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Working Paper

The political economy of complex evolving systems: The case of declining unionization and rising inequalities

LEM Working Paper Series, No. 2024/13

Provided in Cooperation with:

Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies

Suggested Citation: Dosi, Giovanni; Pereira, Marcelo C.; Roventini, Andrea; Virgillito, Maria Enrica (2024) : The political economy of complex evolving systems: The case of declining unionization and rising inequalities, LEM Working Paper Series, No. 2024/13, Scuola Superiore Sant'Anna, Laboratory of Economics and Management (LEM), Pisa

This Version is available at:

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WORKING PAPER SERIES

The political economy of complex evolving systems: the case of declining unionization and rising inequalities

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2024/12

April 2024

ISSN(ONLINE) 2284-0400

The political economy of complex evolving systems: the case of declining unionization and rising inequalities*

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Abstract

This chapter presents an application of the multi-sector labour augmented K+S agent-based model to two contemporary challenges in political economy, namely declining unionization and rising inequality, with reference to mid-term evidence in the US. What has been the effect of declining unionization? We focus, as an example, upon the introduction of legislations such as Right-to-Work (RTW) laws, disfavouring union firms and the way they affected the

*M.E. V. acknowledges support from the Italian Ministry of University and Research (MUR), PRIN 2017 project: "Lost highway: skills, technology and trade in Italian economic growth, 1815-2018" (prot. 2017YLBYZE). M.C. P. acknowledges support of Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), process no. 2015/24341-7.

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dynamics of the labour market. The model proves to be a solid and rich tool in order to confront different scenarios emerging out of the interaction of an endogenous dynamic competition between union and non union firms, the latter arriving at a specific time, mimicking the exogenous introduction of RTW laws. The arrival of non union firms induces direct first-order effects, as rising inequality at the workplace and macro level, but also, indirect, second order effects, as lower rates of employment absorption and consumption patterns skewed toward wealthy, luxury consumption goods. In that, complexity economics proves to be a promising avenue to incorporate and confront the grand challenges of contemporary capitalism.

JEL classification: J51, E02, E24, C63

Keywords: Complexity, Capitalism, Socio-economic structure, Macro-evolutionary agent-based models.

1 Introduction

This chapter discusses the link between political economy and agent-based macro models, drawing upon the multi-sector ([Dosi et al., 2022](#)) labour-augmented K+S model ([Dosi et al., 2017, 2018, 2020](#)). Capitalist forms of socio-economic organization have always been characterized by ubiquitous heterogeneities among economic agents, conflicts among social groups and coordination hurdles. And, with that, the system has always been generating structural imbalances, fluctuations and crises. However, the recent trends are pointing at an increasing fragility of the system, together with deepening inequalities and the erosion of those forms of public intervention and institutions which had guaranteed in the post WWII relatively stable patterns of income distribution, the provision of both public goods and a relatively universal access to social welfare. Indeed, the relationship between the State and the economy has radically changed, with the former that has increasingly given up its role of socio-economic coordinator and basically taken up that of protector of corporate interests.

How can economists analyse, model and identify such alternative modes of socio-economic organization and their properties? The dominant macro theory is

bound to be totally mute on the subject. The litmus test has been the 2008 crisis whose very possibility was ruled out by construction, given its solipsistic agents and the commitment to equilibrium (Colander et al., 2008; Krugman, 2011). And of course it is even less able to address the political economy issues related to changes in the broad institutional set-ups, the latter mostly confined to economic institutions rewarding innovation efforts (Acemoglu and Robinson, 2013).

Agent-based macro models, built on the convergence between evolutionary and complexity paradigms (Dosi and Roventini, 2019; Dosi, 2023), have been in the last three decades an enormous source of scientific knowledge to advance our understanding of the dynamics of capitalism. Evolutionary ABMs have proved to be able to robustly generate and construct scenario analysis matching an impressive ensemble of stylized facts, that is basic statistical regularities - ranging from the micro-level distributions of firm size and growth rates, to the patterns of evolution of industries, all the way to macroeconomic fluctuations and crises. After these results, we are just in the middle of a multipronged effort to understand and also formalize some fundamental generic properties of the anatomy and physiology of the capitalist socio-economic fabric.

However, the dynamics of the socio-economic fabric are subject to profound *phase transitions* shaped by the co-evolution between technologies, institutions and economic processes. And in that there is nothing to prevent transition toward self-cannibalization (Fraser, 2023) and destruction of the system in itself. This is the domain of analysis that we call the *political economy* of Agent Based Macro models. This, we suggest, is the next frontier which the latter are just beginning to tackle. Agent Based models are powerful policy laboratories (Dosi et al., 2020), in that they are consistent simplified worlds, wherein experiments with different policy measures and institutional set-ups can be configured. As such, they can be precious instruments for the exploration of alternative political economy scenarios. This goes well beyond counterfactual exercises concerning the marginal impact, *ceteris paribus*, of single policies upon specific variables, say, the rates of growth or the overall level of functional inequalities. Rather, the exploration of different scenarios regards the painstaking search of *combinations of institutions and policies* able to

reverse the current trends toward dramatically increasing inequalities in the distribution of income and power, and, related, toward the social and environmental catastrophe.

In this chapter we should address two fundamental challenges in contemporary capitalism namely the decline in unionization rate and the rise in income inequalities. Which have been the micro and macro-level effects of declining unionization rate? More specifically, how the introduction of legislations such as Right to Work (RTW) laws, disfavours union firms and paving the way for anti-labour practices, have affected the dynamics of the labour market and with which consequences? In the following, we present an application of the multi-sector labour augmented K+S agent-based model addressing declining unionization and rising inequality, with reference to mid-term evidence in the US. The model proves to be a solid and rich tool in order to confront different scenarios emerging out of the interaction of an endogenous dynamic competition between union and non union firms, the latter arriving at a specific time, mimicking the exogenous introduction of RTW laws. The arrival of non union firms induces direct first-order effects, as rising inequality at the workplace and macro-level, but also, indirect, second order effects, as lower rates of employment absorption and consumption patterns skewed toward wealthy, luxury consumption goods. Take this as just an example of how complexity economics proves to be a promising avenue to incorporate and confront the grand challenges of contemporary capitalism, considering its ability to nest multi-level integrated processes of the capitalist machine, with a single toolbox of analysis.

In the following, drawing upon [Dosi et al. \(2022\)](#) and [Dosi et al. \(2021\)](#), we first discuss the two challenges of political economy we would like to explore; we then move to the agent-based model application, showing our model properties and simulation results. We conclude the chapter by discussing the results and some avenues of future research.

2 Two grand challenges for contemporary political economy: rising inequality and declining union power

The rise of inequality is certainly one of the predominant trend documented in contemporary capitalism. Inequality has increased at the micro-level in wage dispersion among similar occupations located in different establishments (Barth et al., 2016), across occupations in the very same companies, between CEOs and the rest of the workforce (Gabaix and Landier, 2008), in terms of functional income inequality (Dosi and Virgillito, 2019), in terms of personal income and wealth (Piketty, 2015), within countries and across countries (Milanovic, 2024), and with multi-dimensionality effects propagating from economic to political spheres (Stiglitz, 2015), from definition of property rights to access to public goods (Dosi et al., 2024).

The extant literature has mostly attributed individual wage inequality to the skill-biased/routine-biased nature of technological change (Autor and Dorn, 2013). According to such research stream, the determination of wage and the ensuing origin of inequality are a market-based issue, wherein the dynamics of wage remunerations are mainly due to technology-related causes, involving changes in the elasticity of substitution among inputs, yielding “biases” in the demand for different types of labour. In turn, such biases at the beginning derived from ‘wrong’ educational attainments and skill mismatch, with a rising demand for college-educated workers (Tinbergen, 1974; Katz and Murphy, 1992). Under that theory, the *skill-bias* interpretation has been deemed as the dominant inequality explanation. The bias has then gradually moved to job tasks and technological-based factors according to the *routine-biased* or *task-biased* technical change theory (Acemoglu and Autor, 2011), primarily attributed to the rise in computer adoption until the Great Recession, or recently to a general “robotization age” (Restrepo, 2023). In a nutshell, technological-driven factors are seen as responsible for the modification in the composition of the occupational structure, leading to polarization and disappearance of the middle part of occupational categories, but also for the polarization in wages. More recently, with the growing diffusion of AI, complementary but also

less predictable effects induced by technological adoption have been also taken on board ([Acemoglu et al., 2022](#)).

Growing evidence is questioning the technology-driven origin of inequality ([Dosi et al., 2022](#); [Mishel, 2022](#); [Cetrulo et al., 2024](#)). The need of accounting for alternative, deep and persistent non technological drivers behind wage inequality trends has refocused the attention of scholars towards other possible factors that could impact on the determination of wages, departing from a neoclassical approach based on the assumption of perfectly competitive labour markets able to reward individuals for their skills and productivity. Alternative candidates to explain wage levels and their dynamics are socio-institutional dimensions embedded into occupational class structures ([Penissat et al., 2020](#); [Goedemé et al., 2021](#)), the rise of the care economy ([Dwyer, 2013](#); [Folbre, 2021](#)), and the weakening of labour market institutions ([Stansbury and Summers, 2020](#)).

Increasing wage disparities have been linked with a widespread decline in the labour share. Declining labour shares are not only a signal of wage compression and functional inequality but also of the reorganization of capitalism in favour of managerial stockholder power. The rise in managerial power has been acting as a force able to push for managerial remunerations in terms of shares and stock options, up to the point, documented by [Bivens and Kandra \(2022\)](#), of a rise of almost 400 times of the CEO/average worker compensation ratio in listed companies present in the Compustat dataset. Such an increase represents a dramatic process of redistribution of resources on the basis of drivers that cannot be certainly ascribed to worker productivity.

A complementary explanation for the decline in the labour share focuses on the role of *bargaining power* of workers. Under non-decreasing returns and asymmetric power relations between employers and employees, the distribution of income might well be the outcome of a negotiation process between firms and workers, possibly represented by labour unions and mediated by the presence of labour market institutions. Workers, whenever protected by strong unions and pro-labour institutions, are better able to negotiate wage increases in line with productivity, helping to maintain a constant labour share.

Empirically, there is a growing consensus on the role of labour market institutions in affecting labour share dynamics through the bargaining power channel. Several studies have found that factors such as strike activity, collective bargaining arrangements, minimum wages, and union density, affect the labour share (Kristal, 2010; Bentolila and Saint-Paul, 2003; Argitis and Pitelis, 2001). In particular, union density – the percentage of unionized workers within a given worker population – has been shown to have a positive effect on the labour share at the country level (Guschanski and Onaran, 2021; Stockhammer, 2013a; Bengtsson, 2014; Stockhammer, 2013b; Jaumotte and Osorio Buitron, 2020). In addition, the evidence (Dao et al., 2020; Dimova, 2019) suggests that unions may have different effects on the wage-setting process for different skill groups protecting in particular low-skilled workers, thus reducing wage inequality. Long run historical evidence on the positive effects of unionization for taming inequality is in Farber et al. (2021).

Historically, the rise of union power in the US has been described as a spurt dynamics (Freeman, 1998), with a rapid increase from the thirties up to the mid fifties, reaching a peak value of 36%. Two laws were important in that phase. The first was the National Labor Relations Act (NLRA) in 1935, also known as the Wagner Act, providing an institutional framework for union workplaces, ensuring the right to unionize, including collective bargaining, right to strike and the institution of a national commission, the National Labor Relations Board, responsible to prosecute violations of unfair labour practices. With the approval of this law, the initial phase of the spurt started (see Figure 1). A subsequent anti-labor policy, the Taft-Hartley Act in 1947 was introduced to limit the space of action of unions, and also to stop the ascending unionization. The Act allowed each state to pass the Right-to-Work (RTW) laws, that exempt workers in union plants to pay a due even if workers benefit from the union activity (Fortin et al., 2023). Historically, Southern and Midwestern states have adopted RTW laws, recording lower unionization rates. More recent adoptions, post-2010 in five states of the Great Lake area or in its proximity, have produced an acceleration in deunionization rates, as compared to rates in pre-2010, with stronger declines in higher unionized sectors (Shierholz et al., 2024; Fortin et al., 2023).

More generally, the decline in union membership, a socio-institutional trend since the seventies, has been found to account for rising wage inequalities. While unions have always been considered as an institution compressing wage inequalities for union workers, [Western and Rosenfeld \(2011\)](#) also highlight the effects upon wage increases for non union workers by means of the complementary effect on their wages exercised by unions. The decline in unionization has been linked to two main drivers: structural-economic forces, due to the rise in employment outside historically cohesive union industries, and institutional forces, due to increasing employer power and anti-union practices, following in the US the “Reagan moment”, with the defeat of air-traffic controllers strike in 1981 as a pivotal symbolic event, and the appointment of the Reagan Labor Board in 1983 as the institutionalization of a new anti-labour turn for the board ([Farber and Western, 2002](#); [Tope and Jacobs, 2009](#)). Coming to the first group of explanations, mainly linked to a structural change hypothesis, [Hirsch \(2008\)](#) shows that, contrary to what expected, much of the decline in unionization has been driven by within industry dynamics, meaning that even in high-union sectors, a progressive increase in the share of non union firms has emerged. In manufacturing, for example, non union employment rose by about 1.5 million between 1973 and 2006, despite a 2.5 million decline after 2000, while union employment fell from 7.8 million in 1973 to only 1.8 million in 2006. Similar dynamics is shown in [Farber and Western \(2002\)](#). Market competition between union and non union firms has favoured the latter: if unionized firms, paying more equal and higher wages face progressively low-cost competitors, are not able to pass-through higher costs into higher prices to the product market, they will lose market share and exit. As compared to the institutional drivers, [Hirsch \(2008\)](#) favours the competitive-market pressure hypothesis, offering strong empirical evidence that the exit of union firms and related employment has not been compensated by similar firms, but rather by the entry of non union ones.

In the following, we shall propose a model of deunionization that emerges as an endogenous result of market-driven competitive forces, between non union firms entering into the market and competing with union ones. While the end

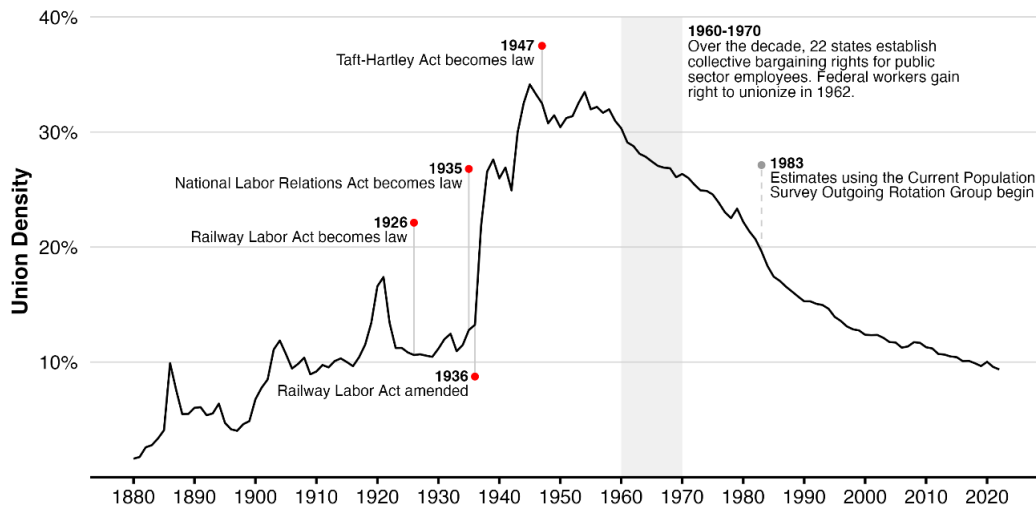


Figure 1: Union density 1880-2022. Figure 1 in [Romero and Whittaker \(2023\)](#).

outcome is fully endogenous, the specific arrival time can be interpreted as the exogenous introduction of an RTW law, empirically proved to be linked with declining unionization rate, specifically with reference to the recent adoption in five US states ([Fortin et al., 2023](#); [Shierholz et al., 2024](#)), as such accounting for both structural and institutional drivers of deunionization. Figure 1 shows the dynamics of union density in the US and marks the timing of different laws, accounting for the rise and decline in unionization. In line, the multi-industry set-up of the model allows to tackle industry heterogeneity in the degree of unionization.

In addition, considering that unionization is an industry specific attribute, with higher unionized industries in the US as construction, education, and public administration, mid-unionized industries as manufacturing, health, transportation & utilities and the remaining as low unionized ones, the effects of the introduction of an RTW law is expected to be also industry-specific. Notably, [Fortin et al. \(2023\)](#) show that the introduction of the RTW laws has induced higher decline of unionization specifically in previously higher unionized industries.

3 The multi-sector K+S model facing political economy

We present a *general disequilibrium*, stock-and-flow consistent, agent-based model, populated by heterogeneous workers, firms, and banks which behave according to heuristic rules.¹

In brief, the economy is composed by five populations of heterogeneous agents, namely, L^S workers/consumers, F_t^1 capital-good firms, F_t^2 consumption-good industries, $F_{h,t}^2$ consumption-good firms in each industry h , and B banks, plus the central bank and the government.² The basic structure of the model is depicted in Figure 2.

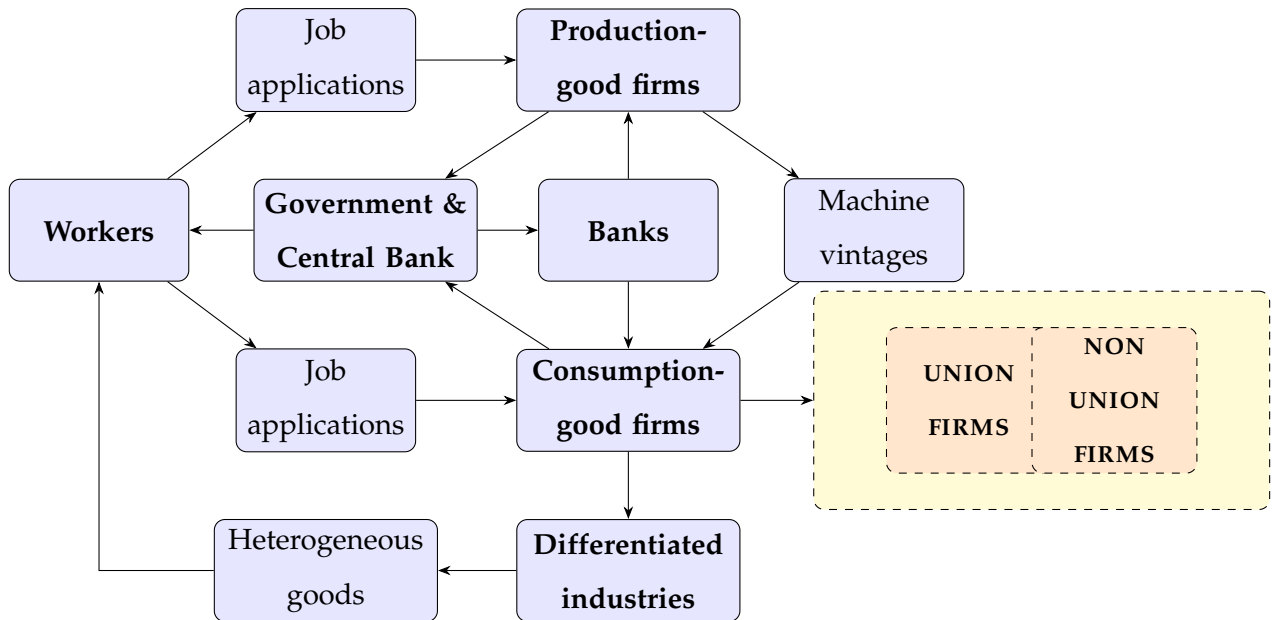


Figure 2: The model overall structure. Boxes in bold style represent the model's agents.

Capital-good firms invest in R&D and produce heterogeneous machine-tools whose stochastic productivity evolves endogenously over time. Less frequently, new generations of machines are discovered, enabling the emergence of new consumption goods and industries. Downstream consumption-good firms combine

¹The section draws upon [Dosi et al. \(2022\)](#).

²Subscript t stands for (discrete) time $t = 1, 2, \dots, T$. Agent-specific variables are denoted by subscript h , in case of industries, i , for capital-good firms, j , for consumption-good firms, k , for banks, and ℓ , for workers.

machines bought from capital-good firms and labour in order to produce quality-differentiated goods for final consumers. Across industries, consumption-good firms compete with heterogeneous products for consumers' expenditures. Workers search for jobs, and firms hire workers according to their individual demand expectation. The banking sector is represented by a fixed number of banks which take deposits and provide interest-paying loans to finance firms' production and investment plans. The central bank manages the monetary policy, imposes regulatory reserves to the banks, and bails out the failing ones. The government levies taxes on firm and bank profits, pays unemployment benefits, imposes a minimum wage, absorbs excess profits and losses from the central bank and keeps a non-explosive public debt trajectory in the long run.

Firms on both sectors are associated with a single bank. A fixed number of heterogeneous banks take deposits from firms (corresponding to their net wealth) and workers (corresponding to temporary savings for future consumption), pay interest, and provide credit to firms under the prudential requirements imposed by the central bank (capital and reserves). Available (limited) credit is allocated to clients according to the respective limit and credit score. Firm limits are based on past sales performance, according to a loan-to-value ratio rule, and the score is based on clients' relative solvency index. Total credit supply to the financial sector is elastic and unconstrained by the aggregate supply side, adapting to credit demand and prudential requirements.

The capital-good industry is the locus of endogenous innovation in the model. Capital-good firms innovate by developing new machine-embodied techniques or imitate the ones of their competitors in order to produce and sell more productive and cheaper machinery. Innovation is of two types, "incremental" or "radical". Incremental innovation gradually increases productivity of existing technologies both on new machine construction and their usage. Radical innovation introduces a new, qualitatively different generation of machines, associated to a new technological paradigm, which is more productive to use but also more expensive to produce and is associated with the arrival of new industry producing "luxury" goods (see below). On demand, capital-good firms supply universal-application

machine-tools to consumption-good firms in any downstream industry, producing with labour as the only input. The capital- good market is characterized by imperfect information and Schumpeterian competition driven by technological innovation. Firms signal the price and productivity of their machines to their current customers as well to a subset of potential new ones, and invest a fraction of past revenues in R&D aimed at searching for new machines or copy existing ones. Prices are set using a fixed mark-up over (labour) costs of production.

Consumption-good firms in each industry produce a single, quality-differentiated good, employing capital (composed by different “vintages” of machine-tools) and labour under constant returns to scale. Desired production is determined according to adaptive (myopic) demand expectations. Given the actual inventories, if the current capital stock is not sufficient to produce the desired output, firms order new machines to expand their installed capacity, paying in advance — drawing on their retained past profits or, up to some limits, on bank loans. Moreover, they 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 (employed) vintages in the capital stocks. Firms choose the capital-good supplier comparing the price and the productivity of the machines they are aware of. They fix their output prices applying a variable mark-up rule on their (labour) production costs, balancing profit margins and market shares, increasing mark-ups and prices whenever market shares are expanding and vice versa. Imperfect information is also the normal state of the consumption-good markets so consumers do not instantaneously switch to the most competitive producer. Market shares evolve according to a replicator dynamics: more competitive firms expand, while firms with relatively lower competitiveness levels shrink, or exit the market.

Consumption-good firms group into different industries. Firms in the same industry produce a homogeneous but quality-differentiated good. From the consumer perspective, there are two broad categories of goods: basic (non-durable) and luxury (durable). Each industry produces goods of a single category. Products from different industries are heterogeneous in five consumer-relevant attributes:

category, price, quality, newness and complexity. Industries compete for the consumer budget (“wallet share”) based on these attributes, which are directly derived from the firm-specific product attributes, in the case of price and quality, while they are identical for the whole industry in terms of category, newness and complexity. Firms compete for a fraction (market share) of the wallet share acquired by the industry which they belong to. Therefore, each industry also defines a (separate) market.

The entry-exit process for industries and firms is entirely endogenous. Industries die and firms leave whenever wallet/market shares get close to zero or (total) net assets turn negative (bankruptcy). Residual positive firm net values are collected by the government, and negative proceedings are supported by the banks. There is a positive probability of a new luxury-good industry entering the economy after the introduction of each new machine generation, due to a successful radical innovation in the capital-good sector. New basic-good industries enter randomly, with probability inversely proportional to the number of incumbent basic industries. At the firm level, the (stochastic) number of entrants in an industry depends on the number of incumbents and on the prevailing financial conditions. When the industrial liquidity-to-debt ratio is growing, firm entry gets easier, and vice versa.

The labour market is modelled as a fully decentralised, search-and-hiring process between workers and firms. For simplicity, banks, the central bank and the government occupy no workers. The aggregate supply of labour is fixed and all workers are available to be hired in any period. When unemployed, workers submit a certain number of job applications to a random subset of firms. Employed workers apply for better positions. Larger firms have a proportionally higher probability of receiving job applications, which are organised in separated, firm-specific application queues. The labour market is also characterized by imperfect information as firms only observe workers’ skills and wage requests on their own queues, and workers are aware only of the wage offers they may receive from firms where they applied for a job. Firms, on the grounds of received orders (capital-good sector), of the expected demand (consumption-good sector), and the current labour

productivity levels, decide whether to (i) hire new workers, (ii) fire part of the existing ones, or (iii) keep the current labour force. Each hiring firm defines a unique wage offer for the best applicant workers, based on firm- and economy-wide productivities. Workers select the best wage offer they get from firms to which they submitted applications, if any. When already employed they may quit the current job if a better offer is received. There are no further rounds of bargaining between workers and firms in the same period. Thus, firms have no guarantee of filling all the open positions, workers may not find a job even when there are still unfilled ones, and no labour market clearing is ever guaranteed. Moreover, there are no firing or hiring transaction costs. The government enforces a minimum wage indexed to the aggregate productivity of the economy.

Consumers split their income between basic- and luxury-good budgets, entirely allocating their income to basic goods up to a given threshold, corresponding to the median of income distribution, and the excess, if any, to luxury consumption. The budget for (divisible) basic goods is (tentatively) spent every period, and split among basic-good industries according to the respective products attributes (price, quality, newness and complexity). Luxury goods, which are not divisible, are acquired whenever three conditions are met: (i) a minimum period from last acquisition passed, (ii) at least one not-recently-bought good is obtainable, and (iii) the available luxury budget (current plus accumulated) is enough to buy at least one unit of the chosen good. If these conditions are not met, the available luxury budget is saved for the next period. So, the consumption bundle at each period is comprised by a set of heterogeneous basic consumption goods, each one supplied by a different industry and firm, plus possibly one or more units of a single luxury good. If total supply of consumer goods is insufficient to satisfy the resulting demands for basic and luxury goods, the excess is saved in banks and turns into additional consumption demand in the next period(s). Workers cannot get credit from banks for consumption.

Table 1 contrasts the wage-setting and other features of union firms and non union firms. Union firms pay the same wages to all workers with the same skills and change wages as aggregate and market productivity change. They fire em-

employees only when profits become negative. Their workers seek alternative jobs less frequently than non union workers, consistent with the exit-voice trade-off in the labor market (Freeman, 1980). In hiring and firing, firms try to keep the more skilled workers. Conversely, non union firms set wages according to worker skills and labor market conditions. Wages are set by an asymmetric negotiation process where firms have the last say over workers. There are no hiring/firing protections and unemployed workers adjust downward their “satisficing” wages. Employed workers search for better paid jobs and firms fire excess workforce according to planned production. Hiring and firing of workers is based on the skills to (individual) wage ratio or just the latter, according to the scenario. The market share of unionized firms is $f_t^u \in [0, 1]$ while that of non unionized firms is $f_t^n \in [0, 1]$.

FIRMS BEHAVIOUR	UNION	NON UNION
Differentiated wages	no	yes
Wage sensitivity to unemployment	low (rigid)	high (flexible)
Wage indexation to average productivity	full	partial
Labour-firing restrictions	under losses only	none
Worker-hiring rule	higher skills	lower wage-to-skill ratio
Worker-firing rule	lower skills	higher wage-to-skill ratio
Worker new-job search intensity	low ($\omega = 2$)	high ($\omega = 5$)

Table 1: Characteristics of the two types of firms.

To focus on the decline in unionization, we assume that non union firms enter and compete with union incumbent firms in an evolutionary process. From $t = 100$, the probability of an entrant being non union is fixed at 50%. The time window ($100 \leq t < 200$) allows non union entrants to grow and achieve some joint market share. At the end of this period the likelihood of union or non union firms entering the consumer-good market is proportionate to their shares f_{t-1}^u and f_{t-1}^n .

Finally, we allow for other pay setting institutions through a profit-sharing mechanism which allows firms with above-average profits distribute bonuses. For simplicity, bonuses are equal for all workers in the firm. Thus, the total bonuses by

firm are:

$$B_{j,t} = \psi_6(1 - tr)\Pi_{j,t-1}, \quad (1)$$

being $\psi_6 \in [0, 1]$ a sharing parameter, $tr \in [0, 1]$ the tax rate parameter, and $\Pi_{j,t}$ the firm gross profit. Therefore, the total income of worker ℓ working for firm j in period t is $w_{\ell,t} + B_{j,t}/L_{j,t}$.

Our primary focus here is on the relationship between deunionization and rising inequality. The validation procedure follows the so called “output validation” approach (Fagiolo et al., 2019), which is progressively becoming the most adopted empirical validation strategy in macro agent-based models. According to such an approach the model properties at different levels of disaggregation are contrasted with the empirical evidence. That is, the model is judged in terms of its ability to robustly generate an ensemble of stylised facts, at different scales of observation. Notice that such an approach is quite different from that based on *matching-moments* and strict parameter calibration on single time series. And it also avoids the trap of ex-post fitting of ex-ante strictly calibrated models.

The multi-sector labour-augmented K+S is meant to analyse the long-term patterns of labour demand under the fundamental duality of technical change between the labour shedding effects of efficiency-enhancing process innovation and the job-creating ones of product innovation. The ABM perspective allows to tackle such a duality under conditions of general disequilibrium, thus avoiding any ex-ante commitment to the idea that the two effects will compensate in the aggregate.

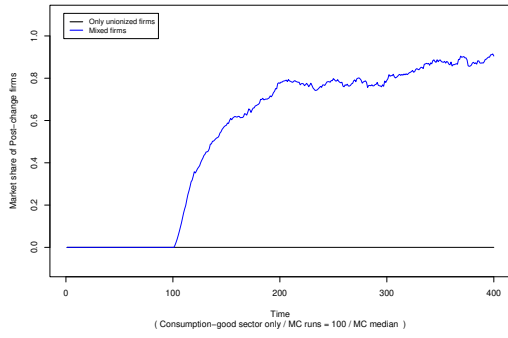
Process innovation is represented by the arrival of new techniques of production embedded in new capital-goods, that are product innovations, which diffuse across producers and among users, for which they are process innovations. Product innovation in final goods here is modelled by means of the emergence of new sectors. Consumers demand goods in a hierarchical order starting from basic and moving to luxury ones. Ubiquitous emergent regularities are humped-shaped diffusion of new products along the industry life-cycle and Engel-type evolution of consumption baskets. New final goods are also more complex in that they also require more stages of production and thus more workers per unit of output: white and gray goods are more complex than breads or pairs of trousers. The full set of

stylized facts and model properties is presented in [Dosi et al. \(2022\)](#), in line with the rich ensemble of micro and macro facts discussed in [Haldane and Turrell \(2019\)](#). Those structural properties are nested into the different institutional dynamics of the labour market, here represented by the two archetypical union and non union firms competing in the market.

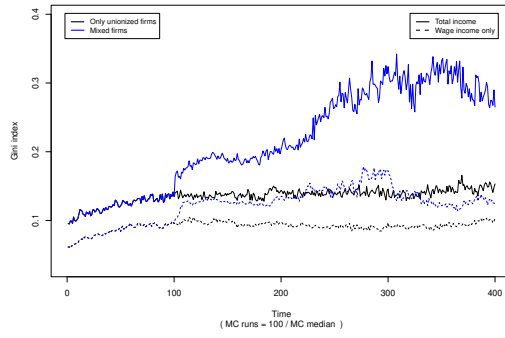
Table 2 shows the list of properties and qualitative scenarios that the model is able to replicate. We next present a battery of simulation results substantiating our findings. Starting with Figure 3.a, the spurt dynamics in deunionization is presented. The arrival time can be interpreted as the approval of a Right-to-Work law, which facilitates the entry of non union firms. The spurt is quite evident as the share of non union firms after a relative short time interval reaches eighty percent. Notably, non union firms populate all sectors but they are not able to dominate the entire market, and a percentage of union firms remain alive, however progressively declining over time. The decline in unionization maps into macro level inequality as shown by the rise in the Gini index from less than 15% up to 30%. Most of the rise is due to the bonus distributed in more profitable firms, as shown in Figure 3.b. In fact, bonuses represent an additional pay scheme that is distributed only in firms whose profitability is higher than the average and they impact upon the wage growth dynamics. Figure 3.c. looks at the process of wage growth across industries. At the industry level, wage growth rates under both institutional scenarios present tent-shaped distributions, in line with the empirical evidence on growth rates in landscapes characterised by competition processes ([Dosi et al., 2017](#)). However, the support of the distribution increases whenever non union firms arrive, with extreme episodes at both tails more frequent. Figure 3.d presents the heterogeneous unionization rate by industries, across 100 MC runs. A U-shaped pattern in terms of incidence of unionized firms do appear, showing the coexistence of cases of highly unionized and non unionized industries in the model, with only non union firms in an industry being the most probable outcome, followed by only union firms. Heterogeneous degrees of unionization rates across industries are less probable, but still possible scenarios. The existence of unionized firms deeply affects the wage dispersion across firms and industries,

and different wage distribution patterns in the unionized vs the mixed scenarios emerge, with larger supports in the second case, reaching more extreme boundary values. This is shown in Figures 3.e and 3.f. We expect, as emergent property, that the higher the share of unionized firms in a given industry the higher the average real wage rate. This expectation is confirmed in Figure 3.g where a positive correlation is detected in the simulated data of the model. Deunionization therefore induces rising i) macro-level inequality, ii) rising wage dispersion between firms, iii) polarization in wage growth dynamics, and iv) it represents an industry-specific attribute.

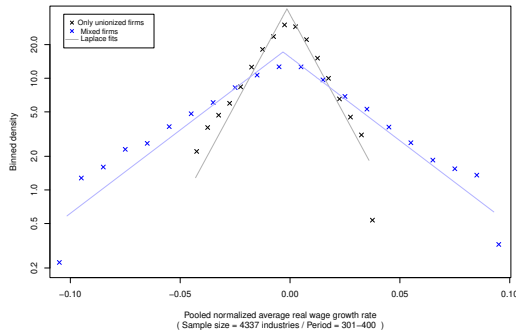
The effects of deunionization are deeper and reverberate into the structural cores of the model, that is the dynamics of labour demand absorption, technological change and consumption patterns. While industries present the typical S-shaped curve of diffusion models (Franses, 1994) showing an industry life-cycle dynamics (Klepper, 1997), in the peak phase the number of workers absorbed in the union setting is higher, 17 thousand workers when compared to the peak of employment absorption in the case of coexisting non union firms, with a peak of 14 thousand workers. The result holds across Monte Carlo average and median realizations. The different employment absorption capacity is due to the pattern of consumption, presented in Figure 3.h where the Engel's law is estimated in each scenario. The Engel's law shows a direct interaction between the structure of distribution of income and the patterns of consumption. In the more egalitarian union setting, the share of basic goods decays over time at a pace by far more tamed than the rate of decay in the scenario populated by non union firms. In the second setting, the share of basic industry goods rapidly shrinks, leaving only space to luxury goods and durable industries, attainable just by the richest population. Therefore, as an endogenous property, the model is able to link inequality from the income perspective with inequality from the consumption perspective inasmuch a more unequal society consumes and desires more luxury, durable goods, say houses, yachts, air planes, more costly and less accessible to workers that are budget-constrained.



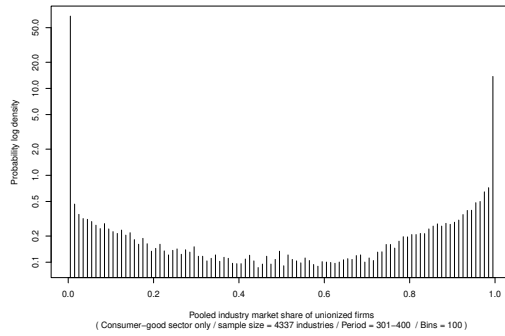
(a) Rise of non union firms



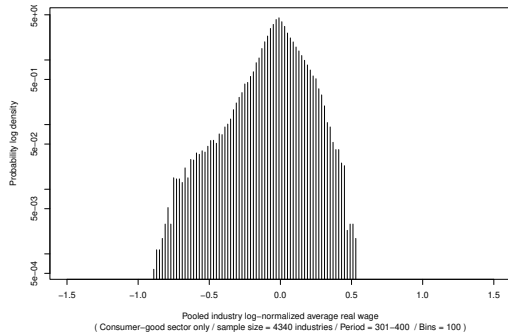
(b) Gini index



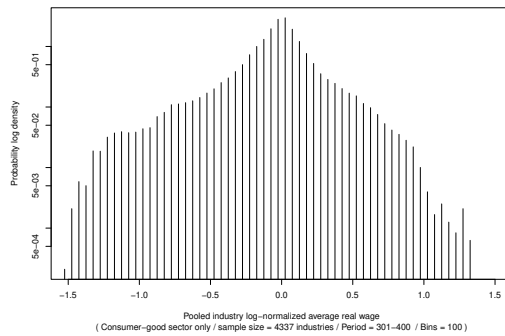
(c) Industry average wage growth distribution



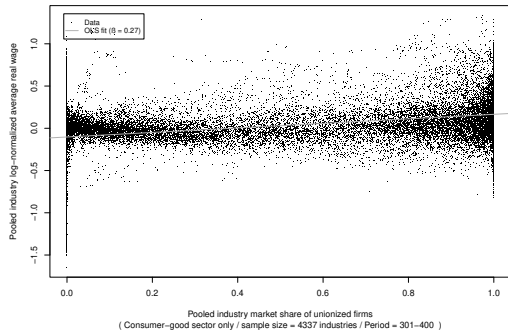
(d) Heterogeneous unionization rate across industries



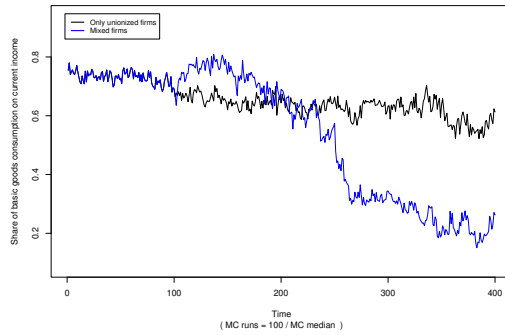
(e) Wage distribution - unionized firms



(f) Wage distribution - Non unionized firms



(g) Unionization vs. wages



(h) Engel's law

Figure 3: Declining unionization and rising inequalities: macro-level, industry-level and consumption patterns

MODEL PROPERTIES	EMPIRICAL EVIDENCE
Spurt dynamics in unionization/deunionization	Freeman (1998)
Positive correlation between unionization and inequality	Farber et al. (2021)
Deunionization as a result of within industry dynamics and competition forces	Hirsch (2008)
Higher wage in union vs non union establishments	Lemieux (1998)
More equal wages in union vs non union establishments	Fortin et al. (2023)
Industry level heterogeneous unionization rates	Fortin et al. (2023)
Positive correlation of unionization rate and wages at the industry levels	Western and Rosenfeld (2011)

Table 2: Model properties facing political economy challenges: declining deunionization and rising inequalities

4 Conclusions

After 2010 five states in the US, located in the Great Lake area or in its proximity, have introduced Right-to-Work laws, a specific juridical instrument disfavouing unionization. Empirical evidence has shown that such laws weaken workers in their unionization rights. These five states join a bulk of states, in the South and Midwest, historically adopting RTW laws since the introduction of the Taft-Hartley Act in 1947. The recent adoption of RTW laws is accompanied by two macro long run structural and institutional trends, namely declining unionization and increasing inequality. How do we interpret such patterns? Can complexity economics provides a coherent representation of the effects of declining unionization? Is deunionization a driver of increasing inequalities, both at the workplace and at the macro-level? Which are the dynamics of employment absorption when non union firms prevail? And, is wage inequality also reflected in consumption inequalities?

These are some of the questions that we can ask in the multi-sector labour augmented K+S model that has indeed shown the capability of complexity economics to be a powerful analytical and theoretical tool to address this and other germane urgent challenges in contemporary capitalism. The proposed model is able both to produce phase transitions with tipping points, such as the spurt dynamics in deunionization, but also to account for cumulative long lasting propagation mechanisms, at different aggregation levels and time scales. Deunionization does not simply affect the wage workers receive in the firm where they are employed, but

propagates at the macro level, affecting the life-cycle pattern of industries and the long-run structure of consumption, via the Engel's law. In this respect, macro-evolutionary agent-based models appear to be among the most promising tools to assess the transformation of the capitalist machine, a multi-level, multi-scale structure of production and exchange, whose mechanisms propagate with alternate speeds and manifest in erratic ways.

Other applications of the current model structure include the analysis of the relationship between product versus labour market concentration, inflation, the impact of firing and plant closures due to firm crises, monopsony in the labour market due to the rise of giant firms, and more generally the effects of changes in labour power and quit rate elasticities, but also labour law legislations, as the introduction/abolition of the minimum wage. New avenues of research certainly include embedding multi-dimensional forms of inequality, such as inequalities linked to distinct group attributes, i.e. gender and race, exposure to diseases and pollutions, associated with environmental and health inequalities. Extensions and variations of the model able to describe the changing role of social institutions, particularly the role of the welfare state and the provision of public goods are other companion lines of research.

In general, the capitalist system rapidly changes, at an unpredictable pace, at least in details and timing. This means that any interpretation of such dynamics in terms of equilibrium models is badly off the mark. However evolutionary ABMs are very promising candidates to face such challenge. And a growing, young community in such macro evolutionary perspective is the best bet to improve our knowledge in social sciences concerned, as they ought to be, with dynamics of complex multi-scale systems permanently subject to technological, organizational and institutional changes.

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