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The labour-augmented K+S model: a laboratory for the analysis of institutional and policy regimes

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Abstract

In this work we discuss the research findings from the labour-augmented Schumpeter meeting Keynes (K+S) agent-based model. It comprises comparative dynamics experiments on an artificial economy populated by heterogeneous, interacting agents, as workers, firms, banks and the government. The exercises are characterised by different degrees of labour flexibility, or by institutional shocks entailing labour market structural reforms, wherein the phenomenon of hysteresis is endogenous and pervasive. The K+S model constitutes a laboratory to evaluate the effects of new institutional arrangements as active/passive labour market policies, and fiscal austerity. In this perspective, the model allows mimicking many of the customary policy responses which the European Union and many Latin American countries have embraced in reaction to the recent economic crises. The obtained results seem to indicate, however, that most of the proposed policies are likely inadequate to tackle the short-term crises consequences, and even risk demoting the long-run economic prospects. More objectively, the conclusions offer a possible explanation to the negative path traversed by economies like Brazil, where many of the mentioned policies were applied in a short period, and hint about some risks ahead.

Keywords: Labour market, Policy evaluation, Agent-based model.

JEL codes: C63, E24, H53, J88

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Resumo

Neste trabalho, discutimos os resultados da pesquisa utilizando o modelo de simulação baseado em agentes *Schumpeter meeting Keynes* (K+S). Ele compreende experimentos de dinâmica comparativa em uma economia artificial habitada por agentes heterogêneos e em interação, como trabalhadores, firmas, bancos e o governo. Os exercícios são caracterizados por diferentes graus de flexibilidade de trabalho ou por choques institucionais causando reformas estruturais no mercado de trabalho, no qual o fenômeno da histerese é endógeno e difundido. O modelo K+S se constitui em um laboratório para avaliar os efeitos de novos arranjos institucionais, como políticas ativas/passivas do mercado de trabalho e austeridade fiscal. Nesta perspectiva, o modelo permite replicar muitas das respostas políticas habituais que a União Europeia e muitos países latino-americanos adotaram em reação às recentes crises econômicas. Os resultados obtidos parecem indicar, no entanto, que a maioria das políticas propostas é provavelmente inadequada para enfrentar as consequências das crises, no curto prazo, e até mesmo com risco de rebaixar as perspectivas econômicas de longo prazo. Mais objetivamente, as conclusões oferecem uma possível explicação para o caminho negativo percorrido por economias como o Brasil, onde muitas das políticas mencionadas foram aplicadas em um período curto, e sugerem alguns dos riscos futuros.

Palavras-chave: Mercado de trabalho, Avaliação de políticas, Modelo baseado em agentes.

1 Introduction

In this work we discuss the previous research findings obtained from the labour-augmented Schumpeter meeting Keynes (K+S) agent-based model concerning comparative dynamic experiments on an artificial economy populated by heterogeneous, interacting agents. The exercises are characterised by different degrees of labour flexibility (Dosi et al., 2017b), or by institutional shocks entailing labour market structural reforms (Dosi et al., 2017a), wherein the phenomenon of hysteresis is endogenous and pervasive (Dosi et al., 2018a). The K+S model constitutes a laboratory to evaluate the effects of new institutional arrangements as active/passive labour market policies and fiscal austerity (Dosi et al., 2018b). In this perspective, the model allows mimicking many of the customary policy responses which the European Union and many Latin American countries have embraced in reaction to the recent economic crises. Table 1 summarizes the main topics covered here and point to the papers in which they were separately discussed.[1] The main contribution of the paper is connecting all these points in a unified perspective.

PAPER	RESEARCH QUESTIONS	MODELLING OBJECTS	POLICY IMPLICATIONS
Dosi et al., 2017b	Persistent unemployment as the result of micro-coordination failures	Decentralised labour market with local search, hiring and firing rules Comparative institutional dynamics	Regimes of growth influencedby the institutional set-up of labour markets More flexibility yields macroeconomic fragility
Dosi et al., 2017a	Effects of labour market "flexibilization" reforms	Regime change during the simulated histories Global sensitivity analysis	Labour market structural reforms increase unemployment, functional and personal inequality
Dosi et al., 2018a	Endogenous emergence of macroeconomic hysteresis	Variable number of firms and endogenous workers' skills Detection of intra- and inter-regime hysteresis	Micro-coordination failures have long-lasting effects More flexible labour markets are more hysteresis-prone
Dosi et al., 2018b	Effects of active and passive labour market policies, and of fiscal austerity	Matching, training and active fiscal policies Active credit market	Supply side polices not enough to restore macro stability in fragile economies Austerity is self-defeating, increases inequality, and hampers growth

Table 1: The labour-augmented K+S papers on the main topics discussed here.

In respect to the existing literature in modelling decentralised labour markets, we shall argue that the labour-augmented K+S model advances the analysis because it nests the process of endogenous technological change and business cycles within the institutional dynamics of the labour market. Declined under different regimes of growth, the model accounts for the emergence of hysteresis, at the macroeconomic level, due to the microeconomic dynamics and the ensuing feedbacks between the two levels. In doing so, the research stream based on the model represents a fresh approach to address a series of old questions in economic theory, including

[1] For earlier vintages of the K+S model see Dosi et al. (2010, 2013, 2015) and the survey in Dosi et al. (2017). Lamperti et al. (2018) extend the K+S model to account for the coevolution of climate and macroeconomic dynamics.

the emergence of involuntary unemployment, the relationship between employment and functional inequality (via class-consumption dynamics), the link between labour market flexibility and wage dispersion, skills deterioration and hysteresis, and the endogenous emergence of long-lasting, severe recessions (super-hysteresis).

The set of theoretical questions presented above are addressed by means of a complexity approach, namely the agent-based modelling (ABM) methodology (Tesfatsion and Judd, 2006). A well-known and familiar approach to macroeconomic phenomena analysis involves simplifying the heterogeneous interactions of a complex evolving system into the behaviour of a rational, forward-looking representative agent, possibly perturbed by some frictions, adjustment lags or informational imperfections. However, such an assumption, that the working of modern economies is basically equivalent to the behaviour of a central planner, rules out – by construction – all the macro questions which entail and/or depend on the interdependence and coordination (including likely failures) among agents. At the opposite methodological end, the ABM approach explicitly acknowledges the threads of interdependence among the multitude of individually- and functionally-differentiated agents, as well the challenge of coordination in such scenario.

More in details, agent-based models are large-scale, computational devices which allow the simulation of artificial economies wherein ensembles of heterogeneous agents interact on the ground of simple, non-optimizing behavioural rules. Aggregate-level outcomes are the emergent properties from the interactions of such bounded-rational agents.[2] Unlikely dynamic stochastic general equilibrium models (DSGE), driven by the search of closed-form solutions derived from linearisation around equilibrium conditions (see Stiglitz, 2018, for the latest critique to DSGE models), ABMs are open-ended systems where the notion of *coordination* substitutes the requirement of equilibrium. Moreover, such models may display path dependence along *each* simulated history, as well as *between* alternative simulations. Short of any derivation from some principle of rationality, ABMs ought to be primarily judged on their ability to reproduce as *emergent properties* sets of *stylised facts*, i.e., empirically observed statistical regularities. The use of agent-based models has become the standard practice in many disciplines dealing with complex phenomena, wherein the micro and the macro levels are *not* isomorphic. More recently, these models have also been adopted in economics (for a recent review on ABM macroeconomics, see Fagiolo and Roventini, 2017). Indeed, the features of ABMs are particularly suited to the analysis of economic phenomena characterised by disequilibrium processes and asymmetric interactions among persistently-heterogeneous agents.

In what follows, the K+S model is employed as a laboratory to study the effects of policy interventions intended to restore steady economic growth and full employment. In particular, we address the impact of labour market structural reforms, and compared the economic system performance under several forms of supply-side and demand-management policies. When performing the policy experiment evaluations, we apply a rigorous validation protocol aimed at replicating both micro and macroeconomic stylised facts, analysing distributional moments and shapes, correlations, and the presence of non-linearity, tipping points and non-ergodicity of/among the time series. Finally, we employ cutting-edge, large-scale, global sensitivity analysis (Dosi et al., 2017) to entirely explore the model parametric space. Additional details about

[2]For a general overview of ABM applications in economics and the social sciences, see Tesfatsion (2006), Epstein (1999) and Gilbert (2008). Axelrod and Tesfatsion (2006) provide a concise introduction.

each of those points can be obtained in the papers listed in Table 1, including the key modelling novelty introduced in each one.

The paper is organized in seven sections, plus this introduction and some concluding discussions. The next section briefly presents the key literature on the points covered here. Section three introduces the K+S model. Section four comparatively assess the performance of different institutional set-ups configured in the model, including the transitional policy shocks. Section five deals with the phenomenon of hysteresis in the macroeconomic system. Section six evaluates the effect of fiscal and active labour market policies to mitigate severe crises. Finally, section seven summarizes the main feedback mechanisms between the micro and the macro levels found in the preceding analyses.

2 Facts or beliefs?

When talking about labour markets, the general belief, widespread both in the profession and in the policy debate, is that the primary cause of unemployment rests on various forms of labour market rigidities. The OECD (1994) *Jobs Study* is a classic reference in the advocacy of benefits from labour market liberalization. The report basically argues that the roots of unemployment reside in social institutions and policies such as unions, unemployment benefits, and employment protection legislation. Under this perspective, the ultimate target for reforms should be fostering productivity and output growth by tackling such bottlenecks. More precisely, the OECD *Jobs Strategy* contains three recommendations directed at making wage and labour cost more flexible, namely (i) remove restrictions that prevent wages being respondent to local market conditions; (ii) reform the employment protection legislation (EPL), abolishing legal provisions that can inhibit the private sector's employment dynamics; and (iii) reform the social security benefits such that equity goals can be reached without impinging the efficient functioning of labour markets (OECD, 1994).

These policy recommendations were the results of a so called "Unified Theory" or "Transatlantic Consensus", also known as the "OECD-IMF orthodoxy" (Howell, 2005) or the "Berlin-Washington Consensus" (Fitoussi and Saraceno, 2013) according to which labour market institutions such as collective bargaining, legal minimum wages, employment protection laws and unemployment benefits foster rigidities that make job creation less attractive for employers and joblessness more appealing for workers. This is supposed to occur via two routes. First, the induced downward rigidity on wages (and thus the purported reduction of labour demand) and, second, an excessively high wage for low-skilled workers (and, thus, again a purported lower demand for them). Such a theory would in fact predict an efficiency-equity trade-off: societies have to choose between efficiency (reducing unemployment but increasing inequality) or equity (reducing inequality but increasing unemployment).

However, the empirical coherence of the "Unified Theory" has proved to be rather weak. Howell and Huebler (2005) find little evidence of the unemployment-inequality trade-off both in level and growth variables for 16 OECD countries in the period 1980-1995. On the contrary, Stiglitz (2012, 2015) suggests that high income inequality induces a lack of aggregate demand which yields higher unemployment rates, having rich people a lower propensity to consume, in line with the whole Keynesian/Kaldorian tradition. Heathcote et al. (2010) find evidence that during recessionary phases low-income workers are more severely hit by lay-offs, implying that income concentration diverts toward upper classes in these periods. Maestri and Roventini

A similar process is performed by firms i in the capital-good sector to define $L^d_{i,t}$, considering effective orders $Q_{i,t}$ and labour productivity in the current machine-producing technique $B_{i,t}$.[5]

In turn, desired consumption-good production $Q^d_{j,t}$ is based on expected demand $D^e_{j,t}$, computed by a simple adaptive rule:[6]

$$D^e_{j,t} = g(D_{j,t-1}, D_{j,t-2}, D_{j,t-h}), \quad 0 < h < t, \tag{2}$$

where $D_{j,t-h}$ is the demand actually faced by firm j at time $t-h$ ($h \in \mathbb{N}^*$ is a parameter and $g : \mathbb{R}^h \to \mathbb{R}^+$ is the expectation function). Additionally, the desired level of production $Q^d_{j,t}$ depends also on the desired inventories $N^d_{j,t} = \iota D^e_{j,t}$ ($\iota \in \mathbb{R}^+$ is a parameter) and the actual inventories left from previous period $N_{j,t-1}$:

$$Q^d_{j,t} = (1+\iota)D^e_{j,t} - N_{j,t-1}. \tag{3}$$

In each period, according to the dynamics of the market and conditional on the labour market regime, firms decide whether to hire (or fire) workers. The decision is taken according to the desired production $Q^d_{j,t}$. In case of an increase in production, $\Delta L^d_{j,t}$ new workers are (tentatively) hired in addition to the existing labour force $L_{j,t-1}$:

$$\Delta L^d_{j,t} = L^d_{j,t} - L_{j,t-1}. \tag{4}$$

Each firm j gets, in probability, a fraction of the applicant workers in its candidates queue, proportional to its market share $f_{j,t-1}$:

$$\mathrm{E}(L^s_{j,t}) = \omega L^S f_{j,t-1}, \tag{5}$$

where $\omega \in \mathbb{R}^+$ is a parameter defining the number of job queues each seeker joins, in average, and $\mathrm{E}(L^s_{j,t})$ is the expected number of workers in the queue of firm j in period t. As workers can apply to more than one firm at a time, firms may not be able to hire all workers in their queue, even when they mean to. Considering the set of workers in the candidates queue $\{\ell^s_{j,t}\}$, each firm has to select to whom to make a job (wage) offer. The set of desired workers $\{\ell^d_{j,t}\}$, among those in the queue $\{\ell^s_{j,t}\}$, is defined as:

$$\{\ell^d_{j,t}\} = \{\ell_{j,t} \in \{\ell^s_{j,t}\} : w^r_{\ell,t} < w^o_{j,t} \text{ and } \#\{\ell^d_{j,t}\} \leq \Delta L^d_{j,t}\}, \tag{6}$$

that is, the firm targets workers that would accept its wage offer $w^o_{j,t}$, considering the wage $w^r_{\ell,t}$ requested (if any), up to its demand of workers $\Delta L^d_{j,t}$. Therefore, the number of effectively hired workers (the size of set $\{\ell^h_{j,t}\}$) is:

$$\#\{\ell^h_{j,t}\} = \Delta L_{j,t} \leq \Delta L^d_{j,t} \leq L^s_{j,t} = \#\{\ell^s_{j,t}\}, \quad \Delta L_{j,t} = L_{j,t} - L_{j,t-1}. \tag{7}$$

[5] In what follows, we represent only the behaviour of consumption-good firms (indicated by the subscript j) in the labour market, as most workers are hired in this sector. However, capital-good firms operate under the same rules, including the hiring of R&D personnel, except they (i) follow the wage offers from top-paying firms in the consumption-good sector and (ii) present their job offers to workers before consumption-sector companies.

[6] The exact type of adaptive expectation rule does not significantly affect the performance of the firms and of the system as a whole. If anything, more sophisticated ones might worsen the performance, see Dosi et al. (2006) and Dosi et al. (2017).

3.2.2 Search, wage determination and firing

The search, wage determination and firing processes differ between the two regimes. More precisely, under the redundancy rules of the Competitive regime any change in the desired production usually entails a (positive or negative) variation in the firm-level labour demand. Not so under the Fordist regime, wherein labour "hoarding" (during the bad times) is the rule.

The baseline: Fordist regime

In the Fordist regime, the implicit pact among firms and workers implies that the latter never voluntarily quit their job, while firms fire employees ($\Delta Q^d_{j,t} < 0$) only when experiencing negative profits $\Pi_{j,t-1}$ and shrinking production $\Delta Q^d_{j,t}$.[7] Conversely, only unemployed workers search for jobs.

Wages are not bargained. Firm j unilaterally offer a wage $w^o_{j,t}$ based on the past offers according to the rule:

$$w^o_{j,t} = w^o_{j,t-1}[1 + \max(0, WP_{j,t})]. \tag{8}$$

The wage premium $WP_{j,t}$ is is defined as:

$$WP_{j,t} = \psi_2 \frac{\Delta A_t}{A_{t-1}} + \psi_4 \frac{\Delta A_{j,t}}{A_{j,t-1}}, \quad \psi_2 + \psi_4 \leq 1, \tag{9}$$

being A_t the aggregate labour productivity, $A_{j,t}$ the firm-specific productivity, and $\psi_2, \psi_4 \in [0, 1]$, parameters. A distinctive feature of this regime is that gains in labour productivity and hence, indirectly, the benefit from innovative activities are passed to workers via wage increases. Moreover, wages are not only linked to firm specific performance but also to the aggregate productivity dynamics of the economy. Finally, note that $w^o_{j,t}$ is simultaneously applied to all existing workers of firm j, so there is no intra-firm differential in wages. Indeed, the Fordist regime describes a wage-labour nexus where the workers purchasing power is directly linked with firm productivity gains: the sum $\psi_2 + \psi_4$, i.e. the institutional parameter which establishes the division of productivity gains between firms and workers, in the Fordist regime is set to 1. The Fordist wage determination process induces a twofold virtuous cycle, namely one which goes from productivity to wages to aggregate demand and the other going from aggregate demand to investments (the Keynesian accelerator) to profits.[8]

The introduction of structural reforms: Competitive regime

The introduction of structural reforms to spur flexibility in the labour market implies that the social compromise embodied in the Fordist Regime is partially or totally removed. In the new Competitive setting, wages adjust to labour market conditions: firms freely hire and fire in each period, and employees can actively search for better jobs all the time.

[7] Of course, firms exiting the market always fire all their workers.

[8] Wages are not unbounded, as each firm j can afford to pay a salary $w^o_{j,t}$ up to a maximum *break-even wage* $w^{max}_{j,t}$ that is the wage compatible with zero unit profits. This wage is defined as the product between (myopically) expected prices $p_{j,t-1}$ times existing productivity $A_{j,t-1}$:

$$w^o_{j,t} \leq w^{max}_{j,t}, \quad w^{max}_{j,t} = p_{j,t-1} A_{j,t-1} \tag{10}$$

Workers have an institutionally-determined reservation wage equal to the unemployment benefit w_t^u they would receive in case of unemployment. The wage $w_{\ell,t}^r$ requested by worker ℓ is a function of the individual unemployment condition and the past wage history. If the worker was unemployed in the previous period, the requested $w_{\ell,t}^r$ shrinks. More specifically, she will ask the maximum between unemployment benefit w_t^{un} (if available) and her own satisfying wage $w_{\ell,t}^s$:

$$w_{\ell,t}^r = \begin{cases} \max(w_t^{un}, w_{\ell,t}^s) & \text{if } \ell \text{ is unemployed in t-1} \\ w_{\ell,t-1}(1+\epsilon) & \text{if } \ell \text{ is employed in t-1} \end{cases}, \tag{11}$$

with the parameter $\epsilon \in \mathbb{R}^+$. The satisfying wage accounts for the recent wage history:

$$w_{\ell,t}^s = \frac{1}{T_s}\sum_{h=1}^{T_s} w_{\ell,t-h}, \tag{12}$$

that is, as the moving average salary of the last $T_s \in \mathbb{N}^*$ periods.

Considering job applications and knowing the required number of workers $\Delta L_{j,t}^d$ to hire, the wage offered by each firm is the minimum that satisfies enough workers in its queue $\{\ell_{j,t}^s\}$. So, it is the highest wage asked by the cheapest available workers which fulfils $\Delta L_{j,t}^d$:

$$w_{j,t}^o = \max w_{\ell,t}^r, \quad \ell \in \{\ell_{j,t}^s\} \quad \text{and} \quad \#\{\ell_{j,t}^d\} \leq \Delta L_{j,t}^d. \tag{13}$$

Employed workers search for better-paid jobs in each period. If a worker gets an offer from another firm n, she decides whether quitting or not the current employer j if $w_{n\neq j,t}^o \geq w_{\ell,t}^r$. That is, worker ℓ quits firm j if she receives a wage offer $w_{n\neq j,t}^o$ from at least one firm n that is equal or higher than her required wage $w_{\ell,t}^r$.

3.3 Model closure: the Government and consumption determination

In the model, a highly stylized government taxes firm profits at the fixed rate $tr \in \mathbb{R}^+$, and provides a benefit w_t^{un} to unemployed workers which is a fraction of the current average wage:

$$w_t^{un} = \psi \bar{w}_{\ell,t-1}, \tag{14}$$

where $\psi \in [0,1]$ is a parameter and $\bar{w}_{\ell,t-1}$, the past period average wage. Therefore, the Government total expenses are:

$$G_t = w_t^{un}(L^S - L_t^D), \tag{15}$$

being L^S and L_t^D the total labour supply (fixed) and demand (employed workers), respectively.

We assume workers fully consume their income.[9] Accordingly, desired aggregate nominal consumption C_t^d depends on the income of both employed and unemployed workers plus the desired unsatisfied nominal consumption from the previous period (the $C_{t-1}^d - C_{t-1}^n$ term), if any:

$$C_t^d = \sum_\ell w_{\ell,t} + G_t + (C_{t-1}^d - C_{t-1}^n). \tag{16}$$

The dynamics generated at the micro level by the decisions and interactions of a multiplicity of heterogeneous adaptive agents is the explicit micro-foundation for all aggregate variables

[9] This is equivalent to assume that workers are credit constrained and therefore cannot engage in standard consumption smoothing. Notice that the conclusions of the paper qualitatively hold as long as, in good Keynesian tradition (e.g., Kaldor, 1956), the propensity to consume out of profits is lower than that out of wages.

of interest (e.g., output, investment, employment). The model satisfies the standard national account identities: the sum of value added of capital- and consumption-good firms Y_t equals their aggregated production $Q_t^1 + Q_t^2$, as in our simplified economy there are no intermediate goods. Total production, in turn, coincides with the sum of real aggregate effective consumption C_t, real investment I_t and change in inventories ΔN_t:

$$Q_t^1 + Q_t^2 = Y_t = C_t + I_t + \Delta N_t. \tag{17}$$

Finally, the Government may establish an institutional minimum wage w_t^{min} which imposes a lower bound to the firm-specific wage setting behaviour:

$$w_t^{min} = w_{t-1}^{min}\left(1 + \psi_2 \frac{\Delta A_t}{A_{t-1}}\right). \tag{18}$$

3.4 Timeline of events

In each time step, firms and workers take their decision according to the following timeline:

1. Machines ordered in the previous period are delivered;
2. Capital-good firms perform R&D and signal their machines to consumption-good firms;
3. Consumption-good firms decide on how much to produce, invest and hire/fire;
4. Firms allocate their cash-flows and (if needed) borrow from bank to produce/invest;
5. Firms send/receive machine-tool orders for the next period (if applicable);
6. Job-seekers send applications to firms;
7. Wages are set by indexation or bargaining;
8. The labour market runs and job vacancies are partly or totally filled;
9. Firms pay wages;
10. Government collects taxes and pays unemployment benefits;
11. Consumption-good market opens and the market shares evolve according to competitiveness;
12. Firms in both sectors compute their profits, and repay debt if needed;
13. Firms with near-zero market share or negative net assets exit the market and replaced by entrants;
14. Aggregate variables are computed and the cycle restarts.

3.5 Empirical validation

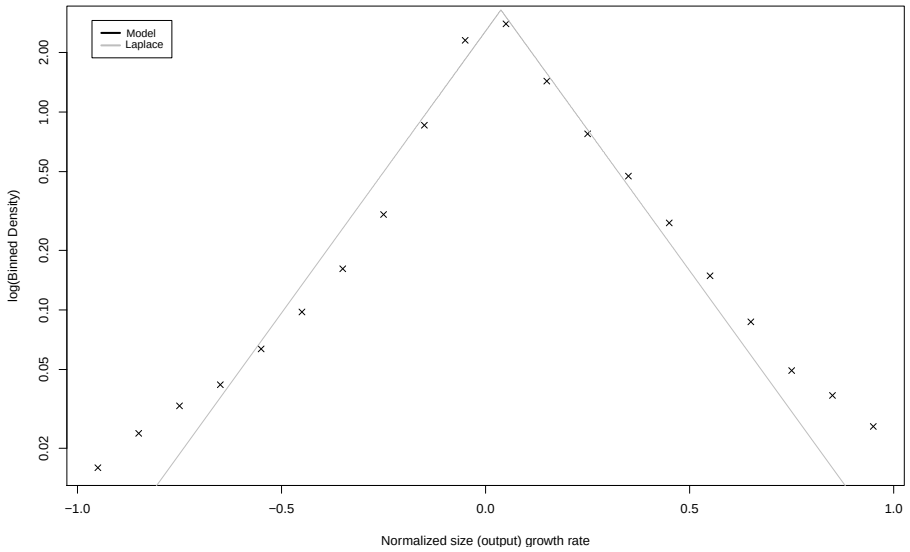
The original K+S model has already shown to be able to reproduce a rich set of macro and micro stylized facts (see Dosi et al., 2010, 2013, 2015). Moreover, the present version, which explicitly accounts for microeconomic firms-workers interactions (cf. Figure 1), is able to robustly reproduce most of the labour market empirical regularities as recalled in Table 3.

MICROECONOMIC STYLIZED FACTS	AGGREGATE-LEVEL STYLIZED FACTS
Skewed firm size distribution	Endogenous self-sustained growth with persistent fluctuations
Fat-tailed firm growth rates distribution	Fat-tailed GDP growth rate distribution
Heterogeneous productivity across firms	Endogenous volatility of GDP, consumption and investment
Persistent productivity differentials	Cross-correlation of macro variables
Lumpy investment rates of firms	Pro-cyclical aggregate R&D investment and net entry of firms in the market
Heterogeneous skills distribution	Persistent and counter-cyclical unemployment
Fat-tailed unemployment time distribution	Endogenous volatility of productivity, unemployment, vacancy, separation and hiring rates
Fat-tailed wage growth rates distribution	Unemployment and inequality correlation
	Pro-cyclical workers skills accumulation
	Beveridge curve
	Okun curve
	Wage curve
	Matching function

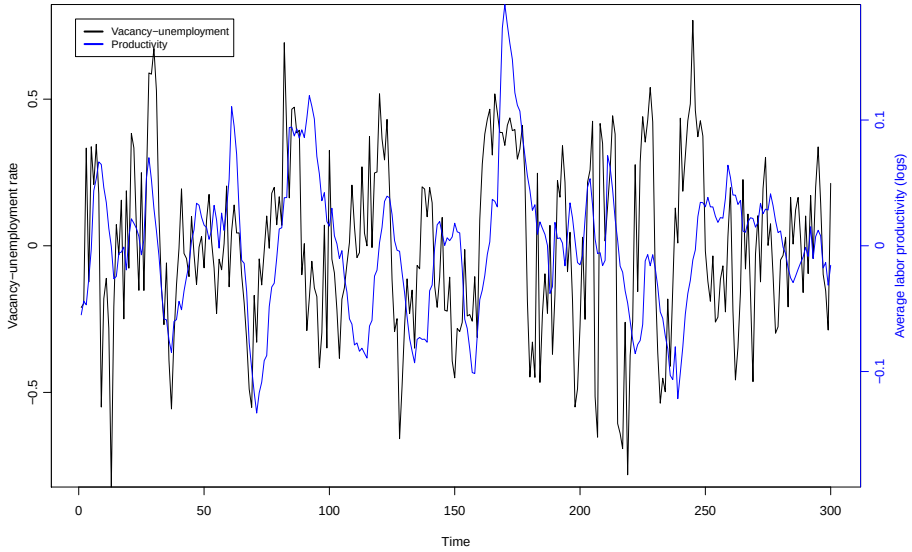
Table 3: Stylized facts matched by the K+S model at different aggregation levels. Source: Dosi et al. (2017b).

Figure 2: Examples of K+S model matching of stylized facts. Source: Dosi et al. (2017b).

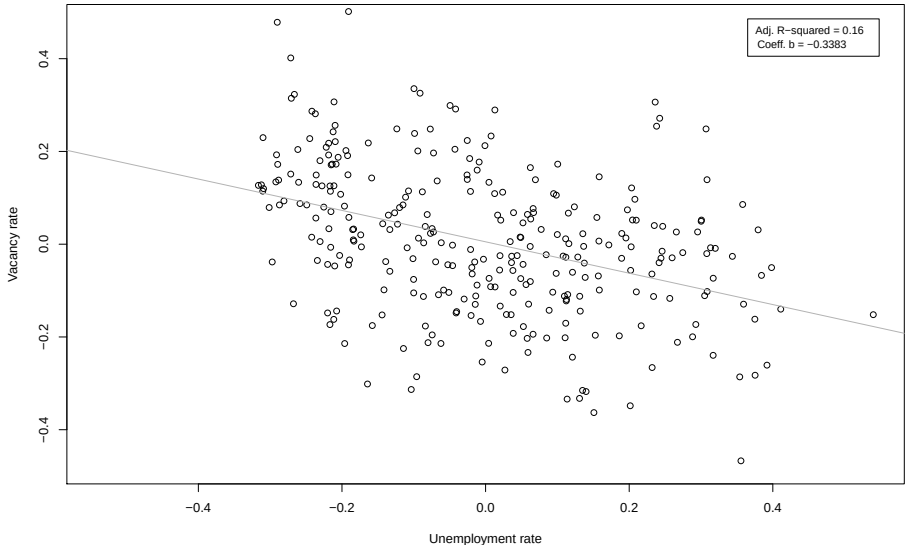
(a) GDP growth rate distribution



(b) Correlation between vacancy-to-unemployment and productivity rates



(c) Beveridge curve



(d) Matching function

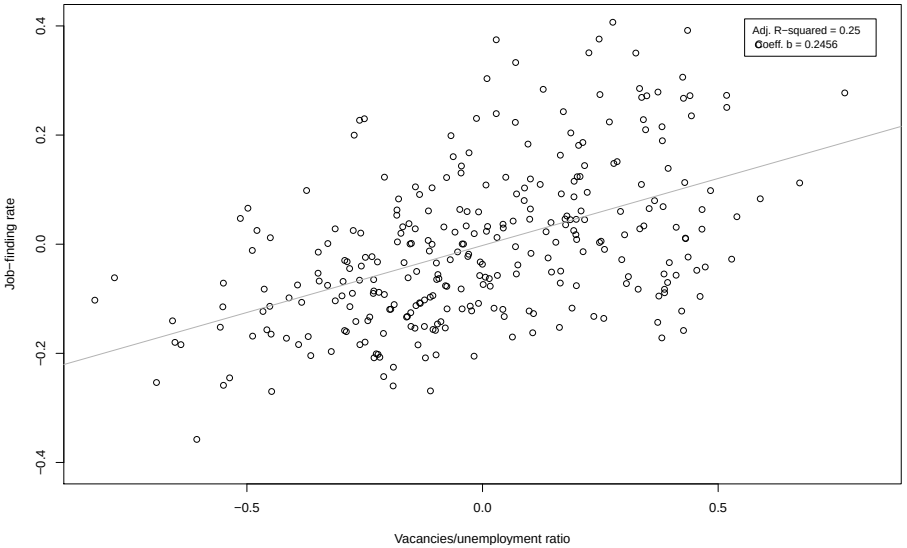


Figure 2 presents the results replicating four of the stylized facts (for the remaining ones, please refer to Dosi et al. (2017b)). Figure 2a shows a (log-normalized scale) histogram of the GDP growth rates produced by the model, plus a Laplace-distribution fit (in line with the evidence in Fagiolo et al., 2008; Ascari et al., 2015). Figure 2b reports the BK-filtered dynamics of the vacancy-to-unemployment rate and the (log) average productivity, displaying the characteristic strong synchronization between the two variables. Figure 2c presents the model's typical Beveridge curve (the negative correlation between unemployment and vacancy rates) and Figure 2d, the matching function curve (the positive correlation between vacancy-to-unemployment and job-finding rates), both similar to the usual empirical data.

4 Comparative institutional dynamics

Initially, we employ the labour-augmented K+S model to undertake a few exercises of *comparative institutional dynamics*, evaluating the long-term performance of economies characterised by labour market institutional set-ups under alternative degrees of liberalization. Next, we study the effect of institutional shocks – the introduction of structural reforms – *within* each simulated history. In both sets of experiments, the term of comparison between the two regimes described above shall be the economic performance measured by a set of common indicators, as the growth rate and volatility of GDP, the likelihood of crises, the unemployment level, and some inequality metrics.

4.1 Comparative dynamics under different labour market regimes

To test the effects of different levels of "flexibility" of the labour market, let us start comparing the Fordist regime with four alternative varieties of the Competitive case, namely:

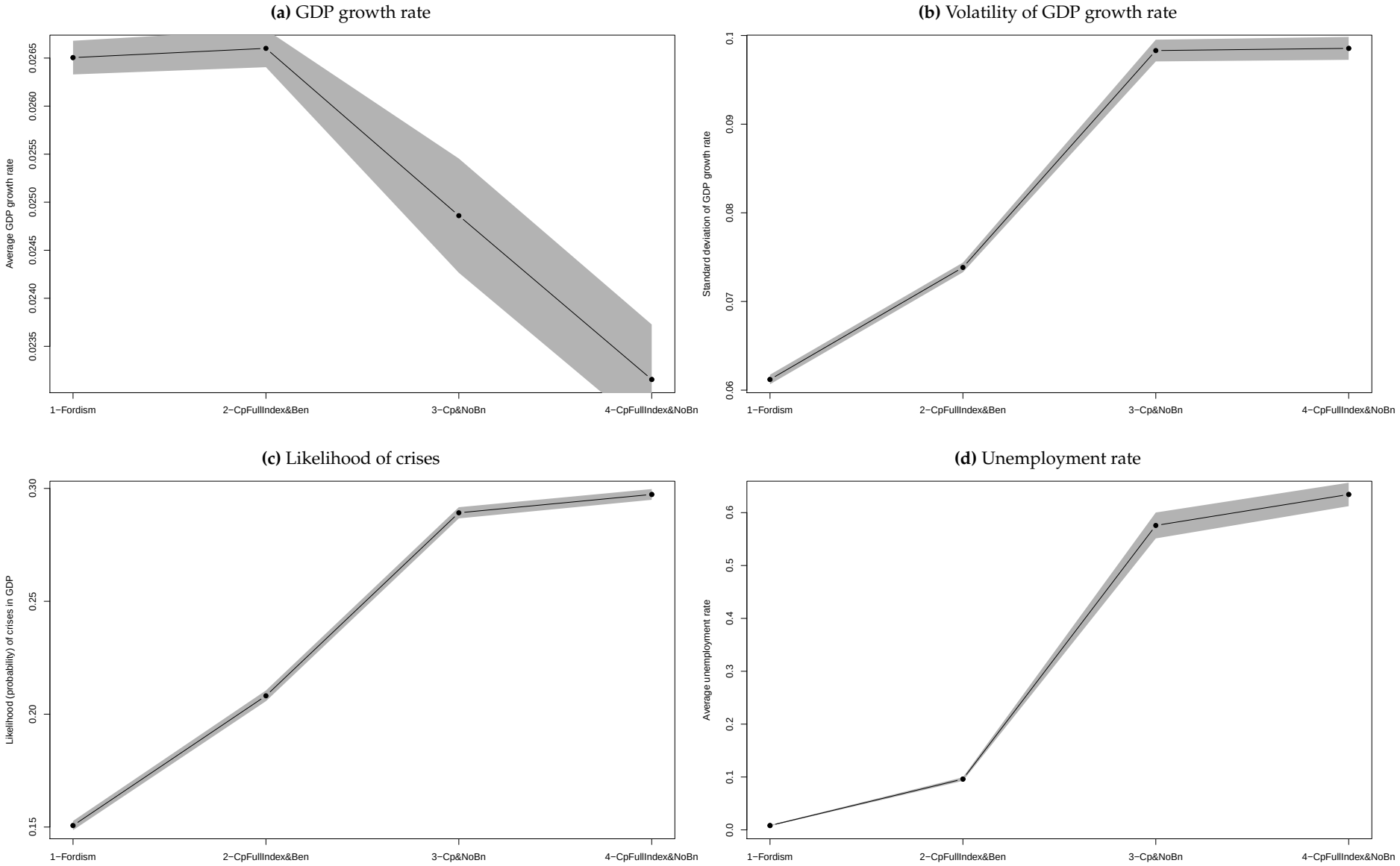
1. FORDIST: the baseline;
2. COMPETITIVE: full indexation of minimum wage and reduced unemployment benefits;
3. COMPETITIVE: partial indexation of minimum wage and no unemployment benefits;
4. COMPETITIVE: full indexation of minimum wage and no unemployment benefits.

We compare the two regimes in terms of (i) long-run rate of GDP growth; (ii) volatility of GDP growth rate; (iii) likelihood of crises; (iv) productivity growth; (v) unemployment rate; (vi) frequency of full employment periods; (vii) tenure rate of the workforce; (viii) Gini index of workers' income. In such comparisons, we hold the Fordist regime as the benchmark, a reference to the "Golden Age" of capitalism, and gradually remove the supposed institutional rigidities in the labour market, somewhat in line with the recent historical record.

Firstly, we do not consider in detail the most extreme, institution-free, version of the Competitive regime, without employment protection, minimum wage, nor unemployment benefits. Note that such scenario is the nearest to textbooks "market perfection". However, under these conditions the modelled economic system is most of the time near to collapse: the *long-term* rate of growth is two orders of magnitude inferior (basically zero) and the *short-run* is dismal, with extremely high unemployment rates under substantial volatility and inequality levels.[10]

[10]Note that throughout our exercises we do not "calibrate and match": rather our purpose is to emphasize robust qualitative comparisons across set-ups. However, if one wants to give an interpretation to the basic model evaluation period in terms of economic time, it should be taken as one quarter.

Figure 3: Performance comparison among scenarios. Averages for 50 Monte Carlo (MC) runs, 95% confidence interval in grey. Source: Dosi et al. (2017b).



Our results add to those from Dosi et al. (2010). There, we found that the "Schumpeterian engine" of innovation alone, without a "Keynesian engine" of autonomous demand generation/stabilization, was basically sterile. The findings here strengthen and refine such conclusion in that an institution-free labour market tends to destroy the link between wages and aggregate demand formation.[11]

The three Competitive set-ups listed above show an overall more fragile and prone to crises when compared to the Fordist regime, even when some level of active welfare policies is present, as depicted by Figure 3. In fact, GDP growth rate (Figure 3(a)), volatility of GDP (Figure 3(b)), likelihood of crises (Figure 3(c)), and unemployment rate (Figure 3(d)) are significantly higher in the competitive scenarios.

	FORDIST (1)	COMPETITIVE (2)		COMPETITIVE (3)		COMPETITIVE (4)	
	Baseline	*Ratio*	*p-value*	*Ratio*	*p-value*	*Ratio*	*p-value*
GDP growth	0.027	1.004	0.801	0.938	0.071	0.874	0.000
GDP volatility	0.061	1.206	0.000	1.606	0.000	1.610	0.000
Crises likelihood	0.151	1.381	0.000	1.919	0.000	1.973	0.000
Productivity growth	0.026	1.012	0.334	0.878	0.000	0.844	0.000
Unemployment	0.008	11.67	0.000	69.93	0.000	77.05	0.000
Full employment freq.	0.597	0.213	0.000	0.080	0.000	0.042	0.000
Tenure	15.43	0.158	0.000	0.193	0.000	0.201	0.000
Vacancy	0.331	1.006	0.841	0.410	0.000	0.338	0.000
Gini index	0.056	1.654	0.000	10.56	0.000	11.56	0.000

Table 4: Performance comparison of (1) Fordist regime with (2) Competitive with full indexation and benefits, (3) Competitive with partial indexation and no benefits, and (4) Competitive with full indexation and no benefits. Selected time series. Baseline values are averages for 50 MC runs. Ratios between baseline and alternative scenario MC averages. p-values for a two-means t-test among scenarios, H_0: no difference between scenarios. Source: Dosi et al. (2017b).

Table 4 presents results for the three Competitive regime specifications defined above as a ratio to the Fordist case (the baseline). The table also shows the two-means t-test comparing if the average values of the three alternative scenarios are significantly different from baseline. The reported p-values show that the Competitive regime under-performs, for all tested specifications, in statistically-significant terms. Indeed, productivity growth is substantially lower in the Competitive scenarios 3 and 4. Inequality *among workers* is higher, and the more so the lower the constraints in wage settings, while the average tenure of workers is dramatically reduced.

4.2 Institutional shocks: the effects of labour market structural reforms

In the following experiments, we shall start from a Fordist regime in all scenarios, and at period $t = 100$, we change institutions governing the labour market in three of them. These institutional shocks represent the introduction of new policies or legislation meant at the implementation of "flexibilizing" structural reforms. Again, the three alternative scenarios represent

[11] Under no unemployment benefits the model applies a zero tax rate. The interesting result is that, against the rhetoric according to which decreasing profit tax rate would improve investment and productivity, in the scenario with no tax the investment rate does not increase, but on the contrary it is hampered by the reduced aggregate demand.

different configurations of the Competitive regime, according to the regulatory firing rules.[12] The tested scenarios are:

1. FORDIST: no institutional shock, our baseline;
2. COMPETITIVE 1: firm fires workers whenever the fixed-period work contract of each worker expires; this rule captures a pattern of purely temporary employment;
3. COMPETITIVE 2: firm fires the unneeded workers whenever shrinking production;
4. COMPETITIVE 3: fresh workers can be freely fired but after some time on job, workers can be dismissed only in case of production shrinkage (*increasing protection policy*).

The order in which the alternative Competitive scenarios are proposed catches a decreasing *notional flexibility*: from Competitive 1 to 3, firms are free to fire but find increasing restrictions from the institutional rules. In all cases, however, the labour market conditions become now crucial in determining the wages requested by workers and offered by firms. Unlike the Fordist baseline, where both firm- and aggregate-level variables enter the wage determination, here only individual employment status and firms vacancies do affect it, by means of a worker-level bargaining process. This implies that wages are respondent and flexible to the unemployment condition, on the supply side, and also to the firms effective labour needs, on the demand side.

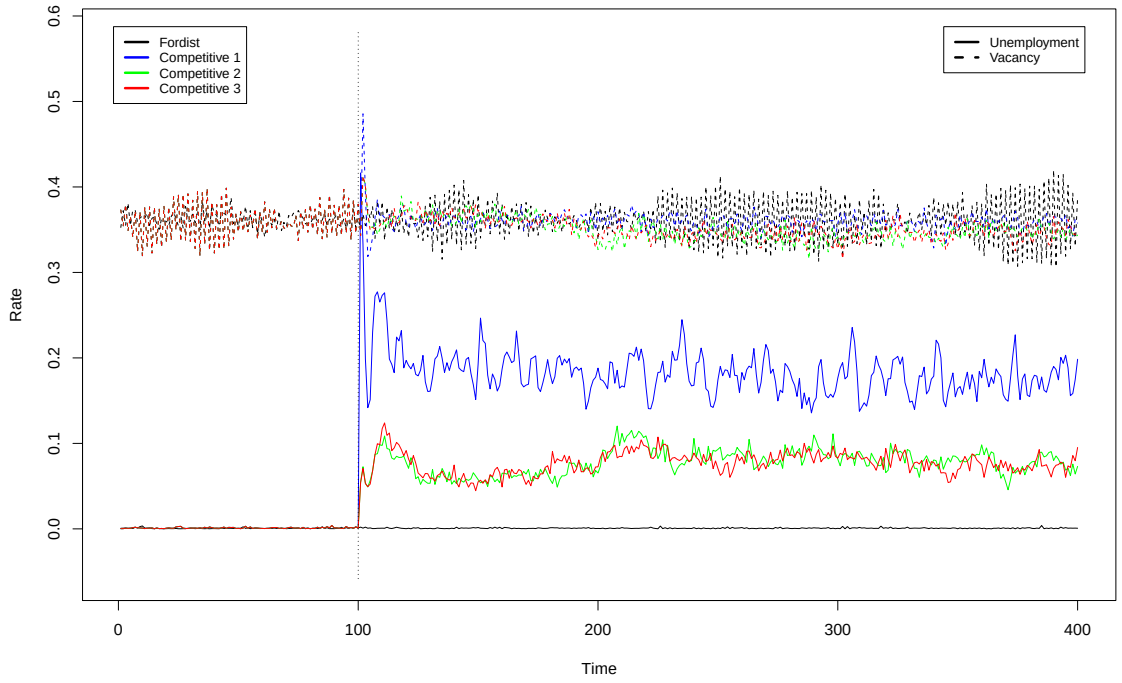


Figure 4: Unemployment and vacancy rates. MC average for 50 MC runs. Regime transition at $t = 100$. Source: Dosi et al. (2017a).

Let us examine the patterns for job vacancy and unemployment rates before and after the introduction of structural reforms (see Figure 4). The job vacancy (open positions) series exhibit a constant level pattern among the experiments, even if with different volatilities. However, the introduction of structural reforms (indicated by the vertical dotted line) at $t = 100$ determines a markedly different behaviour in unemployment, which surges from less than 1% in

[12] Please note that the tested Competitive scenarios presented here are *not* the same used in the previous section, representing different variations of the base structure presented in Table 2.

the Fordist regime to about 10% level in Competitive 2 and 3, reaching a level around 20% in the temporary-only contracts scenario (Competitive 1).

The dynamics of wages is presented in Figure 5(a). After structural reforms, the (log) trajectories gradually diverge, with the average real wage in the Competitive scenarios moving to a lower growth path. This phenomenon is due to the increasing functional income inequality, as the previous wage growth trend is diverted toward profits after the labour market flexibilization. The cause of this functional income redistribution, in all Competitive cases, wage growth does not completely absorb – via wage indexation – productivity growth, which is instead captured by increased mark-ups and profits.[13] Notice the change in functional income distribution highlighted in both Figure 5(b) and table 5: despite the invariance of the mark-up pricing rule, the actual profit share rises almost 5 percentage points.

The structural reforms aimed at "flexibilizing" the labour market do not only impact on the functional income distribution, but also on the personal one (cf. Figures 5(c) and 5(d)). The real wage dispersion and the Gini index allow to grasp the change in personal income inequality from different perspectives. Real wage dispersion, which takes into account only earnings from working activity (i.e., wages from employed workers *excluding* unemployment benefits), tends to be higher in Competitive 2 and 3 scenarios vis-à-vis Competitive 1, as in the latter case only temporary-work contracts exist and *all* workers periodically enter and exit the unemployment status. In such a situation, the possibilities for wage differentiation among workers is obviously reduced but at the cost of an equalization "at the bottom". Conversely, the Gini coefficient, which captures not only the wage income but also the compositional change between employed and unemployed workers, markedly increases in the temporary-only contracts scenario (Competitive 1), due to the higher unemployment. Consistent with Figure 4, this reflects the increased degree of income inequality among all workers, whether employed or not.

	FORDIST	COMPETITIVE 1		COMPETITIVE 2		COMPETITIVE 3	
	Baseline	*Ratio*	*p-value*	*Ratio*	*p-value*	*Ratio*	*p-value*
GDP growth	0.030	0.866	0.000	0.880	0.000	0.876	0.000
Productivity growth	0.030	0.869	0.000	0.877	0.000	0.880	0.000
Unemployment rate	0.001	215.8	0.000	102.3	0.000	98.06	0.000
Full employment freq.	0.557	0.137	0.000	0.311	0.000	0.338	0.000
Wages dispersion	0.057	0.552	0.000	1.508	0.000	1.486	0.000
Gini index	0.032	4.730	0.000	3.409	0.000	3.310	0.000
Mark-up	0.316	1.099	0.000	1.082	0.000	1.086	0.000

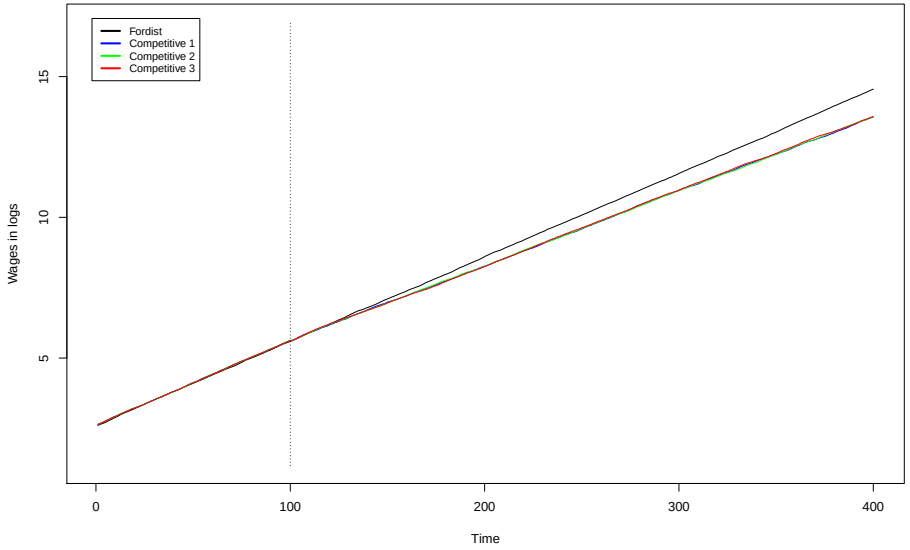
Table 5: Performance comparison of (1) Fordist regime with (2) Competitive with full indexation and benefits, (3) Competitive with partial indexation and no benefits, and (4) Competitive with full indexation and no benefits. Selected time series. Baseline values are averages for 50 MC runs. Ratios between baseline and alternative scenario MC averages. p-values for a two-means t-test among scenarios, H_0: no difference between scenarios. Source: Dosi et al. (2017a).

Finally, Table 5 provides a general assessment on the economic dynamics under the alternative institutional configurations. The increased flexibility in labour market introduced by structural reforms, but it considerably increases the unemployment rate and reduces the frequency of periods the economy spends in full employment.

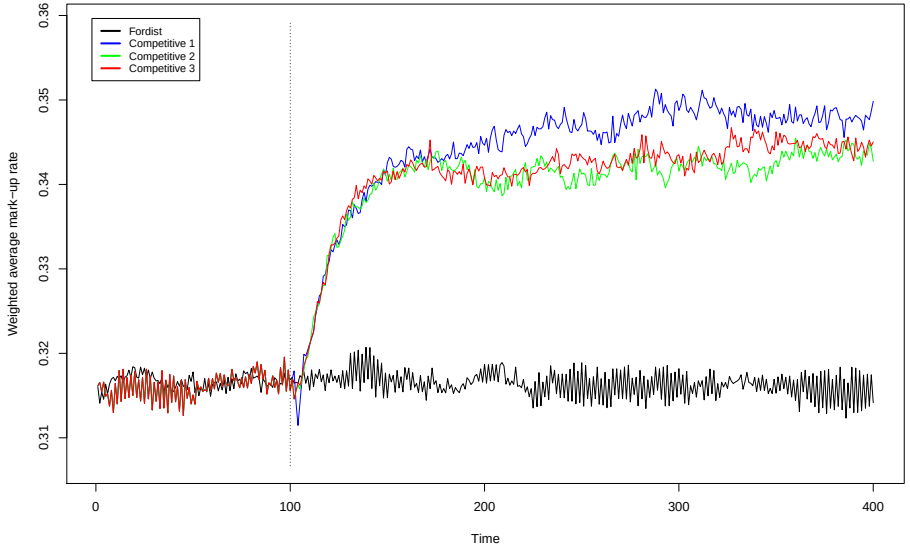
[13] The presence (absence) of a pass-through from productivity growth to wages hikes are usually attributed to the presence (absence) of strong unions, which are not explicitly modelled here.

Figure 5: Comparison of wages and inequality among scenarios. MC averages for 50 MC runs. Regime transition at $t = 100$. Source: Dosi et al. (2017a).

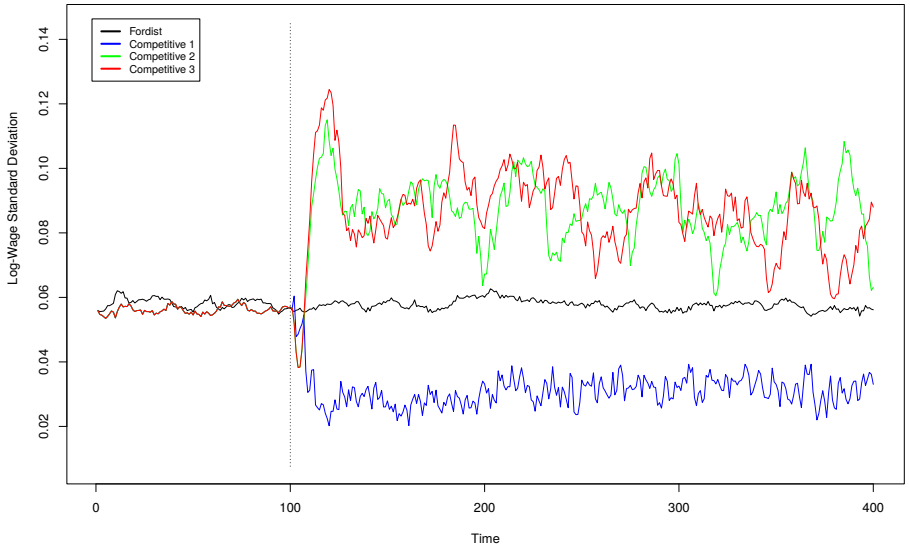
(a) Log average real wage



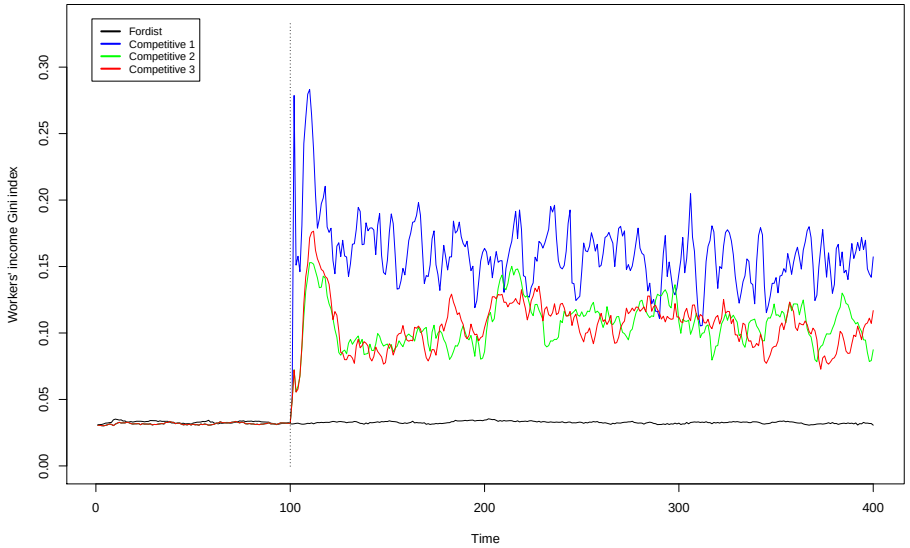
(b) Average mark-up



(c) Log real wage dispersion



(d) Gini index



As noted in Figures 5(c) and 5(d), and Table 5, under the different Competitive regime scenarios, both functional and personal income inequality significantly increase, as witnessed by the surge in both average mark-ups and the Gini index. In contrast to the usual claim of the "standard" policy discourse, structural reforms do not even improve the performance of the economy in the long run. Indeed, the higher inequality resulting from the increased flexibility of the labour market reduces aggregate demand and slows down technological search efforts, and, consequently, the innovation and diffusion rates. As a result, productivity and GDP growth are significantly reduced in the all structural-reform scenarios in comparison to the Fordist regime.

5 The emergence of hysteresis

Dosi et al. (2018a) address the emergence of hysteresis in the labour-augmented K+S model and the ensuing dynamics of long-term unemployment in the two growth regimes presented in Table 2. In order to capture the potential microeconomic roots of hysteresis, according to the literature in the subject, the model was further extended by (i) an endogenous process of worker skill accumulation, and (ii) decoupling the firm-entry and exit processes and allowing for a variable number of firms to exist in each market.

5.1 The labour market and skills dynamics

Once the economy enters a long recessionary phase, firms tend to fire workers. During severe recessions, like the 2008 crisis, unemployment, which under milder downturns could be in principle temporary and cyclical, turns out to be persistent, implying that many workers experience long unemployment spells. Unemployed workers, of course, stop learning by doing and lose contact with the new practices and techniques introduced by firms, and gradually deteriorate their skills. As the economy recovers and the unemployed are finally hired, their productivity is now lower than incumbent workers, reducing the overall productivity.

In order to account for such a process of workers' skill accumulation and deterioration linked to the macroeconomic dynamics, we introduce worker-specific job tenures, assuming a learning-by-doing process when employed and a gradual deterioration of skills while unemployed. The skill level $s_{\ell,t} \in \mathbb{R}_*^+$ of each worker ℓ evolves over time as a multiplicative process:

$$s_{\ell,t} = \begin{cases} (1+\tau)s_{\ell,t-1} & \text{if employed in } t-1 \\ \dfrac{1}{1+\tau}s_{\ell,t-1} & \text{if unemployed in } t-1 \end{cases}, \tag{19}$$

with the learning rate $\tau \in \mathbb{R}^+$ parameter. As a consequence, when worker ℓ is employed her skills improve over time, as she becomes more experienced in her job. Conversely, unemployed workers lose skills. In particular, when a worker is hired in the model, she immediately acquires the minimum level of skills already present in the firm (the existing worker with the lowest skills), if above her present level.

Workers' skills define their individual (potential) productivity $A_{\ell,t}$:

$$A_{\ell,t} = \frac{s_{\ell,t}}{\bar{s}_t} A_i^\tau, \tag{20}$$

where $\bar{s}_t$ is the average worker skill level and A_i^τ, the expected productivity of the machinery vintage when an average worker operates it. The ratio $s_{\ell,t}/\bar{s}_t$, or the worker normalized productivity, represents her ability to produce more (if $s_{\ell,t} > \bar{s}_t$) or less (otherwise) than an average worker when using a certain machine technology. Note that both the firm-level ($A_{j,t}$) and the sectoral aggregated (A_t) productivities are truly emergent properties of the model. They result, simultaneously, from the technical innovation dynamics (the introduction of new vintages A_i^τ), the worker skills accumulation/deterioration process, and, indirectly, the effective demand which guides firms when deciding the desired production $Q_{j,t}^d$, the capital stock dynamics, and the employed machine mix (see Dosi et al., 2018a for details).

5.2 The entry and exit processes

Firm-entry rates in the United States domestic markets have declined after 2006 by about 27%, a widespread phenomenon across all sectors of the economy (Gourio et al., 2014). This has been accompanied by steady exit rates and, consequently, also shrinking *net* entry rates. One direct effect of less entry is the reduced creation of new job opportunities. Decker et al. (2016) document a long term pattern in the declining business dynamism which the authors attribute, mainly, to the contracting share of young firms. In a similar vein, Siemer (2014) introduced the hypothesis of a *missing generation* of entrants after the 2008 crisis, as result of the tightened financial constraints, primarily affecting young and entry-candidate firms.

To capture the possible effects of an unbalanced entry-exit dynamics, the K+S model was upgraded to account for non-zero net entry, so a variable number of firms in both consumption- (F_t^2) and capital-good (F_t^1) sectors is possible. In this new version, entry and exit are modelled as independent processes. As before, firms leave the market whenever their market shares get close to zero or their net assets turn negative (bankruptcy). However,the number of entrants is now defined by the random variables b_t^1 and b_t^2, representing the (gross) number of entrants:

$$b_t^z = F_{t-1}^z \left[(1-o)MA_t^z + o\pi_t^z\right] \qquad \text{(lower bounded to 0)}, \tag{21}$$

where $z \in \{1,2\}$ denotes the sector (capital- or consumption-good, respectively), F_{t-1}^z is the existing number of incumbent firms, MA_t^z the "financial attractiveness" of the industry, $o \in [0,1]$ is a mix-balance parameter and π_t^z is a random draw from a uniform distribution on the fixed support $[\underline{x}_2, \bar{x}_2]$. So, the number of entrants stochastically depends on the count of incumbents with the financial conditions influencing the decision of would-be entrants.

The sector-specific "financial attractiveness" MA_t^z in period t is defined as:

$$MA_t^z = MC_t^z - MC_{t-1}^z \qquad \text{(bounded to } [\underline{x}_2, \bar{x}_2]). \tag{22}$$

MC_t^z is calculated based on firms' balance sheets as the (log) ratio between the aggregate stocks of liquid assets $NW_{y,t}$ (bank deposits) and bank debt $Deb_{y,t}$:

$$MC_t^z = \log\left(\sum_y NW_{y,t-1}\right) - \log\left(\sum_y Deb_{y,t-1}\right), \tag{23}$$

in each sector, $y \in \{i,j\}$, accordingly. So, MC_t^z measures the sectoral liquidity-to-debt ratio and, thus, the tightness of the credit market, and MA_t^z is a proxy to its dynamics. Correspondingly, negative (positive) values of MA_t^z represent leveraged (deleveraged) markets, meaning

that debt is growing faster (slower) than the accumulation of cash equivalents. This means that whenever the overall liquidity-to-debt ratio is shrinking would-be firms are more inclined to enter, and vice versa.

5.3 Detecting hysteresis

Assessing the emergence of hysteresis is not a trivial task as there is no conclusive test or even widely accepted criteria for this. However, there are several properties and techniques which do help uncover particular aspects of hysteresis. In line with the literature, we employ a set of analytical methods, summarized in Table 6, which provide reasonable evidence of the presence of hysteresis in the K+S model, as it was also shown for real data. Dosi et al. (2018a) study whether the time series generated by the model present evidence of (i) remanence, (ii) persistence, (iii) non-linearity, (iv) path dependence, and (v) super-hysteresis. Needless to say, these properties are to some degree overlapping. As before, the analysis is performed considering the two alternative growth regimes presented in Table 2.

PROPERTY	TEST	REFERENCE
Remanence	Duration of employment and GDP recoveries after crises	Jaimovich and Siu, 2012
Persistence	Unit-root tests for stationarity	Blanchard and Summers, 1986
Non-linearity	Brock-Dechert-Scheinkman test	Broock et al., 1996
Path dependence	Ergodicity tests	Wald and Wolfowitz, 1940
Super-hysteresis	Reduced GDP growth trend after crises	Blanchard et al., 2015

Table 6: Selected tests to evaluate hysteresis in macroeconomic times series. Source: Dosi et al. (2018a).

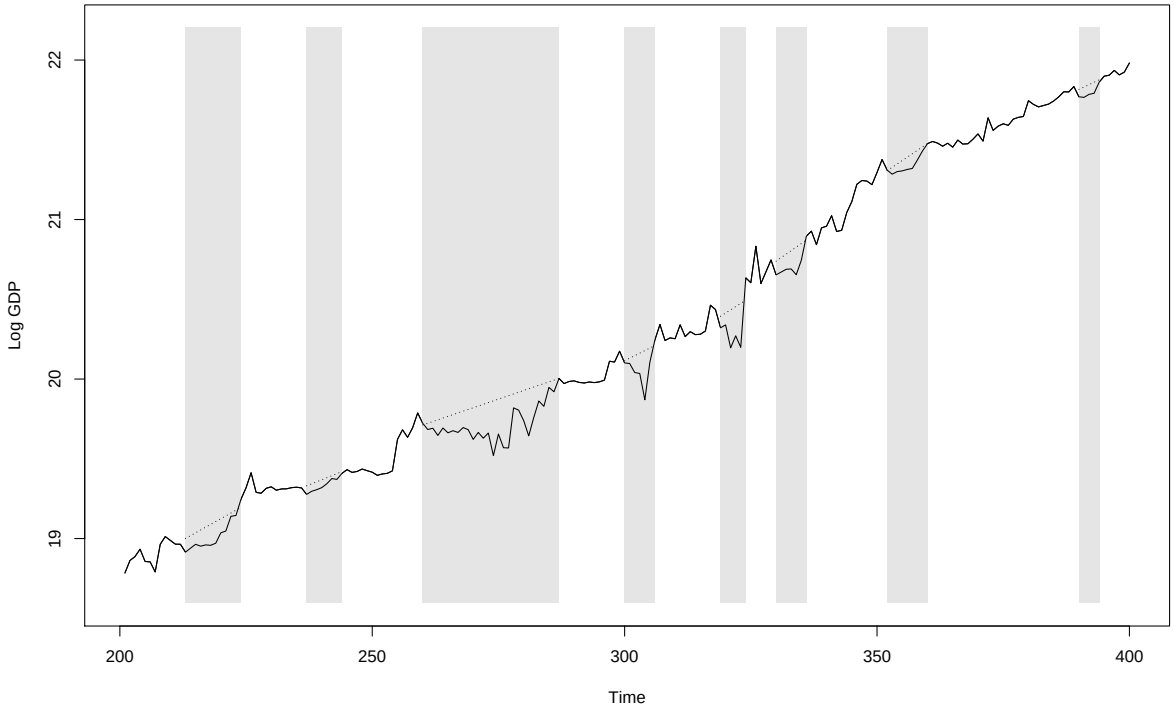
In term of remanence, Figure 6 illustrates the number of periods (grey area) necessary to put the economy back to the pre-crisis growth trend (dashed line) in typical simulation runs.[14] The analysis is inspired by Blanchard et al. (2015) and simply performs an extrapolation of the long-run GDP trend to detect the recovery from crises under the possible presence of hysteresis. The results show the coexistence of shorter business cycle downturns with longer, hysteretical crises, requiring significant more times for the economy to recover. Note also the presence of super-hysteresis, particularly in the Competitive regime, revealed by the different slopes of the peak to to peak GDP trends (dashed lines).

Table 7 reports the average recovery duration for both the GDP and mean unemployment time (the average period a worker takes to find a new job). While the duration of GDP trend recovery is similar among regimes (around 16 quarters), the unemployment time takes almost five times more to return to the pre-crisis level in the Competitive case. In order to better assess the severity of the crises, we also track the peak GDP trend deviation during the recovery period (how farther the GDP gets from the pre-crisis trend) and the accumulated GDP losses in comparison to the trend (the crisis "cost"). The model robustly shows how Competitive regime crises are about twice deeper than in the Fordist scenario. Accumulated GDP losses comparison leads to a similar conclusion.

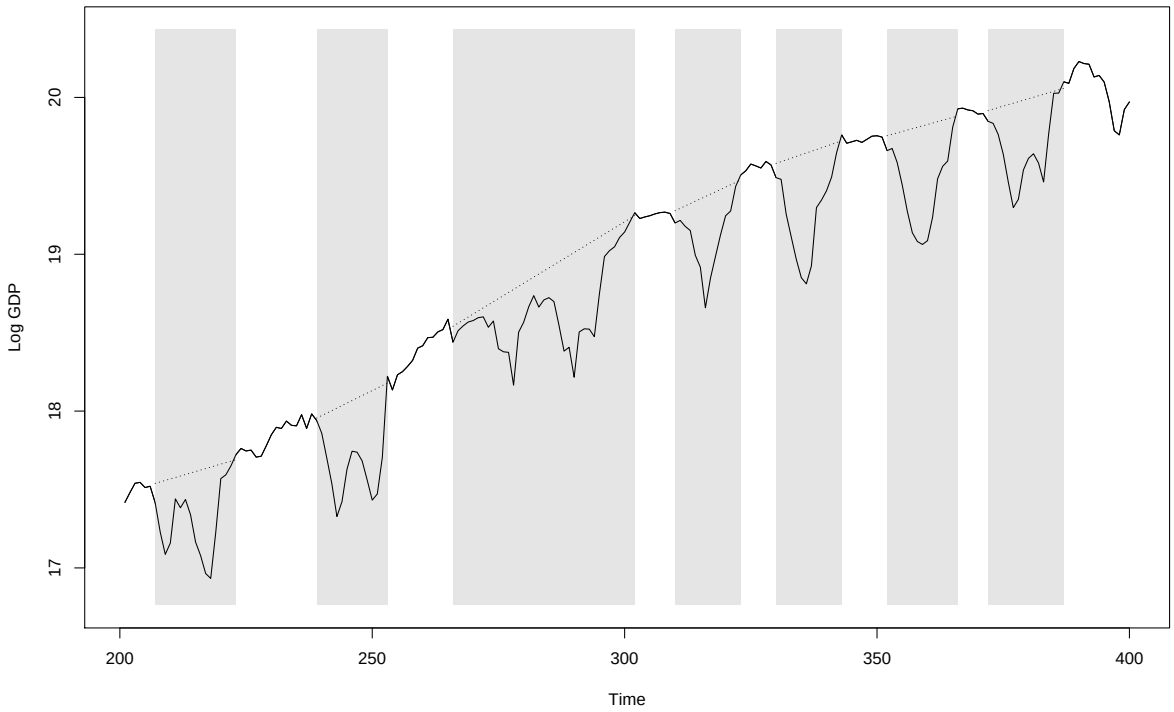
[14] A crisis is defined by a 3% drop of the GDP in a single period which is not recovered in the next three periods. The pre-crisis level is calculated as the average GDP for the four periods before the crisis and the trend, as the output of an H-P filter at the period just before the crisis. The crisis is considered recovered when the GDP reaches back the pre-crisis trend level.

Figure 6: GDP recovery after crises. Typical simulation runs.
Dashed line: pre-crisis trends | Gray boxes: recovery periods. Source: Dosi et al. (2018a).

(a) Fordist regime



(b) Competitive regime



	FORDIST	COMPETITIVE
Number of crises	6.15	5.77
	(0.44)	(0.28)
Crises peak	0.23	0.51
	(0.01)	(0.02)
Crises losses	2.38	4.18
	(0.33)	(0.42)
Recovery duration		
GDP	15.64	16.97
	(1.43)	(1.04)
Unemployment time	6.83	31.22
	(0.55)	(9.04)

Table 7: Comparison between policy regimes: GDP and unemployment time recovery. Averages for 50 MC runs in period $[200, 400]$, MC standard errors in parentheses. Source: Dosi et al. (2018a).

In summary, the expanded model is now able to generically exhibit path dependence, non-linearity and non-ergodicity in its main macroeconomic variables (check Dosi et al., 2018a for the detailed results of all tests in Table 6), presenting hysteresis as a bottom-up emergent property. Moreover, the model suggests that both numerical and wage flexibility, as present in the Competitive regime, are quite prone to increase the hysteretical properties of the macroeconomic system, thus worsening its short- and long-run performance.

6 Fiscal and active labour market policies

Dosi et al. (2018b) compare the different effects of active (supply-side) vs. passive (demand-side) labour market policies (ALMP vs. PLMP) on macroeconomic dynamics, considering the two growth regimes defined in Table 2. In particular, the authors analyse the effects of ALMP directed at promoting job search and/or providing training to unemployed people under the two regimes. Finally, they test such policies in different fiscal scenarios and, in particular, their interaction with fiscal-austerity policies. Considering the burden of unemployment benefits upon the public budget, the K+S model conditions the provision of PLMP to the objectives of "austerity rules" such as the European Stability and Growth Pact (SGP), a 3% deficit-to-GDP and a 60% debt-to-GDP ratio, and the European Fiscal Compact (FC), a restructuring path in case of debt overhang. In doing so, it explicitly accounts for the interactions between decentralized labour and credit markets, coupling the real and financial dynamics.

To evaluate the effect of this policy set, the labour-augmented K+S model was upgraded to include a full banking sector and proactive government and central bank (in line with Dosi et al., 2015). From a policy perspective, the model allows studying the interplay between labour-market and fiscal measures by comparing the relative performance of supply and demand policies during economic crisis. Two types of ALMP were modelled: job search incentives, and government-sponsored training of unemployed workers. As before, the PLMP considered were unemployment benefits. In doing so, we try to closely mimic the type of policies put forward, for instance, by the OECD Jobs Study and by the SGP, and compare it with the classic Keynesian automatic stabilizer represented by the unemployment benefit. Therefore, the model novelty consists in new modelling tools and policy analysis dimensions.

We study policy mixes combining flexible labour markets (Competitive regime) with ALMP and fiscal austerity. The objective is testing how the implementation of the full package of reforms – as several countries recently did – would affect the simulated system. For this purpose, we test the best-performing Competitive variant, which includes an indexed minimum wage and unemployment benefits, under two alternative fiscal policies. The first one simply entails the already analysed automatic stabilizer rule (Competitive AS), wherein there is no hard limit to public expenditure. The second case applies the European Fiscal Compact criteria (Competitive FC), which enforces strict prescriptions for the public deficit and debt. Claimed targets of such reform package are (i) to improve GDP growth, (ii) the stabilization of public finance, and (iii) the smoothing of labour market mechanisms. Also, the no-reform Fordist scenario is included for reference. Table 8 illustrates the tested configurations.

	PLMP	ALMP	FISCAL POLICY
Fordist	yes	no	Automatic stabilizer
Competitive AS	yes	yes	Automatic stabilizer
Competitive FC	contingent	yes	Fiscal Compact

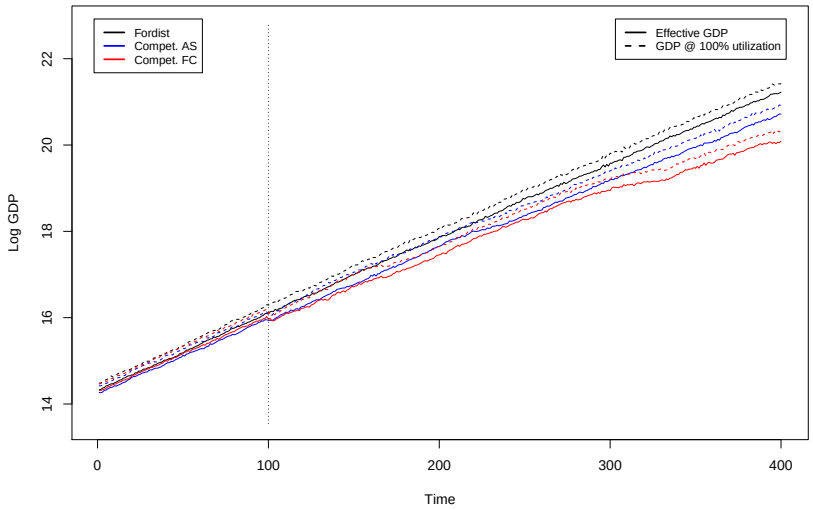
Table 8: The tested fiscal rule configuration scenarios. Source: Dosi et al. (2018b).

Do the alternative reform packages succeed? Let us focus on the economic performance when unemployment benefits have no binding constraint, as in the Fordist and Competitive AS scenarios. In comparison, the Competitive FC set-up may temporarily cut these benefits to comply with the policy prescriptions. Figure 7 and Table 9 present a concise set of the relevant metrics that describe the model results under the AS and FC fiscal rules. Figure 7(a) shows the long-term path of GDP (actual and if all available capacity is employed). Not surprisingly, whenever the FC rule is binding, and so unemployment benefits are temporarily reduced, the GDP growth trajectory is *permanently damaged*. Such super-hysteresis phenomenon (Ball, 2014; Blanchard et al., 2015) is present in both Competitive set-ups but is more pronounced under the FC variant. Moreover, when comparing the GDP losses during crises in Figure 7(b), the FC rule clearly reveals the significant costs associated to "turning off" the Keynesian automatic stabilizers during the periods in which they are actually more required. Table 9 shows the quantitatively-relevant effects of these costs under several dimensions.

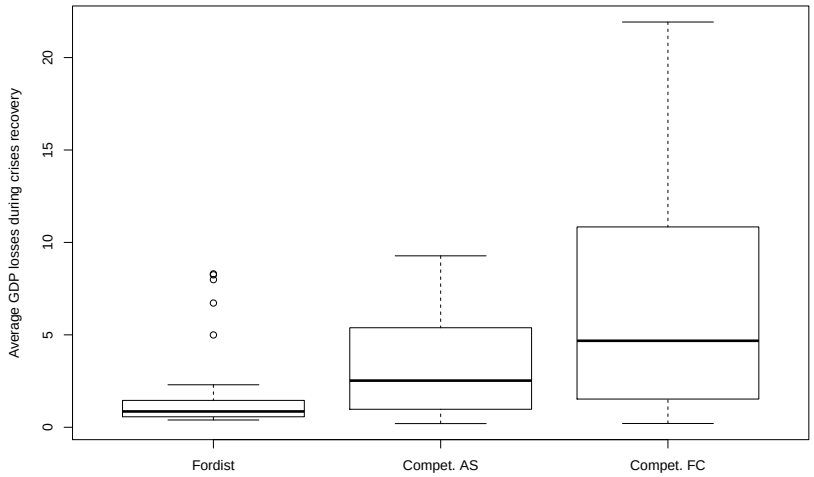
However, the status of public finance *does not improve* in the Competitive set-ups when compared to the Fordist case, well the opposite holds. First, public deficit as shown by Figure 7(c)) indicates a possible long-run sustainability problem of the Competitive AS scenario, given the high level of accumulated public debt revealed in Figure 7(d). Second, even if the Competitive FC scheme is (by construction) sustainable in the long run, its associated social costs may be dramatic, as indicated in Table 9. Figure 7(d) shows that public debt in the FC scenario does not converge to the Fordist case even in the long run due to its short-term *self-defeating* nature. Indeed, as detailed shown in Dosi et al. (2015, 2016), austerity policies are frequently unsustainable in the long run, bringing the economy to a collapse under a relatively high probability. In this respect, the higher degree of banks fragility due to debtor-firm defaults, as discussed above, represents another important channel inducing the self-defeat of austerity. Flexibility and deregulation policies, causing higher bank-failure rates, and therefore triggering bank bail-outs, entail a higher level of public indebtedness and FC rules violation, enacting the rule which force the temporary reduction of unemployment benefits.

Figure 7: Macroeconomic dynamics in alternative policy regimes (a,c,d) and performance comparison (b). Source: Dosi et al. (2018b). Statistics for 50 MC runs averages, (b) in period [200, 400]. Bar: median | box: 2nd-3rd quartile | whiskers: max-min | dots: outliers.

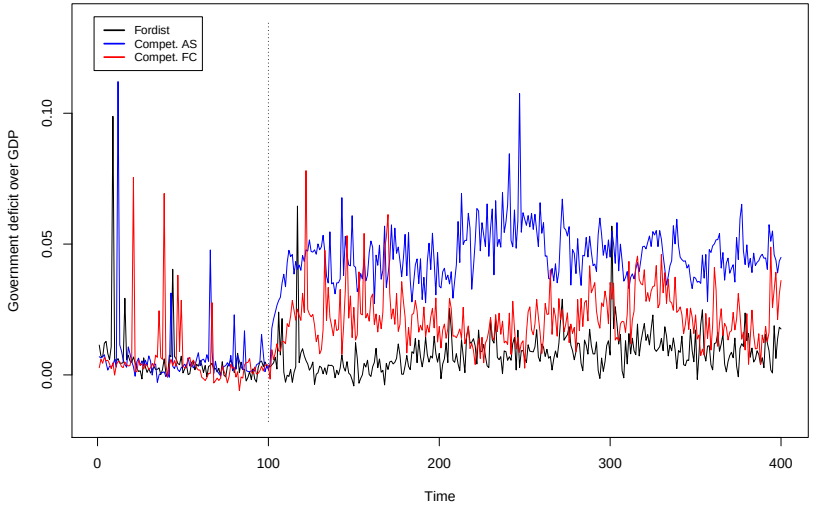
(a) Actual and full capacity GDP



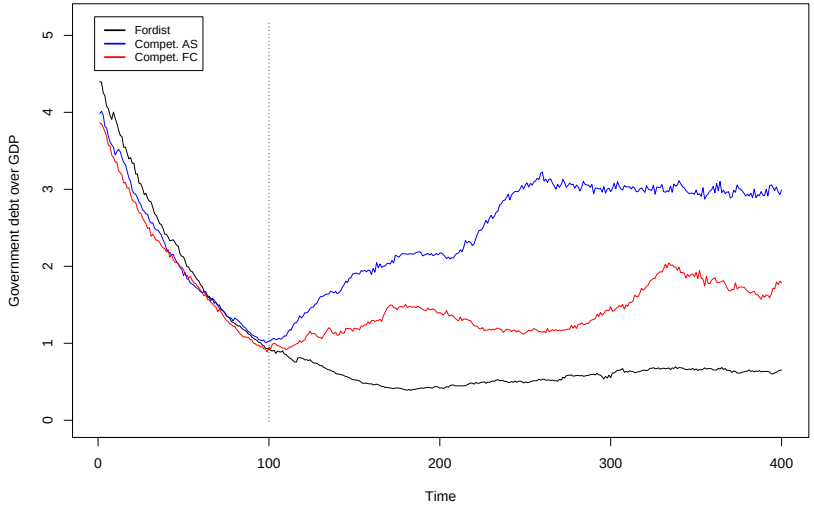
(b) Losses from GDP crises



(c) Public deficit to GDP ratio



(d) Public debt to GDP ratio



	FORDIST	COMPETITIVE			
		AS		FC	
	Baseline	Ratio	p-value	Ratio	p-value
GDP growth	0.02	0.78	0.01	0.68	0.00
GDP volatility	0.11	0.86	0.01	1.19	0.00
Crises losses	1.57	2.57	0.00	5.39	0.00
Recovery duration	11.56	1.49	0.01	2.01	0.00
Productivity growth	0.02	0.81	0.01	0.71	0.00
Unemployment	0.02	8.93	0.00	10.96	0.00
Workers' skills	1.85	0.84	0.00	0.82	0.00
Gini index	0.05	3.60	0.00	5.09	0.00
Mark-up	0.22	1.02	0.00	1.03	0.00
Financial fragility	0.02	1.26	0.02	1.30	0.00
Bank failure likelihood	0.07	1.83	0.08	2.90	0.00
Bank bail-out cost	0.01	5.68	0.19	3.95	0.00

Table 9: Performance comparison among automatic-stabilizer and austerity policies, selected time series. Averages for 50 MC runs in period $[200, 400]$. p-value for a two-means t test, H_0: no difference between scenarios. Source: Dosi et al. (2018b).

As discussed in the previous sections, we have already shown that more flexibility of the labour market, both in terms of wage adjustments and hiring/firing rules, are likely to make the system more fragile and to be detrimental in both the short and the long run in terms of unemployment rates, GDP growth, and inequality. After exploring the extent to which such effects can be reversed, or at least mitigated, by active labour market policies, it gets clear that they cannot. Neither more efficient matching on the labour market, nor government-sponsored skill-enhancing programs are enough when workers face adverse labour demand. Passive labour market policies, sustaining aggregate demand, are better suited to mitigate inequality and to foster long-run growth. Also, adding some deregulation of credit supply in presence of flexible labour markets further adds to the fragility of the system as revealed by the amount of bad loans that the economy accumulates, further worsening the situation.

7 The feedback mechanisms

Overall, the findings of this series of papers (Table 1) may be summarised by the flow diagram presented in Figure 8. The chain of feedback mechanisms at work after the transition to Competitive regime yields higher functional inequality, increased wage dispersion, more income concentration, and macroeconomic hysteresis, which can hardly be deactivated by the usual policy responses, like active labour market policies. The reduced aggregate demand and the persistent long-term unemployment feed back upon both wage and numerical flexibility which in turn amplify the former. The K+S model, deeply Keynesian in spirit, entails a wage-led dynamics wherein inequality is detrimental for the macro dynamics: lower effective demand slows down investment notwithstanding firms relatively higher margins and profits. Let us consider the mechanisms at work in some detail.

1. FROM WAGE FLEXIBILITY TO UNEQUAL INCOME DISTRIBUTION: the first mechanism relates to the lower share of wages and a correspondingly higher share of profits in Com-

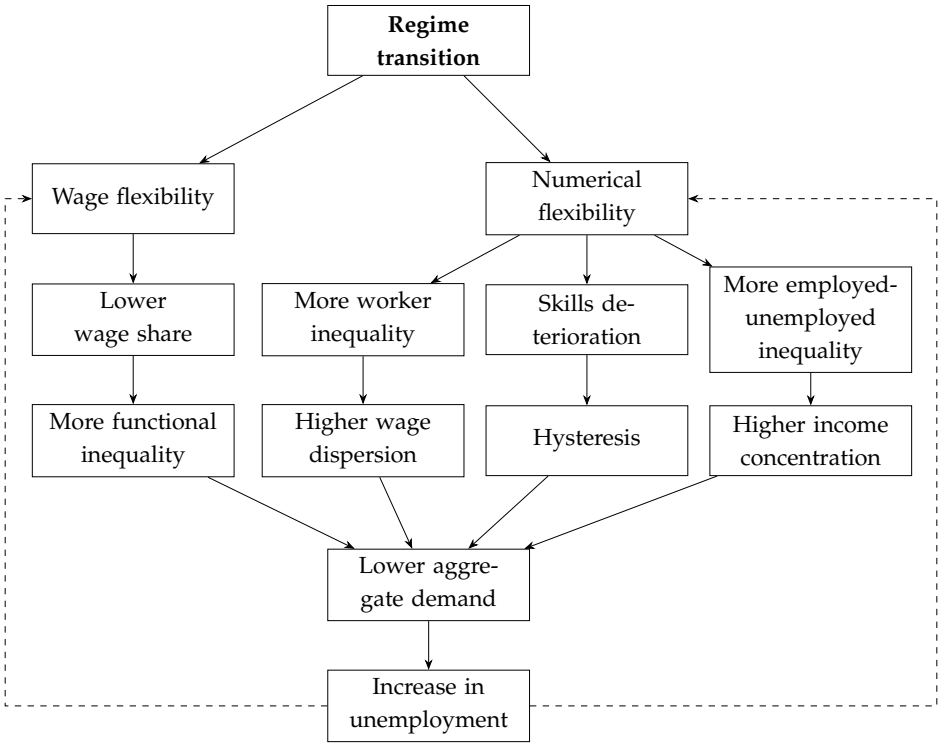


Figure 8: Feedback mechanisms at work after the regime transition.

petitive set-ups. The change in functional income distribution impacts macroeconomic dynamics via different propensities to consume between workers and capitalists. Indeed, even though wages are fully spent in both regimes, the lower wage share leads to a smaller aggregate consumption. In turn, the latter induces a reduction in investments via an accelerator-type mechanism. The ensuing lower aggregate demand is followed by increased unemployment. The larger fraction of unemployed workers causes a surge in inequality as measured by the Gini index. Additionally, the longer the unemployment spells, the lower the wages requested by workers.

2. FROM NUMERICAL FLEXIBILITY TO UNEQUAL PERSONAL INCOME DISTRIBUTION: the second channel concerns the firing process. If firing is easier and unemployment spells are longer, recently hired workers tend to have lower wages, inducing among-worker inequality. On top of that, when firing is linked to the production shrinkage inter-firm wage inequality also increases because firms are heterogeneous in their market performances.
3. FROM NUMERICAL FLEXIBILITY TO SKILLS DETERIORATION AND HYSTERESIS: the third mechanism goes from numerical flexibility toward skills deterioration. The easiness of firing determines a drop in job tenures and, indirectly, has a negative effect on skill accumulation, and so, consequently, on productivity. Not only the firing rule, but also the dismissed worker selection criterion affects the productivity growth dynamics. In the Fordist regime, workers with lower skills are fired first. Conversely, in the Competitive case, firms use the skills-to-wage ratio to dismiss first workers with inferior short-term return. Such a behaviour has negative impact on the average skill level of workers over time.
4. FROM DECLINING AGGREGATE DEMAND TO KEYNESIAN UNEMPLOYMENT: the fourth channel goes from higher unemployment induced by inequality and hysteresis to wage

and numerical flexibility. Higher unemployment reduces workers bargaining power in the wage determination process, yielding lower wage growth, and, consequently, shrinks the effective demand for firms, thus increasing the firing rate. The process exacerbates inequality, and propagates in a vicious cycle.

8 Further discussions and conclusions

In this work we analysed the main findings obtained from the labour-augmented K+S agent-based model. Firstly, the model was used to address the introduction of labour market structural reforms. Secondly, it was used to understand the phenomenon of macroeconomic hysteresis, in particular the influence of the labour skills dynamics on the long-run growth path. Lastly, the model was employed to compare the performance of the economic system under supply- and demand-side management polices, including the presence of fiscal austerity. In summary, the model was employed as a laboratory to evaluate the effects of some recent policy interventions proposed to mitigate the impact of big economic crises, as labour market "flexibilization" reforms, active labour market policies and fiscal austerity. To a good extent, the model mimicked the responses European Union and many Latin American countries, Brazil in particular, have developed in reaction to the recent economic crises.

The model robustly demonstrated that more flexibility in terms of monetary wages and labour mobility induces systematic coordination failures, macro volatility, unemployment, and more frequent crises. Indeed, it is precisely the downward flexibility of wages and employment – as profitable as it might be for individual firms – and the related higher degrees of inequality that leads, recurrently, to aggregate demand failures, as a model's emergent property. The same mechanism, we suggest, was also at the heart of both the 1929 and 2008 crises, no matter what the triggering factors (often to be found at the financial level).

The experiments we have performed vindicate the notion that a too flexible wage-labour nexus can be detrimental for aggregate economic dynamics. Only when flexibility in wages and employment is accompanied by policy measures which mitigates the recurrent downward pressures, like passive Keynesian automatic stabilizers, the system does not collapse. Furthermore, contrary to the argument that higher labour flexibility fosters productivity growth, the model clearly shows the opposite: productivity in regimes without full wage indexation and unemployment benefits cannot grow at the same pace. Yet, the model shows that policy interventions on this direction effectively *cause* the increase of both functional and personal income inequality, on the one hand, and of the unemployment rate, on the other. Conversely, the model fails to provide any evidence of an equity-efficiency trade-off. On the contrary, the two dimensions are highly correlated: a larger fraction of unemployed workers (who get reduced or no unemployment benefits) simply increases the level of personal income inequality. Finally, we found robust evidence on how the degrees of job protection and the wage setting policies directly affects functional income distribution.

Contrary to the economists' common wisdom, structural labour market reforms are far from being a panacea for unemployment, growth and income redistribution. On the contrary, they tend to exacerbate the asymmetry in the bargaining power between workers and firms, in favour of the latter. In turn, this pattern, especially when it comes together with the reduction or elimination of unemployment benefits, tend to *worsen* also macroeconomic conditions in terms of unemployment rates and the long-run growth of income and productivity. Indeed,

it happens that the nearer the system gets to competitive conditions in the labour market, the *harder* it is for the Schumpeterian engine of innovation and growth to operate. More unequal income distribution and higher unemployment spells induce, via Keynesian mechanisms, a stagnation bias in the aggregate dynamics.

Here is where the failure of the Keynesian demand-generating engine feeds back upon the Schumpeterian process of technological advance. Crises are not blissful events whereby the gales of creative destruction break incumbent bottlenecks and open up new opportunities for innovation. On the contrary, crises and the associated lack of aggregate demand reduce the amount of resources invested in innovative search (in our model, the R&D budget of the machine-producing sector), shrink the investment in new vintages of equipment, and slow down the scrapping of old machines. The result is a *reduction* in the rates of productivity growth and, if such recessionary events occur often enough, a reduction in the *long-term growth rate* of the economy, even beyond the permanent loss in GDP levels, verified as a form of super-hysteresis in the model. The K+S model findings, indeed, showed the pernicious long-term effect of austerity policies. After all, austerity- and wage/unemployment-driven deflation are exogenous (the former) and endogenous (the latter) shocks upon the demand coordination process.

Needless to say, the normative implications from the set of papers analysed here are far-reaching and point in directions opposite to the fairy-tales of labour market structural reforms and expansionary austerity. If one trusts the interpretative power of the proposed model, more employment safeguards, less permissive firing rules, less wage inequality, and more welfare protection are not only good for the workers, but also for the economy as a whole.

All this considered, it turns really surprising the directions countries like the members of the European Union and Latin America have taken to attenuate the long-lasting crisis started by the 2008 housing crash. If we take Brazil as a radical, recent example, the delivered set of government responses are an almost perfect *counter-example* of the required policies, according to our results, to mitigate the deepest recessionary period ever faced by the country (almost 10% GDP per capita reduction in three years). For instance, a *nominal* budget constraint was imposed to the public expenditure, irrespective of the effective deficit level, forcing the government to continuously shrink the already weak welfare protection system. Moreover, a *radical* labour market flexibilization reform was passed, in practice removing most hiring/firing restrictions from firms. Such policy mix has not put the Brazilian economy on a minimally satisfying recovery path, with unemployment still close to the historical peaks (around 13%) and the growth of the GDP per capita near zero after five years from the beginning of the crisis. Unfortunately, these are *exactly* the same results our model produce for such draconian policy set-up, hinting on its adequacy for this kind of analysis, and suggesting to move to a policy mix characterized by lower labour flexibility and strongly counter-cyclical fiscal interventions.

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