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Abstract

Wages are an element of cost crucially affecting the competitiveness of individual firms. But the wage bill is also a crucial element of aggregate demand. Hence it could be that more "flexible" and fluid labour markets, while allowing for faster inter-firm reallocation of labour, may also render the whole economic system more fragile, more prone to recession, more volatile. In this work we investigate some conditions under which such a conjecture applies. The paper presents an agent-based model that investigates the effects of two "archetypes of capitalism", in terms of regimes of labour governance – defined by the mechanisms of wage determination, firing, labour protection and productivity gains sharing – upon (i) labour market regularities and (ii) macroeconomic dynamics (long-term rates of growth, GDP fluctuations, unemployment rates, inequality, etc..).

The model is built upon the "Keynes meets Schumpeter" family of models (Dosi et al., 2010), explicitly incorporating different microfounded labour market regimes. Our results show that seemingly more rigid labour markets and labour relations are conducive to *coordination successes* with higher and smoother growth.

Keywords

Involuntary Unemployment, Aggregate Demand, Wage Determination, Labour Market Regimes, Keynesian Coordination Failures, Agent-Based Models

JEL codes

C63, E02, E12, E24

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1 Introduction

Throughout the history of the economic discipline, a major challenge to all scholars ready to give even a cursory glance at the evidence, has been the question: why involuntary unemployment? Or, putting it the other way round, why is not the economic system able to generate levels of activity that absorb all the labour force willing to work?

The pre-Keynesian answer, as known, is in term of frictions and rigidities in primis on the labour market itself. And, basically it is also the neo-Keynesian answer, starting as early as the formalization of Keynes' model by Hicks (1937) and Modigliani (1944) all the way to the generality of contemporary New Keynesian DSGEs (Dynamic Stochastic General Equilibrium models) (Rotemberg and Woodford, 1993 and Blanchard et al., 2015). At a finer level of detail, there are of course differences between rigidities and frictions of the labour market. The former are typically used in aggregated models and the latter more in tune with models attempting to find some sort of equilibrium micro-foundation such as search-and-matching ones (see Yashiv, 2007). Under the rigidity heading, the usual approach is a model with some nominal rigidities whereby the rigidity itself deprives the underlying Walrasian real model from its self-equilibrating properties. Conversely, in the friction perspective, it is some *real, decentralised, but equilibrium dynamics* to yield involuntary, but *frictional* unemployment. There is an alternative view, however, which we believe to be well in tune with Keynes himself. Involuntary unemployment is the outcome of systematic *coordination failures*, – in the current economic jargon –, whereby "bad equilibria" (that is, Pareto-dominated growth paths) are self-fulfilling in decentralised economies. Leijonhufvud (1973) emphasized how prices can be at their "general equilibrium level" but still the effective quantity transactions can differ from the notionally desired rates of selling and buying. Further, under shortfalls of effective demand, prices can even become "false" signals, exacerbating coordination failures: *realised sales are restrictions for demand-signal*. As Cooper and John (1988) insightfully put it:

> *There is a coordination problem [in "Keynesian economies"] if low level equilibria could be avoided by a simultaneous increase in the output of all firms. However, in a decentralised system there may be more incentive for a single firm to increase production because this agent takes the action of the other given. Hence the "externality" is brought about the demand linkages that individual firms do not internalize.* [pag. 454]

Remarkably, all this has nothing to do with the purported efficiency of markets. On the contrary, it might well be that higher collective adjustment flexibility might yield worse equilibria/growth paths. The problem of coordination failures may be seen mainly as problem of *strategic complementarities*. An agent i is positively affected by the others $N-1$ agents behaviours or strategies: that is, in a game theoretic framework, the best response of agent i has a positive slope. Demand linkages (externalities) are the typical example of strategic complementarity in a Keynesian framework (see Solow and Stiglitz (1968) for an early formalization of the lack of aggregate demand). The nexus production-demand-wages is a paramount example: even though firms would like to pay the minimum possible salaries to reduce production costs, wages are, collectively, a crucial source of demand. Hence, cascades of feedbacks between wages, aggregate demand and unemployment can bring the economy to a path characterised by low (or high) levels of activity.

> *The problem that Keynes recognized was that wages can be too* flexible. *Indeed, when wages fall, people's income falls and their ability to demand goods falls as well. Lack of aggregate demand was the problem with the Great Depression, just as lack of aggregate demand is the problem today. Imposing more wage flexibility can result in exacerbating the underlying problem of lack of aggregate demand.* [Stiglitz (2013), pag. 10]

The paper presents an agent-based model (ABM) that investigates the effects of different "archetypes of capitalism" (on the general perspective see Boyer, 1988, Aoki and Dosi, 1992, Hall and Soskice, 2003, Soskice, 2007), in terms of regimes of labour governance – defined by different mechanism of wage determination, firing, labour protection and productivity sharing – upon (i) labour market regularities, and (ii) macroeconomic dynamics (long-term rates of growth, GDP fluctuations, unemployment rates, inequality etc..).

Indeed labour markets are characterised by rich institutional specificities reflecting the distinctive feature of labour as a quite special kind of commodity (cf. the insightful discussion in Solow, 1990). And such institutions are likely to yield significantly different patterns of labour utilization and mechanisms of wage formation. A clear-cut example is the dynamics of unemployment in U.S and U.K. vs. Continental Europe vs. Scandinavian Countries (within a vast literature, see e.g. Faggio and Nickell, 2007 and Nickell, 1997 for an extensive discussion on the differences across OECD countries in terms of employment rates and working hours patterns).

Let us start with some definitions of flexibility. According to J. Atkinson (1985) there are multiple dimensions of that notion, which can be distinguished as: (i) *functional flexibility*, (ii) *external numerical flexibility*, (iii) *internal numerical flexibility*, (iv) *financial flexibility*. *Functional flexibility* refers to the process of redeployment of labour tasks, mansions and required skills within a firm. As technical change proceeds, functional flexibility allows/requires labour force to update their competencies and behavioural repertoire. *External numerical flexibility* implies that workers can be quickly, cheaply and easily hired-fired. *Internal numerical flexibility* stands for flexible working time, via e.g. call-out rearrangements or flexible rostering. *Financial flexibility* which we shall call here, more straightforwardly, *monetary wage flexibility*, stands for the sensitivity of wages to supply/demand conditions and thus to unemployment rates. Here we shall address the effects of external numerical and wage flexibility in our ABM model.

The model is built upon the "Keynes meets Schumpeter" family of models (Dosi et al., 2010, Napoletano et al., 2012, Dosi et al., 2016b). As Stiglitz (2016) forcefully put it, a tall task of any satisfactory theory of macro dynamics ought to be able to account for the *endogenous emergence* of both mild fluctuations and deep recessions. In this respect, we believe, one obtains insightful results on the role of the interaction between endogenous demand formation and fiscal policies in Dosi et al., 2015b; the impact of finance and income inequality in Dosi et al., 2013.[1]

Here we want to focus on the role of wages and labour market rules. Wages are an element of cost affecting the competitiveness of individual firms. But the wage bill is also a crucial element of aggregate demand. Hence it could be that more flexible and "fluid" labour markets, while allowing for faster inter-firm reallocation of labour and lowering costs, may also render the whole economic system more fragile, more prone to recession, more volatile. In this work we investigate the conditions under which such a conjecture applies by exploring to what extent strategic complementarities may lead to coordination failures (and hence, multiplicity of possible growth paths).

On purpose, the aim of the model which follows is *not* to calibrate it to any empirical observation, but rather to show how its basic qualitative properties hold for alternative archetypical configurations. Still, we find revealing that the properties of "fragility" and potential for deep crises conditional upon wages misaligned with productivity and the ensuing increasing income inequality, predicated by our model, are quite in line with the historical circumstances which preceded both the Great Depression of the Thirties and current Great Recession. A remarkable pattern that they have in common is a *great*

[1]In turn, the K+S family of models belong to the broader family of Agent-Based evolutionary models (cf. Tesfatsion and Judd, 2006, LeBaron and Tesfatsion, 2008, Nelson and Winter, 1982). For related ABM which consider a decentralised labour market see Fagiolo et al. (2004), Dawid et al. (2008), Deissenberg et al. (2008), Riccetti et al. (2014) and Russo et al. (2015). See Fagiolo and Roventini (2012) for a survey on macro ABMs.

moderation of wages with excesses of nearly everything else. So for example, manufacturing weekly wages in the US fell from 29.48$ in 1920 to 23.12$ in 1922 (and reached 27.36$ in 1929) in a period characterised by a significant weakening of the unions (Wolman, 1933). Quite similarly, the share of wages in both GDP and corporate manufacturing value in most countries and most sectors in the two decades or more preceding the Great Recession dramatically decreased (for a detailed evidence, cf. Karabarbounis and Neiman, 2014). But, the two deep crises are different in the behaviour of wages *after* the eruption of the crisis itself. So for example, in the US they fell by 33.6% from 1929 to 1932 (Wolman, 1933, pag. 2). Conversely, they remained roughly stable in many OECD countries after 2008. And that, we conjecture in line with the model which follows, has been at the heart of the relative "mildness" of the more recent Recession vis-a- vis the Depression.

Our results show that, indeed, the more flexible are wages and employment, and the weaker are institutions supporting wages and workers' welfare, the more fragile is the economy. *Keynesian coordination failures* are more frequent, average unemployment and inequality are higher, and crises are more likely. Conversely, seemingly more rigid labour markets and labour relations are conducive to *coordination successes* with higher and smoother growth.

We shall proceed as follows: Section 2 outlines the stylised facts (and non-facts) which a satisfactory model of the functioning of the labour market and of wage formation ought to be able to address. Together, we discuss the successes and failures of incumbent models to do so. Section 3 presents the model. Finally in Section 4 we discuss the simulation results, their adherence to the foregoing stylised facts, and their implications in terms of relations between the dynamics of wages and that of other macro variables – aggregate demand, macro fluctuations, unemployment, incidence of crises.

2 The state of the art: facts and theories

2.1 The evidence

As mentioned, a robust way to discriminate among theories is to check their adequacy against a set of empirical regularities – i.e. "stylised facts" – which pertain to the domain of what one is meant to explain. We shall follow such a strategy also in the following, with the major caveat the truly stylised facts in this domain are few and far inbetween.

SF1 UNEMPLOYMENT IS A PERSISTENT AND STRUCTURAL PHENOMENON OF CAPITALIST ECONOMIES.

It was undoubtedly so during the Industrial Revolution in Britain and the subsequent Industrial Revolutions in catching-up countries; it is so even now in less developed countries ("the unlimited supply of labour" of Lewis (1954) still holds well) and it applies throughout the whole history of developed economies. Unemployment persistently fluctuates intertwined by major crises, such as in 1929 and in 2008, with unemployment reaching in many countries one fourth of the labour supply or more. The litmus test for any model, we believe, is to account for such a secular stylised fact. The other possible stylised facts are in comparison second order ones. Remarkably, on the theory side, whenever involuntary unemployment is even acknowledged – which is most often *not* the case – the drivers are identified almost exclusively on the *supply side*. Consider Blanchard and Wolfers (2000) among the most nuanced voices in this perspective: they propose a model where the interaction between aggregate shocks (e.g. changes in TFP and in the real interest rate, etc.) and institutional factors (coverage and duration of unemployment benefit systems, centralization and coordination level of wage determination, employment protection, labour taxes) determine the persistent unemployment rate. Indeed, essentially all supply-side factors. And it is also on this side that the roots of any persistence, in that view, should be found: the *hysteresis hypothesis* (Blanchard and Summers, 1986 and Ball, 2009) proposes that short-run unemployment rates affect also the long-run equilibrium unemployment rate (the NAIRU, Non Accelerating Inflation Rate of Unemployment) via the supply of labour itself.

SF2 Unemployment rates, real wages and monetary wages co-movements
A long-standing literature, pioneered by the evidence analysed by Phillips (1958) suggests an inverse relation between rates of change of *monetary* wages and unemployment rates. This has been indeed for a long-time a pillar of the "old" and later of the New Keynesian ones (DSGE with frictions or rigidities). The empirical evidence on such relation is all but conclusive: in fact it implies that the "queues" of unemployed people are able to influence the monetary wage rate paid by firms. Doubts on the Phillips curve are cast by Solow (1990) and more recently by Blanchard et al. (2015).

A much stronger empirical support goes to the *wage curve*, which relates *real* wages and unemployment rates (typically at local level): so, Blanchflower and Oswald (1994), in an extensive regional analysis covering twelve countries, found elasticities of around -0.1. Note that on the theoretical side a wage curve is not consistent with any interpretation of unemployment in terms of mismatching between labour demand and labour supply because in that case unemployment and wages should be positively correlated (see Blanchflower, 1995 and Blanchflower and Oswald, 2005 for extensive discussions). The wage curve seems to apply to both the short- and long-run (i.e. it is not a purely cyclical phenomenon), consistent with the presence of a bargaining process, according to which in case of high unemployment, unions would ask for low wages in order to ensure job positions, and/or efficiency wages, where in a depressed labour market workers would accept low wages, even though putting higher work efforts because of the threat of being easily substituted. In fact, the empirical wage curve is theoretically consistent with "unemployment as discipline device" (Shapiro and Stiglitz, 1984), or similarly, the Marxian reserve army. Conversely it is *not* consistent with any decreasing return production function, where increases in unemployment should be associated with lower marginal productivity of labour and lower wages.

SF3 The Beveridge curve
Firms expand and contract, hiring and firing workers, and workers – unemployed and sometimes employed ones – look for a job with, mixed success. However, changes in aggregate activity yield changes in the rates of job destruction so that unemployment and vacancy rates ought to be negatively correlated. The evidence on such *Beveridge curve* is discussed in Blanchard et al. (1989), Cooper et al. (2007).

SF4 Separation and hiring rates are highly volatile and to the same order of magnitude. Job-finding rates are pro-cyclical.
These set of stylised facts regards the flow of workforce, moving from unemployed to employed status or vice-versa (where the separation rate includes both firing and voluntary quitting), from unemployment to inactivity (or vice versa), from one job to another one (Yashiv, 2007). There is no consensus on which of the two components, whether the separation rate or the job-finding rate, drive unemployment fluctuations. The former view is sustained in the earlier studies by Blanchard et al. (1989) and Davis and Haltiwanger (1990), while the latter is suggested by more recent studies (Shimer, 2012). Overall, the high frequency volatility of both components hint at a rather turbulent labour market dynamics (at least in the U.S. to which most studies apply).

SF5 Unemployment and vacancy rates are one order of magnitude more volatile than productivity
As discussed in Cooper et al. (2007) and Shimer (2005), the standard deviation of both vacancies and unemployment is around ten times higher then the one of labour productivity (even if pro-cyclical too). And this is indeed a major puzzle for any *equilibrium*, *supply side* interpretation of unemployment fluctuations *cum* standard production functions (recall the Sheppard Lemma...).

SF6 The Okun curve

GDP growth rates and unemployment rates are negatively correlated. In particular, in its seminal paper Okun (1962) estimates that an increase of $2-3\%$ of GDP is associated with just 1% point increase in employment. Okun emphasizes how this relation is the result of the combination of many factors like the potential gains in productivity and the number of working hours. There is obviously no reason to believe that the coefficient remains constant over time and across countries. Nonetheless, what is relevant is the negative cross correlation which tells macroeconomists about a robust positive correlation between output growth rates and productivity growth rates (see among others Prachowny, 1993). The same evidence might be interpreted in a more structuralist perspective, in our view complementary to the Okun curve: under conditions of increasing returns, output growth is likely to yield *permanent* productivity increases. This is the neglected *Verdoon-Kaldor Law*: see Kaldor (1975), Verdoorn (1980), and McCombie and Ridder (1984).

SF7 Unemployment and Inequality are positively correlated

Income inequality has fortunately re-emerged as a focus in the recent economic debate. But what is the relation between unequal income distribution and unemployment? There are two complementary ones nearest our argument here. One, proposed in Stiglitz (2012) and in Stiglitz (2015), suggests that high income inequality induces a lack of aggregate demand which turns out in higher unemployment rates, having rich people a lower propensity to consume. An alternative interpretation goes conversely from unemployment to inequality: during recessionary phases low income workers are more severely hit by layoffs. This implies that income concentration diverts toward upper classes (see Heathcote et al., 2010). Maestri and Roventini (2012) find evidence of a positive cross correlation between inequality and unemployment in Canada, Sweden, and the US.

(NON) SF8 Negative correlation between labour market flexibility and unemployment rate

Of course a precious piece of evidence with bearing upon the results that follow concerns the relationship between the degrees of labour market "perfection" and unemployment rates. Needless to say, there is an unquestionable consensus among "mainstream" scholars that labour market rigidities are the source of unemployment. However, the evidence presented to support the structural reforms recipe is all but robust (Freeman, 2005). The well-known OECD (1994) Jobs Study was among the first studies to advocate the benefits from labour market liberalization. The report and a series of subsequent papers (including Scarpetta, 1996, Siebert, 1997, Belot and Van Ours, 2004, Bassanini and Duval, 2006) basically argued that the roots of unemployment rest in social institutions and policies such as unions, unemployment benefits, employment protection legislation. Unfortunately, at least an equivalent numbers of papers pointed out the fragility and unreliability of the empirical evidence used to support the claim. Particularly, Howell et al. (2007), reviewing the findings on the effects of protective labour market policies (PMLI) on unemployment, argue that the evaluation of the effects of PMLI has been biased by a number of factors: (i) the findings were largely theory driven discarding the empirical evidence, (ii) the explanatory powers of labour market institutions as sources of unemployment decline with the quality of the PMLI indicators and the sophistication of the econometric methodology, (iii) inclination to violate the mantra against endogeneity, phrasing simple cross-correlations as evidence of causation, (iv) remarkable differences in the magnitude of coefficients, statistical significance, and estimation methodology across the works. Even more distinctively, Oswald (1997), Baccaro and Rei (2007), Avdagic and Salardi (2013), Avdagic (2015) and Storm and Naastepad (2012) on more recent datasets find no compelling evidence on the revealed benefits of labour market liberalization. In fact, Adascalitei and Pignatti (2015) and Adascalitei et al. (2015) find that higher labour market flexibility *increases* short run unemployment rate and, together, reduces employment rates.[2]

2.2 The theories

What does the theory says about the foregoing stylised facts (and the lack of them)?

Remarkably, since the old debate between Malthus and Ricardo around two centuries ago, rhetorically won by the latter, and with the outstanding exceptions of Marx (partly) and Keynes, aggregate demand has been eschewed from the interpretation of all persistent regularities in economic phenomena. And the labour market ones are no exception.[3] In so far as involuntary unemployment is acknowledged at all, it is accounted for in terms of frictions or rigidities, under the heading of "stock models with rigidities" and "flow models with frictions". The former find their own root in some notion of NAIRU. These models introduce the idea of nominal rigidities, according to which nominal wage do not adjust to excess supply of labour. The sluggishness in the adjustment process has been typically formalised by means of the Phillips curve, notwithstanding its controversial empirics (see above). Indeed, when changes in the nominal wage growth rate are linked to price changes, the Phillips curve can be expressed both in terms of nominal or real price rigidities and the unemployment rate can be seen as deviation from the NAIRU cum inflationary pressures (see Lubik and Krause, 2014).

Within the same stream of literature, but with more emphasis on institutionally induced rigidities, models of the *genre* of Layard et al. (2005) determine the "natural rate" as the intersection of supply and demand curves, whose slopes are shaped by the purported rigidities on the labour market (e.g. union power, employment protection, wage benefits) and the product market (monopolistic competition, mark-up pricing, etc.) (e.g. see Blanchard, 2006). The Layard-Nickell-Jackman family of models are, in fact, stock models with institutional rigidities. The empirical counterpart of these models are usually panel regressions which try to estimate unemployment as the combined interactions of shocks and institutions (see Nickell et al., 2005).

And, finally, one ought to consider part of this overall perspective also the attempt to add price rigidities due to some sort of "objective" fixed costs within so-called New Classical models whereby no sort of expectational myopia is allowed (for an early attempt, cf. Calvo, 1983). And, indeed, this was basically the route taken later in order to incorporate "homoeopathic quantities of Keynesianism" in DSGE models.

Of course, none of the above family of models is microfounded, unless one deems the purported normative behaviour of any representative agent as an acceptable microfoundation.[4] Conversely, the literature on flow models with friction attempts precisely to do that, grounding it over an overwhelming micro evidence on job creation and destruction flows at the firm level (see Davis and Haltiwanger, 1990). Search and matching models focus on the dynamics of the workforce of the firm which, as Blanchard and Diamond (1992) put it, feature three processes: a labour demand specified in terms of job creation and destruction flows, a matching process between firms and workers, and a wage determination mechanism. They are microfunded, optimising models that address questions like: how unemployment and job vacancies are determined as *equilibrium* phenomena, what determines

[2] Even Blanchard (2006) recognises how establishing causality effects from panel data regressions is beyond the scope of the exercise, being the possible co-evolution between the dependent variable (unemployment) and the covariates (e.g. duration of unemployment benefit) extremely hard to identify.

[3] We were reminded of the Malthus-Ricardo debate by a recent work, unfortunately available only in Italian, by La Malfa (2015) on Keynes, who vehemently argues, after a thorough examination of the correspondence between the two, that the dominance of the Ricardian supply perspective has been a "disaster" for the progress of economic analysis for a century or so (Keynes, 1972 p. 97-98, as cited in La Malfa (2015)).

[4] For a devastating critique on the representative agent see Kirman, 1992 and Forni and Lippi, 1997 on the flaws of aggregation in macroeconomic models.

the transition from unemployed to employed states (and vice versa), ad what determines *equilibrium wages*. The "grains of sand" in these mechanisms are, at best, local informational imperfections. The benchmark remains a fluid and flexible labour market which would allow the best matching between firms and workers, thus minimising unemployment. At the same time, institutional rigidities (like unemployment benefits) remain, carrying with them higher salaries and lower rates of labour activity.

How do both streams of literature fare against the evidence? In our view rather poorly. In primis, neither of the two families of models is able to address the occurrence of repeated although relatively infrequent *deep crises* (Stiglitz, 2016) characterised by abnormally high unemployment rates (**SF1**). Even at a finer level of observation and, so to speak, in "normal" times both families appear to be unable to account, *first*, for unemployment fluctuations at business cycle frequencies. Stock models with rigidity seem largely off the mark, unless one postulates an unobservable stochastic process on aggregate supply (technological) shocks reflected by the observed employment time series. Here, one gets even beyond the "science fiction" of Real Business Cycle.

Second, search and matching (S&M) models, too, lack the ability to match business cycles frequencies, on several dimensions. They are patently inconsistent with any wage curve and are also unable to reproduce the empirical high volatility of vacancies and hiring which comes, as mentioned above, together with a much milder variability of labour productivity. Certainly, there is nowadays a broad consensus that the microfoundation of S&M models, i.e. the Nash bargaining process used for the wage determination is at odds with empirical evidence. The critique by Shimer (2005) and Cooper et al. (2007) is particularly relevant in this respect. Even if there are aggregate supply shocks on productivity, which we doubt, and even if they happen to be mildly pro cyclical, which we find questionable, the puzzle is that they get amplified by an order of magnitude in terms variability in the hiring/firing rates. In turn, this is obviously inconsistent with DSGE and S&M models.

Then what next? There is an alternative, largely unexplored, path. First and foremost, it acknowledges the possibility of multiple quasi equilibria as Krugman (2011) puts it. Which one is chosen crucially depends also on the mechanisms of coordination (or lack of it) in the labour market and the ensuing patterns of aggregate demand generation. Second, it builds on microfoundations which fully account for far-from-equilibrium interactions among agents *also on* the labour market, in addition to product and financial markets. Third, it takes on board the diversity of institutions governing market interactions and prices formation.

In this vein, unlike analyses that consider labour market dynamics as a purely or primarily as a supply side phenomenon, the route we are going to undertake here is a genuinely Keynesian one. It is not a fairytale of menu costs and arbitrary price rigidities. No even just an efficiency wage one. It is a story of "endemic" *coordination failures*. In that, institutional set-ups which might favour the reduction of frictions and thus, other things being equal, favour allocative efficiency, might as well reduce the overall rate of activity of the whole economy via a feedback mechanism that goes from wages to aggregate demand, from aggregate demand to labour demand, from labour demand to unemployment. Conversely, a relatively rigid regime, characterised by sticky wages and relatively low inter-firm labour mobility due to the high level of wages might well ensure relative stability and frequent full-employment states, notwithstanding all the frictions in the matching process.

3 The model

The model is a general *disequilibrium* agent-based one, populated by heterogeneous firms and workers who behave according to bounded rational behavioural rules. Building on the basic structure of the *Keynes+Schumpeter* model (Dosi et al., 2010) the present version allows for a process of decentralised worker allocation across firms (see Figure 1).

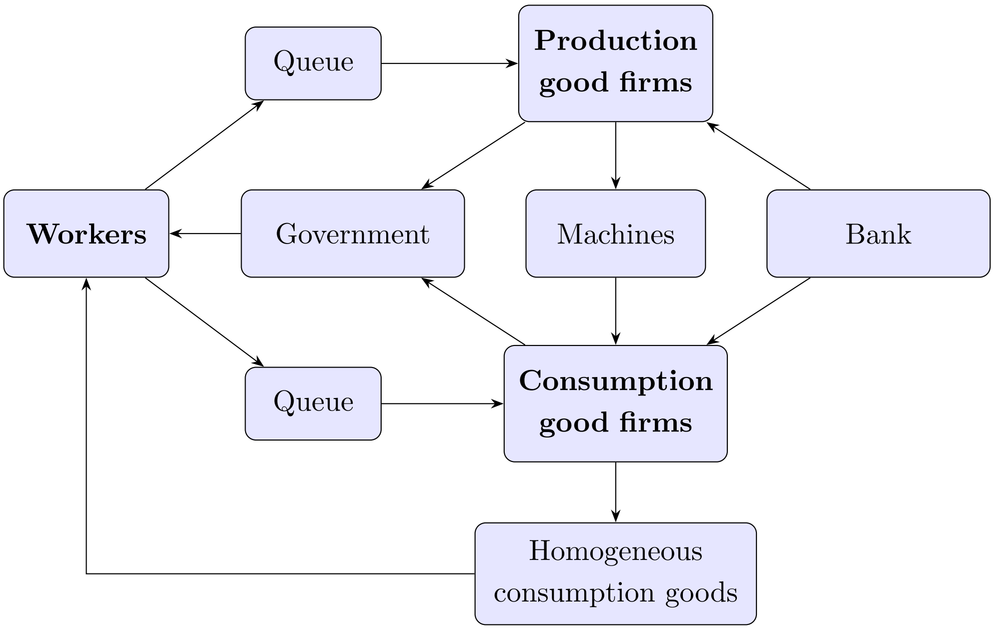


Figure 1: The model structure. Boxes in bold style represent heterogeneous agents populations

The economy is composed of three populations of heterogeneous agents, F_1 capital-good firms, (denoted by the subscript i), F_2 consumption-good firms (denoted by the subscript j), L^S consumers/workers (denoted by the subscript ℓ), plus a bank and the Government. Capital-good firms invest in R&D and produce heterogeneous machine-tools, whose productivity evolves over time. Consumption-good firms combine machines bought from capital-good firms and labour in order to produce an homogeneous product for consumers. There is a minimalistic financial system represented by a single bank that provides finance to firms only, so they can borrow to produce and invest (and pay interest on it). Workers submit job applications to a random subset of firms, which hire according to expectations about demand. Note that the firm demand for labour is *independent* from the wage levels (alike an ensemble of fixed coefficient production functions). Consumption-good firms form adaptive expectation about future demand for product and decide thereafter their desired demand for labour.[5] The government levies taxes on firms and pays unemployment benefits.

In the following we are going to present and discuss two alternative labour market regimes, labelled *Fordist* and *Competitive*, and variations thereof. They entail distinct and explicit microfounded labour markets, distinguished by some key aspects, like the search activity, the firing rules adopted by firms and the mechanism of wage determination. Let us consider the model depicted in Figure 1 at some more detail. The Appendix shows the bare-bone model, Tables 8 and 9 present the labour market variables and parameters set-up. The full model is presented in details in Dosi et al. (2010) and summarised in the Appendix.

3.1 The capital- and consumption- good sectors

The capital-good industry is the locus where innovation is endogenously generated in the economy. Capital-good firms develop new technologies or imitate the ones of their competitors in order to produce and sell more productive and cheaper machine tools that are supplied to consumption-good firms. Capital-good firms invest a fraction of their past profits and/or borrowed funds in R&D in

[5]Following a typical Keynesian expectation formation whereby past demand affect investment and production decisions today.

order to discover new machines or copy existing ones. They produce machine-tools by employing only labour and set prices as a fixed mark-up over unit costs of production.

Consumption-good firms produce homogeneous goods employing capital (composed by different vintages of machines) and labour, under constant returns to scale. Desired production, as mentioned, is determined according to adaptive demand expectations. Given the actual inventories, if the capital stock is not sufficient to produce the desired production, consumption-good firms invest in new machines in order to expand their production capacity (if they have accumulated profits or are able to access bank credit). They may also invest to replace old machines according to a payback-period rule. As new machines embed state-of-the-art technologies, the labour productivity of consumption-good firms increases over time according to the mix of vintages of machine present in their capital stocks. The capital-good market is characterized by imperfect information and Schumpeterian competition driven by technological innovation oriented to the reduction of machine costs and the increase in machine productivity. Machine-tool firms signal the price and productivity of their machines to their actual customers as well to of potential new ones. Consumption-good firms choose in every period their supplier comparing the price and the productivity of the machines they are aware of.
Imperfect information is also the normal state of the consumption-good market. As a consequence, consumers cannot instantaneously switch to the most competitive producer even if the good is homogeneous. Consumption-good firms fix their prices applying a variable mark-up on their production costs, heuristically trying to balance higher profits and market share changes. Thus, mark-up dynamics is driven by the evolution of the latter: firms increase their price whenever their market share is expanding and vice versa. In turn, market shares evolve according to a (quasi) replicator dynamics: more competitive firms expand while firms with relatively lower competitiveness level shrink, or die.

3.2 Labour market regimes

Let us focus here on the labour side of the model exploring the properties of different alternative of searching, firing and wage determination mechanisms. We comparatively study two archetypical types of decentralised labour markets, which we shall call the *Fordist regime* and the *Competitive regime*. The two regimes capture alternative *wage-labour nexus* in the words of the *Regulation Theory*[6] (see, within a vast literature, Boyer and Saillard, 2005). Three main domains of the capitalist dynamics are especially relevant for our analysis, namely: (i) *the accumulation regime* which entails the relation among technological progress, income distribution and aggregate demand, (ii) *the institutional forms* which encompass the wage-labour nexus (Freeman, 2007) and nature of the State, (iii) *the mode of regulation* which is the mechanism by which the former two categories evolve, develop and interact. The modes of regulation capture the specificities of disequilibrium process of adjustments in the accumulation patterns and in the coordination among different types of actors. The dynamics entails phases of "smooth" coordination, mismatches, cycles and crises.

The two regimes are telegraphically sketched in Table 1. Under the *Fordist regime* wages are insensitive to labour market conditions but indexed to productivity. There is a sort of lifetime employment (firms fire only when their profits are negative) matched by the loyalty of the workers to their employers (employed workers do not seek for alternative occupations). Labour market institutions contemplate a minimum wage indexed on productivity and unemployment benefits.

Conversely under (different versions of) the *Competitive regime*, wage changes respond to unemployment. Also employed worker with some probability search for notionally more rewarding jobs. Firms fire their excess workforce given their planned production. Minimum wages are only partially indexed to productivity, if at all and unemployment benefits might or might not be there.

[6]For a recent low dimensional formalization of the Regulation Theory, see Dosi et al. (2015a).

Regime	Fordist	Competitive
Wage sensitivity to unemployment	rigid	flexible
Search intensity	unemployed only	unemployed and employed
Firing	under losses only	shrinkage on production
Unemployment benefits	yes	yes/no
Minimum wage productivity indexation	full	full/partial/no

Table 1: The two archetypical labour regimes

3.2.1 Matching and hiring

The aggregate supply of labour L^S is given. Total desired labour stock by any firm is determined by the ratio between the desired production $Q^d_{j,t}$ and the average productivity of the employed capital stock $A_{j,t}$.

$$L^d_{j,t} = \frac{Q^d_{j,t}}{A_{j,t}} \tag{1}$$

In turn, desired production is based on expected demand $D^e_{j,t}$, computed via a simple adaptive rule:[7]

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

where $D_{j,t-h}$ is the demand actually faced by firm j at time $t-h$ (h is an integer and $g \geqslant 0$ is a function). The desired level of production $Q^d_{j,t}$ depends on the expected demand as well as on the desired inventories $N^d_{j,t}$ and the actual stock of inventories left from previous period $N_{j,t-1}$:

$$Q^d_{j,t} = D^e_{j,t} + N^d_{j,t} - N_{j,t-1} \tag{3}$$

If the desired capital stock (K^d_j) – computed as a function of the desired level of production – is higher than the current capital stock, firms invest (EI^d_j) in order to expand their production capacity:

$$EI^d_{j,t} = K^d_{j,t} - K_{j,t} \tag{4}$$

In each period, according to the dynamics of the market, firms have to decide whether to hire workers. The decision is taken according to the expected production $Q^d_{j,t}$. In case of an increase in production, $\Delta L^d_{j,t}$ new workers are hired in addition to the existing people $L_{j,t-1}$:

$$\text{if } \Delta Q^d_{j,t} = Q^d_{j,t} - Q_{j,t-1} > 0 \Rightarrow \text{ hire } \Delta L^d_{j,t} = L^d_{j,t} - L_{j,t-1} \text{ workers} \tag{5}$$

More precisely, under the redundancy rules of the Competitive regime an increase in the desired production always entails a positive variation in labour demand. Not so under the Fordist regime wherein labour hoarding is always a possibility. Each firm j will get, in probability, a fraction of the number of applicant workers ωL^a in its candidates queue, proportional to firm market share $f_{j,t-1}$:

$$L^s_{j,t} = \omega L^a f_{j,t-1}, \quad \omega L^a > 0 \tag{6}$$

where ω is a scaling factors depending on the number of queues each job seeker is allowed to join and $L^s_{j,t}$ is the number of workers who are in the queue of firm j. When $\omega > 1$ workers apply to more than one firm at a time, so firms may not be able to hire all workers in their queue. Considering the

[7]Note that 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 measures of performance, see Dosi et al. (2006) and Dosi et al. (2016a).

workers in the queue $\{\ell^s_{j,t}\}$, each firm has to select to which worker ℓ propose its wage offer. The set of desired workers $\{\ell^d_{j,t}\}$, among those in the queue, is defined as:

$$\{\ell^d_{j,t}\} = \{\ell_{j,t} \in \{\ell^s_{j,t}\} : w^r_{\ell,t} < w^o_{j,t}\}, \quad \{\ell^d_{j,t}\} \subseteq \{\ell^s_{j,t}\} \tag{7}$$

that is, the firm targets workers that would accept its wage offer $w^o_{j,t}$, considering the wage $w^r_{\ell,t}$ requested by them. So, the number of effectively hired workers is $\#\{\ell^d_{j,t}\} = L_{j,t} \leq \Delta L^d_{j,t} \leq L^s_{j,t}$, given that each firm will hire a number of workers up to its own demand or to all workers in its queue, whatever is lower. To $L_{j,t}$ workers, with the lowest requested wages, is offered a job.

3.2.2 Search, wage determination and firing

The search, wage determination and firing processes differ between the two regimes.

Fordist regime

As mentioned, in the Fordist regime we do rule out any job search by employed workers: they do not quit voluntary and only unemployed people search for a job and firms don't fire except if they are incurring losses. Concerning wage determination, wages are unilaterally offered by firms and are determined as follows:

$$w^o_{j,t} = w^o_{j,t-1}(1 + WP_{j,t}), \text{ if } WP_{j,t} > 0 \tag{8}$$

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

$$WP_{j,t} = \psi_1 \frac{\Delta A_t}{A_{t-1}} + \psi_2 \frac{\Delta A_{j,t}}{A_{j,t-1}} \tag{9}$$

with A_t the aggregate labour productivity and $A_{j,t}$ the firm specific labour productivity. A distinctive feature of the regime is that gains in labour productivity and hence, indirectly the benefit from innovative activities conduced by firm, are passed trough wages. Moreover, wages are not only linked to firm specific performance but also to the aggregate performance of the economy. Finally, note that $w^o_{j,t}$ is applied to *all* workers of firm j, so there is no intra-firm differential in wages. Indeed the Fordist regime describes a wage-labour nexus where worker purchasing power is linked with productivity gains for firms: the sum of ψ_1 and ψ_2 act as an institutional parameter which establishes the division of productivity gains between firms and workers. Under the Fordist regime it is straightforward to set it equal to 1. This wage determination process induces a twofold virtuous cycle: one which goes from productivity to wages and the other from investments to profits.

Each firm can afford to pay a salary up to a *break-even wage* $w^{MAX}_{j,t}$ that is the wage compatible with zero unit profits. The maximum wage is defined as the product between prices $p_{j,t-1}$ times expected productivity $A_{j,t-1}$:

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

Firms fire workers only when suffering losses (negative profits $\Pi_{j,t-1}$), that is, *real* revenues are lower than effective costs:

$$\Pi_{j,t-1} < 0 \Rightarrow \Delta L^d_{j,t} < 0 \tag{11}$$

Historically, the "Golden Age", that is the three decades after WWII, notwithstanding inter-country variations, quite closely resembles such Fordist wage-labour nexus.

Competitive regime

The social compromise embodied in the Fordist Regime is irrelevant in the Competitive setting wherein the wage determination is flexible to labour market conditions. Workers can quit, searching for better jobs, sending applications in any period to a given number of firms. Employment-to-employment movement are then allowed. Workers have a reservation wage equal to the unemployment benefit w_t^u they would receive in case of unemployment. This is an aggregated level variable. The requested worker salary is a function of the individual unemployment conditions. If the worker has been unemployed in the previous period, his wage request $w^r_{\ell,t}$ will be weakened by a lower degree of bargaining power. In facts, she will request the maximum between the reservation wage (aggregate variable) and its own satisfying wage $w^s_{\ell,t}$, which includes the recent worker-wage history:

$$w^r_{\ell,t} = \begin{cases} \max(w_t^u, w^s_{\ell,t}) & \text{if } \ell \text{ is unemployed in t-1} \\ w_{\ell,t-1}(1+\epsilon) & \text{if } \ell \text{ is employed in t-1} \end{cases} \tag{12}$$

being ϵ a positive parameter. The satisfying wage is defined as:

$$w^s_{\ell,t} = \frac{1}{T_s}\sum_{h=1}^{T_s} w_{\ell,t-h}, \quad T_s > 0 \tag{13}$$

that is the moving average salary of the last T_s periods (parameter). After having received applications from workers, the wage offered by a firm corresponds to the minimum amount that satisfies enough workers in its queue, considering the required number of workers to hire for the period ($\Delta L^d_{j,t}$). Therefore, it is the higher wage among the smallest set of the cheapest workers in the queue:

$$w^o_{j,t} = \max w^r_{\ell,t}, \quad \ell \in \{\ell^d_{j,t}\} \quad and \quad \#\{\ell^d_{j,t}\} \leq \Delta L^d_{j,t} \tag{14}$$

The received salary $w_{\ell,t}$ is always a satisfying one. But, in each period workers may search for better-paid jobs. If they do, they decide whether quitting or not from firm j, according to the rule

$$\text{quit if} \quad w^o_{n\neq j,t} > w^r_{\ell,t-1} \tag{15}$$

that is, a worker ℓ quits firm j if she receives an wage offer $w^o_{n\neq j,t}$ from at least one firm n among the others that is strictly higher than its own required wage. In this set-up, the unemployment condition becomes crucial in determining the wage request: unlike the Fordist case where both firm level and aggregate level variables enter in the wage determination, here only individual unemployment status does affect wage determination. This implies that wages are respondent and flexible to unemployment condition.

Firing occurs whenever firm j *desires* a shrinkage of its production, $\Delta Q^d_{j,t}$, irrespective to its *real* profitability or to the medium- and long-term perspectives for it:

$$\Delta Q^d_{j,t} < 0 \Rightarrow \Delta L^d_{j,t} < 0 \tag{16}$$

This specification models what we called above *numerical flexibility*: firms are free to fire without encountering any institutional restriction. Manpower is flexible and can easily hired and thrown out. Historically, the Competitive regime qualitatively matches both the pre 1929 crisis and to some extent also the Thatcher-Reagan periods, characterised by a low level of employment protection legislation or at least by its reduction.

3.3 Government sector and closure of the model

Unemployed workers receive a subsidy (w_t^u) which is a fraction of the current wage:

$$w_t^u = \psi \frac{1}{L^S} \sum_{\ell=1}^{L^S} w_{\ell,t-1}, \quad \psi \ [0,1] \tag{17}$$

Given the total labour demand L_t^D, the total amount of unemployment subsidies to be paid by the Government (G_t) is:

$$G_t = w_t^u (L^S - L_t^D) \tag{18}$$

We assume workers fully consume their income.[8] Accordingly, desired aggregate consumption C_t^d depends on the income of both employed and unemployed workers plus the desired unsatisfied consumption from the previous period (the $C_{t-1}^d - C_{t-1}$ term):

$$C_t^d = \sum_{\ell=1}^{L^S} w_{\ell,t-1} + G_t + (C_{t-1}^d - C_{t-1}) \tag{19}$$

$$C_t = \min(C_{t-1}^d - Q_t^2), \quad Q_t^2 = \sum_{j=1}^{F_2} Q_{j,t} \tag{20}$$

being C_t the effective demand, that is bounded by the effective production of firms in the consumption-good sector Q_t^2. Taxes paid by firms on their profits are gathered by the Government at the fixed tax rate tr. Finally, the Government (except in the most extreme competitive set-ups) establishes an institutional minimum wage which imposes a lower bound to firm specific wage setting behaviour:

$$w_t^{minPolicy} = w_{t-1}^{minPolicy} \left(1 + \psi_1 \frac{\Delta A_t}{A_{t-1}}\right) \tag{21}$$

The dynamics generated at the micro level by the decisions of a multiplicity of heterogeneous adaptive agents and by their interactions is the explicit microfoundation for all aggregate variables of interest (e.g., output, investment, employment).

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

$$\sum_{i=1}^{F_1} Q_{i,t} + \sum_{j=1}^{F_2} Q_{j,t} = Q_t^1 + Q_t^2 = Y_t = C_t + I_t + \Delta N_t, \quad Q_t^1 = \sum_{i=1}^{F_1} Q_{i,t} \tag{22}$$

3.4 Timeline of the events

1. Machine-tool firms (sector 1) perform R&D, trying to discover new products and more efficient production techniques and to imitate the technologies and the products of their competitors. New machines, when found, are characterised by higher productivity in their production (i.e. they are cheaper) and/or in their use. Capital-goods producing firms signal their machines to consumption-good firms.

[8] The above 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 fashion (e.g. Kaldor, 1955), the propensity to consume out of profits is lower that that out of wages.

2. Consumption-good firms (sector 2) decide how much to produce and invest. If gross investment is positive, consumption-good firms choose their supplier and send their orders. Moreover, their desired production determines firm-specific labour demand.

3. In order to fulfil their production and investment plans, firms first allocate their cash-flows and they, if need borrow from a bank up to a multiple of their cash flows.

4. Each firm determines how many positions have to be open, in front of which job-seekers stochastically "queue" (which in one regime are made only by unemployed workers and in the other also by employed seekers).

5. Depending on the wage setting regimes, wages are set and vacancies are partly or totally filled.

6. The Government pays unemployment subsidies.

7. Imperfectly competitive consumption-good market opens. The market shares of firms evolve according to their price competitiveness.

8. Firms in both sectors compute their profits, repay debt and distribute dividends.

9. Entry and exit take places. In both sectors firms with near zero market shares or negative net liquid assets are eschewed from the two industries and replaced by new ones.

10. Machines ordered at the beginning of the period are delivered and become part of the capital stock at time $t + 1$.

11. At the end of each period, aggregate variables (e.g. GDP, investment, employment) are computed, summing over the corresponding microeconomic variables.

3.5 The explored regimes

Below we shall analyse the two regimes and some variants thereof, comparing their performance in terms of both short and long-run dynamics. More precisely we shall study the following five alternative scenarios:

1. Fordist (which we shall consider the reference set-up).

2. Competitive with full indexation of minimum wage and unemployment benefits.

3. Competitive with partial indexation of minimum wage and no unemployment benefits.

4. Competitive with full indexation of minimum wage and no unemployment benefits.

5. Competitive without minimum wage and without unemployment benefits.

4 Empirical Validation

Let us start by empirically validating the model and present a set of stylised facts that we are able to replicate, in addition to the long list of stylised facts both at the firm and at the macro-level which the incumbent family of the K+S models is able to reproduce (see Dosi et al., 2016b, for an extensive discussion). Table 2 recalls all such empirical regularities with the ones presented and extensively discussed in the current paper in bold type. In what follows our focus will be on the empirical regularities of the labour market discussed in Section 2.

Firm level SF	Aggregate level SF
Skewed firm size distribution	Endogenous self-sustained growth with persistent fluctuations
Fat-tailed firm growth rate distribution	Fat-tailed GDP growth rate distribution
Productivity heterogeneity across firms	Relative volatility of GDP, consumption and investment
Persistent productivity differentials among firms	Cross-correlation of macro variables
Lumpy investment rates at firm-level	Pro-cyclical aggregate R&D investment
	Persistent unemployment
	Wage curve
	Beveridge curve
	Okun curve
	Separation and hiring rates volatility
	Matching function
	Productivity, unemployment and vacancy rates volatility
	Unemployment and inequality correlation

Table 2: Stylised facts matched by the model

In Figures 2, 3, 4, 5 we present the results for both the Fordist and the Competitive regimes (in each most institutionally rich form, i.e. set-up 2, above). Figures 2.a and 2.b show the output of a bandpass filter (BPF parameters 6, 32, 12) applied on unemployment, vacancy and productivity (in logs), for the two regimes respectively.[9] Productivity presents a longer *period* than unemployment and vacancies, consistent with the long-run trend shown in Figures 2.c and 2.d. Figures 3.a and 3.b illustrate the vacancy-unemployment (v/u) ratio and the labour productivity, both constructed like in Shimer (2005). The v/u ratio and productivity are expressed as deviations from a Hodrick-Prescott filter (HP smoothing parameter 10^5), this time to remove only long-term trends. Consistently with empirical data, the range of oscillations of the v/u ratio is one order of magnitude higher than that of the labour productivity. In doing that the model answers to the Shimer critique and outperforms a large body of search and matching models. Figures 3.c and 3.d show the separation probability produced by the model; additionally Figures 4 and 5 report the Beveridge curve and the Matching function, and the Wage and the Okun curves respectively.

Even if the general dynamics between the two regimes may look similar, several features are markedly different. Comparing the Wage and the Okun curves, for instance, while there is no significant inclination in the Fordist regime, confirming a wage-labour nexus wherein wages are insensitive to unemployment condition and output growth cannot be fostered by reducing unemployment, a steep negative correlation emerges in the Competitive one, where wages are much more influenced by the unemployment rate. Additionally, it should be noted that the matching function – the relation among the probability of finding a job and v/u – has a negative inclination in the Fordist regime and, conversely, a positive one in the Competitive one more in line with contemporary empirical evidence. This important difference attains to the specification of the search activity: in the Fordist regime only unemployed people search for a job, then the higher the number of unemployed people consequently the lower is v/u and the higher is the job finding rate. This justifies the negative correlation between the two variables. However, when employed people are also job-searching, as in the Competitive regime, this mechanism nullifies and the expected positive correlation is recovered.

[9] As known, the filtering allows to identify frequency components of the series, detrending them and isolating business cycle components (see Baxter and King, 1999).

More in details, Table 3 illustrates the correlation structures of the model for the labour market in the two set-ups. In those tables we replicate the analysis performed in Shimer (2005), where the labels stand, respectively, for unemployment (u), vacancy (v), job finding (f), separation (s) and productivity (p). The latter Table shows how the Fordist regime matches all but one result, namely the job finding rate correlation, consistently with the negative slope of the matching function discussed above. The unemployment-vacancy correlation is negative, the separation probability is negatively correlated with vacancy and positively correlated with unemployment. Productivity is negatively correlated with the separation rate. In reference to Table 3, the Competitive regime is even better in matching (recent) empirical data while keeping immune to the Shimer critique: the standard deviation of v/u is one order of magnitude higher than the productivity one. Conversely, the Fordist regime, being most of the time in full employment, exhibits a lower level of unemployment variance as compared to (relatively recent) empirical data.

Table 4 illustrates the long-run dynamics of GDP, consumption, investment, productivity and real wage. Augmented Dickey-Fuller (ADF) tests indicate the presence of unit roots in most cases, justifying the application of the BPF. All variables grow in the range ($2.5\% - 3.0\%$) in both regimes, indicating the push represented by the Schumpeterian "engine" in the supply side, as detailed in Dosi et al. (2010). We shall come back to the long-run results of the model in next section. Finally, Tables 5 and 5 show the correlation structure between GDP and several relevant macro variables (*ibid.*).

5 When more flexibility yields more fragility

If the reader is convinced of the robustness of the K+S model by its ability to reproduce the large ensemble of stylised facts discussed above, then she will might follow us in its use as a "policy and institutional laboratory" able to investigate the macro effects of different labour market set-ups. In particular we can compare, other things being equal, a rigid regime – which we labelled Fordist – with a Competitive one, characterised by the absence of labour protection (i.e. no firing restriction for firms that can freely throw out labour force in excess); flexible wages; and, in its extreme version no institutionally determined lower bounds to wages and no safety nets for the unemployed. We compare the two archetypes in terms of (i) long-run rates of GDP growth; (ii) volatility of growth rates themselves; (iii) likelihood of crises; (iv) productivity growth; (v) average unemployment rates; (vi) frequency of full employment periods; (vii) average tenure rates of the workforce; (viii) concentration coefficient of wage levels (Gini index as such a measure of inequality, here within the labour force).

First, let us compare the Fordist regime with the most extreme version of the Competitive one, basically institution-free, with no employment protection and also with no minimum wage and no unemployment benefits. Note that the latter is the nearest to textbooks "market perfection". Well, under such perfection the whole system is always near to collapse (cf. last column of Table 7: the *long-term* rate of growth is two order of magnitude lower (basically zero) and the *short-run* is equally dismal with extremely high unemployment rates, higher overall volatility and higher inequality.[10]

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

Next, let us compare the Fordist regime with other milder forms of Competitive regimes, embedded nonetheless into institution of wage and income support. Figure 6.a shows the aggregate patterns

[10] Note that, here and throughout we do not want to "calibrate and match": rather our purpose is to emphasize robust qualitative comparisons across set-ups.

of GDP, consumption and investment in the other four alternative scenarios. The model is able to generate long-run economic growth in all the four set-ups. Nonetheless, the levels of the three variables are evidently different in the four cases (the vertical axis is in log). This is due to the different initial institutional conditions, as in the long-run the paths remain approximately parallel.[11] The Competitive regime can generate the same output level of the Fordist *only* under full indexation of the minimum wage (i.e., an integral productivity pass-trough with $\psi_1 = 1$) and significant unemployment benefits. In fact, Figure 6.b illustrates an enormously high structural level of unemployment, which in the two Competitive set-ups without any form of State subsidy (cases 3 and 4) is around 50%.[12] The dynamics of real wages matches that of GDP: cf. Figure 6.c, which shows a clear divergence of the growth paths, with an obvious impact on the income distribution between capitalists and workers, given GDP growth rates are similar in all scenarios. Finally, Figure 6.d illustrates the time evolution of average mark-up and the Gini index. As the latter shows, the distribution of wages among workers becomes particularly skewed when wages may vary within the same firm and no form of welfare policy does mitigate income disparity.[13]

Figures 7 and 8 presents both the short- and long-run dynamics of the four scenarios (except the extreme Competitive one discusse above) by the direct comparison of key macro variables. The Competitive set-ups show an overall fragile and more prone to crises dynamics when compared to the Fordist, even in presence of active welfare policies. In fact, volatility of GDP (Figure 8.b), likelihood of crises (Figure 8.c), unemployment rate (Figure 8.d) are significantly higher in the competitive scenarios. Conversely, the Fordist case is in full employment for about 60% of the simulation time. Productivity growth is significantly lower in the Competitive scenarios 3 and 4. And finally, in the Competitive regimes inequality *even among workers* is higher and the more so the lower the constraints in wage settings.

Table 7 presents the four specifications for the Competitive set-ups as a ratio with respect to the Fordist case (the baseline). We perform a two means t test comparing whether the average values of the four scenarios for the tested variables are significantly different from the baseline. The p-values[14] reported show how the markedly under-performing Competitive regime – in all tested specifications – is significantly worse than the Fordist one.

[11]The different initial institutional conditions are the partial indexation of the minimum wage and the lack of unemployment benefits. Dosi et al. (2010) identifies this arrangement with a weak "Keynesian engine".

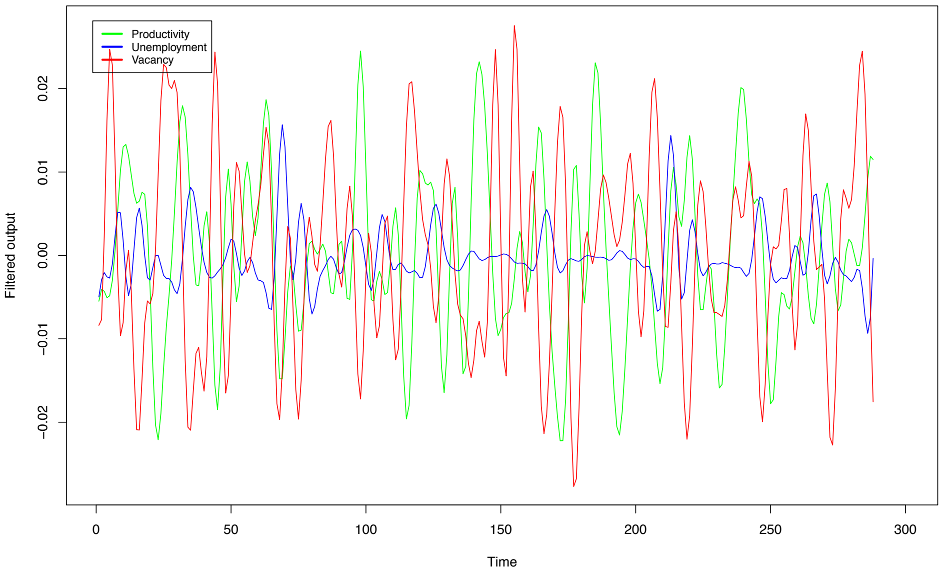
[12]Indeed, the Fordist Regime shows a lower unemployment level and a higher activity level also when unemployment benefit are set to zero and the minimum wage is partially indexed, as in the case of competitive scenarios 3 and 4.

[13]Note that in our model for sake of simplicity, and also in order to make an "a fortiori" argument, we do not have either different skills or learning by doing.

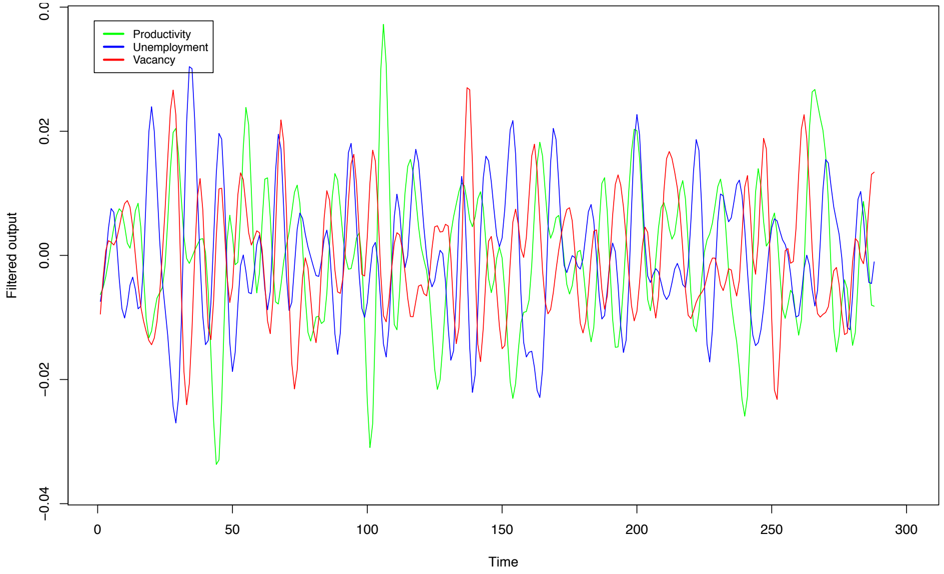
[14]The test H0 is that there is no difference between the particular scenario variable average and the baseline.

Figure 2

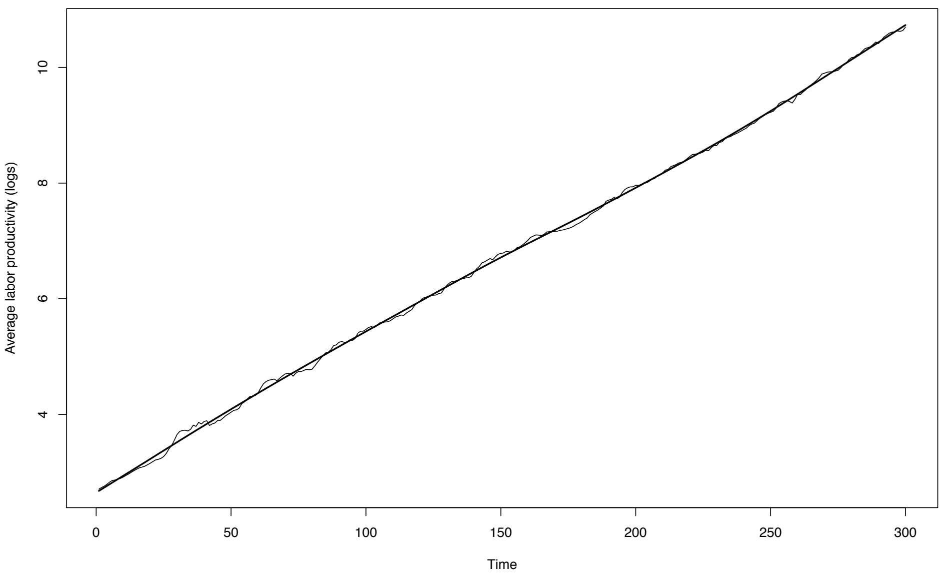
(a) BPF(6,32,12) productivity, unemployment and vacancy - Fordist



(b) BPF(6,32,12) productivity, unemployment and vacancy - Competitive



(c) Average log labour productivity - Fordist



(d) Average log labour productivity - Competitive

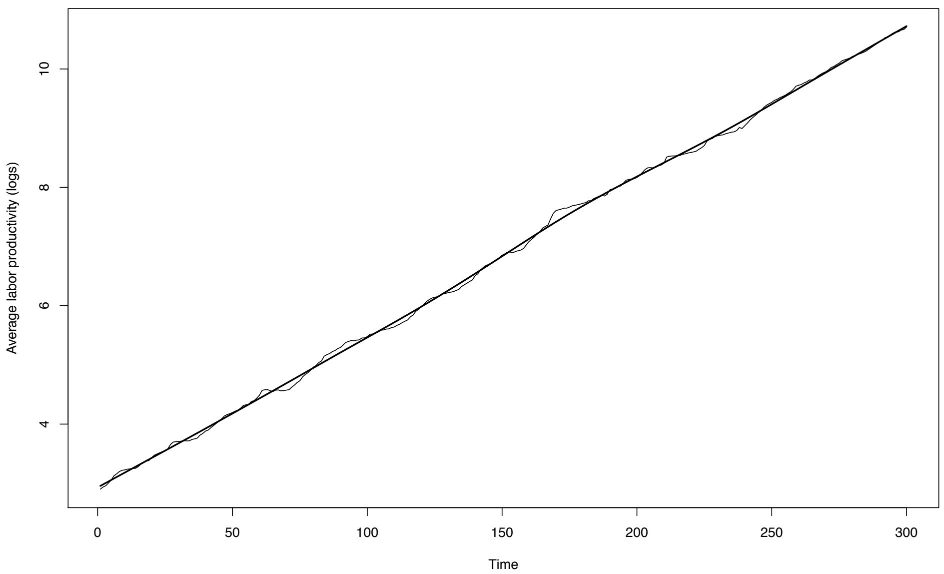
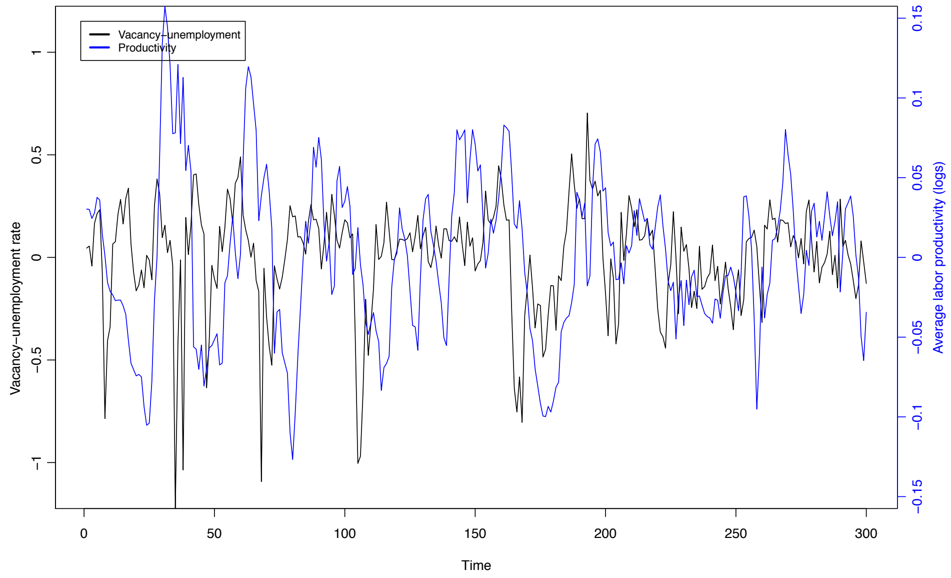
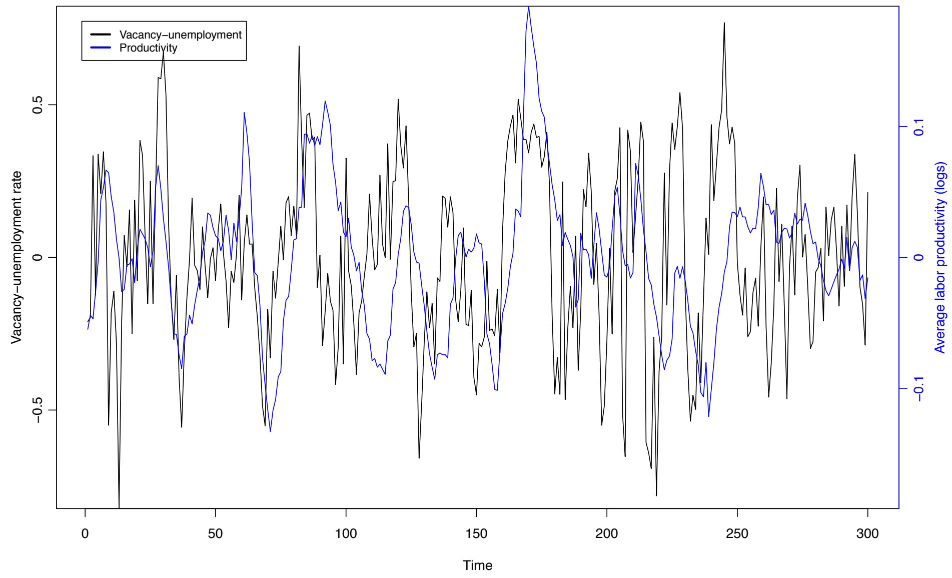


Figure 3

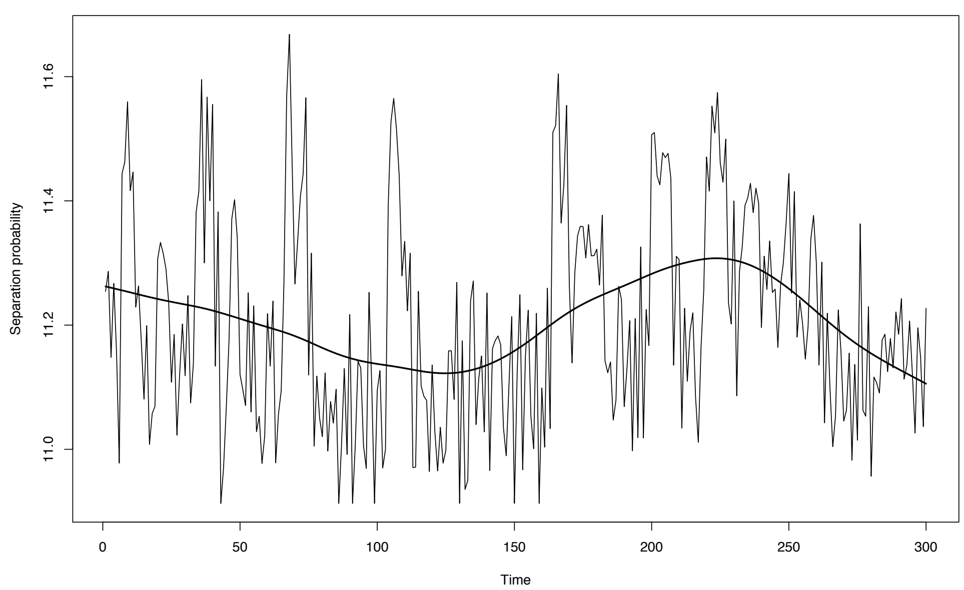
(a) Vacancy-unemployment vs productivity standard deviations - Fordist



(b) Vacancy-unemployment vs productivity standard deviations - Competitive



(c) Periodic separation probability (HP filter trend and deviation) - Fordist



(d) Periodic separation probability (HP filter trend and deviation) - Competitive

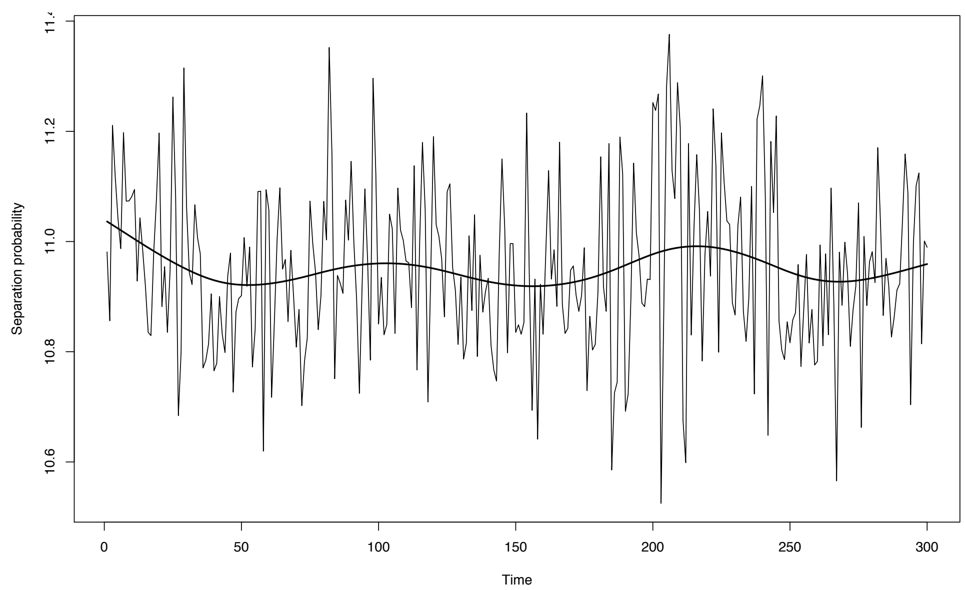
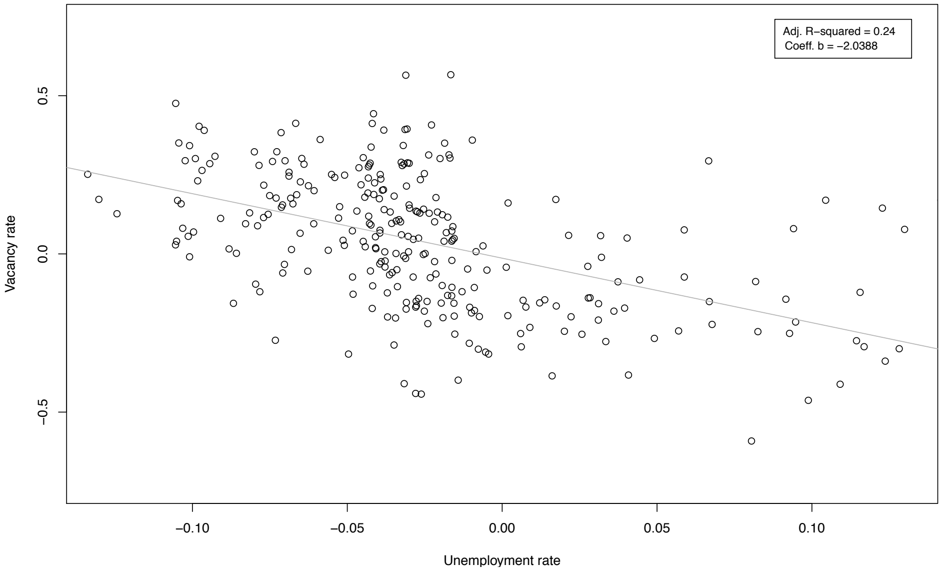
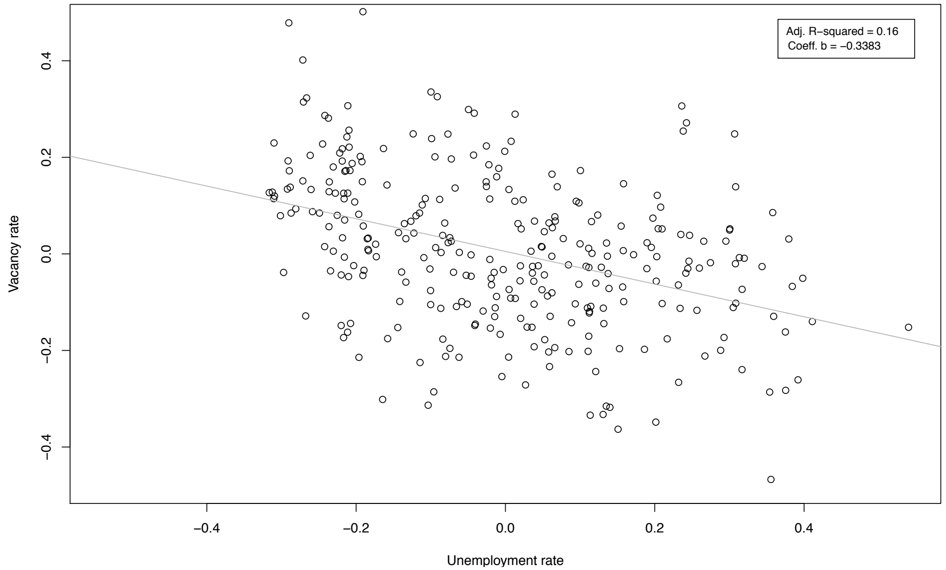


Figure 4

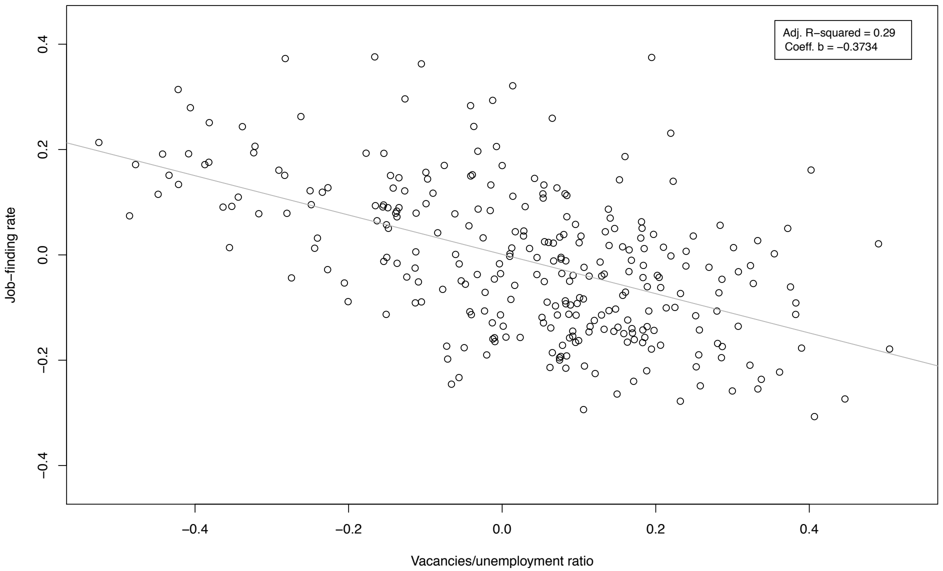
(a) Beveridge curve - Fordist



(b) Beveridge curve - Competitive



(c) Matching function - Fordist



(d) Matching function - Competitive

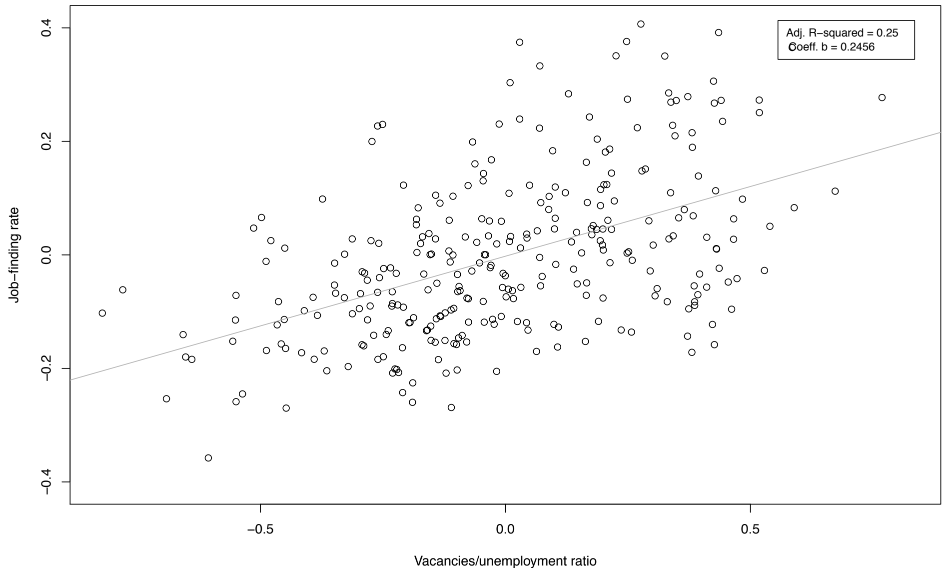
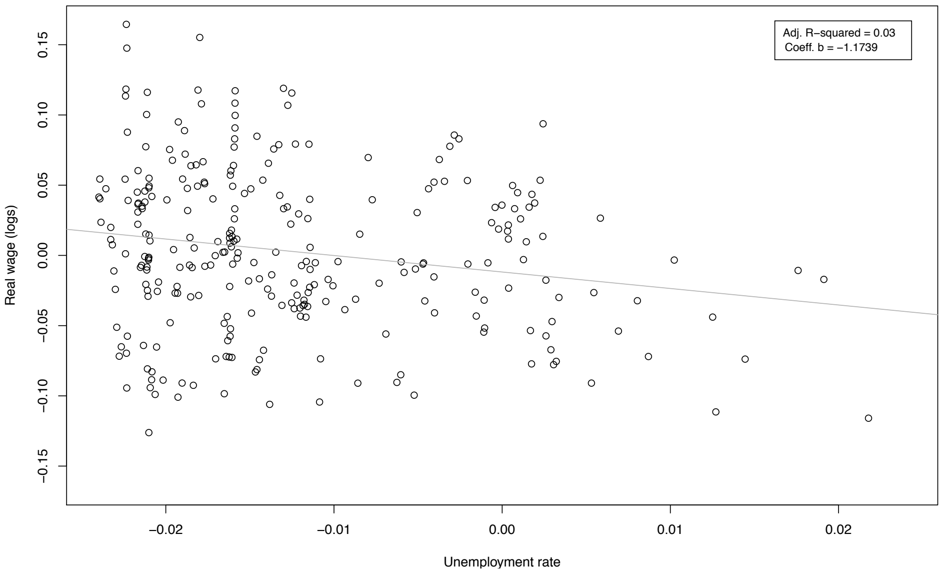
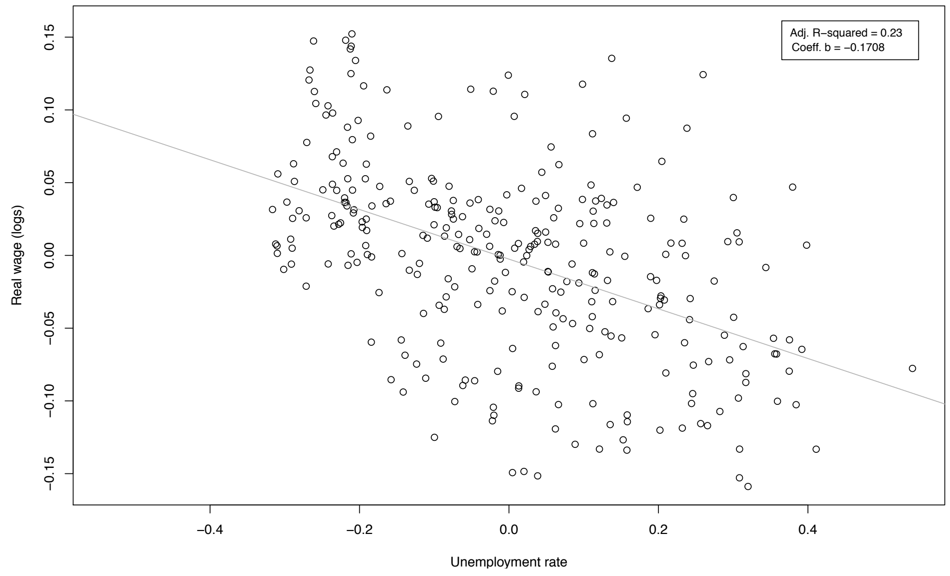


Figure 5

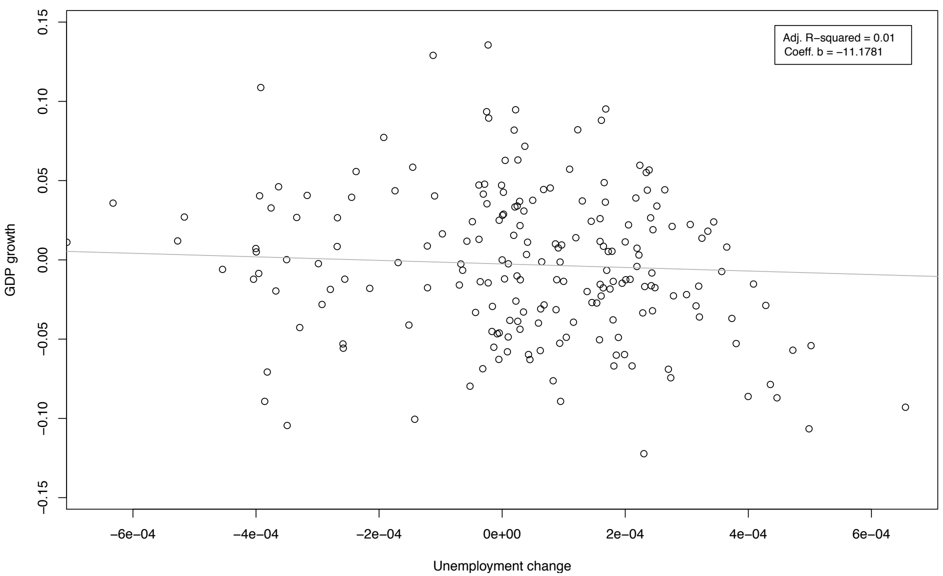
(a) Wage curve - Fordist



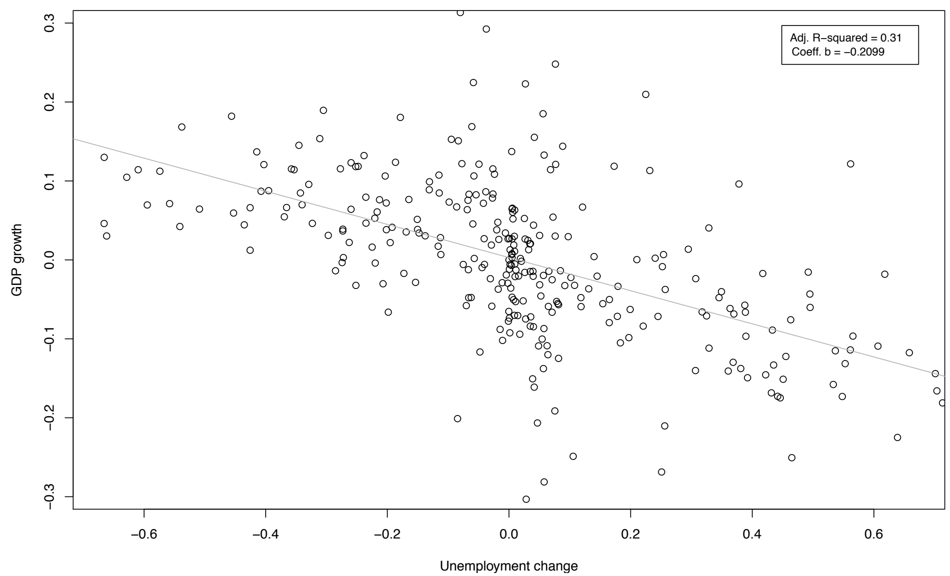
(b) Wage curve - Competitive



(c) Okun curve - Fordist



(d) Okun curve - Competitive



Fordist regime	**u**	**v**	**v/u**	**f**	**s**	**p**
Standard deviation	0.05	0.234	0.266	0.152	0.153	0.051
Quarterly autocorrelation	0.56	0.604	0.613	0.476	0.467	0.888
u	1.00	-0.612	-0.718	0.488	0.602	0.130
v		1.000	0.990	-0.532	-0.612	0.084
v/u			1.000	-0.555	-0.647	0.050
f				1.000	0.968	-0.068
s					1.000	-0.050
p						1.000
Competitive regime	**u**	**v**	**v/u**	**f**	**s**	**p**
Standard deviation	0.19	0.167	0.295	0.148	0.15	0.055
Quarterly autocorrelation	0.72	0.405	0.605	0.126	0.10	0.939
u	1.00	-0.392	-0.854	-0.269	0.11	-0.306
v		1.000	0.813	0.616	0.31	0.116
v/u			1.000	0.518	0.11	0.259
f				1.000	0.48	-0.114
s					1.00	-0.065
p						1.000

Table 3: Correlation structure for Shimer (2005) statistics.

Fordist regime	GDP	CONSUMPTION	INVESTMENT	PRODUCTIVITY	REAL WAGE
avg. growth rate	0.0277	0.0275	0.0316	0.0262	0.0258
(s.e.)	0.0004	0.0004	0.0003	0.0003	0.0004
ADF test (logs)	-3.2757	-3.0960	-6.7267	-2.6176	-2.3970
(s.e.)	0.1681	0.2212	0.1533	0.2086	0.2113
(p-val.)	0.1247	0.1978	0.0100	0.3485	0.4057
(s.e.)	0.0320	0.0425	0.0000	0.0657	0.0791
ADF test (bpf)	-8.2323	-8.5021	-9.0509	-8.3431	-7.9342
(s.e.)	0.2403	0.2170	0.2504	0.2036	0.1524
(p-val.)	0.0100	0.0100	0.0100	0.0100	0.0100
(s.e.)	0.0000	0.0000	0.0000	0.0000	0.0000
s.d. (bpf)	0.0608	0.0706	0.3012	0.0330	0.0423
(s.e.)	0.0033	0.0043	0.0151	0.0011	0.0011
relative s.d. (GDP)	1.0000	1.1623	4.9565	0.5433	0.6958
Competitive regime	GDP	CONSUMPTION	INVESTMENT	PRODUCTIVITY	REAL WAGE
avg. growth rate	0.0284	0.0282	0.0314	0.0265	0.0260
(s.e.)	0.0003	0.0004	0.0005	0.0003	0.0003
ADF test (logs)	-4.1301	-3.9620	-6.8954	-2.6941	-2.8085
(s.e.)	0.2895	0.2914	0.2611	0.3115	0.3457
(p-val.)	0.0721	0.0818	0.0100	0.3307	0.3268
(s.e.)	0.0383	0.0461	0.0000	0.1004	0.1005
ADF test (bpf)	-9.0556	-8.4894	-9.2741	-8.0235	-8.4802
(s.e.)	0.2180	0.1462	0.1620	0.2167	0.2639
(p-val.)	0.0100	0.0100	0.0100	0.0100	0.0100
(s.e.)	0.0000	0.0000	0.0000	0.0000	0.0000
s.d. (bpf)	0.0882	0.0951	0.3044	0.0341	0.0438
(s.e.)	0.0019	0.0022	0.0060	0.0021	0.0014
relative s.d. (GDP)	1.0000	1.0783	3.4502	0.3860	0.4966

Table 4: Key macro statistics (bpf: bandpass-filtered (6,32,12) series; Monte Carlo simulation standard errors and unit roots test p-values in parenthesis).

	$t-4$	$t-3$	$t-2$	$t-1$	0	$t+1$	$t+2$	$t+3$	$t+4$
GDP (output)	-0.0621	0.2389	0.5936	0.8849	1.0000	0.8849	0.5936	0.2389	-0.0621
(s.e.)	0.0361	0.0300	0.0174	0.0052	0.0000	0.0052	0.0174	0.0300	0.0361
(p-val.)	0.3776	0.0006	0.0000	0.0000		0.0000	0.0000	0.0006	0.3776
Consumption	-0.0620	0.2396	0.5811	0.8564	0.9662	0.8643	0.5953	0.2588	-0.0377
(s.e.)	0.0319	0.0268	0.0168	0.0068	0.0030	0.0125	0.0255	0.0369	0.0411
(p-val.)	0.6402	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.1457
Investment	-0.5139	-0.5182	-0.3914	-0.1376	0.1812	0.4630	0.6225	0.6234	0.4942
(s.e.)	0.0169	0.0165	0.0205	0.0251	0.0268	0.0225	0.0147	0.0126	0.0228
(p-val.)	0.0000	0.0000	0.0000	0.0746	0.0063	0.0000	0.0000	0.0000	0.0000
Unemployment	0.1328	-0.0009	-0.1635	-0.3039	-0.3753	-0.3370	-0.2410	-0.1306	-0.0439
(s.e.)	0.0370	0.0274	0.0252	0.0349	0.0411	0.0440	0.0398	0.0356	0.0345
(p-val.)	0.1539	0.9662	0.0144	0.0001	0.0000	0.0002	0.0006	0.0620	0.3726
Productivity	0.4060	0.5457	0.6280	0.6159	0.5015	0.3121	0.1009	-0.0804	-0.2014
(s.e.)	0.0370	0.0290	0.0157	0.0242	0.0451	0.0580	0.0587	0.0493	0.0353
(p-val.)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0025	0.0284	0.0656	0.0084
Real Wage	-0.0485	0.1879	0.4653	0.6966	0.7989	0.7381	0.5390	0.2777	0.0374
(s.e.)	0.0251	0.0284	0.0262	0.0161	0.0103	0.0215	0.0308	0.0344	0.0338
(p-val.)	0.8979	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.5800
Mark-up	0.3780	0.2725	0.1000	-0.0651	-0.1575	-0.1568	-0.0942	-0.0254	0.0069
(s.e.)	0.0449	0.0506	0.0529	0.0485	0.0400	0.0340	0.0343	0.0370	0.0376
(p-val.)	0.0001	0.0037	0.0123	0.1456	0.0855	0.0587	0.2101	0.3384	0.5972
Total firm debt	0.0454	0.0006	-0.0400	-0.0560	-0.0404	-0.0073	0.0272	0.0456	0.0439
(s.e.)	0.0206	0.0393	0.0523	0.0561	0.0505	0.0372	0.0222	0.0125	0.0171
(p-val.)	0.9802	0.4289	0.0353	0.0202	0.0931	0.6393	0.9895	0.9992	0.9942
Vacancy rate	-0.0633	0.1573	0.3938	0.5695	0.6208	0.5286	0.3338	0.1094	-0.0743
(s.e.)	0.0564	0.0653	0.0622	0.0492	0.0382	0.0393	0.0420	0.0390	0.0347
(p-val.)	0.0748	0.0117	0.0005	0.0000	0.0000	0.0000	0.0002	0.0747	0.3963
Hiring rate	-0.1334	-0.2942	-0.3991	-0.4196	-0.3556	-0.2359	-0.1007	0.0111	0.0794
(s.e.)	0.0416	0.0331	0.0560	0.0774	0.0789	0.0610	0.0390	0.0304	0.0328
(p-val.)	0.1988	0.0001	0.0002	0.0000	0.0000	0.0001	0.1837	0.8848	0.2390
Firing rate	-0.0656	-0.2103	-0.3262	-0.3822	-0.3622	-0.2761	-0.1503	-0.0267	0.0618
(s.e.)	0.0485	0.0341	0.0481	0.0727	0.0806	0.0672	0.0443	0.0309	0.0328
(p-val.)	0.2008	0.0047	0.0005	0.0000	0.0000	0.0001	0.0265	0.8824	0.2919

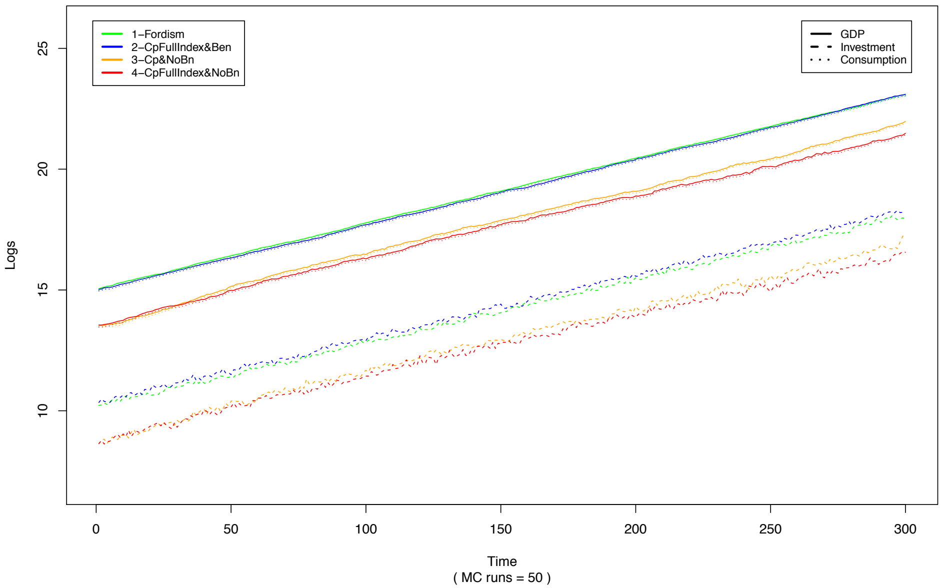
Table 5: Fordist regime: Correlation structure between GDP and some macro variables (non-rate/ratio series are bandpass-filtered (6,32,12); Monte Carlo simulation standard errors and lag significance test p-values (5% significance) in parenthesis).

	$t-4$	$t-3$	$t-2$	$t-1$	0	$t+1$	$t+2$	$t+3$	$t+4$
GDP	-0.0684	0.2283	0.5852	0.8818	1.0000	0.8818	0.5852	0.2283	-0.0684
(s.e.)	0.0284	0.0256	0.0161	0.0051	0.0000	0.0051	0.0161	0.0256	0.0284
(p-val.)	0.5824	0.0003	0.0000	0.0000		0.0000	0.0000	0.0003	0.5824
Consumption	-0.1010	0.1725	0.5171	0.8267	0.9849	0.9204	0.6662	0.3219	0.0060
(s.e.)	0.0278	0.0271	0.0195	0.0086	0.0013	0.0034	0.0125	0.0227	0.0276
(p-val.)	0.3512	0.0113	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9555
Investment	-0.3813	-0.4406	-0.4030	-0.2145	0.1062	0.4546	0.6994	0.7486	0.6036
(s.e.)	0.0296	0.0264	0.0258	0.0291	0.0306	0.0274	0.0195	0.0143	0.0262
(p-val.)	0.0000	0.0000	0.0000	0.0015	0.2972	0.0000	0.0000	0.0000	0.0000
Unemployment	0.0938	-0.2362	-0.5684	-0.7851	-0.8115	-0.6431	-0.3764	-0.1192	0.0543
(s.e.)	0.0448	0.0388	0.0256	0.0123	0.0120	0.0170	0.0192	0.0179	0.0192
(p-val.)	0.0311	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.1331	0.9745
Productivity	0.3961	0.5465	0.6660	0.6985	0.6056	0.3893	0.1088	-0.1593	-0.3512
(s.e.)	0.0242	0.0214	0.0163	0.0178	0.0260	0.0316	0.0333	0.0324	0.0304
(p-val.)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2938	0.0258	0.0000
Real Wage	0.0202	0.2293	0.4944	0.7322	0.8459	0.7795	0.5503	0.2409	-0.0461
(s.e.)	0.0232	0.0194	0.0139	0.0081	0.0090	0.0110	0.0159	0.0258	0.0334
(p-val.)	0.9913	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.6977
Mark-up	0.4179	0.3664	0.2390	0.0895	-0.0255	-0.0775	-0.0834	-0.0814	-0.1007
(s.e.)	0.0324	0.0378	0.0423	0.0436	0.0410	0.0370	0.0397	0.0493	0.0554
(p-val.)	0.0000	0.0000	0.0044	0.1278	0.4041	0.5274	0.4650	0.0421	0.0062
Total firm debt	0.1296	0.1843	0.2024	0.1738	0.1078	0.0249	-0.0491	-0.0969	-0.1138
(s.e.)	0.0386	0.0343	0.0303	0.0279	0.0252	0.0231	0.0225	0.0254	0.0327
(p-val.)	0.1597	0.0165	0.0036	0.0119	0.0689	0.9878	0.9605	0.4759	0.1923
Vacancy rate	-0.0546	0.0088	0.1254	0.3000	0.4907	0.6217	0.6266	0.4888	0.2553
(s.e.)	0.0184	0.0253	0.0316	0.0299	0.0226	0.0153	0.0119	0.0131	0.0220
(p-val.)	0.9792	0.9812	0.0644	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hiring rate	-0.2980	-0.3267	-0.2706	-0.1097	0.1274	0.3648	0.5138	0.5212	0.3971
(s.e.)	0.0257	0.0252	0.0251	0.0207	0.0203	0.0234	0.0209	0.0178	0.0272
(p-val.)	0.0000	0.0000	0.0000	0.2935	0.0907	0.0000	0.0000	0.0000	0.0000
Firing rate	0.2565	0.2248	0.0802	-0.0797	-0.1426	-0.0652	0.1042	0.2518	0.2829
(s.e.)	0.0207	0.0195	0.0179	0.0179	0.0264	0.0354	0.0395	0.0360	0.0264
(p-val.)	0.0000	0.0001	0.8135	0.8257	0.0226	0.4577	0.1554	0.0010	0.0000

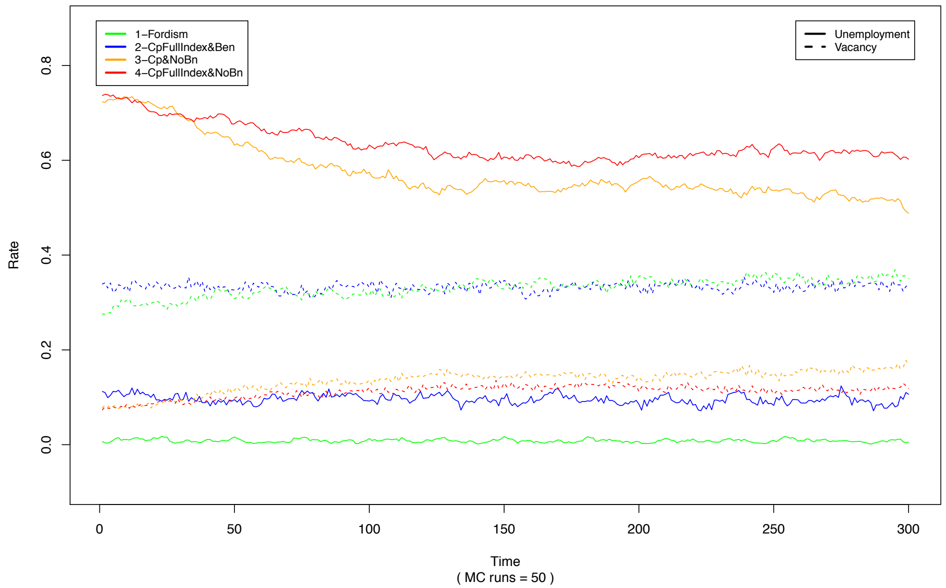
Table 6: Competitive regime: Correlation structure between GDP and some macro variables (non-rate/ratio series are bandpass-filtered (6,32,12); Monte Carlo simulation standard errors and lag significance test p-values (5% significance) in parenthesis).

Figure 6: Aggregate dynamics of alternative scenarios

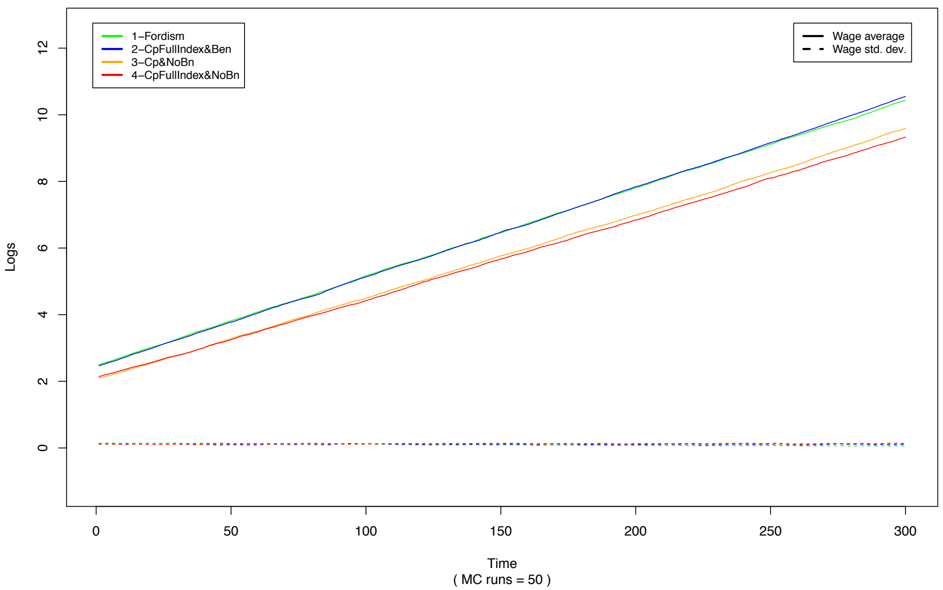
(a) GDP, Consumption, Investment (log-levels)



(b) Unemployment and Vacancy Rate



(c) Average Real Wages and dispersion (log-levels)



(d) Average Mark-up and Gini Index

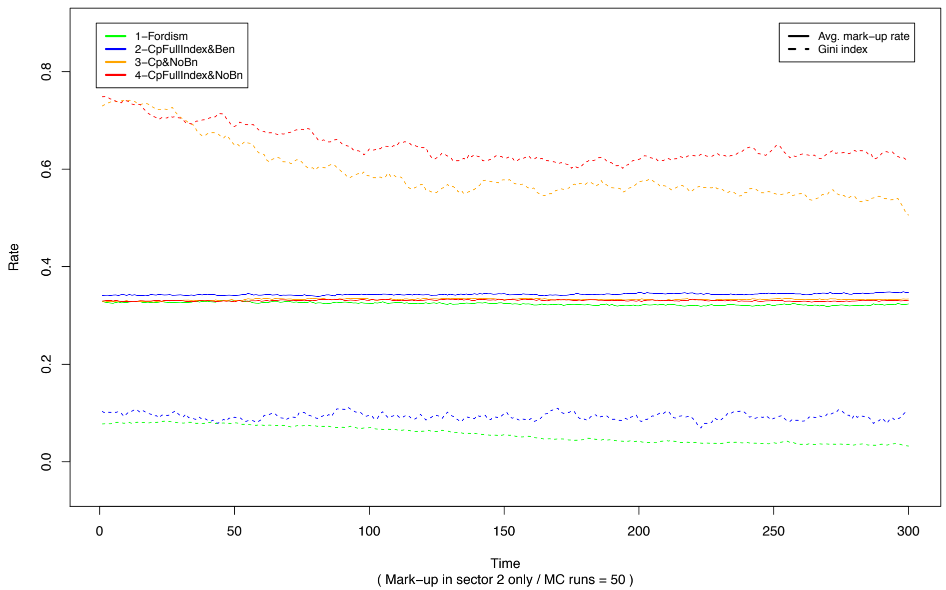
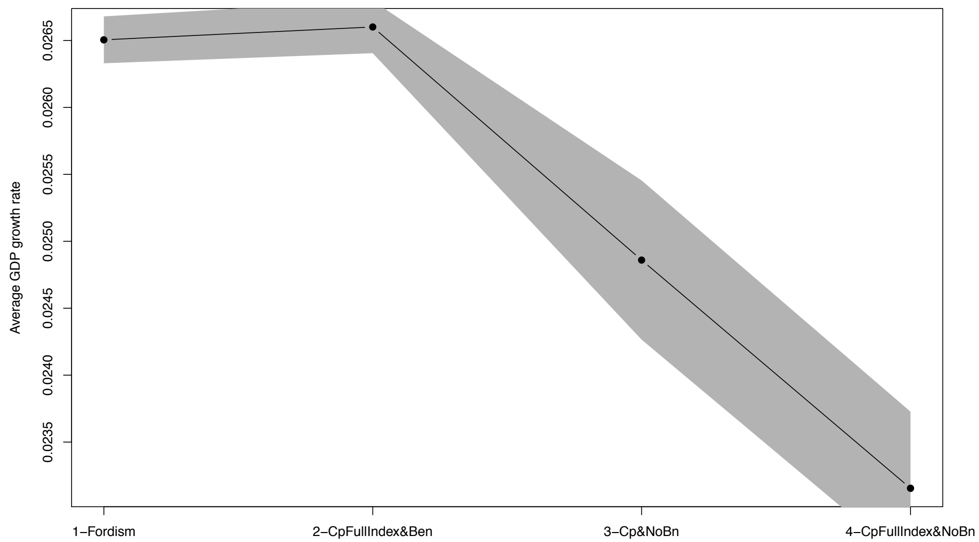
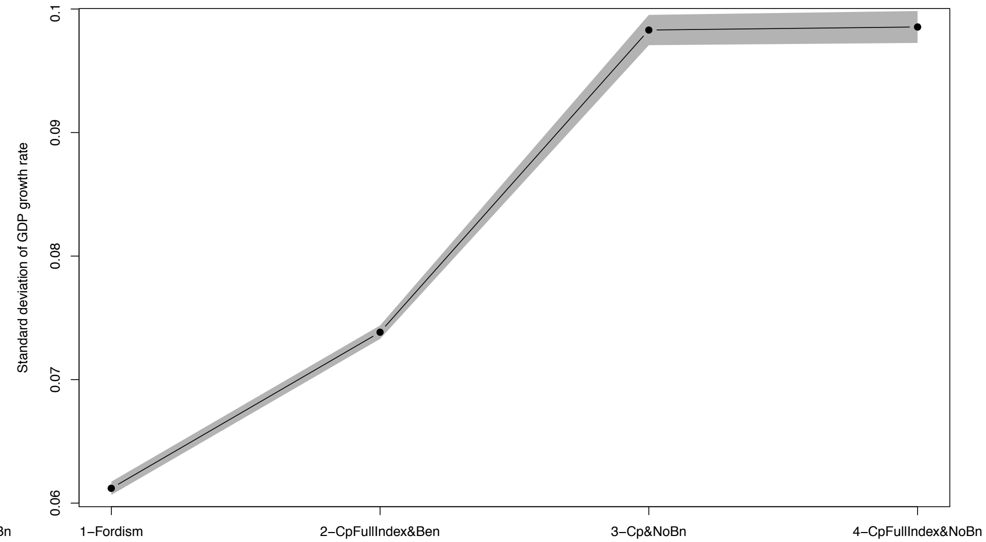


Figure 7: Comparison of key metrics on GDP and productivity among alternative scenarios (gray bands indicate the Monte Carlo averages 95% confidence interval). The lines are simply a visual device highlighting the steepness of the differences among regimes.

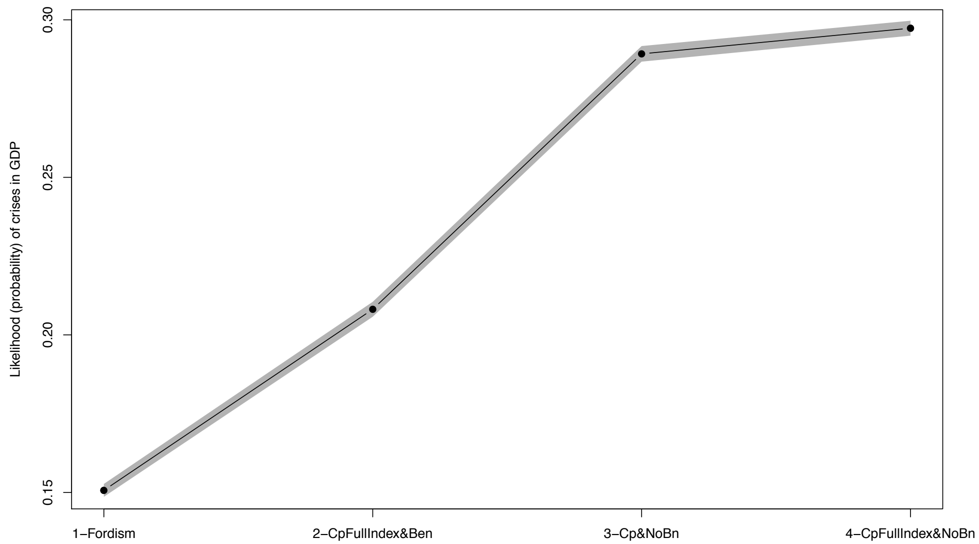
(a) GDP growth rate



(b) Volatility of GDP growth rate



(c) Likelihood of crises



(d) Productivity growth

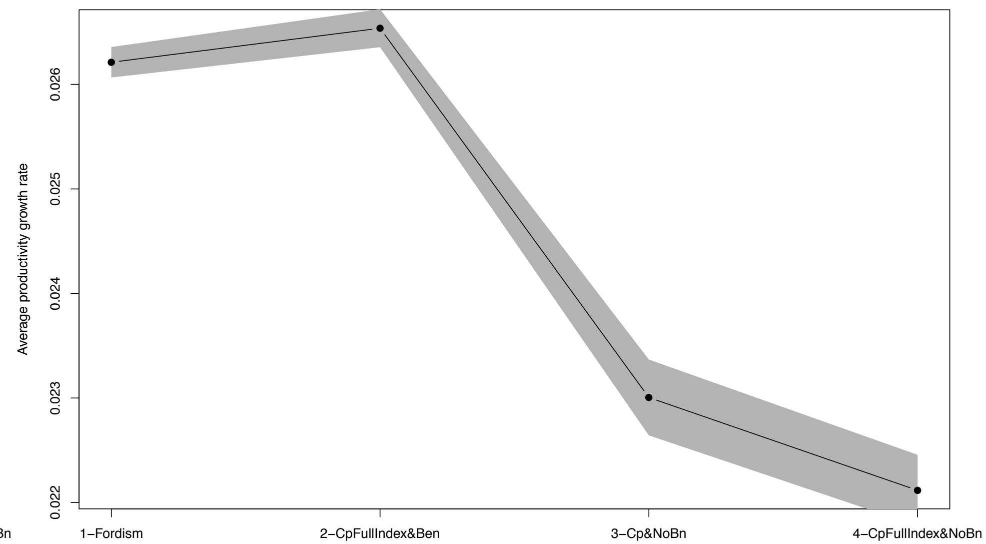
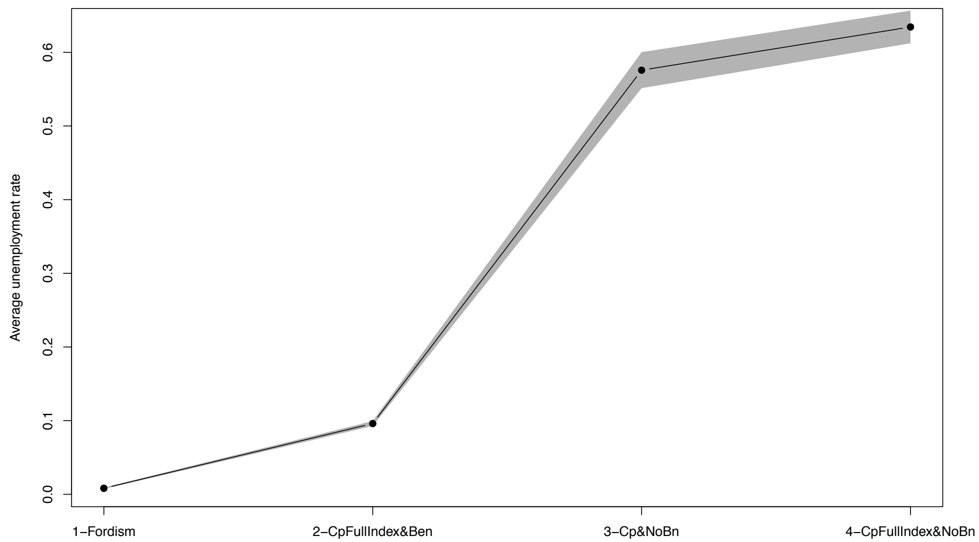
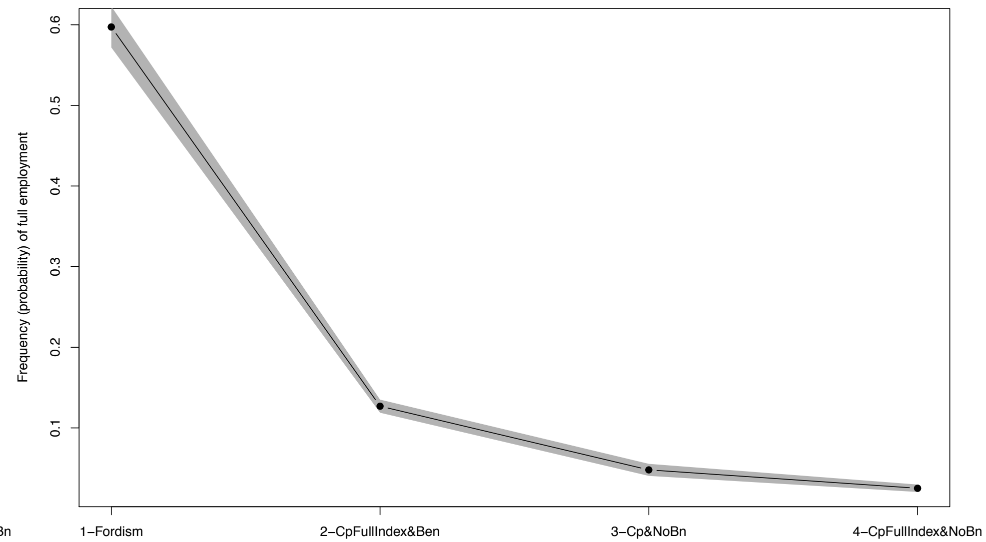


Figure 8: Comparison of key metrics on unemployment and inequality among alternative scenarios (gray bands indicate the Monte Carlo averages 95% confidence interval). The lines are simply a visual device highlighting the steepness of the differences among regimes.

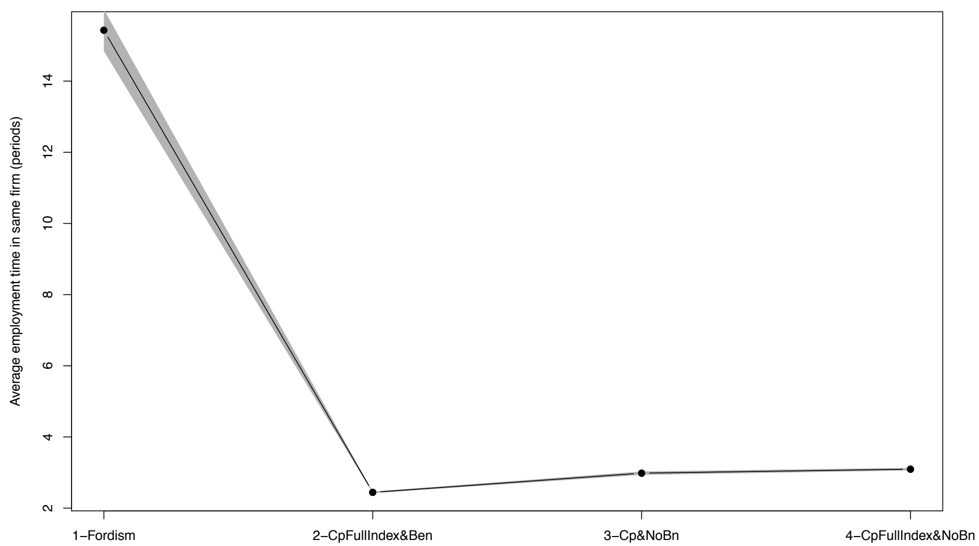
(a) Unemployment rate



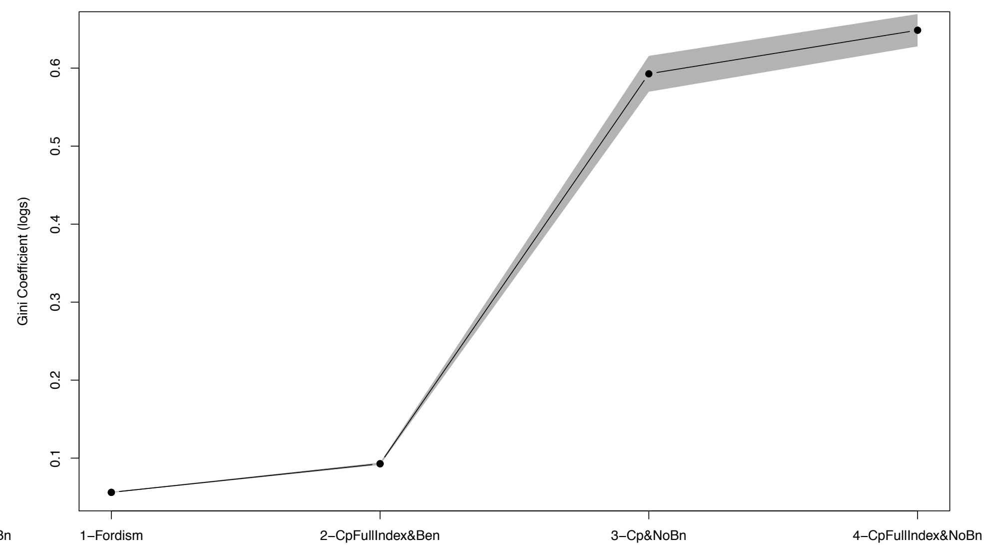
(b) Frequency of full employment



(c) Tenure length



(d) Gini index



	Baseline[1]	Ratio[2]	Ratio[3]	Ratio[4]	Ratio[5]
GDP Growth	0.027	1.004	0.938	0.874	0.068
p-val.		0.801	0.071	0.000	0.000
Volatility of GDP Growth Rate	0.061	1.206	1.606	1.610	1.498
p-val.		0.000	0.000	0.000	0.000
Likelihood of Crises	0.151	1.381	1.919	1.973	1.483
p-val.		0.000	0.000	0.000	0.000
Productivity Growth	0.026	1.012	0.878	0.844	0.753
p-val.		0.334	0.000	0.000	0.000
Unemployment	0.008	11.672	69.931	77.054	84.757
p-val.		0.000	0.000	0.000	0.000
Frequency of Full Employment	0.597	0.213	0.080	0.042	0.067
p-val.		0.000	0.000	0.000	0.000
Tenure	15.430	0.158	0.193	0.201	1.506
p-val.		0.000	0.000	0.000	0.000
Vacancy	0.331	1.006	0.410	0.338	0.250
p-val.		0.841	0.000	0.000	0.000
Gini Coefficient	0.056	1.654	10.561	11.557	1.189
p-val.		0.000	0.000	0.000	0.000

Table 7: Comparison of [**1**] baseline Fordist regime with: [**2**] Competitive with full indexation and benefits, [**3**] Competitive with partial indexation and no benefits, [**4**] Competitive with full indexation and no benefits, and [**5**] Competitive with no indexation or benefits (scenario/baseline ratio and p-value for a two means test where H0: no difference with baseline).

6 Conclusions

The model robustly shows that more flexibility in terms of variations of monetary wages and labour mobility – irrespectively of how it fosters allocative efficiency, a topic outside the concerns of this paper – is prone to induce systematic coordination failures, higher macro volatility, higher unemployment, higher frequency of crises. In fact, 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 lead recurrently as system level emergent properties to small and big aggregate demand failures. This properties, we suggest, is 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, the system does not collapse. Furthermore, contrary to the argument that higher labour flexibility fosters productivity growth, our model clearly shows the opposite: productivity in the Fordist and in the Competitive regime with full indexation and unemployment benefit (which is still more volatile and prone to crises than the Fordist) grows at the same path. Conversely, productivity growth is significantly lower in most set-ups of the Competitive regime.

Here is where the failures of the Keynesian demand-generating mechanisms feedback upon the Schumpeterian processes of technological advance. Crises are not the panaceas 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 also the amount of resources invested in innovative search (in our model the R&D of the machine-producing sector), shrinks the investment in new vintages of equipment, and slows down the scrapping of old ones. 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 rates of growth* of the economy, even beyond the permanent loss in

GDP levels (as captured by Stiglitz, 1993). The findings here, in fact, complement those from Dosi et al. (2016c) showing 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 are far reaching and point in directions opposite to the fairytale of so called "structural reforms". If one trusts the interpretative power of our model, more employment guarantees, more rigidities in firing rules, less wage inequality, more welfare protection are not only good for the workers concern, but also for the economy as a whole.

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Appendix

Technical change, production- and consumer-goods markets

The technology of a capital-good firms is (A_i^τ, B_i^τ), where the former coefficient stands for the labour productivity of the machine-tool manufactured by i for the consumption-good industry (a rough measure of product quality), while the latter coefficient is the labour productivity of the production technique employed by firm i itself. The positive integer t denotes the current technology vintage. Given the monetary average wage w_i paid by firm i, the unit cost of production of capital-good firms is

$$c_{i,t} = \frac{w_{i,t}}{B_i^\tau} \tag{23}$$

With a fixed mark-up $\mu_1 > 0$ pricing rule, prices (p_i) are defined as:

$$p_{i,t} = (1 + \mu_1)c_{i,t} \tag{24}$$

The unit labour cost of production in the capital-good sector associated with each machine of vintage t, produced by firm i is

$$c_{A_i^\tau,t} = \frac{w_{i,t}}{A_i^\tau} \tag{25}$$

Firms in the capital-good industry "adaptively" strive to increase their market shares and their profits trying to improve their technology both via innovation and imitation. Both are costly processes: firms invest in R&D a fraction of their past sales (S_i):

$$RD_{i,t} = \nu S_{i,t-1} \tag{26}$$

Firms split their $R\&D$ efforts between innovation (IN) and imitation (IM) according to the parameter $\xi \in [0, 1]$:

$$IN_{i,t} = \xi RD_{i,t} \tag{27}$$

$$IM_{i,t} = (1 - \xi)RD_{i,t} \tag{28}$$

Innovation is a two-step process. The first one determines whether a firm obtains or not an access to innovation – irrespectively of whether it is ultimately a success or a failure – through a draw from a Bernoulli distribution, whose parameter $\theta^{in}_{i,t}$ is given by

$$\theta^{in}_{i,t} = 1 - e^{-\zeta_1 IN_{i,t}} \tag{29}$$

with $0 < \zeta_1 < 1$. If a firm innovates, it may draw a new machine embodying technology (A^{inn}_i, B^{inn}_i) according to

$$A^{inn}_{i,t} = A_{i,t}(1 + x^A_{i,t}) \tag{30}$$

$$B^{inn}_{i,t} = B_{i,t}(1 + x^B_{i,t}) \tag{31}$$

Alike innovation search, imitation follows a two steps procedure. The possibilities of accessing imitation come from sampling a Bernoulli $\theta^{im}_{i,t}$:

$$\theta^{im}_{i,t} = 1 - e^{-\zeta_2 IM_{i,t}} \tag{32}$$

with $0 < \zeta_2 < 1$. Firms accessing the second stage are able to copy the technology of one of the competitors (A^{im}_i, B^{im}_i). Capital-good firms select the machine to produce according to the following rule:

$$\min[p^h_{i,t} + bc^h_{A^h_i,j,t}], \quad h = \tau, in, im \tag{33}$$

where b is a positive payback period parameter.

Firm j replaces machine $A^\tau_i \in \Xi_{j,t}$ according to its technology obsolescence as well as the price of new machines:

$$RS_{j,t} = \left\{ A^\tau_i \in \Xi_{j,t} : \frac{p^*_{i,t}}{c_{A^\tau_i,j,t} - c^*_{j,t}} \right\} \tag{34}$$

where $p^*_{i,t}$ and $c^*_{j,t}$ are the price and unit cost of production upon the new machines. Given their current stock of machines, consumption-good firms compute average productivity ($\pi_{j,t}$) and unit cost of production ($c_{j,t}$). Prices are set applying a variable markup ($\mu_{j,t}$) on unit costs of production:

$$p_{j,t} = (1 + \mu_{j,t})c_{j,t} \tag{35}$$

Mark-up variations are regulated by the evolution of firm market shares ($f_{j,t}$):

$$\mu_{j,t} = \mu_{j,t-1}\left(\upsilon \frac{f_{j,t-1} - f_{j,t-2}}{f_{j,t-2}}\right) \tag{36}$$

with $0 < \upsilon < 1$. Firm market shares evolve according to a replicator dynamics:

$$f_{j,t} = f_{j,t-1}\left(1 + \chi \frac{E_{j,t} - \overline{E_t}}{\overline{E_t}}\right), \quad \overline{E_t} = \sum_{j=1}^{F_2} E_{j,t} f_{j,t-1} \tag{37}$$

Further details are available in Dosi et al. (2010).

Variables and parameters description

Variable	Description
L_t^D	Aggregate demand for workers
$L_{j,t}^d$	Number of demanded workers by firm j
$L_{j,t}^s$	Number of workers which queue in firm j
$L_{j,t}$	Number of effectively hired workers by firm j
$w_{j,t}^{MAX}$	Break-even (maximum) wage offered by firm j
$w_{j,t}^o$	Offered wage by firm j
$w_{\ell,t}^r$	Required wage by worker ℓ
$w_{\ell,t}^s$	Satisfying wage for worker ℓ
$w_{\ell,t}$	Effective wage (income) of worker ℓ
w_t^u	Unemployment benefit
$w_t^{minPolicy}$	Minimum policy wage

Table 8: Labour market variables (other variables described in Dosi et al., 2010).

Parameter	Description	Value
L^S	Aggregate supply of workers	250000
ψ	Fraction of aggregate wage for unemployment subsidies	0.4
ψ_1	Aggregate productivity pass-trough	0.5
ψ_2	Firm-level productivity pass-through	0.5
ϵ	Desired wage increase	0.02
ωL^a	Number of firms to which send applications	5
T_s	Wage memory periods	4
w_0	Initial wage (income) of all workers	1
$w_0^{minPolicy}$	Initial minimum policy wage	1
ψ	Fraction of aggregate wage for unemployment subsidies	0.4
MC Runs		50
Simulated periods (A)		400
"Burn-in" periods (B)		100
Effective periods ($A - B$)		300

Table 9: Labour market parameters (other parameters described in Dosi et al., 2010).