If bad money drives out good money: deunionisation and productivity slowdown

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Abstract

We develop an agent-based model able to account for the macroeconomic consequences of an endogenous process of de-unionisation resulting from a competition mechanism between two types of firms, namely unionised and non-unionised. Whenever non-unionised firms prevail, the average productivity growth declines, the productivity standard deviation and the market concentration increase, in a "winner-takes-it-all" scenario, cost competition induces a deflationary spiral, and product quality is reduced. By means of a shift and share decomposition, we track the *within*, *between*, *cross*, *entry* and *exit* components of productivity growth and the ensuing wage-productivity nexus.

Keywords: Deunionization, productivity slow-down, agent-based model

Desenvolvemos um modelo *agent-based* capaz de analizar as consequências macroeconômicas de um processo endógeno de dessindicalização resultante de um mecanismo de concorrência entre dois tipos de firmas, sindicalizadas ou não. Sempre que as empresas não sindicalizadas prevalecem, o crescimento médio da produtividade declina, o desvio padrão da produtividade e a concentração do mercado aumentam, em um cenário "o ganhador fica com tudo", a competição de custos induz uma espiral deflacionária e a qualidade do produto é reduzida. Por meio de uma decomposição do tipo *shift-and-share*, rastreamos os componentes do crescimento da produtividade e o nexo salário-produtividade resultante.

Palavras-chave: Dessindicalização, desaceleração produtividade, modelo *agent-based*
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1 Introduction

A new emerging malaise of capitalist organizations is currently affecting many mature economies, namely productivity slowdown. Since the First Industrial Revolution productivity has been the engine pumping wage and output growth and ensuring better standard of leaving. Currently, the dynamics of productivity does exhibit alarming trends. Syverson (2017) documents that US productivity growth more than halved between 1995 and 2015, moving from 2.8% in (1995-2004) to 1.3% (2005 – 2015). A similar pattern characterizes 29 out of 30 countries analysed in the same study, with an average decline of 1.2 percentage points and 0.9 p.p. of standard deviation.

Less new are the patterns affecting wage dynamics: stagnant real wage growth and the surge in wage inequality. Already since the late Eighties, scholars have been studying the increasing patterns of wage dispersion (Freeman, 1984; Lee, 1999). More recent is the acknowledgement of a declining labour share in developed countries (Hutchinson and Persyn, 2012; Karabarbounis and Neiman, 2013). If the Golden Age of capitalism was characterized by a proportional wage/productivity growth, and a constant wage share, since the eighties the wage-productivity nexus has weakened its relationships, with a declining pass-through of productivity growth on wage growth. The decoupling of wage-productivity growth is therefore the result of two concurrent factors: declining labour share and increasing divergence between median and average income (Schwellnus et al., 2017).

Moving from macro to micro, a growing stream of literature digs inside into the dynamics of firm/establishment level wage dispersion. In particular, looking at the main drivers of wage inequality, since the contribution by Dunne et al. (2004), it appears that the between-establishment component of the overall wage inequality has been the main driver of the growth of wages dispersion, while the within one, contributed more moderately to the increase in the latter. Recent findings by Barth et al. (2016), linking the Census Bureau's Longitudinal Business Data Base (LBD) and the Longitudinal Employer-Household Dynamics data (LEHD) show that the inter-establishment wage dispersion does contribute roughly twice with respect to the intra-establishment one. In fact, paraphrasing the article by Barth et al. (2016), it is exactly where you work that has been strongly impacting on the increase in wages and earnings dispersion in the US. In a similar vein Berlingieri et al. (2017) have recently documented a surge in both wage and productivity dispersions across 16 OECD countries from the mid-1990s to 2012, especially in the service sectors and concerning the bottom-part of the distributions (50-10 percentiles).

Which are the causes at the root of the latter empirical patterns? Among the main possible mechanisms, ranging from demand to supply side ones, the explanation we are going to explore in this work is the link between the wage structure and firms market performance, in terms of productivity growth: if low-productive firms are also low-wage firms they might in tune remain alive leveraging on their cost structure. In this respect, alternative wage setting schemes act as a selection/non selection mechanism cleansing or not the market. This selection process, going from wage, to productivity to survival/exit is tightly linked to the changing nature of labour market organization, which in the last decades has seen, together with many fundamental changes, a dramatic decline in the unionization rate.

How much of the emerging pattern of average productivity slowdown and increasing productivity dispersion can be accounted by the process of deunionization of firms? This paper is meant to address the latter question by means of a simulated economy populated by a set of heterogeneous interacting agents, according to the modelling practice going under the heading of Agent-Based Models (ABMs). ABMs are large-scale, computational models which allow the simulation of artificial economies wherein ensembles of heterogeneous agents interact on the ground of simple behavioural rules. Aggregate-level outcomes are the emergent properties from the interactions of such boundedly rational agents. Unlikely DSGE models driven by the search of closed-form solutions derived from linearisation around equilibrium conditions, ABMs are open-ended systems where the notion of *coordination* substitutes the one of equilibrium. Moreover such models may display path-dependency along *each* simulation history, as well as *between* alternative simulations. Short of any derivation from some principle of rationality, ABMs ought to be primarily judged on their ability to reproduce as *emergent properties* sets of *stylised facts*, i.e. empirically observed statistical regularities. The use of agent-based models has become the standard practice in many disciplines dealing with complex phenomena, wherein the micro and the macro levels are not isomorphic. More recently, these models have also been adopted in economics. Indeed, the features of ABMs are particularly suited to the analysis of economic phenomena characterised by (i) disequilibrium processes and (ii) persistent heterogeneity. Therefore we model the process of deunionziation following a bottom-down perspective, according to the *spurt* model first investigated in (Freeman, 1997). Unionised and non-unionised firms do compete in the product market arena in terms of their relative efficiency, affected by prices, quality and quantity (excess, unfilled demand) variables. The model produces two possible statistical equilibrium patterns: a stable case of unsuccessful invasion by non-unionised firms, and a stable case of invasion by non-unionised firms.

Whenever non-unionised firms prevail the average productivity growth declines, productivity standard deviation and market concentration increase, mimicking a "winners-take-all" scenario, cost-competition induces a deflationary spiral, and also product quality is reduced. By means of a shift and share decomposition, we track the *within*, *between*, *cross*, *entry* and *exit* components of productivity growth and the ensuing wage-productivity nexus.

2 At the source of weak selection

Microeconometric firm level studies have been devoting attention to the patterns of firm level idiosyncratic learning, in terms of productivity growth, and of market selection, focusing on the reallocation dynamics between incumbent firms and at the entry/exit patterns (Foster et al., 2001). Results from this stream of literature emphasize the phenomenon of job reallocation as a signal of the cleansing occurring in the market, with workers moving from low-productivity to high-productivity firms (Davis et al., 1998). However, recent findings provide contrasting evidence: Dosi et al. (2015) using a sample of US listed, big firms (COMPUSTAT) show that also in the US economy, considered to be quite prone to the purported reallocation dynamics, according to which less efficient firms lose market shares in favour of the more efficient ones, the main driver of productivity growth is a within (inside the firm) process of accumulation of learning, while the selection process appears to be quite weak. In line, Foster et al. (2016) find that the pace of reallocation in terms of job creation/job destruction rates and the ensuing cleansing effect in the Great Recession was lower than those recorded in previous crisis periods. Additionally, the evidence on the relationship between relative efficiency and firm growth does not provide a strong link on the co-variations between the two latter variables: in a way, improvements in productivity do not directly translate into firms market-performance, in terms of sales growth (Bottazzi et al., 2010). These findings suggest (i) the existence of ample heterogeneity in firm level productivity dynamics, (ii) a weak productivity-growth nexus, (iii) the absence of any converge process in the productivity dynamics across firms. A tale of double divergence seems to emerge: not only firms do present persistent heterogeneity in their performance variables – including productivity - , but there is also no sign of convergence in wages. On the contrary, divergence seems to prevail and grow.

Currently investigated causes of this divergence are the impact of easy access to credit and entry slowdown. A recent OECD study (McGowan et al., 2017), recalling the idea of zombie firms, analyses how, over the last decade (2003-2013), the share of zombie firms - defined as those firms in such financial troubles that are unable to meet their interest payments, but are still alive - have been steadily increasing. Keeping alive, those firms might hamper productivity growth. This latter evidence is again in line with some slow-down of the selection/reallocation process, which is lacking to produce the expected cleansing effect, especially during recessionary phases. Related, the declining business dynamism, with a slowdown of entry and a constant exit rate, is the further signal of the reduction in the selection process (Decker et al., 2016).

However, less attention has been devoted to the link between labour market organization and the ensuing productivity and technological conditions. Given the emerging tale of double divergence, it is naturally to investigate to what extent the increasing wage dispersion has allowed low productivity firms to remain alive. Some empirical evidence points in favour of the latter mechanism. Barth et al. (2014) when looking at the Scandinavian model do find evidence that more compressed wage structures, like those in Norway, Sweden and Denmark, are able to fuel more creative destruction in the market, reducing the dispersion in productivity. Similarly, Hibbs Jr and Locking (2000) find that lower within-plant wage dispersion exerts a positive effect on productivity, with a shift of capital and labour from low-productivity to high-productivity firms. If less unequal between-plant wage level might foster selection, the process of deunionization, which has largely invested many advanced economies, is one of the major force pushing in the opposite direction. In this respect, the increasing wage dispersion between firms induced by deunionization (Freeman, 1984), has been an implicit buffer which indirectly helped low productivity firms to survive.

Granted the deunionization-productivity slowdown link we intend to explore, an inherent problem relies on *how* to model the process of deunionization. Freeman (1997), documenting the patterns of unionization in many advanced economies, proposes the metaphor of the *spurt*: unionization was a phase transition occurred after that some thresholds/tipping points have been reached, resulting as a bottom-up emergent property of the system; clearly, the probability that the spurt occurs positively depends on the existence of already unionised workers/firms. On the contrary many labour historians and economists see unionism as the result of some top down act, as the Wagner Act in US, the Blum government in France, the PC 1003 in Canada. However, the exogenous shock interpretation leaves reduced scope to interpret the spurt dynamics of union rise and decline and it predicts a stable unionization rate over time, which is clearly not revealed by the data.

Interpreting unionization as a bottom up process allows also to model the process of deunionization. Bryson et al. (2017) argue that the process of union decline, more than due to abandonment rate from previously unionised workers is due to the "never-member" effects, which see new cohorts of worker never adhere to union organizations. Those firms experiencing the "never-member" effects result into being non unionised ones, therefore moving

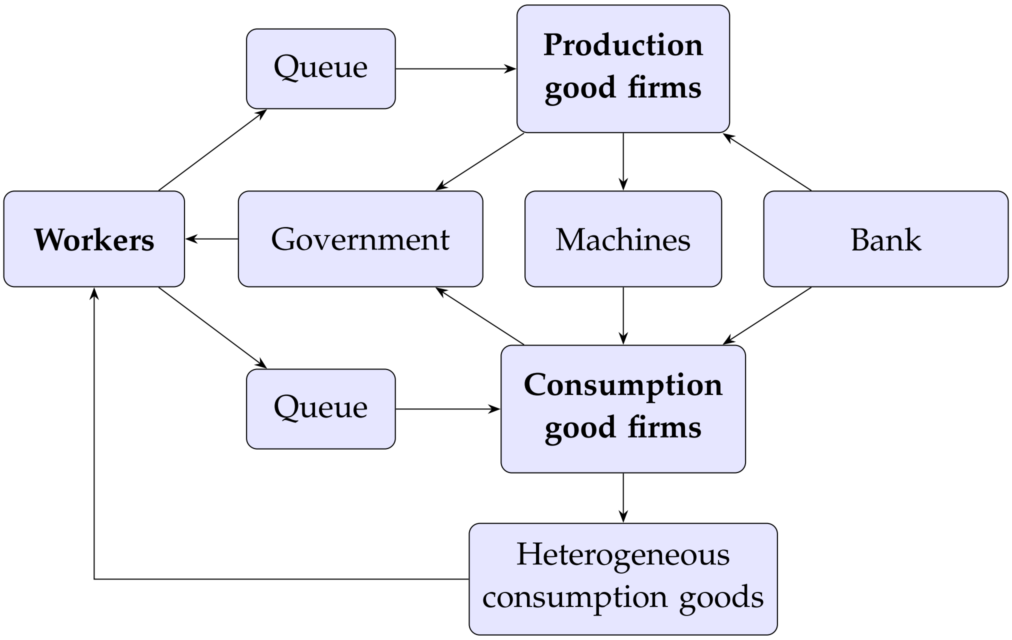


Figure 1: The model structure. Boxes in bold style represent heterogeneous agents populations.

from worker-level to firm-level unionisation/deunionization process.

Our ABM, presenting an inherent non-linear strucure allows, in line with the model in Freeman (1997), to identify two convergence states (statistical equilibrium) of the system, namely a zero union density and a high (complete) union density. After accounting for the process of rising and fall of unionism, we shall study the ensuing technological regimes emerging in the two states in order to explore the deunionization/productivity slowdown nexus.

3 The model

We build a general *disequilibrium*, stock-and-flow consistent agent-based model, populated by heterogeneous firms and workers, who behave according to bounded-rational rules. More specifically, we extend the existing Keynes Meets Schumpeter (K+S) model (Dosi et al., 2010), including decentralized interactions among firms and workers in both the product and the labour markets (Dosi et al., 2017, 2016), to introduce an endogenous process of workers' skills accumulation and variable number of firms.

The two-sector economy is composed of three populations of heterogeneous agents, F_t^1 capital-good firms (denoted by the subscript i), F_t^2 consumption-good firms (denoted by the subscript j), L^S consumers/workers (denoted by the subscript ℓ), plus a bank and the Government. The basic structure of the model is depicted in Figure 1. Capital-good firms invest in R&D and produce heterogeneous machine-tools whose productivity stochastically 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 minimal financial system represented by a single bank that provides credit to firms to finance production and investment plans. Total credit is allocated to each firm according to their own credit demand, which is constrained by their past sales, according to a loan to value ratio rule. Credit supply is conversely completely elastic and unconstrained, adapting to credit demand. Workers submit job applications to a subset of the firms. Firms hire according to their individual adaptive demand expectations. The government levies taxes on firms, pays unemployment benefits and set minimum wages, according to the policy setting, absorbing excess profits and losses from the bank and keeping a relatively balanced budget in the long run.

In the following, we first summarize the functioning of the capital- and the consumption-good sectors of our economy, with a focus on the entry process, and then present the labour market dynamics, detailing the skills accumulation and deterioration mechanisms. Finally, we describe the two alternative policy regime settings (and variations thereof) under which the model has been explored.

3.1 The capital- and consumption-good sectors

The capital-good industry is the locus where innovation is endogenously generated in the model. Capital-good firms develop new machine-embodied techniques or imitate the ones of their competitors in order to produce and sell more productive and cheaper machinery. On demand, they supply machine-tools to consumption-good firms, producing with labour as the only input. Firms have access to bank loans to cover liquidity problems up to a limit. The capital-good market is characterized by imperfect information and Schumpeterian competition driven by technological innovation. Machine-tool 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 produce a quality-differentiated single 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 limit, 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 vintages of machines in their capital stocks. Consumption-good firms choose in every period their capital-good supplier comparing the price and the productivity of the machines they are aware of. Firms then fix their prices applying a variable mark-up rule on their production costs, trying to balance profit margins and market shares. More specifically, firms increase their mark-up and price whenever their market share is expanding and vice versa. Imperfect information is also the normal state of the consumption-good market so consumers do not instantaneously switch to the most competitive producer. Market shares evolve according to a (quasi) replicator dynamics: more competitive firms expand, while firms with relatively lower competitiveness levels shrink, or exit the market.

The process of entry-exit is entirely endogenous in both sectors. Firms leave the market whenever their market shares get close to zero or their net assets turn negative (bankruptcy). Conversely, the number of entrants stochastically depends on the number of incumbents and on the prevailing financial conditions. When the sectoral liquidity-to-debt ratio is shrinking new firms find it easier to enter, and vice versa.

3.2 The labour market and skills dynamics

The labour market in the model implements a fully-decentralized search and hiring process between workers and firms. The aggregate supply of labour L^S is fixed and all workers are available to be hired in any period. When unemployed, workers submit a certain number of job applications to firms. Employed workers may apply or not for better positions, according to the institutional set up. Larger firms have a proportionally higher probability of receiving job applications, which are organized in separated, firm-specific application queues. The labour market is characterized by imperfect information as firms only observe workers skills and wage requests and workers are aware only of the wage offers they may receive.

Firms decide about their individual labour demand based on the received orders (capital-good sector), the expected demand (consumption-good sector), and the expected labour productivity levels. Considering the number and the productivity of the already employed workers, firms decide whether to (i) hire new workers, (ii) fire part of the existing ones, or (iii) keep the existing labour force. Each hiring firm defines a unique wage offer for the applicant workers, based on its internal conditions and the received applications. Workers select the best offer they get from the firms to which they submitted applications, if any. If already employed, depending on the institutional regime, they might quit the current job if a better wage offer is received. There are no further rounds of bargaining between workers and firms in the same period. Thus, firms have no guarantee of fulfilling all the open positions, and no market clearing is ever guaranteed. Moreover, there are no firing or hiring transaction costs.

3.3 Competition between unionised and non-unionised firms

We employ the model described above to study a process of evolutionary competition between two types of firms, which we call *unionised* and *non unionised*. The distinctive features of the two types of firms are telegraphically sketched in Table 1.

In *unionised firms*, whose market share are denoted as f_2^{U}, wages are insensitive to the labour market conditions and indexed to the productivity gains of the firms. There is a sort of covenant between firms and workers concerning "long term" employment: firms fire only when their profits become negative, while workers are loyal to employers and do not seek for alternative jobs. When hiring/firing, firms aim to keep the more skilled workers. Labour market institutions contemplate a minimum wage fully indexed to aggregated economy productivity and unemployment benefits financed by taxes on profits. Conversely, in *non-unionised firms*, whose market share are denoted as f_2^{NU}, flexible wages respond to unemployment and decentralised market dynamics, and are set by means of an asymmetric bargaining process where firms have the last say. Employed workers search for better paid jobs with some positive probability and firms freely adjust (fire) their excess workforce according to their planned production. Hiring/firing workers by firms are based on a balance between skills and wages, using a simple payback comparison rule. Non unionised firms operate under different labour institutions: minimum wage is only partially indexed to productivity and unemployment benefits – and the associated taxes on profits – are relatively lower.

We simulate an artificial economy where at the beginning only unionised firms exist. After 100 periods non unionised firms start to enter into the market according to an evolutionary competition process. For the following 100 time steps, defined by the parameter

$ent_{2trdChg}$, non unionised firms enter with a fixed proportion with respect to unionised ones, namely 50%, defined by the parameter $ent_{2HldPer}$. This time window serves as a buffer in order to let the new entrant firms growing and populating the market. After the critical threshold is met, there exists a given probability for a new born firm of being non unionised, being this probability the realization of a random draw from a uniform distribution bounded from below by a minimum floor f^2_{min} and from above by the share of existing types of non-unionised firms $f^{2,NU}_{t-1}$:

$$f^{\mathrm{NU}}_{b^2,t} = \mathcal{U}[f^2_{min}, f^{NU}_{2,t-1}] \tag{1}$$

where $f^{\mathrm{NU}}_{b^2,t}$ is the share of new entrant firms of type NU, while $1 - f^{\mathrm{NU}}_{b^2,t}$ is the share of existing firms of type U. Firms compete in the product market according to their relative competitiveness. In particular, Consumption-good prices are set applying a variable markup $\mu_{j,t}$ on average unit costs:

$$p_{j,t} = (1 + \mu_{j,t})c_{j,t}. \tag{2}$$

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

$$\mu_{j,t} = \mu_{j,t-1}\left(1 + \upsilon \frac{f_{j,t-1} - f_{j,t-2}}{f_{j,t-2}}\right) \tag{3}$$

with $\upsilon \in (0, 1)$. Firm market shares evolve according to a replicator dynamics:

$$f_{j,t} = f_{j,t-1}\left(1 + \chi \frac{E_{j,t} - \bar{E}_t}{\bar{E}_t}\right), \quad \bar{E}_t = \frac{1}{F^2_t} \sum_j E_{j,t} f_{j,t-1}, \tag{4}$$

where the firms relative competitiveness $E_{j,t}$ is defined based on the individual normalized prices $p'_{j,t}$, unfilled demands $l'_{j,t}$ and product qualities $q'_{j,t}$:

$$E_{j,t} = -\omega_1 p'_{j,t-1} - \omega_2 l'_{j,t-1} - \omega_3 q'_{j,t-1}, \tag{5}$$

being $(\omega_1, \omega_2, \omega_3) \in \mathbb{R}^2+$ parameters. Unfilled demand $l_{j,t}$ is the difference between the demand $D_{j,t}$ the firm gets and its production $Q_{j,t}$ plus inventories $N_{j,t}$, if positive:

$$l_{j,t} = \max\left[D_{j,t} - (Q_{j,t} + N_{j,t}), 0\right]. \tag{6}$$

Product quality is defined as the average of the log skills $s_{\ell,t}$ of the firm's workers:

$$q_{j,t} = \frac{1}{L_{j,t-1}} \sum_{\ell \in \{L_{j,t-1}\}} \log\left[s_{\ell,t-1}\right]. \tag{7}$$

The skill level $s_{\ell,t} > 0$ of each worker ℓ evolves over time as a multiplicative process:

$$s_{\ell,t} = \begin{cases} (1 + \tau_T)s_{\ell,t-1} & \text{if employed in } t-1 \\ \dfrac{1}{1 + \tau_U} s_{\ell,t-1} & \text{if unemployed and not under training in } t-1, \end{cases} \tag{8}$$

where $\tau_T \geq 0$ is a parameter governing the learning rate while the worker is employed, and $\tau_U \geq 0$ is the corresponding parameter accounting for the skills deterioration when a worker is unemployed. As a consequence, when worker ℓ is employed her abilities improve over time, as she becomes more experienced in her task or acquire new skills. Conversely, unemployed workers lose skills. When a worker is hired, she immediately acquires the minimum level of skills already present in the firm (the incumbent worker with the lowest skills), if above her present level. Workers have a fixed working life: after a fixed number of periods T_r, workers retire and are replaced by younger ones,[1] whose skills are set to the current minimum level of employed workers.

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

$$A_{\ell,t} = \frac{s_{\ell,t}}{\bar{s}_t} A_i^{\tau}, \qquad \bar{s}_t = \frac{1}{L^S} \sum_{\ell} s_{\ell,t}, \tag{9}$$

where $\bar{s}_t$ is the average worker skills level, A_i^{τ} is the "standard" productivity of the vintage of the machinery which the worker operates, and L^S, the (fixed) total labour supply. Thus, the ratio $s_{\ell,t}/\bar{s}_t$, the worker normalized skills, represents her ability to produce more (if $s_{\ell,t} > \bar{s}_t$) or less than the "standard" associated with a given machine technology.[2]

	UNIONISED	NON UNIONISED
Wage sensitivity to unemployment	low (rigid)	high (flexible)
Labour firing restrictions	under losses only	none
Workers hiring priority	higher skills	lower payback
Workers firing priority	lower skills	higher payback
Unemployment benefits	yes	yes (reduced)
Minimum wage productivity indexation	full	partial

Table 1: Main characteristics of the two types of firms

In order to better characterize contemporary labour markets we have also introduced a profit-sharing mechanism, according to which firms performing better than the average ones, distribute bonuses to their workers. If distributed, bonuses are equal for all workers inside the firms, and they are distributed proportionally to firms net profits. Only those firms whose profit rate is higher than the average one distribute bonuses:

$$B_{j,t} = \psi_6 \Pi_{j,t}(1 - tr) \quad if \quad \frac{\Pi_{j,t}}{K_{j,t}} > \overline{\frac{\Pi_t^2}{K_t^2}} \tag{10}$$

3.4 Timeline of events

In each simulation time step, firms and workers behavioural rules are applied according to the following timeline:

1. Machines ordered in the previous period (if any) are delivered;
2. Capital-good firms perform R&D and signal their machines to consumption-good firms;
3. Consumption-good firms decide on how much to produce, invest and hire/fire;

[1]At the start of each simulation, initial workers ages are randomly draw in the integer range $[1, T_r]$ and all start from the same skills level.

[2]Note that, in this specification, the firm-level effective productivity $A_{j,t}$ is a truly emergent property, resulting together from the technical innovation dynamics (the introduction of new vintages A_i^{τ}), the worker skills evolution and the effective demand, which guides firms when deciding the capital stock dynamics and the employed machine mix.

4. To fulfil production and investment plans, firms allocate cash-flows and (if needed) borrow from bank;
5. Firms send/receive machine-tool orders for the next period (if applicable);
6. Workers (employed and unemployed) update their own skills;
7. Firms open job queues and job-seekers send applications to them ("queue");
8. Wages are set (indexation or bargaining) and job vacancies are partly or totally filled;
9. Government collects taxes and pays unemployment subsidies;
10. Consumption-good market opens and the market shares of firms evolve according to competitiveness;
11. Firms in both sectors compute their profits, pay wages, distribute bonuses and repay debt;
12. Exit takes place, firms with near-zero market share or negative net assets are eschewed from the market;
13. Prospective entrants decide to enter according to the markets conditions;
14. Aggregate variables are computed and the cycle restarts.

4 Deunionization and productivity slowdown

Let us now focus on the process of deunionization. The model produces two endogenous statistical equilibria in terms of market shares, or equivalently convergent states. In Figure **????** the stable statistical equilibrium of Invasion is presented: as shown by the light grey area, representing the maximum and the minimum realizations, there are cases in which the occurrence of complete invasion by non-unionised firms does not happen. The latter is the result of the stochastic competition between the two types of firms as defined in Table 1 and the sign of the path-dependency entailed by the model structure.

Scenarios	Conditions on NU firms
Invasion	Lower/higher payback (wage/skills ratio) workers are hired/fired first
No Invasion	Lower/higher wage workers are hired/fired first

Table 2: Model conditions for the equilibrium of unsuccessful invasion (No Invasion scenario).

What are the conditions under which the process of invasion is not successful? Given that the baseline configuration of non-unionised firms, as presented in Table 1, produces the Invasion scenario, where unionised firms are expelled from the marker, we intend to understand under what conditions the survival of unionised firms occurs. The modification to the baseline configuration is presented in Table 2. The case of unsuccessfully invasion depends on non-unionised firms becoming more cost-sensitive changing their hiring/firing order scheme: under the new conditions they simply perform cost-minimization and hire/fire lower/higher wage workers first. Differently from the baseline configuration presented in Table 1, if non-unionised firms do not use a payback rule, evaluating the cost of labour relative to worker skills, they end up loosing competitive advantage, offering too much lower quality products in the market. Note in fact that under Equation 5, the product quality affects firm competitiveness, and quality, under Equation 7 depends on the average workers' skills at the firm level.

What type of wage patterns do emerge in the two scenarios and to what extent the prevalence of one of the two types of firm produces a less/more equal wage distributions? Figure 2(a) presents the pooled wage distribution of firm-level wages. As expected, the distribution of wages is extremely more concentrated and less dispersed in the No Invasion case, wherein the majority of the firms are unionised ones. Not only in terms of remuneration but also in terms of wage growth (see Figure 2(b)) the No Invasion scenario presents the most compressed wage growth patterns, with a range of variation between $[-0.05, 0.05]$. The range of wage growth variation more than double in the Invasion scenario, explaining the more skewed distribution in wage level.

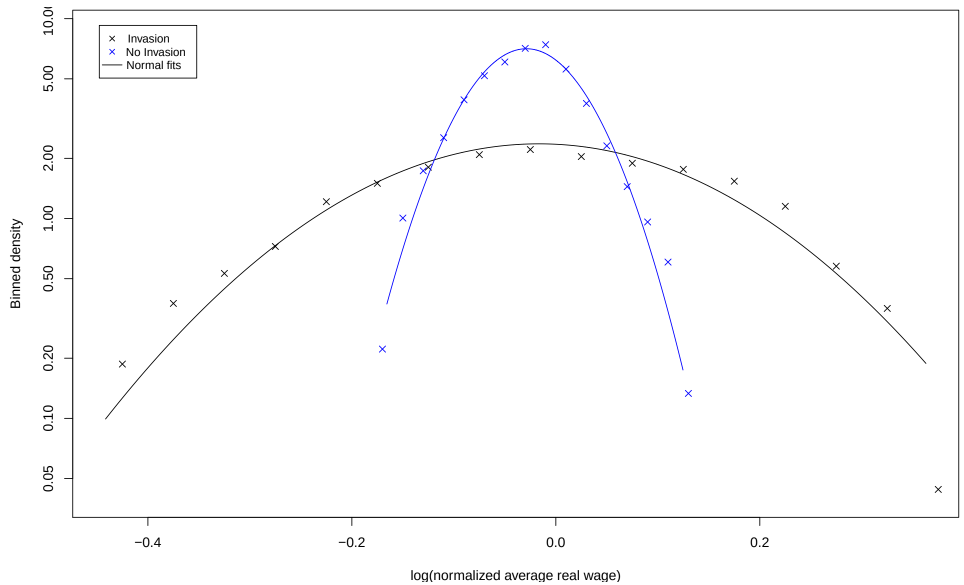
Figure 2(c) presents the time evolution of productivity in the two scenarios, by firm type, separately accounting for the role of unionised and non unionised firms. Figure 2(c) does not simply account for the absolute level of productivity dynamics by firm type but it is also affected by the dynamic evolution of each type of firm in the market. Starting from the Invasion scenario, non-unionised firms, that are the fraction largely populating the market, present a higher level of productivity which decouples from the one of unionised firms before $t = 300$. The lower productivity level of the latter firms is however largely due to the reduced numerous of unionised firms. Although largely invaded, the few unionised firms remaining alive in the market, maintain a positive productivity level, and keep surviving. The opposite patterns instead occur in the No Invasion scenario: in this case non-unionised firms completely disappear from the market. A first side note is that, comparing in both scenarios failing unionised vs non unionised firms, the former are more productive and resilient to the process of invasion.

In Figure 2(d) it is shown the dynamics of productivity standard deviation. Looking at the Invasion case, after the process of invasion occurred, unionised firms do present a much lower between firm productivity differential. The latter evidence is also revealed by the increasing standard deviation spurring after non unionised firms start populating the market, at $t = 100$, in both scenarios: in general the variation of productivity across firms is always higher between non unionised firms (dotted line), as expected from the empirical evidence.

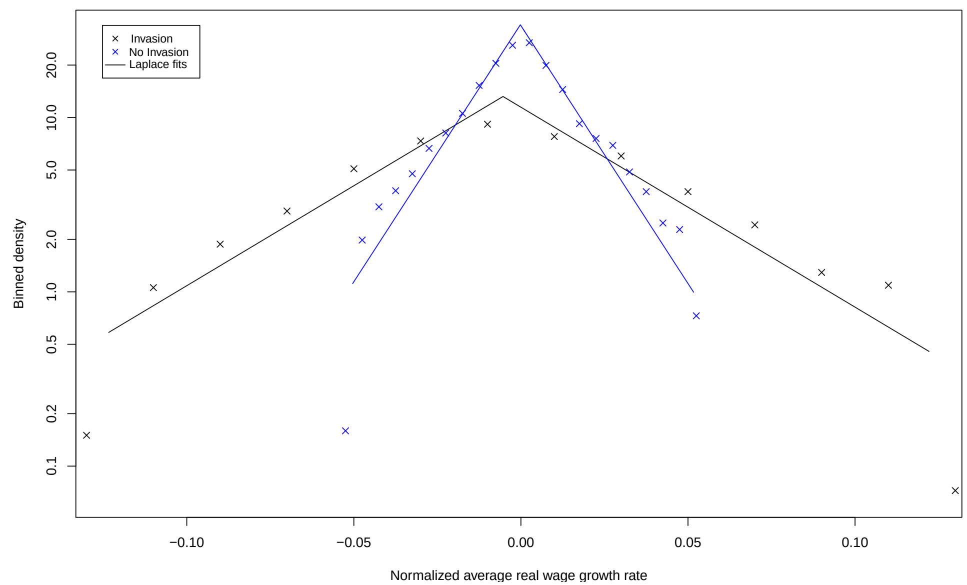
Figure 3(a) presents the average productivity growth in the two scenarios comparing the average value of the latter variable across 50MC runs in each of the two respective scenarios. The invasion of non unionised firms entails a reduction of the average productivity growth of 0.17%, signalling that the process of deunionization in our model causes a productivity slowdown. Not only non unionised firms have in average a lower productivity, they also produce products of lower quality (Figure 3(b)): the latter mechanism is due to the different organization of labour market occurring in the two types of firms: in fact, in non unionised firms, characterized by external flexibility, workers are in average less skilled. The lower degree of workers competence maps into lower quality products, according to Equation 7.

Figure 2: Wage and productivity dynamics I - Distributional and time series analysis

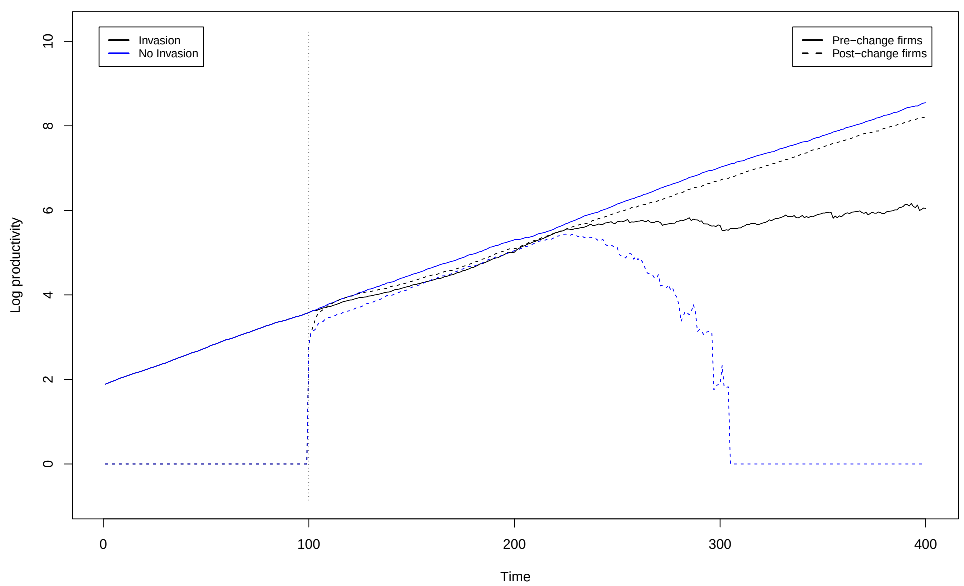
(a) Pooled wage distribution



(b) Pooled wage growth rate distribution



(c) Productivity dynamics by firm type



(d) Productivity standard deviation by firm type

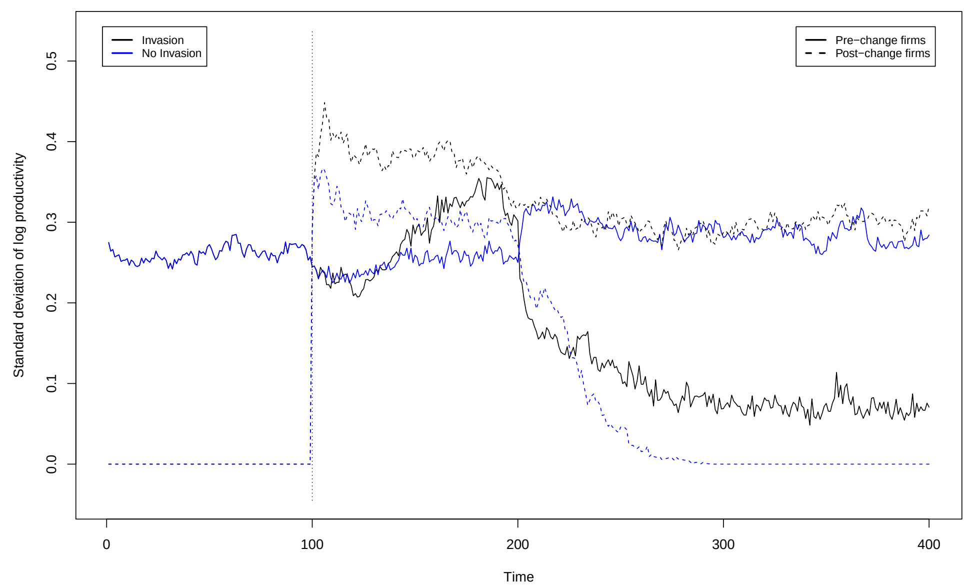
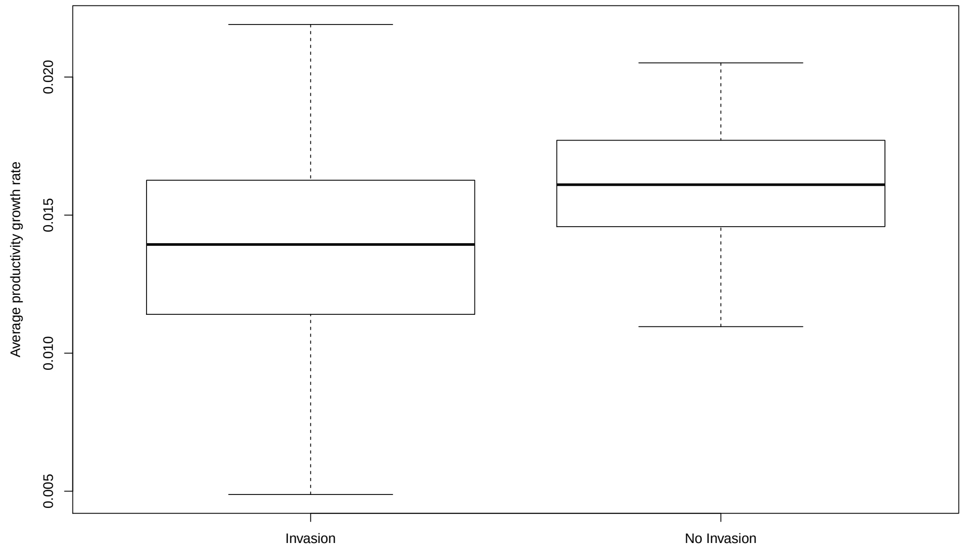
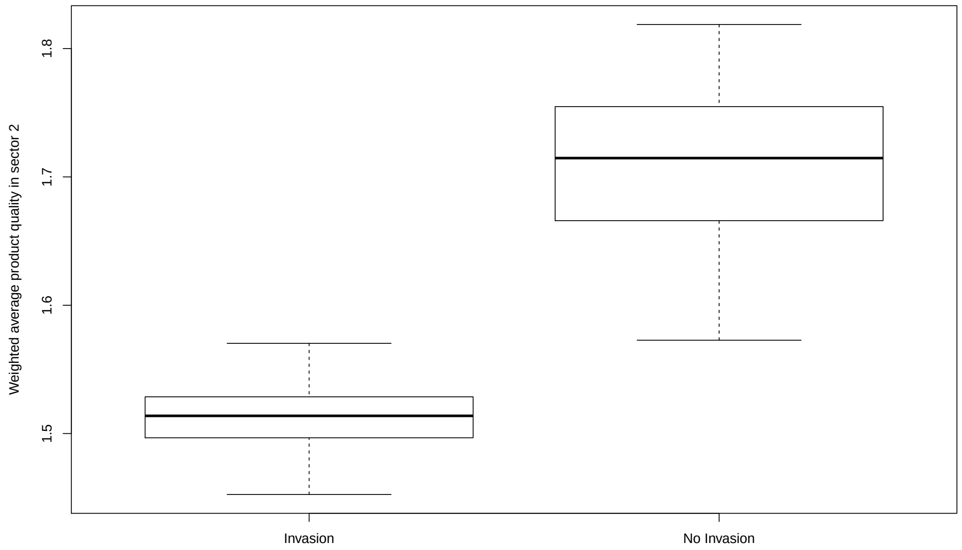


Figure 3: Market competition performance comparison between unionised and non-unionised firms

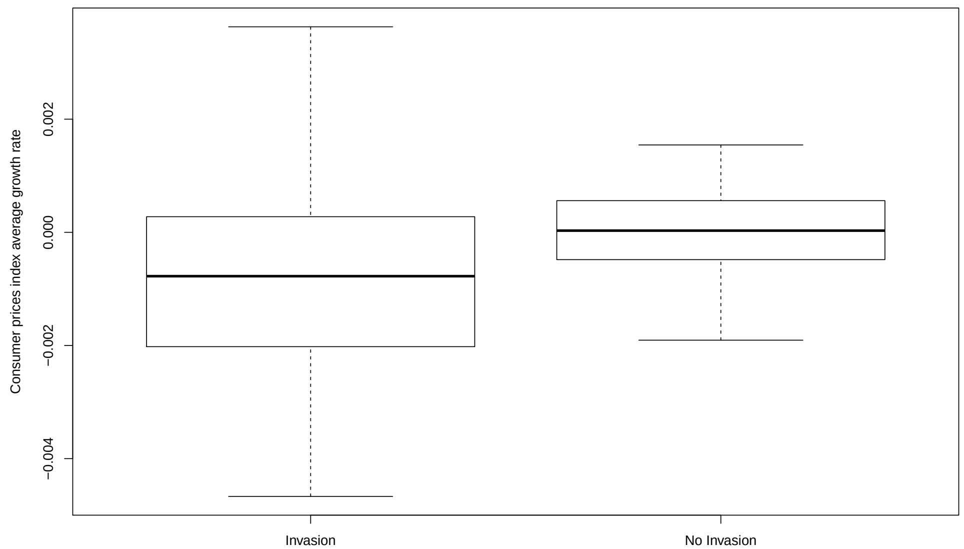
(a) Average productivity growth



(b) Product quality



(c) Variation of price consumer product



(d) Market concentration - HHI

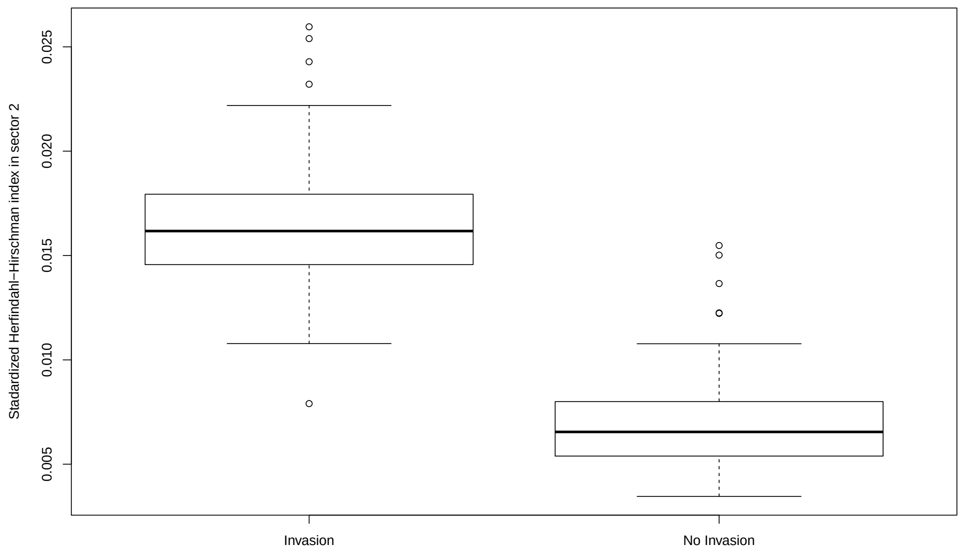
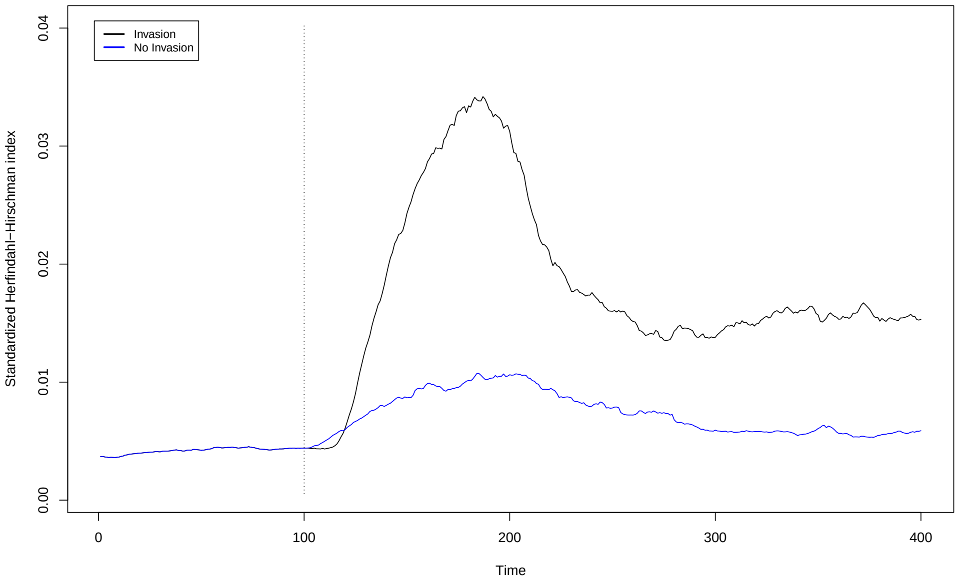
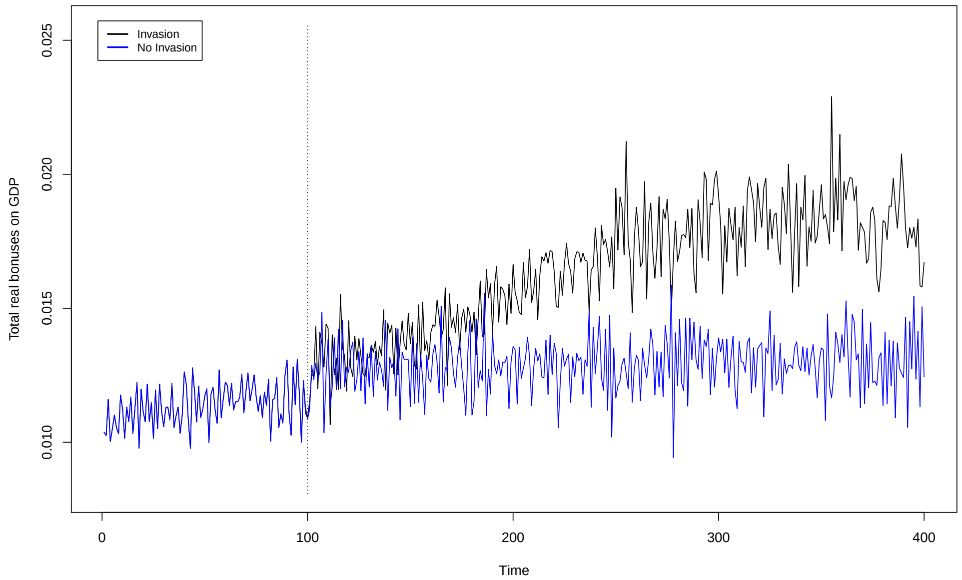


Figure 4: Market concentration and income distribution dynamics

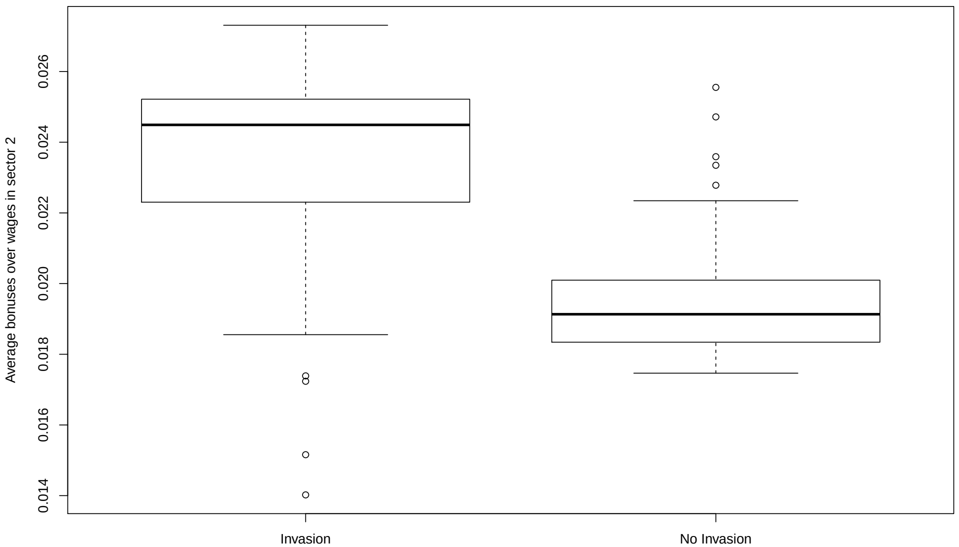
(a) Market concentration



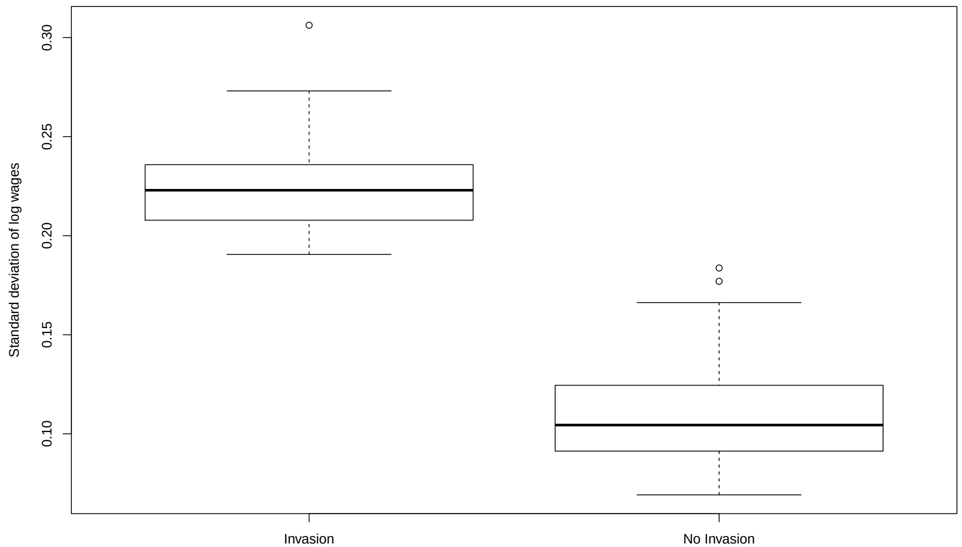
(b) Bonus share over GDP



(c) Bonus to wage ratio



(d) Wage standard deviation



Note that, in the Invasion scenario, non unionised firms prevail, *independently* of their product quality. This is so because the latter firms leverage on the lower labour costs due to wage and numerical flexibility, imposing lower prices and and taking advantage on unionised ones. As a result the long-run price consumer index presents a deflationary spiral, and is much lower than the case of unionised firms (Figure 3(c)). The type of market structure that emerges in the two cases is rather different: in fact, the degree of market concentration is much higher in the invasion case, with fewer firms appropriating a higher fraction of the market, as the performance comparison of the HH index shows in Figure 3(d). The latter finding is consistent with an average sales growth dynamics more heterogeneous in the invasion case, with few firms experiencing gains and the rest experiencing losses.

The temporal dynamics of the HH index is presented in Figure 4(a): note that the degree of market concentration increases in both scenarios as non-unionised firms start to enter into the market. Once the process of competition between the two types is over, the index stabilizes in both scenarios, with a considerably higher level in the Invasion case. Which are the implication of the two different industrial structures? They are reflected, among other variables, in the different fraction of bonuses distributed to workers. In fact, in the Invasion scenario the bonus share over GDP is much higher, entailed by the higher distance characterizing the total profits of the top performing firms and the average ones (Figure 4(b)). A higher share of bonuses and lower wages, results into a higher bonus-to-wage ratio (Figure 4(c)), which in turn is reflected into a more skew wage distribution, as shown by the higher wage standard deviation in the Invasion scenario (Figure 4(d)). Table 3 presents a summary of our performance comparison.

	Baseline[1]	Ratio[2]	p-val[2]
GDP growth	0.01	1.17	0.00
Productivity growth	0.01	1.16	0.00
Quality	1.52	1.13	0.00
Inflation	-0.00	-0.01	0.00
Market concentration	0.02	0.41	0.00
Wages standard deviation	0.22	0.49	0.00
Bonus to wage ratio	0.02	0.82	0.00

Table 3: Summary statistics of the performance comparison. Experiments: [1] Invasion, [2] No Invasion (numbers in brackets indicate the experiment number / H0: no difference with baseline / MC runs = 100 / period = 301 - 500)

5 Shift-and-share decomposition

After this inspection, we now move to better account for the process of productivity growth and reallocation across firms. We therefore perform a productivity decomposition on the simulated data, according to Foster et al. (2001). The decomposition reads as in Equation 11 below, where $f_{j,t}$ and $\pi_{j,t}$ define employment shares and labour productivity of sector 2 only, and $\log \pi_{t-1} = \sum_j f_{j,t-1} \log \pi_{j,t-1}$. The first term in this decomposition represents a within plant component based on plant-level changes, weighted by initial shares in the industry. The second term represents a between-plant component that reflects changing shares, weighted by the deviation of initial plant productivity from the initial industry index. The third term represents a cross (i.e., covariance-type) term. The last two terms represent the contribution of entering and exiting plants, respectively. In this decomposition, the between-plant term and the entry and exit terms involve deviations of plant-level productivity from the initial industry index. For a continuing plant, this implies that an increase in its share contributes positively to the between-plant component only if the plant has higher productivity than average initial productivity for the industry. Similarly, an exiting plant contributes positively only if the plant exhibits productivity lower than the initial average, and an entering plant contributes positively only if the plant has higher productivity than the initial average.

$$\Delta \log \pi_t^2 = \underbrace{\overbrace{\sum_j f_{j,t-1} \Delta \log \pi_{j,t}}^{WITHIN} + \overbrace{\sum_j \Delta f_{j,t} (\log \pi_{j,t-1} - \log \pi_{t-1})}^{BETWEEN} + \overbrace{\sum_j \Delta \log \pi_{j,t} \Delta f_{j,t}}^{CROSS}}_{INCUMBENTS} + \overbrace{\sum_j f_{j,t} (\log \pi_{j,t} - \log \pi_{t-1})}^{ENTRY} - \overbrace{\sum_j f_{j,t-1} (\log \pi_{j,t-1} - \log \pi_{t-1})}^{EXIT} \tag{11}$$

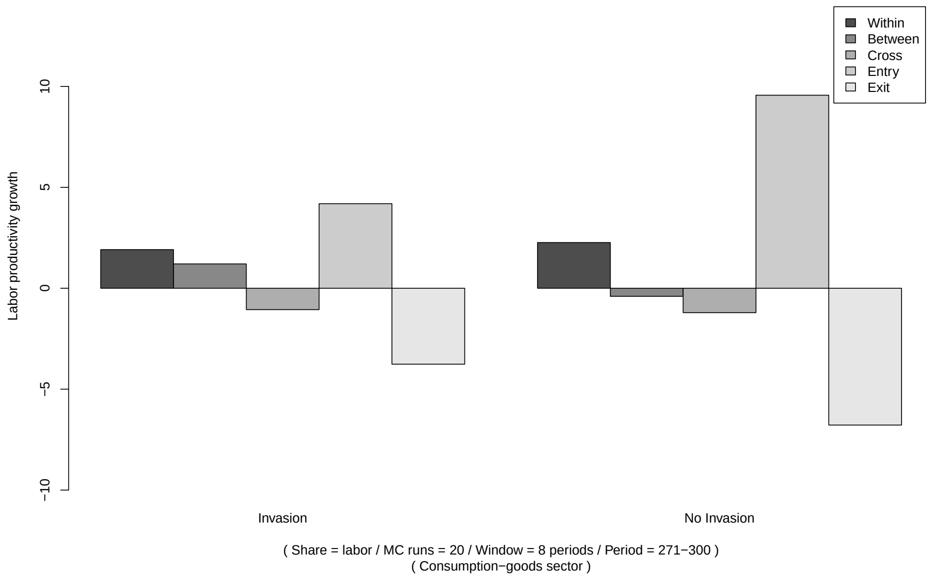
Table 4 splits the overall productivity growth documented into the five components of the FHK decomposition. The decomposition exercise allows in fact to compare the sign and the intensity of the above components. Figure 5(a) presents the results for all types of firms during the transient period ($t = 270 - 300$) of coexistence and then separately analyses the process of reallocation for unionised (Figure 5(b)) and non unionised firms (Figure 5(c)). Note that the analysis of the transient phase allows us to understand productivity reallocation when both type of firms do coexist.

Interesting properties do emerge from this analysis. (1) In line with the empirical evidence, the *within component* does always account for the higher fraction of productivity growth, signalling that the process of productivity growth is mostly explained by the accumulation of internal firms capabilities. (2) The *between* component is lower and positive in both regime, the cross effect is negative, and higher in the No Invasion case. (3) The *cross* effect becomes positive when using market instead of employment shares: the latter finding is due to the fact that market sales move in the same direction of productivity growth, while in case of employment shares, more productive firms reduce their employment demand. (4) The *entry-exit* components play a more negligible roles in the long-run, while they are rather important in the short-run. (5) In both scenarios, the *exit of unionised firms reduces* productivity growth to a higher degree than the exit of non unionised firms. (6) During the entire simulation period the No Invasion scenario exhibits always a higher degree of the *all* components, irrespectively of the type of reallocation used, in line with the slowdown of productivity induced by the invasion of non-unionised firms. (7) The selection process, including all components of the decomposition but the within one, is much higher in the No Invasion scenario, signalling that in the latter case competition favour more productive firms.

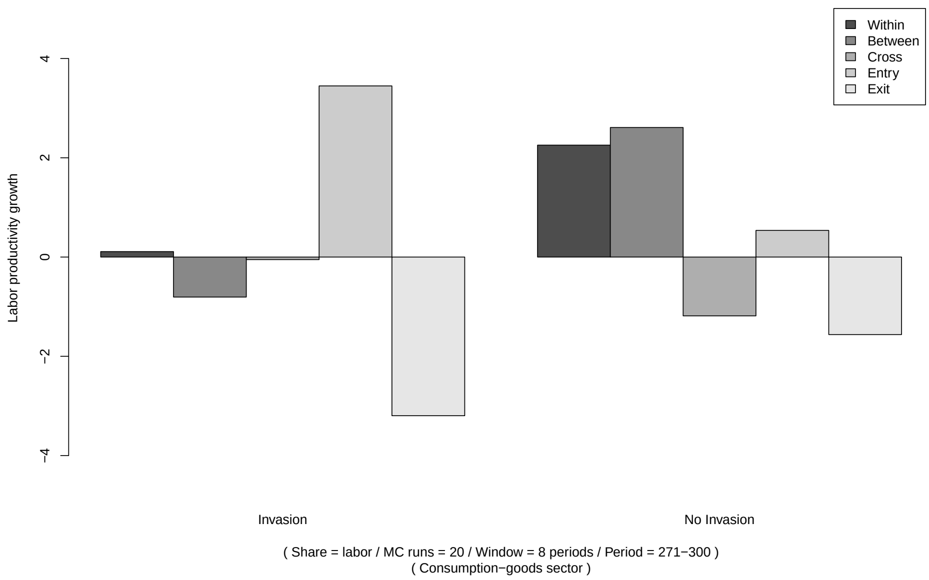
The latter battery of analysis we undertake shows the degree of correlation between productivity and wage. In particular, following Bagger et al. (2014) we regress wage level on productivity levels across firms. The latter regression allows to capture the degree according

Figure 5: FHK decomposition of productivity growth - Transient phase

(a) All firms



(b) Unionised firms



(c) Non Unionised firms

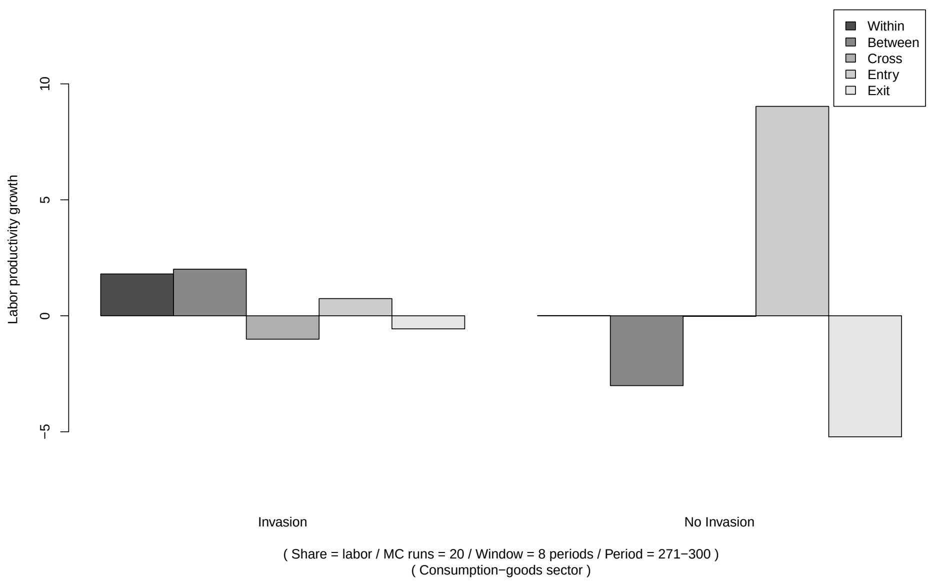


Table 4: Productivity growth decomposition - Sample size = 934019 firms / Window = 8 periods / MC runs = 20 / Period = 301 - 500

INVASION	Total	Within	Between	Cross	Entry	Exit	Error
Overall	23.00	17.54	7.66	-5.36	-0.76	2.09	2.71
(s.e.)	1.15	1.35	0.65	0.67	0.36	0.60	0.39
Unionised firms	-1.73	0.14	-0.14	-0.05	0.38	-1.96	0.03
(s.e.)	0.21	0.03	0.17	0.03	0.09	0.23	0.01
Non Unionised firms	24.73	17.40	7.80	-5.30	-1.14	4.05	2.83
(s.e.)	1.21	1.34	0.66	0.68	0.30	0.45	0.42
NO INVASION	**Total**	**Within**	**Between**	**Cross**	**Entry**	**Exit**	**Error**
Overall	25.94	20.40	8.05	-7.85	1.26	0.13	4.17
(s.e.)	0.61	1.07	0.27	0.78	1.07	1.34	0.59
Unionised firms	30.89	20.37	10.17	-7.82	-0.59	4.12	4.89
(s.e.)	1.06	1.09	0.57	0.80	0.43	0.74	0.86
Non unionised firms	-4.95	0.03	-2.12	-0.03	1.84	-3.98	0.03
(s.e.)	0.88	0.07	0.58	0.03	0.68	0.74	0.03

to which high-productive firms are also high-wage firms and conversely, the extent to which low-productive firms are also low-wage firms. Results are presented in Table 5 which shows a parametric estimation for 20 MC realizations. The No Invasion scenario is characterised by a *lower* productivity-wage correlation, signalling that the wage-productivity nexus is more flat and equal across firms: a more compressed wage structure implies that wages are less sensitive to productivity variations, in both direction. Conversely, in the Invasion case, the wage structure is much more linked to the productivity dynamics: productivity gains are appropriated by those workers employed in more productive firms, conversely workers employed in less performing firms, enjoy relatively less productivity gains.

Table 5: Monte Carlo regressions summary - Sample size = 10393 firms / MC runs = 20 / Cross-section = 300 - 304 by 4

Scenario	Invasion	No Invasion
Intercept	1.77	4.49
(s.e.)	0.31	0.21
Beta	0.63	0.14
(s.e.)	0.06	0.04
Std. error	0.05	0.01
(s.e.)	0.00	0.00
p-value	0.00	0.08
(s.e.)	0.00	0.06
R2	0.36	0.24
(s.e.)	0.03	0.05
Firms	296.80	313.05
(s.e.)	8.92	10.50

6 Conclusions

This paper presents an ABM which endogenously accounts for the process of deunionization. The process of deunionziation occurs following a bottom-down perspective, according to the *spurt* model first investigated in (Freeman, 1997). Unionised and non-unionised firms do compete in the product market arena in terms of their relative efficiency, affected by prices, quality and (excess) quantity variables. The model produces two possible statistical equilibrium patterns: a stable case of unsuccessful invasion by non-unionised firms, and a stable case of stable invasion by non-unionised firms.

The results from our analysis provide support in favour of the efficient dynamics fostered by a "Social market economy", populated by unionised firms, wherein the process of innovation, and therefore productivity growth is triggered by the accumulation of firms level capabilities, workers skills, incremental innovation and an egalitarian wage structure. Under these conditions, the process of firms competition in the product market features a positive selection dynamics, with high-productivity firms prevailing upon low-productivity ones. At the opposite end of the spectrum, a "Free market economy", populated by non-unionised firms ensuing a more dispersed wage structure, results into a slowdown of market selection, with low-productivity firms remaining in the market, therefore reducing average productivity and increasing its standard deviation. In this latter case, the exit dynamics negatively contributes to the average growth of productivity, such as the negatively contributes the cross effect, capturing the covariation between market share and productivity. .

Acknowledgements

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