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LEM
Working Paper Series

# Labor Market Dynamics and Institutions: an Evolutionary Approach

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**2002/07** **June 2002**

ISSN (online) 2284-0400

# Labor Market Dynamics and Institutions: an Evolutionary Approach

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**Abstract**

We analyse labor market dynamics with an agent based model, which replicates a set of stylized facts in the labor market as well as aggregate regularities. We are able to reproduce the Beveridge curve, job creation and destruction flows, a persistent unemployment level, and wages stickiness. On the aggregate level, we observe a self-enforcing process of real income growth and average productivity growth. Model simulations allow us study the role of dynamic interactions among agents –individuals and firms– in a changing environment shaped by institutions. The key features are the microfoundations of the processes governing the labor market, such as job search by individuals, and matching and bargaining among firms and potential employees

*Keywords: Unemployment, Beveridge curve, matching, job creation flows, job destruction flows, technical change.*

*JEL-Codes: J63, J64, O12, J41.*

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[†]Earlier versions of this paper were discussed with Giovanni Dosi. I would like to thank also Giorgio Fagiolo, Carolina Castaldi, Angelo Secchi, Mishael Milaković and the participants to the ETE workshop in Jena. Usual disclaimers apply.

# 1 Introduction

The paper proposes a framework to analyze labor market aggregate outcomes as a result of microeconomic interactions of heterogeneous firms and individuals. I propose an agent based model to interpret jointly the flows of jobs and worker, the emergence of the Beveridge curve and the process of growth of system driven by technological change. The theoretical starting point of the approach is rooted in the seminar paper of Blanchard and Diamond (1992). They proposed the "flow approach to labor market" to understand aggregate regularities. They recognized the importance of jobs flows, frictions, wage dynamics, and of the process of matching between jobs and workers in shaping the market. I want to go a bit further proposing a "disaggregate approach to labor market". I would like to look for an explicit microfoundation supporting a wide set of empirical evidences of the labor market. In addiction I show how different institutional setups can lead to different growth paths for the economy, alternative levels of jobs and workers flows and persistently different unemployment rates. The core of the approach is the observation that macroeconomic smoothness of outcomes in labor market is supported by a huge microeconomic turbulence. Different outcomes emerge from different microeconomic conditions and from alternative institutions.

As a result it is possible to re-interpret regularities as the Beveridge curve (Beveridge 1936) as a robust property of the labor market, that comes out from micro interactions of agents and firms, and from dynamic features of the system. The model take into account the interactions between labor market and good market. The process of selection of firms act mainly in labor market through the probability to find workers, but is related with the process of aggregate demand formation in good market.

I modeled explicitly the processes governing labor market, i.e. job searching by individuals, matching and bargaining among firms and potential employees. I added a microfounded process of search for a new technique to increase the productivity of labor over time. The aggregate outcomes of the system are emerging properties Lane (1993*a*) and Lane (1993*b*) obtained through the microeconomic interactions of agents in the whole set of activities they have to carry on both in labor and good market.

Summing up the main features added to the "flow approach" are:

- Abandoning the concept of equilibrium of the system to analyse dynamic evolution of labor market;
- Microfounding the behavioral aspects of individuals and firms;
- Taking into account explicit interactions among agents;
- Assuming richer institutional setup.

In particular I studied briefly the capacity of the model to be considered in its simplest form as a matching model. The proof of that assertion lead me to

consider the model an enrichment of the broad class of model called "matching models". Then I move towards the exploration of the model to find out its dynamic properties, pointing out what are the advantages of the approach. Finally I explore the effects of different degrees of technological opportunity in the economy and of different bargaining strength of firms in the labor market.

A simulation approach is used to derive the results. Robustness of results is ensured by a Montecarlo analysis.

The paper is organized as follows. In section 2 I introduce the stylized facts to account for. In Section 3 I discuss briefly the main features of the "standard" approach for this set of issues. In Section 4 I present the model. Section 5 starts with a comparison between a simple matching model and the model discussed, then present the design of the experiments and the expected results. Section 6 presents results and comments.

# 2 Which stylized facts should we account for?

The fundamental point is to choose the empirical evidences, and the stylized facts I can deduce from them, to account for. Looking at empirical literature in labor economics we find two main branches of studies. One has to do with job creation and destruction flows and the second with aggregate regularities.

Davis, Haltiwanger and Schuh (1996) provided a complete study of job creation and destruction for U.S. economy. Looking at that study I can enumerate a set of important issues[1]:

- Magnitude of job creation and destruction flows; in economic systems we observe a large amount of flows of destruction of existing jobs and, at the same time, a large activity of creation of jobs;

- Distribution and links with micro-dynamic aspects of firms: The dynamic of firms in terms of entry -exit processes from the market and in term of capacity to shrink and to expand are responsible of the flows we observe at aggregate level. It is possible to rank the firms in the system according to their capacity to grow or to contract (in terms of job opening and closing activities). It comes out that more dynamic firms are responsible for a considerable percentage of creation and destruction of jobs. In particular: entrant firms have an important role in the overall creation of jobs and a big part of job destruction is explained looking at closing firms –and to their overall destruction of jobs.

The Beveridge Curve is one of the most well known and discussed regularities of labor markets. Since the curve was introduced by Beveridge (1936) it was clear that there was a lot to understand in labor market functioning to explain the existence of the curve. The Beveridge curve was introduced in the economic debate as an empirical negative relationship between the rate of unemployment and the rate of

[1] See also Burda and Wyplosz (1993) for a complete discussion of empirical evidences for European countries.

vacancies in the system. It is the starting point of the labor market literature that takes into account frictions in the market. In fact, if one allows frictions then it is reasonable to find at same time vacancies and unemployment in labor market. The intuition behind the curve is quite simple: if the system is able to sustain a higher number of jobs to be filled then the number of individuals that are able to find a job increases. The shape of the curve (a convex negative sloped locus in the unemployment-vacancies space) shows that there are decreasing marginal returns in the process of matching between individuals and jobs.

The standard framework to account for such a regularity is represented by matching models (Pissarides 2000)[2]. We can consider the Blanchard and Diamond model as a benchmark for that class of models (Blanchard and Diamond 1989). In the model the analytic core is represented by the matching function and the focus is on the job creation and job destruction processes. The job and workers flows are responsible for the equilibrium levels of relevant variables.

The matching function is the "standard" device used to model a labor market at aggregate level and is simply a function that relates the unemployment level (U) and the number of vacancies (V)[3]. The marginal productivities of U and V are assumed positive and the second partial derivatives are negative.

Empirical results (Nickell, Nunziata, Ochell and Quintini 2001) show that the Beveridge curve arises in all OECD countries.

Another stylized fact of labor market is the stickiness of wages[4]. Wages fail to lower even in periods of negative economic cycle. An explanation of this phenomenon is related with the existence of institutions governing labor markets, that put some boundaries on the variability of wages, but there are also market mechanisms that lead to this result.

The last but not the least, stylized fact I would like to account for is the process of real income growth and of the productivity of labor that we can observe in almost every economic system (see Verspagen (2000) for empirical evidences).

The effort of the paper is in the direction to find a framework to replicate the wide set of stylized facts enumerated in the present section. Let me discuss the labor market literature that deal with the class of puzzles I described.

# 3 A brief discussion about the basic theoretical concepts

The standard interpretation of aggregate regularities of labor market are Matching models. They are based on a set of assumptions that I will enumerate and then

[2]See also Bleakley and Fuhrer (1997) for an empirical discussion on Beveridge curve.

[3]There is a high number of different functional forms related to the concept of matching function depending on the purpose of the model. See Pissarides (2000),Petrangolo and Pissarides (2001), Mortensen and Pissarides (1999) for surveys. I am referring to the simplest version of that function used in Blanchard and Diamond (1989).

[4]See Nickell et al. (2001) for an extensive exposition of the empirical evidences about OECD.

discuss briefly[5]:

1. The Beveridge curve is directly obtained from the functional form and parametric assumptions of the matching function. It is rather an assumption of the models than a result.

2. The Beveridge curve is treated as an equilibrium locus in the U-V space. This is the direct consequence of the referring framework: a stable environment with optimizing representative firm and individual.

3. The micro-foundation of the model is obtained through the solution of a problem of maximization of the expected stream of returns over time of the representative agents (the worker and the firm).

4. The analysis of the results is in terms of "comparative dynamics".

Looking at this brief list of features one soon realize that there is no room for microeconomic features of labor market and for actual interactions of agents. The starting point is to recognize that mechanisms governing labor market are peculiar and hence there is the need for a specific framework to deal with them. The concept of frictions is central in all the literature. The "failures" in labor market and the Beveridge curve are the result of the existence of these frictions. What is missing is a *trait d'union* between macro and micro aspects[6]. Hence, from a theoretical point of view, the model I propose highlights some aspects that appear to have not been sufficiently analyzed:

- The role of coordination among agents as a dynamic process of explicit interactions;

- Institutional features: I consider different institutional set-ups defined by degree of opportunity, firms learning ability, contractual strength of workers *vs* firms, agents behavioral rules;

- The wage bargain process as a phenomenon related with labor market dynamics and institutions;

- The matching process as a micro-founded dynamic process yielding a Beveridge Curve as an emerging property of the system;

- The job creation and destruction flows as a result of dynamic aggregation of individual histories of heterogeneous firms.

[5]I am not taking into account the models that do not deal with "flows", but are based on the stocks of labor market variables, as they are focused on structural aspects. See Katz and Blanchard (1997) for a survey.

[6]The self-organization approach is strongly related with the framework I am proposing. The two methodologies run parallel: Modeling micro environment and to find out at aggregate level regularities. In particular see les for a whole class of labor market models.

- The selection of the firms: firms are selected not only in the product market but also in labor market [7].

The model I propose in this paper can be seen as a contribute to the labor market analysis under two different points of view:

- A new framework to re-interpret the regularities as evolutionary dynamic features of the labor market and to shed light on disaggregated features of labor market;
- An attempt to provide a framework able to capture a wider set of labor market stylized facts and to reproduce at the same time a process of endogenous growth.

# 4 The model structure

## 4.1 An outline of the model

The labor market is composed of a fixed number of individuals $L$ (supply side) and a certain number of firms $F(t)$ endogenously evolving[8]. Both individuals and firms have bounded rationality, in particular they are endowed with behavioral routines to act both in the labor and in the commodity market. The model is set in discrete time. At each time $t$ each individual and each firm is involved in a set of economic activities.

I will organize the explanation of the model giving first a brief description of the timing of different actions, then I will describe in detail all the equations forming the structure of the model. Hence, let me sketch the model functioning inside a period $t$.

At the beginning of the period $t$, firms, given the earnings of period $t-1$, decide the number of desired productive jobs. They set the vacancies (see section 4.3). Unemployed individuals have to look for a job; so they engage in a process of searching for vacancies in the labor market (see section 4.2). In each period $t$ there is a fixed number of search rounds $r$. Each individual in each round $t_r$ draws at random a firm to apply to as a worker. The probability of drawing a specific firm is a function of the relative size and the relative level of wage of the firm itself. Once an individual chooses a firm, she becomes part of a queue of its potential employees. After all individuals complete the searching process firms start to look at queues choosing among applicants the new workers to fill a certain number of vacancies. Firms engage in a process of bargaining over the wage with the chosen individuals. As a result they establish a contractual wage that will be paid in advance to the workers (sec. 4.5).

[7] From an evolutionary point of view a model of competition among firms is proposed. It is based on the concept that selection exists both in product market and labor market (Metcalfe 1997).

[8] The initial number of firms $F(0)$ is a parameter of the model.

After $r$ rounds of search, firms start other economic activities. First of all, they try to upgrade their technology; and this results in a new level of productivity for the current period(sec. 4.7). At this point the production process starts. Firms have a technology that employs only labor good which is the only input. Each firm produces an amount of homogeneous good which is given by the productivity level of the firm and by the duration on the job of its workforce (sec. 4.6).

The good is sold in a competitive market in which the level of demand is determined by the overall wages paid by the firms to individuals. The price of the asset is established by the meeting of supply (given by the sum of the productions of whole set of firms) and demand; firms are price takers. In this market we have at work a sort of Say law, that allow firms to sell all the asset produced. Firms earn an income from this process. They can then calculate their profits in period $t$. If the level of profits goes below zero, firms are forced to exit the market, loosing their market shares and their workforces (sec. 4.8). At this point processes of revision of relevant variables start. Individuals revise their demanded wages, taking into account their employment status. Firms revises their offered wages (see sec. 4.4 and sec. 4.3).

Finally, at the end of a period $t$ a certain number of firms enter in the market looking at the profitability of the market itself; they are chosen at random from a pool of entrant firms (sec. 4.8).

## 4.2 The searching process of the individuals

I assume the existence of frictions in the market (i.e. geographical dispersion of jobs, imperfect information regarding vacant jobs). For this reason unemployed individuals do not possess full information about the availability of vacant jobs and must engage in a costly process of search. Workers have the opportunity to search for a given number (the parameter $s$) of "searching rounds" in the same period $t$. The sequence in which unemployed workers search is set to be random, to avoid ordering dependence of the process. Each unemployed worker draws a firm with a vacancy to be filled; she becomes candidate for that job position for the current period becoming part of its pool of applicant – forming a queue. At the end of the search round each firm chooses in its queue of potential employees to fill vacancies, then clears the queue.

The probability $Pr_j(i;t)$ depends upon the number of vacancies opened in period $t$ by that firm ($vac_i(t)$) and by its offered wage ($wf_\mu(t)$). We assume in particular the following:

$$Pr_j(i;t) = f[\frac{wf_i(t)}{wf_\mu(t)}, vac_i(t)] \tag{4.1}$$

In equation (4.1) the parameter $\lambda$ is a measure of the relative importance of the two variables $vac_i(t)$ and $wf_\mu(t)$. When $\lambda = 0$ we are dealing with a market in which the size of firms is the only signaling variable. On the other hand $\lambda = 1$ reproduces a market where firms do wage posting to signal the presence of vacancies and individuals are interested only in level of wage. Thanks to equation (4.1) one

has a sort of replicator dynamic in labor market. The firms characteristics are compared with the average levels of wages and vacancies. Firms are selected via the probability to be chosen by individuals. In fact if a firm is not selected by workers in a period it is not able to go on with the desired level production, because it faces a shortage in the supply of labor.

## 4.3 The behavioral rules of firms

Firms have three different behavioral routines to take decisions in the labor and good market: a wage setting rule, a job opening rule and an investment rule. The level of the wage offered in the current period ($wf_i(t)$) is determined as an adjustment of the wage offered in the previous period, hence I have:

$$wf_i(t) = \begin{cases} wf_i(t-1) \cdot (1+\delta_{wf}) & if \quad \frac{vac_i(t-1)}{fil_i(t-1)} > q \\ wf_i(t-1) \cdot (1-\delta_{wf}) & if \quad \frac{vac_i(t-1)}{fil_i(t-1)} \leq q, wf_i(t-1) < cow_i \end{cases} \tag{4.2}$$

where $\delta_{wf}$ is the dimension of wage shift, as a percentage of $wf_i(t)$, and $cow_i$ is the cut-off wage of firm, a maximum level of wage that she can offer.

The parameter $\frac{vac_i(t-1)}{fil_i(t-1)}$ is the ratio between the number of vacancies ($vac_i(t-1)$) and the number of filled jobs ($fil_i(t-1)$) in period $t-1$ and represents a measure of the firm's capacity to fill in the vacancies. This level is compared with a desired ratio $q$ parametrically given. The routine is built to capture the intuition that if a firm does not attract the desired number of individuals it concludes that a change is needed to become more "attractive" to the workers. Hence, the firm raises its wage because it knows that the finding probability is positively affected by the level of wage and so operates on it.

The number of job opening (vacancies) ($vac_i(t)$) for the current period is a function of the firm profits of the previous period:

$$vac_i(t) = \frac{prof_i(t-1) - rd_i(t)}{wf_i(t) + c_i(t)} \tag{4.3}$$

where: $c_i(t)$ is the unit cost for firm $i$ to open a vacancy, $wf_i(t)$ is the wage offered in period t, $y_i(t-1)$ is the income of period $y_i(t-1)$ and $rd_i(t)$ is the expenditure in research process and is a fixed percentage of income of the previous period. The percentage of income that firms are not able to invest in labor is consumed in a luxury good not modeled here.

## 4.4 Wage setting rule for individuals

Individuals are described by the search process discussed and by the wage setting routine. The latter allows workers to set a demanded wage ($ww_j(t)$). The behavioral rule is given by the following:

$$ww_j(t) = \begin{cases} ww_j(t-1) \cdot (1+\delta_{ww}) & if \quad occ_j(t-1) = 1 \\ ww_j(t-1) \cdot (1-\delta_{ww}) & if \quad occ_j(t-1) = 0, ww_j(t-1) > wr_j \end{cases} \tag{4.4}$$

where $occ_j(t-1)$ is the employment status of worker $j$ at period $t-1$, $wr_j$ is the reservation wage and $\delta_{ww}$ is the size of adjustment from period to period as a percentage of previous demanded wage. Each worker raises its demanded wage if in the period $t-1$ she was employed and lowers it if she was unemployed. This means that employed workers can exploit a sort of insider rent subsequent to the formation of the matching. At the same time outsiders are induced to reduce their wages to raise their probability of being hired in the current period.

Note that the reservation wage is parametrically given as an exogenous threshold. One can think about this parameter as the result of a process of optimization of individual under the constraints of specific tastes and personal ability not modeled explicitely.

## 4.5 The bargaining process

Once a worker decides to accept the offer of a firm, she starts a bargaining process with that firm. I assume that the bargaining takes place between the firm and the applicants of a current round of search. The technical solution is similar to a Nash Bargaining rule[9] in which $\beta$ measures the contractual strength of firm. The difference in this framework is that $1-\beta$ is the strength of the pool of workers and not the individual strength. The firm offers the same contractual condition to all the applicants in a period, hence firms set the contractual wage $(wc_i(t))$ according to the following:

$$wc_i(t) = \beta \cdot wf_i(t) + (1-\beta) \cdot \overline{w}_i(t) \tag{4.5}$$

where $\overline{w}_i(t)$ represent the average level of demanded wage for the individuals forming the queue of the firm in the period $t$ and $wf_i(t)$ is the offered level of wage of firm $i$ before starting the bargaining process.

## 4.6 Production and demand

Firms produce an homogeneous good. The consumers are the workers themselves, and they spend all their income in the consumption of the existing asset. Hence the demand level of the asset depends in each period on the sum of wages paid to employed workers.

The production $(q_i(t))$ of each firm is given by a technology that uses only labor, hence:

$$q_i(t) = \sum_{j=1}^{l_i(t)} \alpha_{i,j}(t) \tag{4.6}$$

where $l_i(t)$ is the number of individuals employed in the firm and $\alpha_{i,j}(t)$ is the productivity of each worker on its job.

[9]The assumption of Nash bargaining between firm and worker is the standard assumption in matching models.

The income of firm $i$ at time $t$ $y_i(t)$ is obtained multiplying production $(q_i(t))$ with the price level of the asset $(P(t))$:

$$y_i(t) = q_i(t) \cdot P(t) \tag{4.7}$$

The market for the consumption commodity is assumed to be competitive. Hence the price $(P(t))$ is set by a demand curve in the following way:

$$P(t) = \frac{W(t)}{Q(t)} \tag{4.8}$$

where $W(t)$ is the global amount of wages paid by firms to the workers:

$$W(t) = \sum_{i=1}^{F(t)} \sum_{j=1}^{l_i(t)} wc_{i,j}(t) \tag{4.9}$$

where the first sum is over the existing firms at time $t$ $(F(t))$ and the second sum is over the workers employed in each living firm $(l_i(t))$. $Q(t)$ is the total quantity of asset produced in $t$:

$$Q(t) = \sum_{i=1}^{F(t)} qi(t) \tag{4.10}$$

## 4.7 The process of technical change

The firms are characterized by a specific level of productivity given by the accumulated technical change as a result of a stochastic process of research over time. If we distinguish between firms that are entering in the market and firms that are already on the market (incumbents), we have the following analytic representations of adjustments in productivity $(\alpha_i(t))$:

Entrant firms:

$$\alpha_i(t) = \begin{cases} \overline{\alpha}(t-1) \cdot (1+\eta) & if \quad \eta > 0, \eta < k \\ \overline{\alpha}(t-1) & if \quad \eta \leq 0, |\eta| > k \\ \overline{\alpha}(t-1) \cdot (1+k) & if \quad \eta > 0, \eta > k \end{cases} \tag{4.11}$$

Incumbent firms:

$$\alpha_i(t) = \begin{cases} \alpha_i(t-1) \cdot (1+\rho) & if \quad |\rho| < k \\ \alpha_i(t-1) \cdot (1+k) & if \quad , |\rho| > k \end{cases} \tag{4.12}$$

where $\eta$ in (4.11) and $\rho$ in (4.12) are stochastic variables that have a normal distribution with average equal to, respectively, $\overline{\alpha}(t)$ and $\alpha_i(t-1)$ and finite variance $\sigma^2$. Note that $k$ is a parameter used to "cut" the draws from the normal distributions while the size of $\sigma^2$ defines the degree of opportunity of technical changes. I assumed normality of the distribution to capture the intuition that firms make steps in a neighborhood of their position in the "technological space" and that is small increments are more likely than big ones.

### 4.8 Entry and exit processes

Firms in the market are subject to a selection process. The level of profits for firm $i$ at time $t$ is given by:

$$prof_i(t) = y_i(t-1) - rd_i(t) - \sum_{j=1}^{l_i(t)} wc_{i,j}(t) - c_i(t) \tag{4.13}$$

where the lag used for the income of firm $y_i(t-1)$ implies the Ricardian assumption: firms decide the number of vacancies and the wages looking at previous income level, then they pay in advance the wage to their workers and the other expenses for the period $t$. Firms decide to stay in the market or to exit from it looking at the level of profits. Hence I have the selection rule:

$$ex_i(t) = \begin{cases} 1\, if\ prof_i(t) \geq 0 \\ 0\, if\ prof_i(t) < 0 \end{cases} \tag{4.14}$$

where $ex_i(t) = 0$ correspond to firm $i$ staying in the market for the period $t+1$ and $ex_i(t) = 1$signals the exit of the $i$ after period $t$.

In each period $t$ there exists a pool of entrant firms. The probability of entering in the market ($Pr(entr(t) = 1)$) is related with the level of profitability of the market. There is a two stage process governing the entry in the market. Hence we have the following:

$$Pr(entr_i = 1) = f(\overline{prof_i(t)}) \tag{4.15}$$

where $\overline{prof_i(t)}$ is the average level of profit calculated over the existing firm at time $t$ (i.e. firms with positive level of profits).

Once a firm is selected to enter in the market, draws its size from a random distribution with mean equal to the average dimension of the firms in the market. The level of productivity is determined by equation (4.11).

## 5 Definition of the experiments

### 5.1 Some standard results or the search for similarities

The first question is if the model is in accordance or not with standard matching models. This is an important issue to provide a proof that the model is a further development towards a more deep exploration of labor market dynamics. What I find out from simulations of a benchmark version is quite straightforward.

I create a stable framework for my artificial economy working on some parameters. In particular I set:

- The adjustment parameters for wages to zero - i.e. I set $\delta_{ww} = 0$ and $\delta_{wf} = 0$. Both firms and workers decide once for all at time $t = 1$ the levels of wages, then also the contractual wage is sticky to the level calculated during the first bargaining process;

- The technological opportunities parameter to zero - i.e. $\alpha_i = 0$ for each firm $i$.
- The contracts length is infinite. Once a worker is hired cannot be fired and she cannot quit the job. enditemize Another step towards standard matching models has to be to recreate a situation with representative firm and representative individual. To achieve this result I assumed an homogeneous population of firm and homogeneous labor force. The aggregation under those assumptions is obtain simply multiplying by the number of agents the individuals results.

What are my results? I obtain a situation in which firms have a fixed level of production and a given size of their labor force over time. The workers hired at the beginning in a firm remain for ever with her. As a consequence unemployment is also stable. We have a given number of unemployed individuals, dependent on the parameters of the model - i.e. initial values of wages, degree of bargaining strength, productivity levels, profit levels. The system under those conditions can only reproduce itself over time. What is interesting is that behind the macroeconomic stability we also a situation of microeconomic stable state. Note that the only difference with standard models of matching is that I am obtaining the set of results described not referring to optimizing perfect rational agents. The requests in terms of rationality of the agents are really low: they are endowed with behavoiural routines; and the outcomes are simply derived from the structure of the market, in terms of agents individual behaviors and of "physic" of interactions among them.

I sketch now some of the comparative dynamic exercises performed to test the capabilities of the model to reproduce the standard results of matching models. In particular we can think at this class of exercises as the study of the properties of equilibria of the model[10]:

1. Labor productivity: the common result is that an higher labor productivity lead to a shift in the job creation, and to an influence to a wage equation and to market tightness - i.e. the ratio between unemployment rate and vacancy rate. More in detail there is more job creation and an higher wage and, through assumptions on Beveridge curve, we have an higher market tightness dued to an higher level of vacancies an a lower level of unemployed. In the model the effects of higher productivity are the same. through the increment in labor productivity firms can open an higher number of vacancies. This will lead to a probability of find a job for workers higher (remember that the number of job opened by a firm is a variable that raise the probability for workers to choose a specific firm). As a consequence we have lower level of unemployment that together with the previous effect on vacancies determines a lower market tightness.

2. Bargaining strength: Matching models show that higher level of $\beta$ leads to an higher wage, as a direct effect of the wage schedule shift. But the new level of

[10] I am comparing the model to the simple model exposed by Pissarides (2000)

wage reduces the capacity of firms to open vacancies, and this raises the market tightness. This phenomenon affects the efficiency of matching process and so we have in the end an higher level of unemployment. The effect in the model proposed of a rise in $\beta$ is similar. Through the bargaining process we have a raise in the contractual wages that leads to a lower number of vacancies at aggregate level, given the fact that firms experiment a reduction of the part of the "pie" they can appropriate during the bargaining process. This reduces the probability to find a job for workers and conduces to an higher unemployment level.

Note that in matching models the results showed are obtained assuming a Beveridge curve, while in this model the curve itself is an aggregate outcome; the values of individual parameters together with the physic of the market over time are responsible of the "shape" of the system.

The conclusion of the previous analysis is that I can interpret the benchmark version of the model presented as a matching model. Moreover I can think to the model as a starting point for the analysis on the dynamics of labor market. The focus of the study is on the microeconomic structures able to sustain regularities over time at macro level that we can codify in a set of stylized facts.

## 5.2 The building blocks of dynamic analysis

Given the broad discussion of the previous paragraph, I have to introduce now the setup to start the dynamic analysis of the model, in order to obtain from the model a set of general results related with: Beveridge curve, jobs flows, the process of growth and the stickiness of wage. To test the behavior of the model I start with a vector of parameters, and I refer to it as defining *canonical simulation*[11].

The chosen values reproduce a market with at time $t = 0$ an homogenous group of firms and workers.The number of the agents is set coherently to $F(0) = 10$ initial number of firms; and to $L = 100$ total number of existing workers[12]. I run a set of experiments working on two crucial parameters of the model:

- $\beta$, the strength of the firms in the bargaining process;
- $\rho$, the variance of the random extraction from the normal distribution for incumbent firms during the search for new techniques.

[11] The vector of values that defines the canonical simulation was chosen looking at the stability of the results in a iper-sphere neighborhood of the point represented from the vector itself.

[12] At microeconomic level the parameters are set according the following scheme:

- $wf_i(0) = 95$; $cow_i = 300$; $\delta_{wf} = 0.2$; $q = 0.1$; $\alpha_i(t) = 0.1$; $q_i(0) = 40$; $\xi = 0.5$ for $i = 1, ..., F(0)$.
- $ww_j(0) = 95$; $wr_j = 80$; $\delta_{ww} = 0.1$ for $j = 1, ...L$.

For the price I set: $P(0) = 100$. The number of search rounds is set to $r = 2$.

For both the parameters I built a grid of ten values, hence I have: $\beta$ ranging from 0 to 1; and $\rho$ from 0.1 to 0.

I define two possible limit cases, setting $\beta$ equal to 1, as:

- *Entrants learning*, $(EL)$ in which only entrant firms are capable of exploring the space of new technologies ($\rho = 0$).
- *Entrants and incumbents learning*, $(IEL)$ in which both entrant and incumbent firms are able to undertake research to improve their productivity ($\rho = 0.1$).

# 6 Some results

It is possible to obtain a sets of "general" results from the canonical simulations of the model presented in Gabriele (1999):

- The Beveridge curve: the model generates a negative relation between unemployment and vacancies;
- The job flows, in terms of magnitude and distribution among firms ranked on the basis of their dynamic properties[13];
- The self enforcing process of growth, both in terms of income growth and productivity growth;
- The stickiness of real wages: over time wages seem to be "sticky";

Let me discuss more in detail the results mentioned above and then shift to the comparative analysis.

## 6.1 The Beveridge curve as an emerging property

The model reproduce a Beveridge curve. It is possible to recognize an ordered pattern for the points in the U-V space. Actually it's possible to refer to two different curves:

- The unemployed-"job openings" locus (UJ curve);
- The unemployed-unfilled jobs locus (UV curve).

The parameter *rounds* has an important role in determine the distance of the UV curve from the axis, but its effect does not have a significant impact on UJ curve. This is quite intuitive, because the parameter has to do with static efficiency of the labor market, but is not directly responsible for the process of job openings. From a dynamic point of view we can analyze the UJ curve observing that its shape has to do with a concept of "dynamic efficiency" of the market. In this sense it is the market

[13]See Davis et al. (1996) for an exhaustive exposition of this set of stylized facts referred to U.S..

functioning that determine the number of job openings and the sustain-ability of that level of "activity" of the market. So the ability of the firms to find the workers works as a selection device in labor market. I observe a cyclical movement around the estimated Beveridge curve that is the result of the ongoing dynamic processes[14]. In fact, the number of job opening is endogenously given by the various processes that the market is experimenting. At micro level we can observe that an higher level of profits, as a result of the competition and the exploration of new technologies, leads to an higher number of jobs opened in a period. The level of profits at aggregate level has an effect on the number of entrant firms, via the relation (4.15) and on the overall number of job opened in that period. If we have high profits and an high number of vacant jobs in the period $t+1$ probably we observe an high level of production and hence via the competitive market for the good a low level of the price (see eq.4.8). This leads to a low level of profits and hence to a lower level of jobs opened in $t+1$.

The fig. 7.4 represents the time series for the variables vacancies and unemployment. The fig. 7.3 represents the usual scatter plot defining the Beveridge curve. We can observe, from both the graphics, the strong negative relationship between the two variables. An interesting feature of the time series plot is represented by the shifts of the two series. The microeconomic conditions and the stochastic processes underline the model functioning determine phenomena of lock in of the aggregate performances. The model remains locked into a configuration for a set of simulation periods and then shifts again. Each shift is related with the overall number of firms in the market and with their capacity to open vacancies. The causal link is from vacancies to unemployment: The higher is the number of vacancies the lower is the market tightness and so the probability to find a job for unemployed individuals is higher. At aggregate level we observe, hence, a lower level of unemployment.

## 6.2 The job creation and destruction flows

The simulations present job creation and destruction flows that follow the same patterns of the stylized facts introduced in section (2):

- The magnitude is relevant compared with the stock of existing jobs on the market (see table 7.2);
- The distribution of the size of firms: smaller firms are responsible of a consistent percentage of both jobs creations and jobs destructions (see table 7.3);
- The births and deaths of the firms in the market determine a consistent part of the flows. In particular new entrants create many jobs and exiting firms contribute to the destruction of many jobs (see again table 7.3).

[14] Matching models (Pissarides 2000) describe this movements as counterclockwise movements around a steady state locus. I am proposing a dynamic interpretation of this stylized fact.

The flows emerge from the model as the result of the dynamic interaction of firms mainly on the labor market[15]. Once again the retroaction from the good market and the effect of the labor market conditions are absolutely crucial. In fact, the decision about the creation of new jobs is related, at micro level, to the net income at the end of each period. But the level of income depends on the wages paid[16] in two ways. First wages determine the costs of the firm, second they create, at aggregate level, the "effective" demand for the asset produced.

## 6.3 The growth process of the economy

The simulations show a self enforcing process of growth both in real income and in productivity level. I performed DF-test to test the existence of an "explosive" process of growth for the productivity and for the real income and the results reject the assumption of unit root. The process of technical change seems to be the "engine" of growth. But the labor market works as a selection device. Firms with higher productivity are able to produce more than the average and then they can earn higher profits. This leads to a higher number of job openings and higher wages for that group of firms. These firms enjoy a process of growth, given that visibility is related with wages and size . There are two main limits to this chain: the entry of new firms that are more productive and the possibility for the market to create an adequate level of demand. In the figures 7.1 and 7.2 are shown the time series of labor productivity growth[17] and of real income growth obtained for the canonical simulation. We can observe that real income growth follow a pattern strictly related with the time series of labor productivity. In fig. we observe also an higher variability of real income series. This fact is a consequence of the selection process that is operating in the model: period in which we an level of production can depress the price of the good eroding firms profits in the next period. This will lead to an higher level of selection in the market -i.e. more firms could experiment negative profits.

## 6.4 Stickiness of wage

The model reproduce sticky time series of the contractual wage. The level of past wage is important in determining the future level and the movements towards lower levels of wages are limited. This is a stylized fact shared by all the OECD countries[18].

[15]In matching models the flows are result of an underlying stochastic process that bring together jobs and workers (Pissarides 2000); exogenous parameters, hence, are responsible of the flows.

[16]It depends of course also on the price of the asset sold in the competitive market.

[17]To calculate the growth rates of variables I used the relation:

$$g_x = [(\frac{x(T)}{x(0)})^{(1/(T+1))} - 1] \tag{6.1}$$

The formula was used to reduce the dependence of results on variability of variables over time series and the dependence over sample size $T$.

[18]The differences are in the levels of wages and depends on the institutions governing the bargaining processes.

The result is not imposed by the rules governing the microeconomic decisions. The interactions of the different market mechanisms have an important role in the determination of the contractual wage time after time. The wages determine the visibility of the firm and also on the level of the "effective" demand in the model and hence they tend to increase over time due to the competition among firms in the market.

## 6.5 A comparative institutional analysis

The results show that there is a set of robust outcomes:

- There is a persistent degree of heterogeneity of the agents during the market functioning in terms of productivity, sizes and wages for firms, and in terms of wages for workers;
- All the simulations show a self-sustained process of growth of real income and of productivity (the time series of both the variables passed a DF test). See fig. 7.1;
- There is a persistent positive unemployment level in the system (see fig. 7.7).

The $\rho$ parameter is a crucial one to shape the outcomes of system. In particular the growth rate of real income and of productivity is highly influenced by a positive value of $\rho$ (see tab. 7.1). Instead the influence on the wage growth process is not relevant. The unemployment rate in the $IEL$ regime is lower than in$EL$ regime. The flows of destruction and creation of jobs are bigger in the $IEL$ regime than in $EL$ (tab. 7.2). The distribution of these flows shows that the $IEL$ regime is more "turbulent". There is a higher number of exiting firms and entrants firms and this phenomenon has a clear impact on the processes of creation and destruction of jobs(tab. 7.3). Graphics from 7.5 to 7.8 show an exploration of the results in the space of the two parameters $\beta$ and $\rho$. The results of the regimes can be obtained looking at points with coordinates ($\beta = 1$, $\rho = 0.1$) fro the $IEL$ regime and ($\beta = 1$, $\rho = 0$) for the $EL$ regime.

# 7 Conclusions

The paper shows that it is possible to build a model with "evolutionary" features like: agents with bounded rationality, out-of-equilibrium interactions, selection of firms in labor and product market, which is able to fit a wider set of stylized facts compared with existing labor market models (matching models).

The model is able to reproduce regularities of labor market as the Beveridge curve, the wages stickiness and some patterns on jobs destruction and creation flows; at the same time it reproduces a process of technical change that is the engine of the process of growth of real income. The key feature is the selection processes of firms in labor market that generate an entry exit process of firms over time.

The comparative analysis performed is useful to understand the effects of different institutional setups; in particular I consider the strength of the firms in the bargaining process [19] and the level of technological opportunity. Results show that the level of technological opportunity has a clear effect not only on to the growth rate of the economy but also on the level of unemployment rate, regardless of the characteristics of the bargaining process.

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[19] The strength of firm in the bargaining process can be considered a the result of existence of some kind of unions in the system affecting the behaviors of firms.

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| | Learning Regimes: | |
|---|---|---|
| Aggregate variables: | *EL* | *IEL* |
| Productivity growth | 0.625 | 0.788 |
| Real income growth | 1.12 | 1.25 |
| Real wage growth | 0.43 | 0.39 |
| Unemployment rate | 0.500 | 0.460 |

Table 7.1: Comparative analysis results of the two regimes analysed: Average growth rates of income, wages and productivity and average unemployment rates (average results over 100 sims).

| Regimes: | *EL* | | *IEL* | |
|---|---|---|---|---|
| | *Mean* | *std error* | *Mean* | *std error* |
| *(JC/vac)%* | 26.32 | 0.422 | 29.12 | 0.393 |
| *(JD/vac)%* | 25.87 | 0.511 | 27.30 | 0.557 |

Table 7.2: Magnitude of jobs flows in the two regimes: percentages of jobs created and destroyed over the overall number of existing jobs (average results over 100 sims).

| JC (%) | | | JD (%) | | |
|---|---|---|---|---|---|
| Classes of firms: | EL | IEL | Classes of firms: | EL | IEL |
| *New entrants* | 22.36 | 34.22 | *Shut down* | 20.60 | 32.66 |
| $\leq 25\%$ | 33.41 | 22.28 | $\leq 25\%$ | 29.20 | 20.46 |
| $> 25\%$ | 44.23 | 43.50 | $> 25\%$ | 50.20 | 46.88 |
| Total | 100 | 100 | total | 100 | 100 |

Table 7.3: Jobs flows Concentration in the two regimes: percentages of jobs created and destroyed ranked by capacity of firms to shrink or to expand.

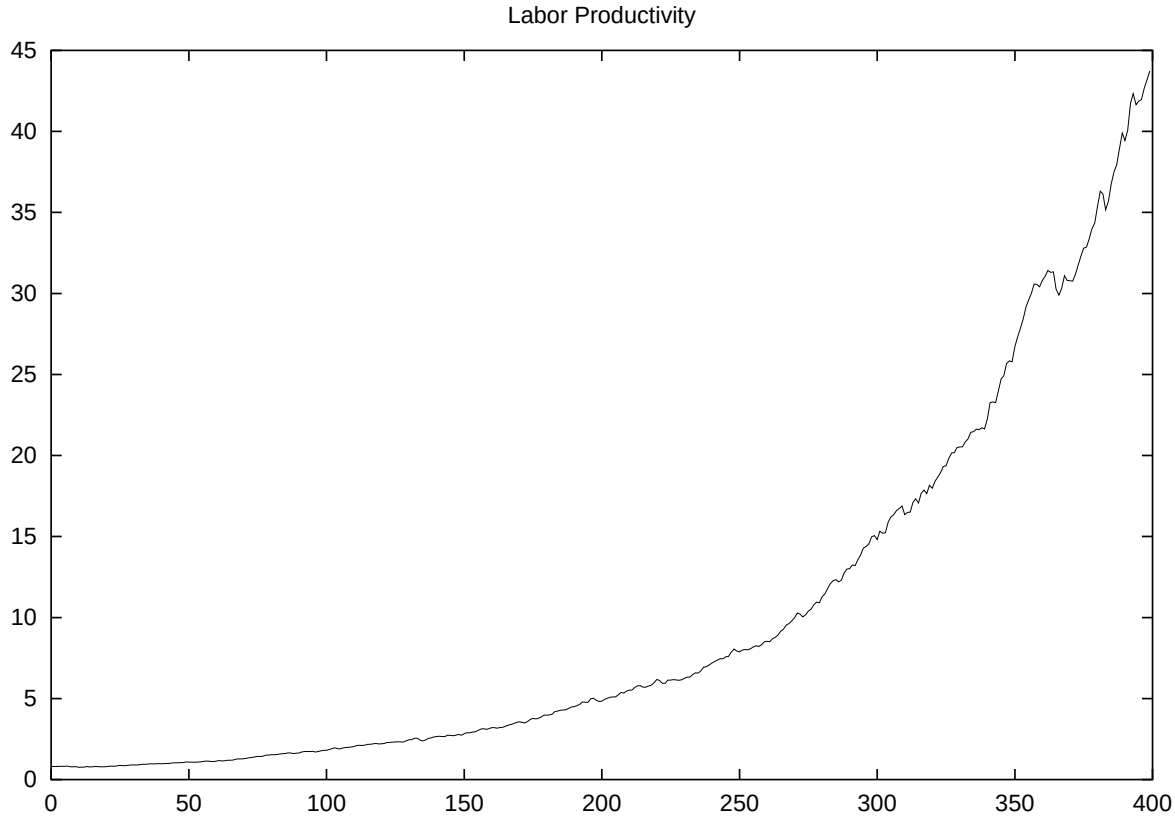


Figure 7.1: Time series for productivity growth rates over time in the canonical parameterization

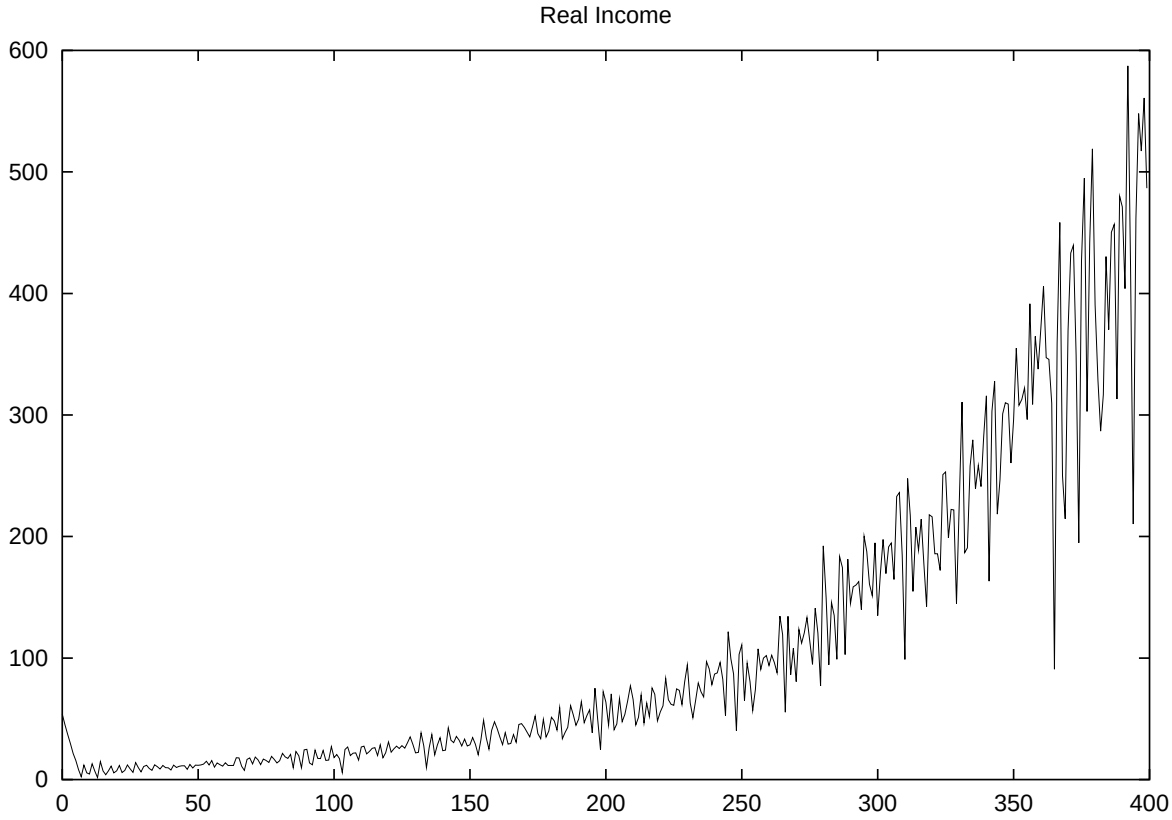


Figure 7.2: Time series for real income growth rates over time in the canonical parameterization

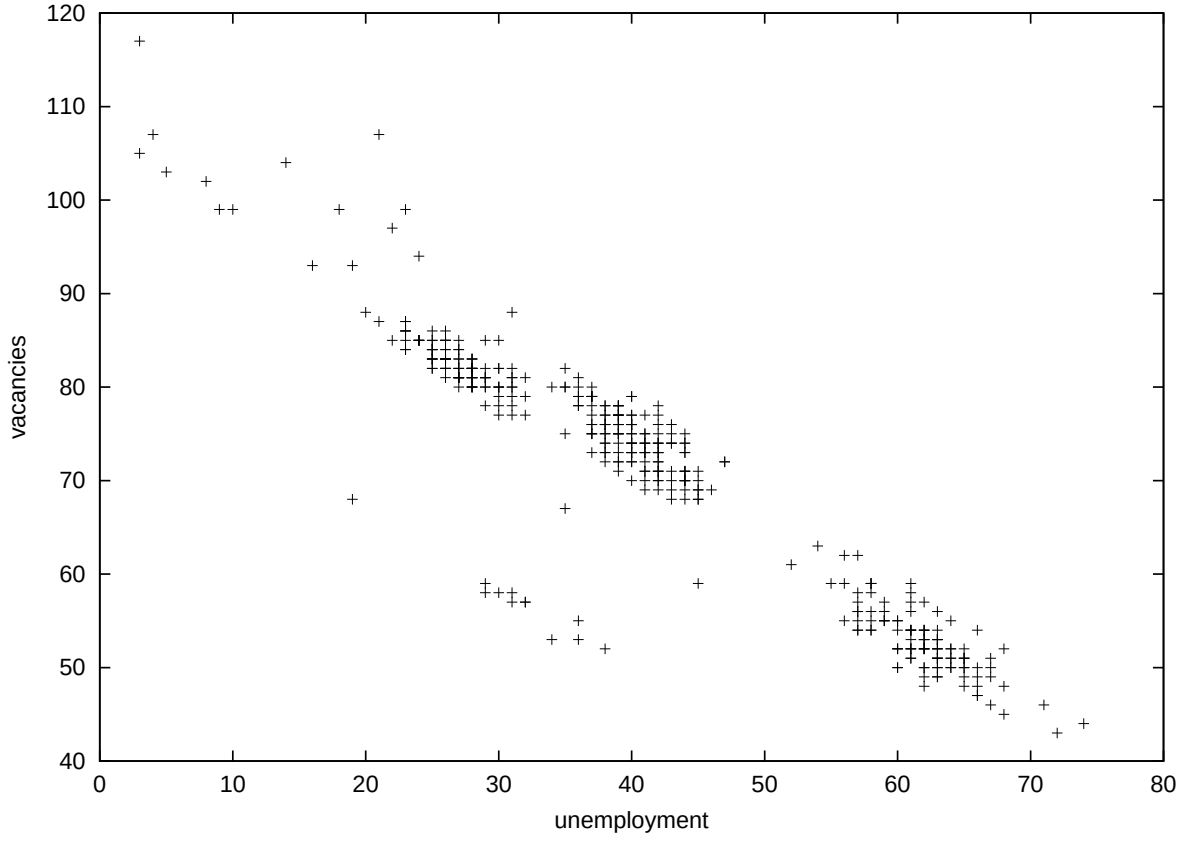


Figure 7.3: The Beveridge curve: scatter plot of vacancies and unemployed in the canonical parameterization

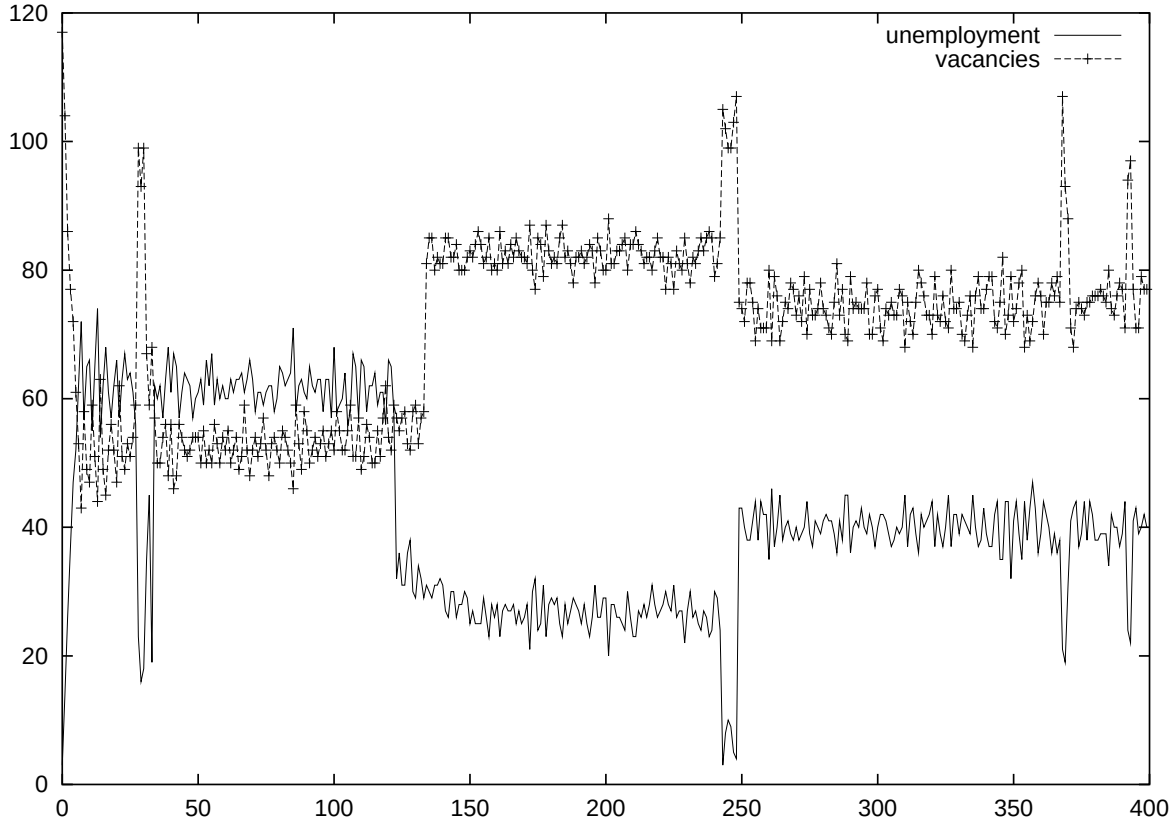


Figure 7.4: Time series of vacancies and unemployment in the canonical parameterization

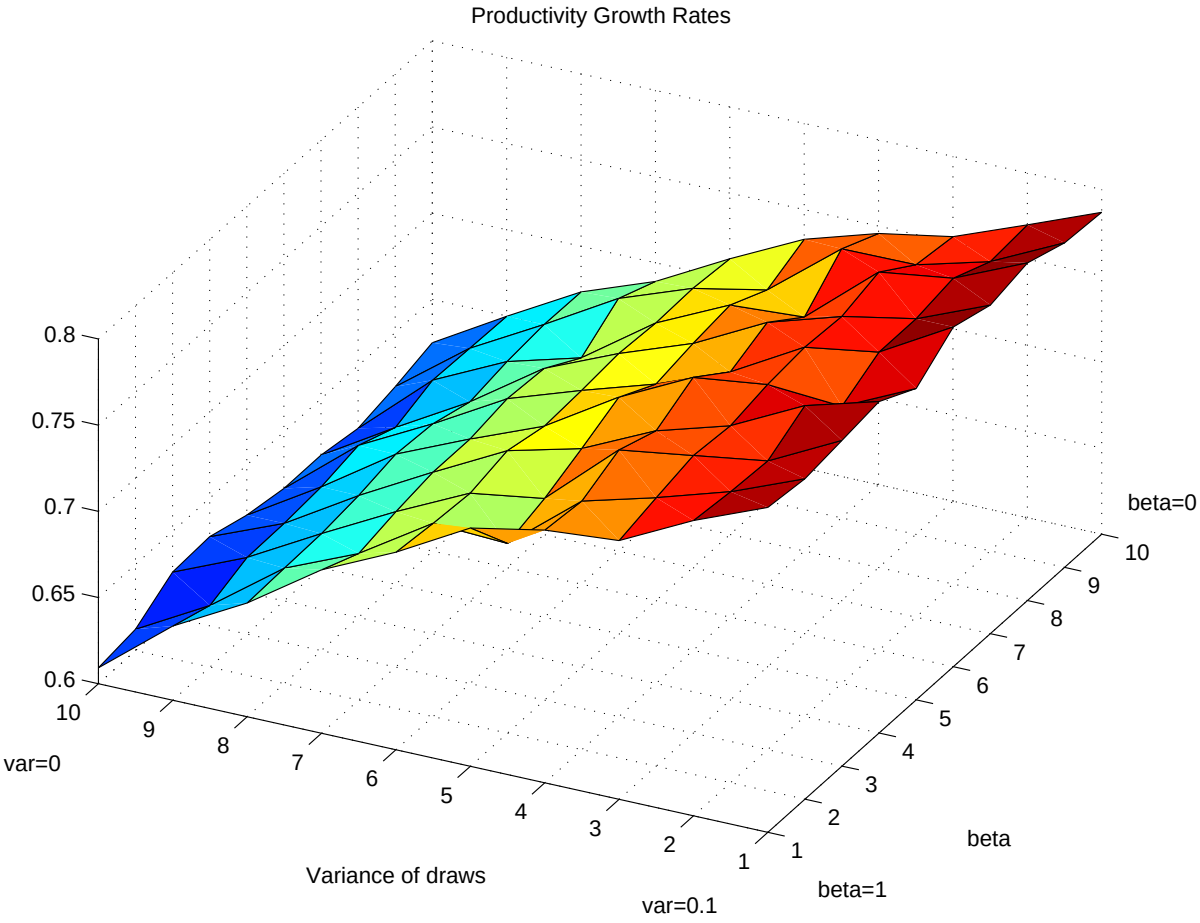


Figure 7.5: Average productivity growth rates over 400 steps and 100 different seeds varying the two parameters ($\beta$ and $\rho$).

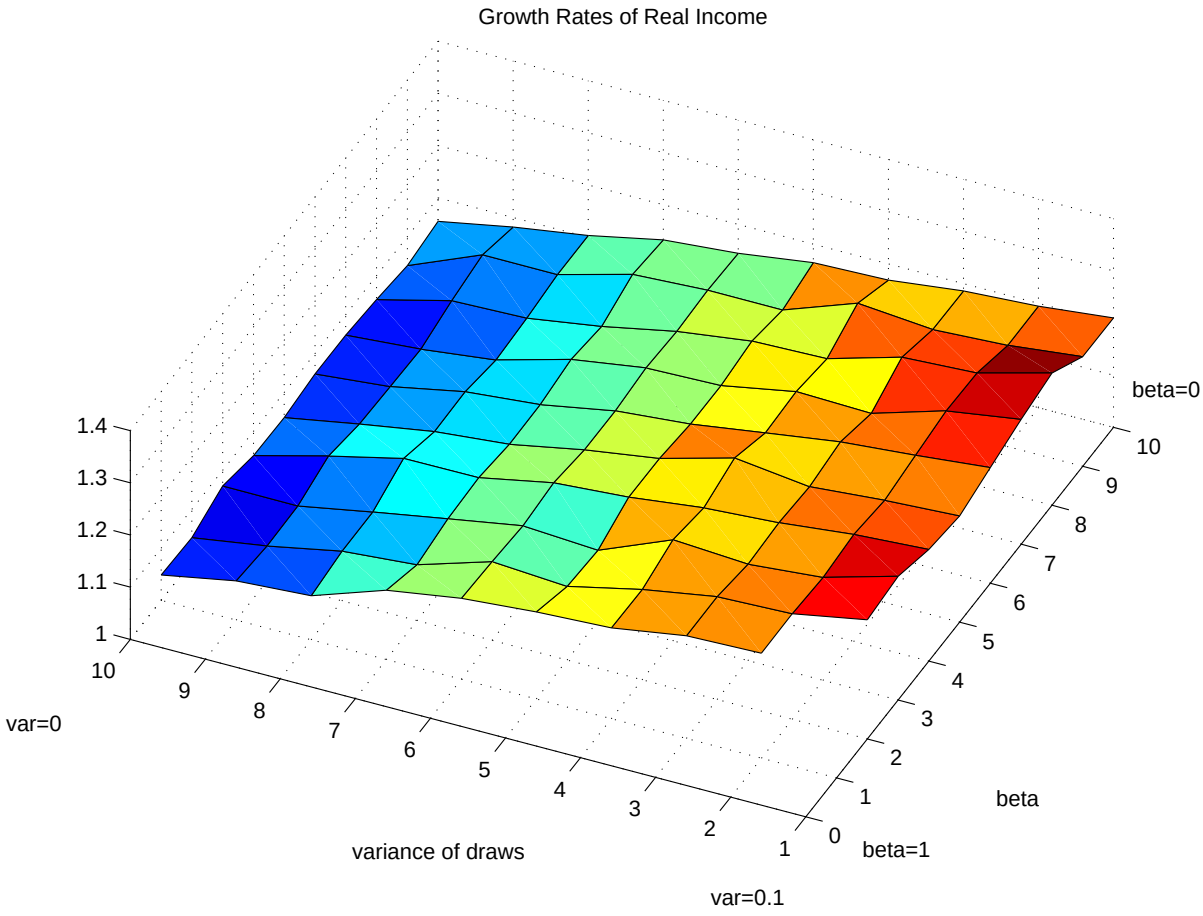


Figure 7.6: Average real income growth rates varying the two parameters ($\beta$ and $\rho$) over 400 steps and 100 different seeds

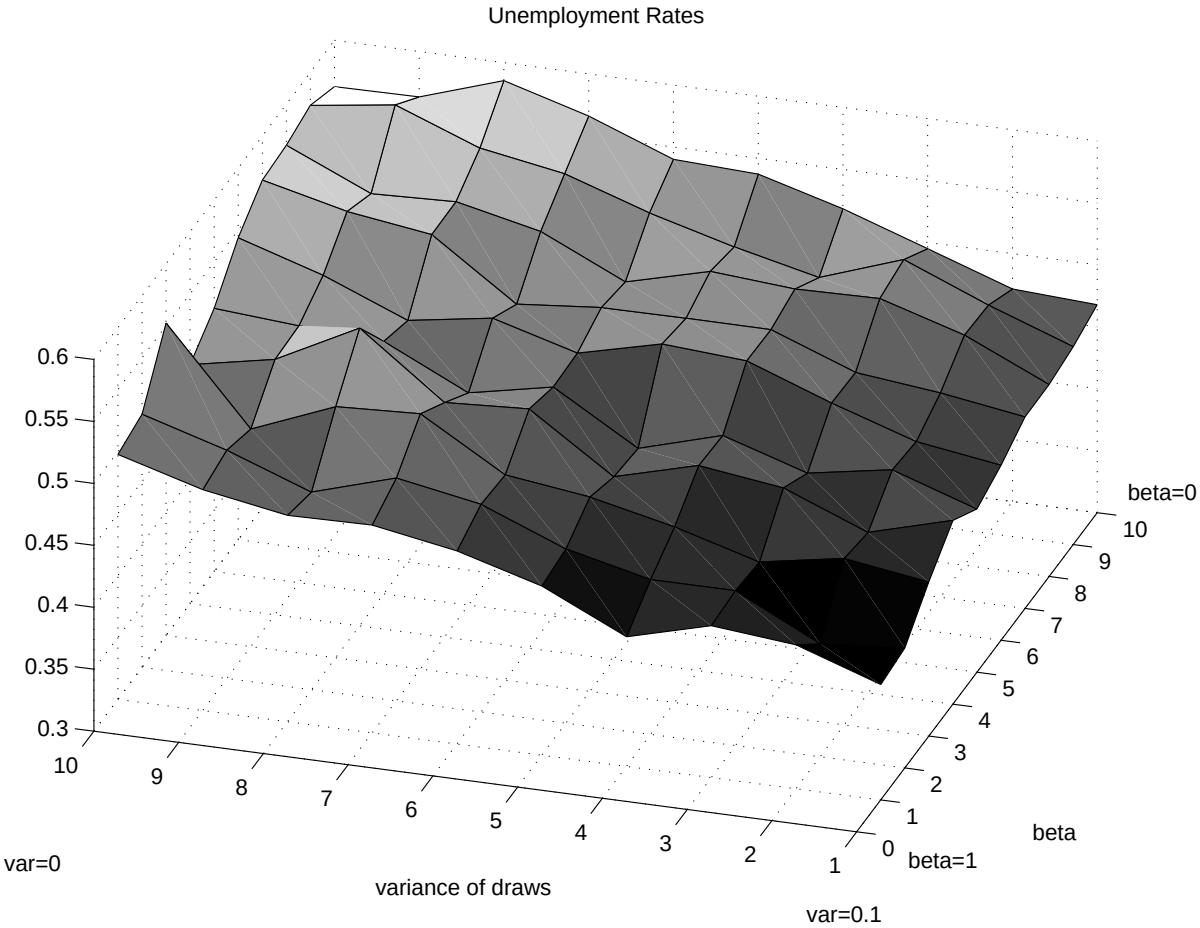


Figure 7.7: Average level of unemployment over 400 steps and 100 different seeds varying the two parameters ($\beta$ and $\rho$)

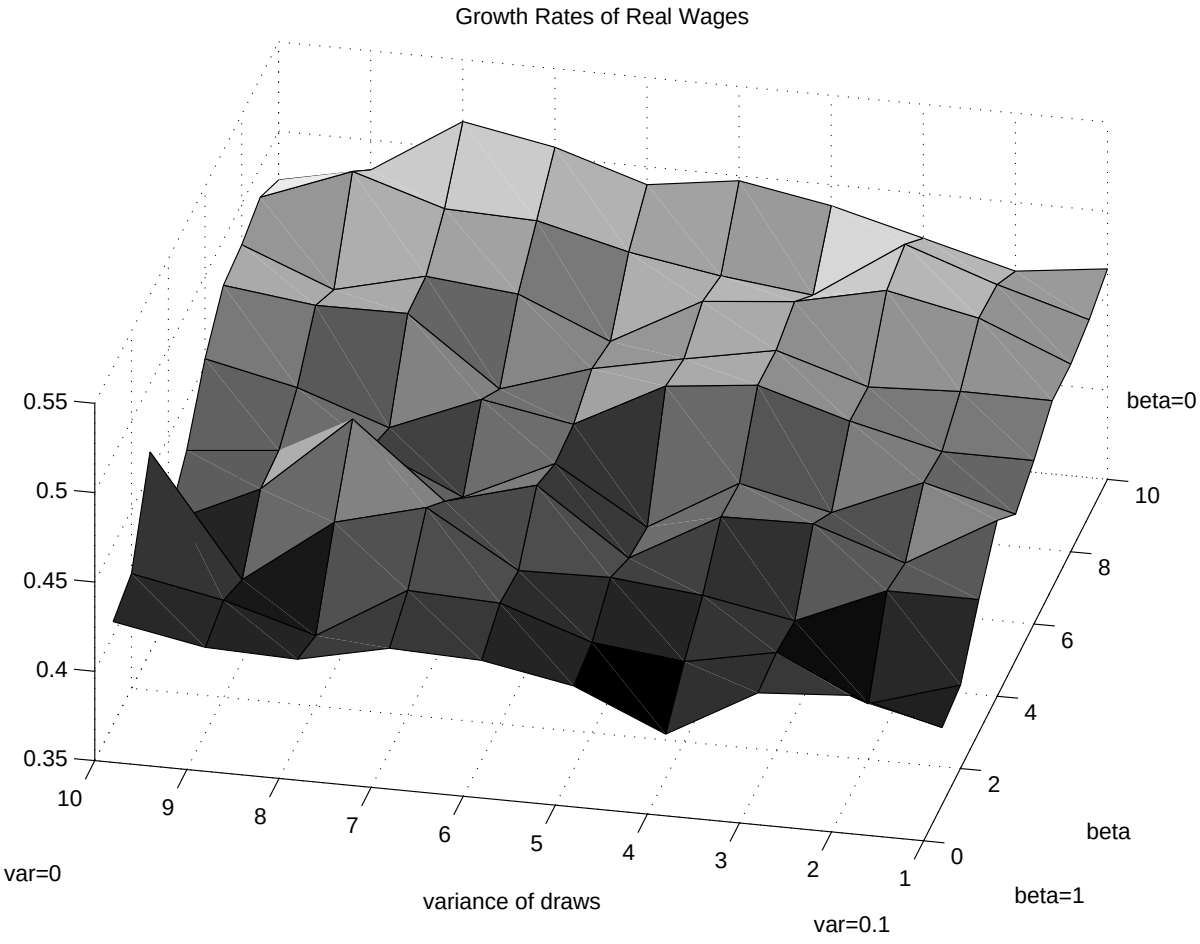


Figure 7.8: Average level of Contractual Wages over 400 steps and 100 different sims varying the two parameters ($\beta$ and $\rho$)