Study of African Economies.
- Epstein, J. and R. Axtell (1996), *Growing Artificial Societies: Social Science from the Bottom-Up*, Washington D.C.: MIT Press.
- Fagiolo, G., G. Dosi and R. Gabriele (2004), “Matching, bargaining and wage setting in an evolutionary model of labor market and output dynamics”, *Advances in Complex Systems*, vol. 7, pp. 157–186.

- Freeman, R. B. (1995), “Are your wages set in Beijing?”, *Journal of Economic Perspectives*, vol. 9, pp. 15–35.
- Gottschalk, P. (1997), “Inequality, income growth and mobility: the basic facts”, *Journal of Economic Perspectives*, vol. 11, pp. 21–40.
- Gregg, P. and J. Wadsworth (1995), “A short history of labour turnover, job tenure and job security”, *Oxford Review of Economic Policy*, vol. 11, pp. 73–90.
- Hamermesh, D. (1993), *Labor Demand*, Princenton, N.J.: Princenton University Press.
- Hamermesh, D. and G. Pfann (1996), “Adjustment costs in factor demand”, *Journal of Economic Literature*, vol. 34, pp. 1264–1292.
- Haveman, H. (1995), “The demographic metabolism of organizations: industry dynamics, turnover, and tenure”, *Administrative Science Quarterly*, vol. 40, 4, pp. 586–618.
- Howell, D. R. and E. N. Wolff (1991), “Trends in the growth and distribution of skills in the US workplace 1960-1985”, *Industrial and Labour Relations Review*, vol. 44, pp. 485–502.
- Jensen, B. J. and K. Troske (1997), “Increasing wage dispersion in U.S. manufacturing: Plant-level evidence on the role of trade and technology”, in *Growing Apart: The Causes and Consequences of Global Inequality*, A. Fishlow and K. Parker, editors, New York: Council of Foreign Relations.
- Johnson, G. (1997), “Changing in earnings inequality: the role of demand shifts”, *Journal of Economic Perspectives*, vol. 11, 2, pp. 41–54.
- Katz, I. and D. Autor (1999), “Changes in the wage structure and earnings inequality”, in *Handbook of Labor Economics*, O. Ashenfelter and D. Card, editors, vol. 3A, North-Holland: Elsevier Science, pp. 1463–1559.
- Lesourne, J. (1992), *The Economics of Order and Disorder*, Oxford: Clarendon Press.
- Lorenz, E. and A. Valeyre (2004), “Organisational change in Europe: national models or the diffusion of a new ‘one best way’?”, Working Paper 04-04, DRUID.

- March, J. and H. Simon (1958), *Organizations*, New York: Wiley.
- Mortensen, D. and C. Pissarides (1999), “New developments in models of search in the labor market”, in *Handbook of Labor Economics*, O. Ashenfelter and D. Card, editors, chap. 39, North-Holland: Elsevier Science.
- Nelson, R. (1995), “Recent evolutionary theorizing about economic change”, *Journal of Economic Literature*, vol. 33, pp. 48–90.
- Nelson, R. and S. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass. and London: Belknap Press.
- Nelson, R. and S. Winter (2002), “Evolutionary theorizing in economics”, *Journal of Economic Perspectives*, vol. 16, 2, pp. 23–46.
- Nickell, S. (1986), “Dynamic models of labour demand”, in *Handbook of Labour Economics*, O. Ashenfelter and R. Layard, editors, Amsterdam: North-Holland.
- Richardson, D. (1995), “Income inequality and trade: How to think, what to conclude”, *Journal of Economic Perspectives*, vol. 9, 3, pp. 33–56.
- Rutherford, M. (1994), *Institutions in Economics. The Old and the New Institutionalism*, USA: Cambridge University Press.
- Sargent, R. G. (1999), “Validation and verification of simulation models”, paper, Proceedings of the 1999 Winter Simulation Conference.
- Simon, H. (1955), “A behavioral model of rational choice”, *Quarterly Journal of Economics*, vol. 69, pp. 99–118.
- Simon, H. (1956), “Rational choice and the structure of the environment”, *Psychological Review*, vol. 63, pp. 129–138.
- Stinchcombe, A. (1965), “Social structure and organizations”, in *The Handbook of Organizations*, J. March, editor, chap. 4, Chicago: Rand McNally & Company, pp. 142–193.
- Sutton, J. (1997), “Gibralt’s legacy”, *Journal of Economic Literature*, vol. 35, 1, pp. 40–59.

- Teixeira, A. A. C. (2004), “Strategic complementarities between innovation and human capital. The neglected role of human capital demand”, *Revista Brasileira de Inovação*, vol. 3, pp. 169–200.
- Tesfatsion, L. (1997), “How economists can get alive”, in *The Economy as an Evolving Complex System II*, W. Arthur, S. Durlauf and D. Lane, editors, Santa Fe Institute, Santa Fe and Reading, MA, Addison-Wesley.
- Thurow, L. (1975), *Generating Inequality*, New York: Basic Books.
- Valente, M. (1998), “Laboratory for simulation development”, Working Paper 98-5, DRUID.
- Valente, M. and E. S. Andersen (2002), “A hands-on-approach to evolutionary simulation: Nelson-Winter models in the Laboratory for Simulation Developments”, *Electronic Journal of Evolutionary Modeling and Economic Dynamics*, , 1003, pp. [http:// www.e-jemed.org/1003/index.php](http://www.e-jemed.org/1003/index.php).
- Wood, A. (1998), “Globalization and the rise in labor market inequalities”, *The Economic Journal*, vol. 108, pp. 1463–1482.

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