Structural Change and the Income Distribution: a post-keynesian disequilibrium model

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Abstract

This paper constructs a post-Keynesian disequilibrium model in order to analyse the structural transition characterized by the emergence of a new sector. It will be shown that, in an economy where preferences and technology adapt over time, multiple outcomes are mainly brought about by different distributive rules governing the assignment of innovative gains between workers and entrepreneurs. In particular, a successful transition to a two-sector economy is ensured by a balanced distribution. Instead, when innovative gains are too concentrated in favour of either workers or entrepreneurs, the system does not fully accomplish the transition and unemployment might emerge; in contrast with the standard view of a negative relationship between real wages and employment. We show that this result is robust to various configurations of the key parameters; in particular, redistribution among workers allows to escape demand-constrained final equilibria.

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1 Introduction

In recent growth literature inequality acquired a prominent role as a source of multiple equilibria. By and large, following a supply-side view, multiple equilibria emerge if the accumulation of human capital is affected either by stringent borrowing constraints or by political distortions associated to high inequality (Galor and Zeira 1993, Perotti 1996, Benabou 2000). A demand-side channel through which inequality in factor endowments can influence growth is investigated by modern macroeconomics in the case of hierarchical needs with satiation limits (Matsuyama 2002, Bertola et al. 2006). Following this view, demand constraints can be removed favouring the emergence of modern sectors which allow to escape satiation traps. Inequality can have opposite effects on growth depending on the relative importance attributed to innovations in 'existing' or 'new' sectors. On the one hand, lowering inequality increases growth if a critical mass of consumers is required to trigger innovations that reduce the cost of basic goods and allow poor households to access goods with low priority (trickle-up). On the other hand, an increase in inequality benefit growth if pioneer consumers enable innovations in the new sector, making the consumption of new goods affordable to all (trickle-down).

None of these approaches, however, addresses the issue of the relationship between structural change and inequality pointing to the role played along the transition process by the dynamic interaction of supply and demand. This rules out the possibility that the selection of which final equilibrium will prevail might depend on the characteristics of the transition process itself (Arthur 1989). The assumption that agents are functionally heterogeneous–i.e. workers mainly consume, while entrepreneurs mainly invest–, first stressed by the post-Keynesian growth literature (Kaldor 1956, Kaldor 1957), allows to overcome the limits of the standard analyses in so far as inequality changes directly translate into supply-demand unbalances and can generate, through this channel, multiple outcomes[1].

Considering multiple outcomes as the result of 'what happens step-by-step along a way that begins with the breaking of the existing steady state' (Amendola et al. 2001, p.1) implies rethinking the stark dichotomy between short- and long-run processes that mirror the one between demand and supply factors. Out-of-Equilibrium sequential models (Amendola and Gaffard

[1] This result is related to the underlying Predator-Prey ecology that characterizes these models (Goodwin 1967), namely: each of the two classes needs the other to survive as long as entrepreneurs' investments depends on workers' demand whereas wages are paid in advance out of profits and hence depends on profits throughout investments.

1998, AG 1998 henceforth) represent a suitable tool for connecting demand and supply, short- and long-run through a direct focus on the transition process from a state-of-rest to another. Similarly to Gaffard and Saraceno (2008), we extend out-of-equilibrium models to study structural change in a two-sector economy. Our model, however, differs from theirs in two features: on the one hand, we assume that agents are functionally heterogeneous; on the other hand, as in Saviotti and Pyka (2004), we endogenize the long-run evolution of preferences and technology to study the emergence of a new sector. What we claim is that, by including these new features in an out-of-equilibrium model, transitory distributive changes turn out to bring about not only short- and medium-term demand-supply unbalances, but they crucially affect long-run outcomes of the process of structural change.

Consistently with this, another critical feature of our analysis is that the breaking of the initial steady-state is accompanied by a change in the existing rule governing the assignment of innovative rents between workers and entrepreneurs[2]. Assuming that phases of profound structural change are characterized by distributive changes is historically grounded (e.g. Polanyi 1944) and particularly useful in capturing recent economic trends. Following the advent of ICT technologies, the gains of innovations accrued to a small fraction of the population, leaving the income of individuals under the 90th income percentile substantially unchanged and well below the long-run improvements of labour productivity (e.g. Wolff 2006, Lemieux 2008). It is worth noticing that the key role played here by distributive changes both between functionally heterogeneous agents and within workers differentiates our model by similar ones analysing the emergence of new sectors (Saviotti and Pyka 2004).

Our analysis allows to robustly establish an inverse U-shaped relationship between distributive changes and the final outcome of the transition, in which both output maximization and full employment are reached at the level of moderate distributive changes. When the distribution of innovative rents is too much in favour of workers, entrepreneurs' funds required to invest in new capital and innovation are not enough, hence the supply-side of the economy restrains growth and employment. In the opposite distributive case, the system ends up either in a steady-state characterized by Keynesian unemployment or in an unviable harrodian path. Since the emergence of temporary rents to innovation is essential to enable the process of structural

[2]Additionally, since unemployment is an unavoidable and at least temporary by-product of processes of inter-sectoral reallocation, the extent to which workers make agreements to insure themselves against unemployment is a form of redistribution that affects the level and the composition of demand.

change, this result can be also interpreted with Schumpeterian lenses where the underlying distributive problem, i.e. access to innovation opportunities, is here restated in terms of conflict between functionlly heterogeneous agents.

The paper is organized as follows. Section 2 provides the theoretical background to our assumptions on the evolution of preferences and technology, which represent the two main novelties of our model with respect to the standard out-of-equilibrium framework. Section 3 lays down the model and explicit the mechanism governing the evolution of the economic fundamentals. Section 4 is devoted to the discussion of the results and the robustness of the model. Section 5 concludes.

2 The evolution of preferences and technology

The mechanism of adaptation of preferences and technology constitutes the channel through which short-run events, such as market disequilibria, turn out to affect long-run ones. In the first part of this section, we provide a behavioural justification of the observed logistic patterns that characterize the consumption of most goods. In the second part, we sketch the rationale behind innovative choices driven by market disequilibria and the sectoral complementarity generated through this channel.

2.1 Habits Formation and Learning

At least since the work of Georgescu-Roegen (1936), the idea that preferences remain fixed over time has been questioned. However, changes in preferences were not extensively investigated until new notions of rationality provided the background to justify individual learning and non-optimizing behaviour. Moving from the idea that individuals are rationally bounded, the evolutionary literature applies the concepts of routine and search to consumption activities (e.g. Metcalfe 2001, Witt 2001); in this framework, learning takes time and crucially depends on experience in so far as consumers gradually discover the characteristics of a new good. Moreover, according to Nelson and Consoli (2009), consumer's behaviour–i.e. habits–are insensitive to small changes in the external environment, but are significantly affected by significant novelties such as the appearance of new products or wants.

To the aims of this paper, a simple way to approach the issue of how habits change following the emergence of a new want is to look at the degree of substitutability between the old and the new want. If substitutability is perfect and, for simplicity, each good satisfies a unique want, all the resources devoted to the old good can be gradually relocated to the new one. Furthermore, this process can be slower or faster according to the learning effort required to extract the maximum utility out of the new good. On the opposite end of the spectrum, if two wants are hierarchically ranked and the old one is 'more essential' than the new, the quota spent in the satisfaction of the existing want stays fixed in face of the emergence of the new one. In this case, agents will start to experience the consumption of the new good only if two conditions are jointly satisfied: 1. consumption of the existing good is at its satiation level, 2. there must be a certain budget flexibility in order to trigger the process of self-reinforcing learning.

The existence of satiation limits is essential to justify states-of-rest where consumers are endowed with idle funds. When satiation of a given want is reached, consumers search for a new want whose discovery might bring about the formation of a new habit. The discovery of the new want can be easily modelled as an increase of the willingness-to-pay above its price (e.g. Wathieu 2004). Once this jump in the willingness-to-pay takes place, agents begin to consume the new good, hence the 'experienced willingness-to-pay' increases, gradually shaping a new habit. It is easy to show that this simple type of habituation takes time and displays a typical logistic pattern provided that the budget constraint is not binding; otherwise, the consumption of the new good eventually aborts. Put another way, workers' funds, and their evolution through the distributive changes, represent the critical dynamic constraint to the effective viability of consumers' learning.

To be consistent with post-Keynesian literature (Pasinetti 1981), throughout the paper we will focus on the case in which the new good satisfies a want hierachically lower in ranking, i.e. less essential. This allows us to connect structural change with long-run growth: escaping satiation is ensured by the on-going emergence of new wants that coexist with old ones[3].

2.2 Structural Change and Demand-Driven Innovations

The other pillar of our model is the way of conceiving technical change, which is closely related to Pasinetti's suggestion (1981) that innovations are driven

[3]Note that this view is in contrast with the view of endogenous growth theorists who maintain that the mere replacement of old sectors and technologies with new ones eventually fuel long-run growth (see Aoki and Yoshikawa 2002). Note also that, when old and new wants are perfect substitutes, the emergence of a new want and of a corresponding good/sector is analytically equivalent to the replacement of the old technology with a new one in the existing sector. Thus, the analysis of this simpler case would be equivalent to the out-of-equilibrium literature dealing with the effect of technical change (AG 1998).

by the existence of expected excesses of demand or by the emergence of 'adjustment gaps' between the potential and the effective level of demand in one sector (Metcalfe 1981, Saviotti and Pyka 2004). It is important to recall that the emergence of the new sector is here conceived as an exogenous shock, i.e. a radical innovation, that opens the opportunity of consuming a latent good. On the other hand, the role of subsequent, demand-driven innovations is to improve the technological level in a such a way as to enable the transition to an economy satisfying an additional want. This implies that, differently from the standard approach (i.e. Bertola et. 2006), product innovations that allow to satisfy a new want are essentially seen as phenomenon that breaks the existing equilibrium and triggers profound behavioural changes.

For the purposes of our discussion, it is useful to reiterate the distinction between hierarchical wants and perfect substitution. In the latter case, excesses of demand would appear in the new sector to the detriment of the old one. As a result, innovations will be uniquely concentrated in the new sector, whereas the technology for the production of the basic good remains the same. In the case of a hierarchical relationship between wants, overall demand expands since the fresh demand for the new good is added to the unchanged demand for the old one. The key issue is, therefore, how the supply-side of the economy adjusts to this expansion. In a paper similar to ours (Aoki and Yoshikawa 2002), supply matches the increase of demand provided that growth is not constrained by fixed factors of production (i.e. AK model).

A strong implication of the Aoki and Yoshikawa (2002) paper is that technological change is concentrated only in new sectors which enjoy high growth rate of demand since preferences are assumed to be 'logistic-shaped'. In our model, instead, the appearance of a new want brings about sectoral unbalances triggering innovations in both sectors, in order to mitigate the sectoral competition over scarce resources[4]. This way of modeling innovation is consistent with historical experience in so far as technological improvements directed towards backward sectors appear to be a critical feature of structural change. For instance, the technological revolution in agriculture was, by and large, the reaction of the process of urbanization brought about by industrialization (David 1975). In recent times, the application of ICT to the retailing and other ICT-users' sectors followed the formation of an autonomous ICT sector (e.g. Dew-Becker and Gordon 2008).

[4] Also Saviotti and Pyka (2004) and, from a more orthodox perspetive, models presented in Bertola et al. (2006) allow innovations to occur in any sector. However, to the best of our knowledge, our model is the first in considering the link between sectoral competition over scarce resources and innovation.

To give a simple idea of how the dynamic interaction between demand and supply works in our model, let us start from a system at the satiation level for a given want. In this state-of-rest, all efforts aimed at enhancing the productivity of the technology used in the old sector are useless because the demand for this good stagnates, hence investments in innovation are null. Once a new good emerges, investments start to be reallocated to the new sector while learning gradually increases the share of income spent in the new good. As a result, aggregate demand increases and generates further profit opportunities. In this situation, entrepreneurs will find it profitable to invest in innovations aimed at improving the productivity of labour in both sectors: in the new one, because, provided that the workers' budget constraint is not binding, consumers' learning brings about a steady demand expansion; in the old one, because less workers (those that are not relocated to the new sector) should be able to produce an unchanged quantity in order to meet demand at satiation. Overall, we will see that the initial disequilibrium due to the discovery of a new market brings about a self-sustaining interaction of preferences and technology whose success mainly depends on how innovative rents are distributed between workers and entrepreneurs during the transition.

3 The Model

Our model is grounded in out-of-equilibrium literature (e.g. AG 1998); in particular, we use four standard elements of out-of-equilibrium models: 1. Adaptive behaviour: agents are rationally bounded and adapt current plans to past disequilibria; 2. Intertemporal complementarities: production takes time and is carried on in vertical integrated firms with fixed proportions of capital and labour; 3. Monetary economy: money matters as a cash-in-advance constraint is assumed; 4. Markets open sequentially: labour market and final goods markets open respectively before and after production takes place. Here, we extend adaptive behaviour to model learning and technological change.

3.1 Technology

There are two final goods/sectors ($i = F, G$). Each of these goods is produced in a vertical integrated firm in two stages: the capital good production c and the final good production u.

Each final good is produced by mean of labour and capital with a Leontieff technology: there is complementarity between labour L and capital

K:

$$S_t^i = \min(A^i K_t^i;\ 1/\lambda_t^{u,i}\ L_t^{u,i})\ , \tag{1}$$

where S_t^i is the sectoral production, and A^i is the sectoral capital productivity, and $\lambda_t^{u,i}$ is the requirement of labour per unit of output, in sector i at time t.

In each sector i, capital goods depreciate at a rate δ, whereas investments become productive capacity after one gestation lag

$$K_t^i = (1-\delta)K_{t-1}^i + I_{t-1}^i\ , \tag{2}$$

where I_{t-1}^i are the capital goods produced at time $t-1$. Capital goods are produced only by means of labour

$$I_t^i = \frac{1}{\lambda_t^{c,i}} L_t^{c,i}\ , \tag{3}$$

where $\lambda_t^{c,i}$ is the requirement of labour per unit of investment.

The technology changes over time. We consider the case of a lobour saving technical progress consisting on a reduction of labour coefficients; in particular, as standard in the growth literature (e.g. Aghion and Howitt 1998) technical progress is a concave function of the past amount of investments in innovation e_j^i (see eq. 12) up to time $t-1$:

$$\lambda_t^{h,i} = \lambda_0^{h,i}\left(1-\psi\left(\sum_{j<t-1} e_j^i\right)^{\zeta}\right)\ , \tag{4}$$

with $h = u, c$ and $\psi, \zeta \in (0,1)$.

3.2 Entrepreneur Behaviour: production, investments and innovation

In our model we assume all agents to be rationally bounded. As a result, entrepreneurs do not have an optimizing behavior. Instead, we assume them to form expectations according to final market conditions by following adaptive rules, setting production plans compatible with such expectations, and then eventually rearrange such plans according to the constraints (monetary or real) emerging before production takes place.

At the beginning of each period, entrepreneurs decide over production, investments and innovation in three stages. First, demand expectations are formed in each sector and available entrepreneurs' funds are allocated to carry on current production. Second, the remaining funds, if any, are invested in each sector to replace and eventually adjust the capital stock. Lastly, when desired investments are constrained by labour scarcity, investments in innovations are carried on in order to increase labour efficiency.

3.2.1 Production decisions

As usual in these models, the expected demand $\widetilde{X}^i$ in sector i varies according to an adaptive rule:

$$\widetilde{X}_t^i = \eta X_{t-1}^i + (1-\eta)\widetilde{X}_{t-1}^i \ . \tag{5}$$

As to satisfy expected demands in real terms $\widetilde{X}_t^i/p_t^i$, the corresponding level of production will be:

$$S_t^i = min(\widetilde{X}_t^i/p_t^i - o_{t-1}^i; \ A^i K_t^i) \ . \tag{6}$$

where o_{t-1}^i are the real stocks eventually accumulated for past disequilibria and brought back into the market and the second term is the capital constraint. The desired amount of labour required to produce the final output in each sector i is: $L_t^{S,i} = \lambda_t^{u,i} S_i^t$.

At equilibrium production equals expected demand in real terms and expectations are fully realized:

$$S_t^i = \widetilde{X}_t^i/p_t^i = X_t^i/p_t^i \ . \tag{7}$$

Furthermore, capital is used at its efficient level: $L_t^{S,i} = \lambda_t^{u,i} A^i K_t^i$.

3.2.2 Investments

Once decided the resources devoted to final production, entrepreneurs make investments to restore and to adapt the productive capacity. According to eq. 2, the investments needed to restore the productive capacity are:

$$I_t^{\delta,i} = \delta K_t^i \ , \tag{8}$$

At the initial stationary equilibrium total investments correspond to such replacement investments. During the transition, net investments are needed to adapt the level of capital. When disequilibria emerge, in each sector producers may observe a gap between the demand, in real terms, and quantity that could be produced by existing capital:

$$\Delta S_t^i = \frac{X_t^i}{p_t^i} - A^i K_t^i \ . \tag{9}$$

Our hypothesis is that, in the following period, they will react making further investments $I_t^{\gamma,i}$ as to partially recover such gap. Total investments will be:

$$I_t^i = I_t^{\delta,i} + I_t^{\gamma,i} = \delta K_t^i + \mu \frac{\Delta S_{t-1}^i}{A^i} \ , \tag{10}$$

where, according to eq. 1, $\frac{\Delta S_{t-1}^i}{A^i}$ is the capital corresponding to the previous observed gap[5]. The parameter $\mu \in (0,1)$ embodies both the adaptive feature of next period expectation (similar to η) than the perception of such disequilibria to be permanent or transitory. Indeed, since capital lasts in time, μ represents also the degree of prudence in expanding the productive capacity and, implicitly, in reallocating resources to a different sector. The labour demand corresponding to such investments is:

$$L_t^{c,i} = \lambda_t^{c,i} I_t \ . \tag{11}$$

3.2.3 Funds constraints

Out-of-equilibrium, the producers initial period funds, could be insufficient to finance the desired level of sectoral production and investments:

$$J_t < w(L_t^{u,F} + L_t^{u,G} + L_t^{c,F} + L_t^{c,G}) \ .$$

In this case, we adopt the standard rule (see AG 1998) that investments I_t^i are cut first. Investments in each sector are reduced proportionally as to maintain the decided share of investments between the two sectors.

On the other end, labour can be the binding factor as its supply is fixed at L:

$$L < L_t^{u,F} + L_t^{u,G} + L_t^{c,F} + L_t^{c,G} \ .$$

This typically occurs when the excess of demand is so large that it can not be satisfied by the existing labour capacity. Again the reduction of labour concerns first investments, and in each sector proportionally to the planned share.

[5]In case of supply excesses, net investments are negative, this corresponds to a partial restoring of capital. Trivially, total investments can not be negative.

3.2.4 Innovation

The residual fund R_t^i, that comes out if the labour constraint is binding, is therefore used to improve labour efficiency through innovation. In particular, similarly to Amendola and Vona (2010), the fund R_t^i is used to pay a retraining program for workers. Likewise, one could interpret R_t^i as R&D financing. Given the funds R_t^i, the amount of investments in innovation e_t^i depends on the size of the sector, proxied by the number of workers:

$$e_t^i = \frac{R_t^i}{L_t^i} \ , \tag{12}$$

where L_t^i is the total labour employed in each sector. Equation 4 implies that, at the beginning of the transition, innovation turns out to be more efficient in the new sector, that is relatively smaller. The fund invested in innovation can either represent an additional component of demand or accrue to the entrepreneurs' fund. Throughout the paper, we will make the former hypothesis; however, our results remain unchanged if we make the latter[6].

3.3 Demand

The functional distinction of income sources is captured in a simplified way, that is: labour income is spent to consume, while profits are devoted to investments. We could consider less extreme versions in which both income sources (labour and capital) are spent in both final consumption and investments. Our simplification does not substantially alter the results as long as the propensity to consume on labour income is higher than that on capital income.

Hence, consumers own a fund composed by idle funds H_t, the aggregate labour income (the wage fund) wL_t, and the income accruing from the training investments R_t. We assume that also at equilibrium there exists a desired level of idle funds $\bar{H}$ that consents a minimal flexibility to trigger the process of change.

Along the transition, unemployment may emerge. Consumption decisions are taken by each consumer and employed should have access to more

[6]We also implicitly assume that innovations are directly produced by the monetary funds, that is, no specific resource are needed. Because of the binding resource is labour, this simplification corresponds to excluding the impact of R&D workers on the labour market that would further squeeze the labour constraint.

funds than unemployed. This create another source of inequality that depends on the degree of redistribution between the two groups. To model simply the impact of this heterogeneity on the demand, we consider the number of consumers to be a weighted mean of employed and total labour force LF:

$$N_t = \sigma LF + (1-\sigma)L_t \ , \tag{13}$$

a higher σ, corresponds to a higher distribution of funds to unemployed. In the extreme cases 0 and 1, respectively only workers or else all labour force, would have access to wages and accumulated funds.

For each consumer, consumption habits $\bar{q}^i_t$ evolve adaptively as a linear combination of previous habits $\bar{q}^i_{t-1}$ and past consumption q^i_{t-1}:

$$\bar{q}^i_t = (1-\theta)\bar{q}^i_{t-1} + \theta q^i_{t-1} \ , \tag{14}$$

Satiation consists on a upper limit $\hat{q}^i$ to the consumption of each good.

In value terms, the aggregate demand that would result from consumers habits, is:

$$\bar{X}^i_t = p^i_t N_t \bar{q}^i_t \ . \tag{15}$$

The effective demand depends on consumers' monetary funds and habits and on market prices. For sake of simplicity, we choose a linear specification:

$$X^i_t = \bar{X}^i_t (1 - \epsilon_P \frac{p_t - p_0}{p_0} + \epsilon_H \frac{H_t - \bar{H}}{\bar{H}}) \ ; \tag{16}$$

where ϵ_p and ϵ_H are respectively the elasticities to price and funds. At equilibrium habits and realizations coincide: at the initial equilibrium the effect of price and that of idle funds are null. Instead, as will be shown, at the final state of rest these two effects offset each other: both real prices and idle funds are lower than the initial levels.

The hierarchy between the two goods is included by the hypothesis that, when the fund constraint is binding, the reduction of the demand concerns first the new good.

3.4 Price Setting and Distributive Shares

At the steady-state equilibrium, prices p are set as in a competitive context, according to marginal cost of production plus capital reproduction p^*:

$$p^i_t = p^{*i}_t = \left(\lambda^{u,i}_t + \frac{\delta}{A^i} \cdot \lambda^{c,i}_t \right) \cdot w \ . \tag{17}$$

In out-of-equilibrium transitional dynamics, to the contrary, the stable relationship between technological and distributive parameters breaks. When innovation takes place, p_t^{*i} decreases as a result of the productivity improvements which follow innovation. A critical assumption of our model is that, in line with the endogenous growth theory (Aghion and Howitt 1998), entrepreneurs earn temporary innovative rents that slow down the process of price adjustment to the new competitive level. Here, rents are required in order to provide the resources to invest in innovation. In particular, we suppose that only a fraction $(1-\xi)$ of the gap between actual and competitive price is filled in one period, hence:

$$p_t^i = (1-\xi)p_t^{*i} + \xi p_{t-1}^i \ . \tag{18}$$

It is worth to notice that 18 implies that since innovations finish, the price always converges in the long run to the competitive level p^{*i}, that is, the accruing of innovative gains to investors is transitory[7].

As measure of the total rents that accrue to entrepreneurs during the transition process with respect to the competitive benchmark, we use the sum over time of the relative gap between actual and the competitive prices, which corresponds to the monotonic transformation:

$$\Pi = \sum_1^\infty (\xi)^i = \xi/(1-\xi) \ . \tag{19}$$

We can interpret the parameter Π as the outcome of the bargaining process between entrepreneurs and workers over the innovative rents represented by equation 18. This is the key parameter that we will use to analyze the role of distribution on the process of change. Clearly, when $\Pi = 0$, the lower bound, the prices are always set at the competitive level, thus all the gains from innovation accrue to workers.

3.5 Market outcomes

In our sequential model, exchange takes place at the end of each period whereas prices change only at the junction between periods. In value terms, the market outcome of sector i at time t is the minimum between the demand of workers and the supply of entrepreneurs at given prices:

[7] Note that we take monetary wages as fixed because we want to condemse distributive changes in a single parameter ξ. Instead, assuming that prices and wage also change according to market disequilibria will make less limpid the key role played by ξ without substantially altering the results.

$$Y_t^i = \min(S_t^i p_t^i; X_t^i) \ . \tag{20}$$

Whenever the two sides of the market do not exactly match, market disequilibrium emerges. Also the labour market can be characterized by disequilibria, hence either unemployment or residual innovative funds can emerge.

After each market round, new funds are determined. The evolution of consumers' funds reads as:

$$\Delta H_t = wL_t + \sum_i R_t^i - \sum_i Y_t^i \ . \tag{21}$$

In turn, the dynamic of entrepreneurs' funds is:

$$\Delta J_t = \sum_i Y_t^i - wL_t - \sum_i R_t^i = -\Delta H_t \ . \tag{22}$$

3.6 Steady-state equilibrium

At equilibrium, demand excesses and unemployment are null, the labour income equals the aggregate demand and funds do not vary. For a given set of technological parameters, assigning arbitrary values to w and K_0^G, the steady state values of all other nominal and real variables are determined[8].

Notice that, in steady state, investments in innovation are null as all market opportunities are matched, the entrepreneurs' fund is equal to the total wage fund needed to carry on investments and current production, and prices are set at marginal costs.

Since we focus on the emergence of a new sector, at time 0 the old good is at satiation level while the new good would have a price too high to be demanded:

$$q_0^G = \hat{q}_0^G = \bar{q}^G; \qquad q_0^F = \bar{q}_0^F = 0 \ . \tag{23}$$

All the other parameters matter only out of the steady-state equilibrium. In the next two sections, we will analyse the out-of-equilibrium dynamics brought about by an exogenous preference shock and later on we will check the robustness of our findings to different values of the parameters.

4 Structural Change and the Income Distribution

In this section, we present the main results obtained by the means of simulations. We consider a technological shock that lowers the production cost of

[8]For the simulation analysis, we use the normalization $K_0^G = w = 1$

the new good by 1%. The reduction on the new good market price involve the emergence of a small mass of demand for the new good.

By opening new opportunities in the market, this initial shock breaks the existing steady-state and triggers the formation of a small mass of demand for the new good and an initial wave of (labour saving) innovations. The technological progress induces temporary extra-profits, and an increase on real wages, whereas both the learning on demand and the building of the new sector capacity start. The higher labour demand induces investments in innovations that enable further technological progress. This virtuous circle enables a logistic pattern of diffusion of the new good. Overall, the final result of such process of growth depends on the coordination between the two sides of the market. This coordination hinges on the dynamics of the distribution of innovation gains between investors and consumers that sustain respectively the expansion of the productive capacity and of demand. This expansion comes to a halt before the full transition is reached if one of these two processes stops as a result of a constraint on respectively consumers' and investors' disposable funds.

Our results can be conveniently summarized in the two curves in figure 1 that depict the long-run level of aggregate output as the distributive parameter Π varies. While for very high Π the system experiences a crisis ($Q^i = 0$), for lower values the system converges to a stationary configuration. In these long run equilibria, capital and monetary funds have reached a steady stable level, and prices equal marginal costs.

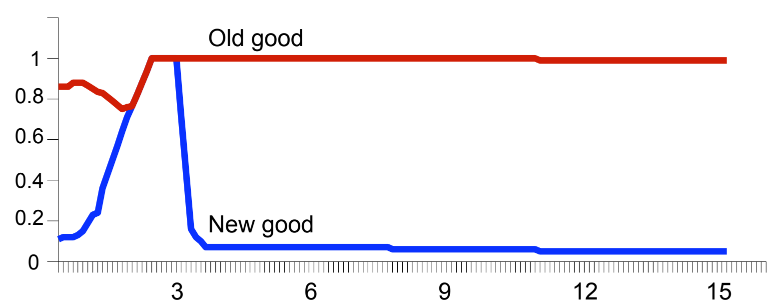

Figure 1: Long-run quantities as a function of Π.

Output is maximized for intermediate values of Π and, according to the level of such parameter, four different regions of final outcomes can be identified:

1) Supply-constrained transition: investors do not gain enough extra-

profits to invest in new capital and innovation.

2) Full transition: the new good spreads in the economy up to the saturation point.

3) Demand constrained transition: the stickiness on the increase of real wages hampers the formation of new consumption habits.

4) Unviable: the interaction of the demand constraint and of the initial labour saving wave of innovation generates an harrodian unstable path.

In the first region the expansion of the new sector, though non complete, mainly occurs at the detriment of the old one. The hierarchy of the two sectors is only on the demand side, while in this case the supply-side is the binding one, hence the reduction of the old good production is due to the initial shifting of investments to the new one. When instead the demand constraint binds, as in the third and the unviable region, it involves first and mainly the new sector, as a result of the hierarchy on the demand side.

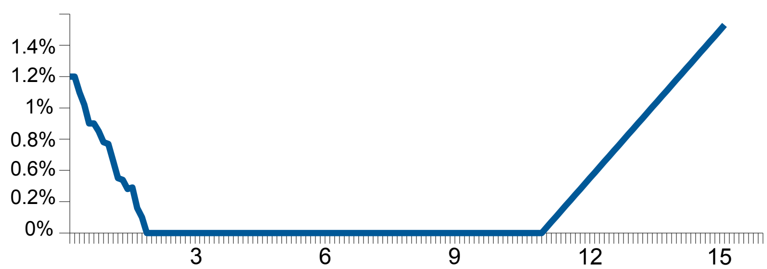

Figure 2: Rate of unemployment as a function of Π.

At the extreme of the first and the third region unemployment emerges (figure 2). This happens because the emerging constraints do not allow the increase of capital needed to employ the labour force freed by the labour saving technical progress. This identifies an U-shaped (non-linear) relationship between unemployment and distribution. The downward sloped branch of this is of particular interest in so far as wage moderation is normally supposed to foster investments and therefore employment. In our model, the employment-enhancing effect of higher inequality occurs only for moderate distributive changes. Large distributive changes, instead, impose a (Keynesian) bound to demand that might generate unemployment or crisis.

4.1 The dynamics of the 4 regions

When prices adapt fast to new lower marginal costs (figure 3), the investors do not gain enough extra-profits to keep investing in new equipments. The emergence of the new sector mainly occurs at the detriment of the old one (figure 3). In the old sector G, demand remains unchanged while the productive capacity is reduced, reflecting the initial investment shift. The old good production goes below the level of the demand. In sector F, the capital constraint is binding because the new productive capacity does not match yet the new demand. These two excesses of demand provide the right signal to increase invested funds.

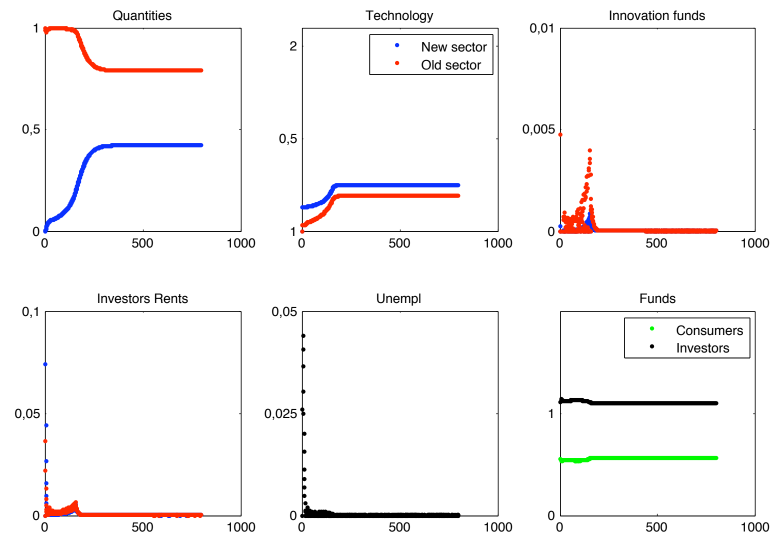

Figure 3: Dynamic in the supply constrained region: $\Pi = 1.5$.

However, given the unfavourable distributive conditions, investing in innovation does not pay back and eventually generates a net cut in entrepreneurs' funds. As a result, the expansion breaks before the transition is complete. For very low Π the initial labour saving progress is not matched with the increase in capital and then unemployment emerges as a consequence of a permanent lack of investments, which coincide with entrepreneurs' funds. This finding has as a classical flavour in so far as, in this range of Π, a distributional change in favour of capitalists, the only class that invests, tends to increase the final output of the economy.

The larger the entrepreneurs' rents, the more they can afford investments in physical capital, matching the increase on demand. However, entrepreneurs' funds are only sufficient to carry on replacement investments, and not to sustain net investments; thereby supply factors restrain growth and the new sector spreads only partially.

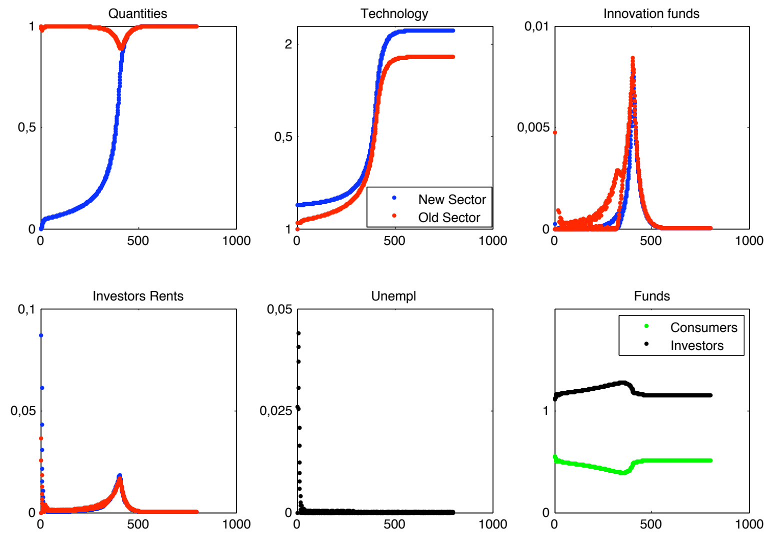

Figure 4: Dynamic in the full transition region: $\Pi = 2.4$.

In the region of full transition (figure 4) the system is driven by the acquiring of extra-profits to investors and the increase in demand up to the saturation levels of both goods. The appropriate distribution of innovation gains allows the right coordination of demand and supply in both sectors[9]. At the final equilibrium funds are restored at the initial levels and unemployment is reabsorbed. Looking at the funds' dynamics (figure 4), the increase of entrepreneurs' funds fuels a wave of innovations that is larger the higher the distributive change. The dynamic interaction of the two funds mirrors the one of two competing species (Goodwin 1967). During the transition phase, the system is characterized by the reciprocal stealing of funds' quota. In the final state-of-rest, a new ecology is restored only if funds return to a stable level. Of particular interest is the fact that the initial disequilibrium triggers sectoral unbalances that generate new opportunities for profits[10]. These inter-sectoral spillovers emerge only out-of-equilibrium as a signal that provides the incentives to dampen the emerging labour constraints,

[9] In this case the dynamic of the quantities in the two sectors is very similar to that resulting in Saviotti an Pyka (2004).

[10] For those familiar with the work of Albert Hirshman (1958), it is interesting to stress the similarity between the mechanism of induced innovation driven by disequilibria in our model and its idea of a development process driven by the self-reinforcing interaction of sectoral disequilibria.

hence ensuring the modernization of the economy through the coordination between the expansion of the new sector and technological improvements in the old one.

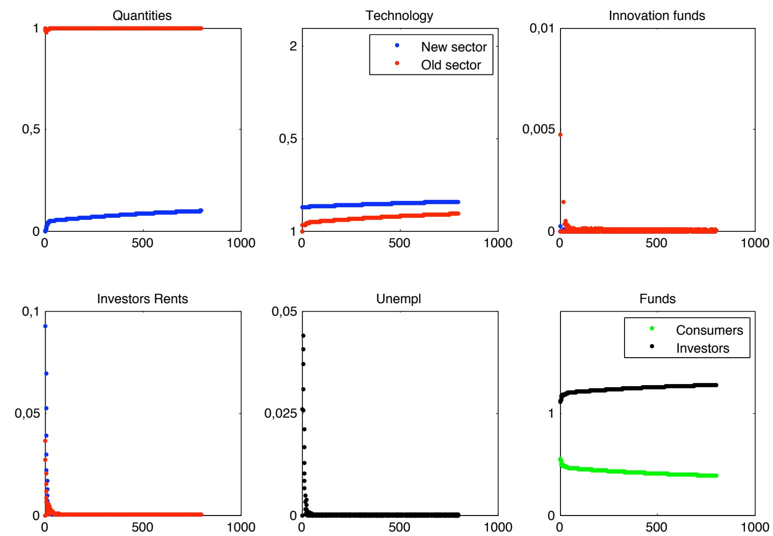

Figure 5: Dynamic in the demand constrained region 3: $\Pi = 3$.

For higher values of the 'rent extracting power' of investors Π it is demand that tends to restrain growth. In particular, the emergence of the new sector is slow and hardly partial since an appropriate mass of demand does not emerge (figure 5). The old good sector is almost left unchanged as long as small excesses of demand also bring about a small shift in investments behaviour. Compared to the full-transition region, here habits reflect unbalances between supply and demand in so far as the final level of consumers' idle funds turns out to be lower constraining the process of habituation.

Finally, at the extreme end of this region, the lack of final demand is so large that entrepreneurs are induced to cut back permanently not only innovative investments but also replacement investments, letting without job the mass of workers freed by the first wave of technical progress. In this case, the neo-classical argument supporting a negative relationship between real wages and employment level is confuted in so far as distributional changes above a certain level turn out to harm the consumption of workers and, therefore, employment via aggregate demand.

When prices adapt very slowly to marginal cost, few idle funds are used

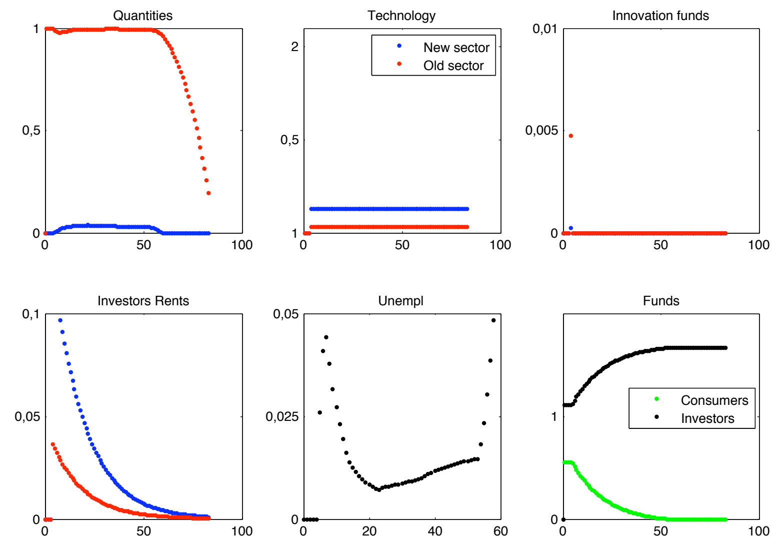

Figure 6: Dynamic in the unviable region: $\Pi = 16$.

to demand the new good. In this case, the learning process is not sufficient to enable the modernization of the economy because the consumers' funds are not able to sustain the demand for the new product. The system displays an extreme scenario in which the demand shortage, combined with the initial technological unemployment, involves a vicious declining spiral unemployment-demand-investment that brings to a crisis (figure 6).

4.2 The role of parameters

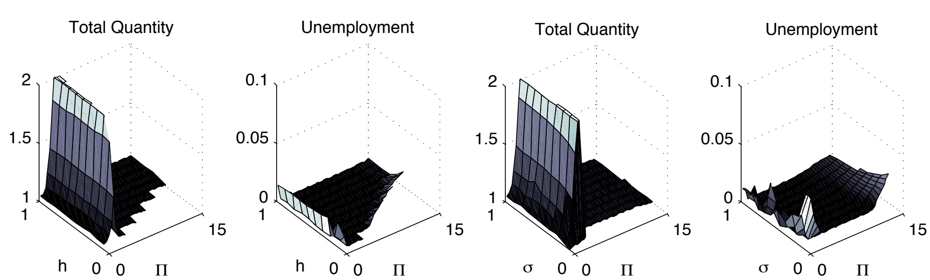

Figure 7: Initial share of idle funds $\bar{H}$ and income redistribution σ.

In order to analyze the role of the key parameters we plot the curves of long-run quantities and unemployment conditioned to different Π as in figure 1 and 2, varying the values of each parameter of interest while keeping fixed all the others. The resulting surfaces show the relationships between each parameter and the ranges of the different regions.

The initial level of idle funds $\bar{H}$, that embody the relative slackness of the funds constraint, and the consumers' redistribution parameter σ have similar impact. Indeed, both low distribution to unemployed than few initial idle funds increase the unviability of the system enhancing the harrodian effects of an unbalanced distribution in favor of investors (figure 7), i.e. a self reinforcing spiral demand-unemployment. $\bar{H}$ has not a natural bound, extending its range we can notice that the higher level of idle funds the wider the full transition range. Of particular interest is the fact that redistribution between employed and unemployed has not only the well-known stabilizing effect on aggregate income, but also an effect on the emergence of the new sector. Finally, the existence of idle funds of workers, which can be seen in a more general model as credit to consumption, appears as a surrogate for policies redistributing the wage fund among workers.

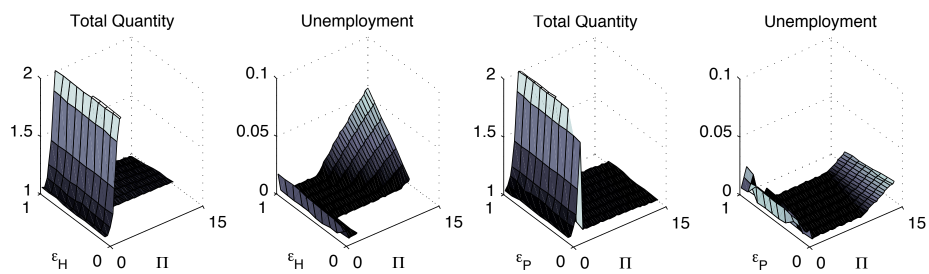

Figure 8: Elasticity of demand to idle funds ϵ_H and to prices ϵ_P.

The two elasticities of the demand, the one to idle funds and that to price, have, as expected, opposite effects (figure 8). For high ϵ_P and low ϵ_H, the demand constraint region becomes tighter, while both the full transition and the unviable regions are wider. Indeed, both a stronger reaction to price cut than a weaker reaction to the decumulation of idle funds–i.e. less prudent consumers–favor the required learning process on the demand, but, at same time, hamper the harrodian effects that may bring about a crisis.

If investment are too sensible to disequilibria, i.e. for high values of μ, the first phase of the transition is characterized by strong fluctuations that affect the viability of the process of change[11]. If we restrict the range

[11] This result is in line with the out-of-equilibrium literature (AG 1998), where slow

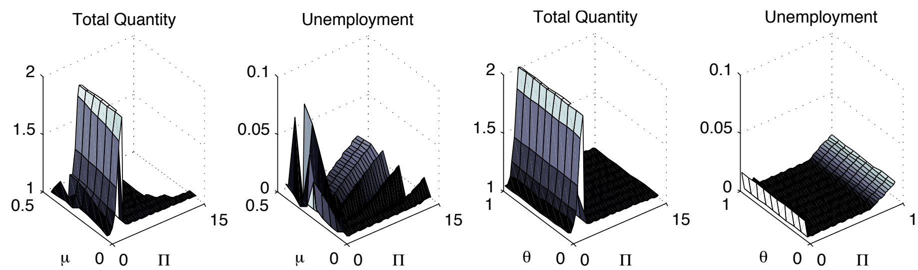

Figure 9: Investors sensitivity to market disequilibria μ and Habits reaction θ.

of the parameter as to exclude the predominance of these effects, a higher μ entails stronger effect on technological unemployment as a result of the overshooting of innovation investments (figure 9). However, a lower sensitivity to disequilibria makes more difficult to deal with market and sectoral unbalances limiting the range of the full transition region.

Faster learning on habit formation θ and demand expectation η have the same effect of speeding up the transition but the effect on the final outcome is only a little positive impact on the full transition range.

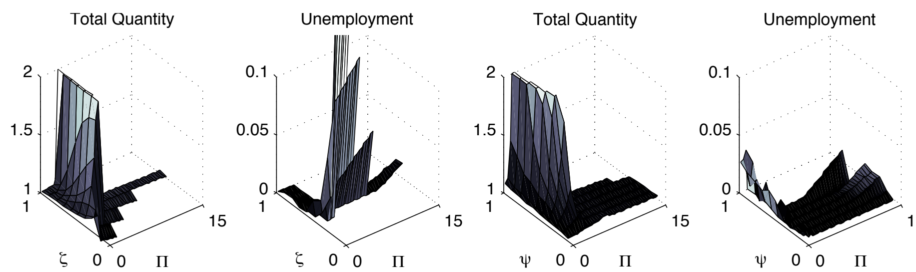

Figure 10: Concavity ζ and productivity ψ coefficients of technological progress.

Both a too concave or a quasi-linear technological progress function limit the viability of the system. Furthermore, in the first case, technological unemployment is magnified as the impact of the first waves of innovation is very strong but further investments have little effects. In the second case, technical change is more gradual but the absence of decreasing returns to innovation makes the system less stable.

adjustments of agents' behaviours to disequilibria increase the system viability.

A strong efficiency of the innovation investments ψ favors the transition but, as in case of a quasi-linear function, reduces the viability range. Overall, ψ has a large effect upon the outcomes of the transition as long as it affects the size of the innovative rents–i.e. innovation is more productive–and therefore magnifies the distributive effects described throughout the paper.

4.3 Robustness

To check for the robustness of our results to parameters changes, we extract 1000 random set of the parameters σ, h, ϵ_H, ϵ_P, μ, ζ, η and θ, in their relevant range[12] and observe the region of the long run outcome of the transition for different values of the distribution parameter Π.

Table 1: Robustness.

Distribution	Sup. Constr.	Full Trans.	Dem. Constr.	Unviable
0.6	78.5%	0.0%	3.7%	17.8%
1.2	73.0%	0.6%	7.5%	18.9%
1.8	57.3%	11.7%	10.1%	20.9%
2.4	42.5%	14.2%	16.9%	26.4%
3	33.4%	6.2%	28.6%	31.8%
3.6	27.1%	4.2%	35.1%	33.6%
4.2	22.4%	2.4%	38.8%	36.4%
4.8	19.5%	1.7%	41.3%	37.5%
5.4	17.9%	0.5%	42.7%	38.9%
6	15.8%	0.2%	43.2%	40.8%

The Table 1, which shows the frequency of the four regions for each considered value of Π, strongly confirm our results. The first region prevails for low values of Π, while the opposite is true for the third and the unviable region. Full transition is reached only for an intermediate distribution.

5 Conclusions

This paper constructs a post-Keynesian disequilibrium model in order to analyse the structural transition characterized by the emergence of a new sector. We show that, in an economy where preferences and technology adapt over time, multiple outcomes are mainly brought about by different distributive rules governing the assignment of innovative rents between workers and entrepreneurs. Both output maximization and full employment

[12] All parameters are taken in the full interval $(0, 1)$ except for μ that is limited to .3 consistently with previous partial analysis.

are reached in an internal region of the distributive change. Above the upper bound of this internal range, since real wages do not catch productivity improvements during the transition, the system falls short of creating the final demand to satisfy the expansion in the possibilities of production. As a result, Keynesian unemployment or long-run slumps emerge depending on how fast investment and innovation react to disequilibria. In contrast, below the lower bound of the full employment region, entrepreneurs' resources to invest in innovations dry up before the system has successfully expanded its productive capacity, hence a supply constraint emerges. Furthermore, internal redistributions between employed and unemployed workers sustain demand and hence ease the transition to a fully developed two-sector economy especially in cases where innovative rents are larger.

The relationship between distributive changes and the final outcomes in terms of output and employment recalls a Predator-Prey ecology (Goodwin 1967) leading to a continuum of results. This generalization enriches post-Keynesian results in two directions. On the one hand, we are able to robustly generate states-of-rest characterized either by supply-constrained or by demand-constrained unemployment, casting serious doubts on the negative relationship between real wages and employment. On the other hand, the model provides an original glance on the relationship between long and short-run in so far as the co-evolution of demand and supply factors turns out to affect long-run steady states. In particular, we show that there might exist cases where a shortage of final demand–due to a redistribution too favourable to the high class–ends up having permanent consequences on the size and the structure of the economy. This suggests a careful reconsideration in growth theory of the long-run effects of the distribution of income through the composition of the final demand.

Finally, we introduce a new framework for analysing the relationship between structural change and income inequality that can be easily extended, for instance, to the analysis of the green industrial revolution, characterized by a large share of need-based or demand-driven innovations. In future and on-going works (Vona and Patriarca 2010), our aim is to extend the model to assess whether our results change considering not only workers' heterogeneity in employment status but also in factor endowments. This will allow to disentangle the ways in which the functional and the structural sources of inequality interact.

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