PRODUCTION PROCESS HETEROGENEITY, TIME TO BUILD, AND MACROECONOMIC PERFORMANCE

Mario Amendola
University of Rome "La Sapienza"
Jean-Luc Gaffard
OFCE and SKEMA Business School
Francesco Saraceno
OFCE

This paper describes the out-of-equilibrium approach to the analysis of economic processes. We argue that such an approach is adapted to study qualitative (or structural) changes, like technical progress or changes in preferences. Truly sequential analyses manage to capture the essential features of qualitative change. In particular, we show how this approach shifts the focus from the issue of optimality to the one of *viability* of the processes of change. The objective of the paper is, first, to highlight the analytical elements of an out-of-equilibrium approach, so as to serve as a guide for the construction of this type of models; second to show, how this analysis allows to see controversial phenomena, like for example the debate on wage rigidity or the productivity paradox in a new and different light ; third to identify the real causes of the on-going crisis.

Keywords: Out-of-equilibrium, Structural change, Credit constraints, Agent-based models, Adaptive expectations, Time-to-build, Sequential analysis, Macroeconomic policy, Productivity paradox, Wage rigidity

The purpose of this article is twofold: first, to highlight the interest of out-of-equilibrium analysis, that can as a first approximation be defined as the construction of models that allow dealing with phenomena that are in the nature of *qualitative change*. Changes, in other words, that entail modifications in the structure of the economy, and that are in the nature of *processes* that take place over time. An equilibrium analysis that, by its very nature, is

limited to the comparison of equilibrium states (or paths), is not apt to the analysis of what happens during the process triggered by qualitative change. Out-of-equilibrium analysis allows studying the process of change as a sequence of constrained choices: which, as we shall see, shifts the focus from the question of *optimality* of the path followed by an economy to its *viability*.

The second purpose of the article is to detail the logical structure of out-of-equilibrium models, and to emphasize the necessary analytical departures from the simplifying hypotheses used in standard equilibrium analysis. This article should hence serve also as a guide for the construction of this type of models.

The paper is structured as follows. Section 1 discusses the out-of-equilibrium approach, emphasizing its departure from standard equilibrium growth theory and its methodological pillars. Section 2 expounds the logical structure of a typical out-of-equilibrium model, based on a sequential structure and on irreversibility in production and in decision making. Section 3 shows how this approach allows shedding a different light on some long standing controversies such as, e.g., the desirability of wage rigidity or the so-called "productivity paradox". It will be shown that the specific results obtained hint at more general conclusions that are a guide line for policy interventions quite different and sometimes opposite to those inspired by the prevailing equilibrium analytical approach. We conclude the paper by stressing the relevance of our approach for a better understanding of the current crisis and possible ways out of it (section 4). The analytical elements are finally discussed in an appendix.

1. The out-of-equilibrium approach

Most processes of economic change are not 'quantitative'—that is, a simple modification of the intensity of a given functioning of the economy—but 'qualitative' changes, that is, changes in the very way of functioning (like changes in technology, a speeding up of the growth rate, the introduction of new products, the entering of new markets, the irruption of new countries and new firms in the international trade, changes in the distribution of income, and so on). This means by definition the breaking of equilibrium. It implies the disruption of the existing productive structure, on

which the behaviour of the economy depends, and the construction of a new and different one. This is a process that takes time, and the market economy is not necessarily self-adjusting. Co-ordination failures are unavoidable, because problems of co-ordination arise in the first place in the production process itself. These problems, on the other hand, extend to the whole economic system. New goods or techniques imply new types of production processes and new activities that, in turn, call for new forms of interaction among the existing agents and institutions, or even the appearance of new actors and institutions. The heterogeneity of the agents involved is an essential feature of processes of structural change, as we shall stress in what follows.

The *viability* of the process of change, and even its outcome, are not predetermined, but depend on the way the co-ordination problems, both at the micro and macro level, are dealt with. *Different outcomes* may in fact be associated, e.g., with a given technological advance, depending on the effective development of the process, *i.e.* in the way in which co-ordination is (or is not) restored. As a matter of fact, technical changes that potentially allow for substantial increases in productivity may actually result, at the end of the process, in a waste of productive resources.

The focus on processes of change has momentous analytical implications. In the first place, the usual distinction between a long-term, where equilibrium obtains, and a disequilibrium short term disappears[1]. A process is neither a short nor a long term: it is a sequence of linked disequilibria that shape the evolution of the process itself. This is no longer seen as a transition path between equilibrium positions. In an out-of-equilibrium perspective the point of arrival becomes blurred. It is lost to sight, not necessarily in the sense that it ceases to exist, but because everything that matters is inside the process.

The analysis of this process does not call for a traditional type of model, that is, a model capable of generating a 'solution' in the sense of a behavior of the economy characterized by certain

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1. The standard view, which considers trend and cycle as unrelated phenomena, is misleading. "When we turn our attention to long-run questions, we aren't turning away from co-ordination and adjustment problems, we are simply looking at them from a different perspective" (Howitt, 1994, p. 765).

specific features (efficiency, optimality, and so forth). What becomes important, instead, is to follow the evolution of the economy, traced out step by step by the sequence of disequilibria. The essence of a thorough process is in its going on, that is, in its being viable. This calls for a monitoring of the process itself to bring to light its salient moments: which can only be achieved by means of numerical experiments, that is, by simulations that, under certain conditions (chosen so as to stress aspects relevant to the analysis) allow to unveil what happens "along the way".

In this light also the usual distinction between the terms 'exogenous' and 'endogenous' must be interpreted in a different way. "In a model there are variables and there are parameters, which reflect the existing constraints. In the standard analysis the constraints, which exist outside and above the economy and which determine its behaviour, are taken to be exogenous. But once we recognize that the time over which change takes place is an irreversible process that shapes the change itself, 'it is impossible to assume the constancy of anything *over time*}...The only truly exogenous factor is *whatever exists at a given moment of time,* as a heritage of the past' (Kaldor, 1985, p.61). While the standard approach focuses on the right place to draw the line between what should be taken as exogenous and what should be considered instead as endogenous in economic modelling—a line that moves according to what we want to be explained by the model—out of equilibrium the question is no longer that of drawing a line here or there but rather one of the time perspective adopted. Everything can be considered as given at a certain moment of time, while everything becomes endogenous over time" (Amendola and Gaffard, 1998, pp.32-3).

Out-of-equilibrium, oscillations no longer appear as short-term deviations due to demand shocks from a long-term trend determined beforehand by fundamentals alone. Focusing on co-ordination mechanisms implies to recognize that the short term actually determines what the long term will be, and that supply conditions and demand conditions interact with each other.

Finally, it must be stressed that different evolution paths can be associated in fact to given fundamentals, according to how the out-of-equilibrium process actually evolves, and the fundamentals themselves undergo a change during this process, given the very

definition of qualitative change. The 'fundamentals', in other words, are no longer fundamental.

A framework that helps dealing with the co-ordination problems concerning the heterogeneity of the entities involved in out-of-equilibrium paths is Agent Based Modelling (ABM), that "seeks to model the process by which one among many possible futures is selected, rather than imposing constraints on the model that ensure only a single equilibrium outcome" (Mehrling, 2006, p. 77). With this kind of model, 'agent' refers broadly to an encapsulated collection of data and methods representing an entity residing in a computationally constructed world. Individual biological life forms, social groupings, institutions, and physical entities can all be represented as agents" (LeBaron and Tesfatsion, 2008, p. 246).

Our sequence analysis shares most of the properties of ABM modelling, namely, heterogeneity of agents, bounded rationality, and non-market clearing. Here, those are production processes of different ages, and incorporating different technologies, which are represented as agents. Economic dynamics is mainly driven by the evolution of the composition of these processes, that is, by the time structure of productive capacity.

2. The logical structure of the model

The main objective of out-of equilibrium models is to allow the study of processes of change. Standard equilibrium analysis is carried out by comparison of equilibria, be them points or steady state paths. Transitional dynamics are most of the time neglected because inherently short term phenomena, and because they are pre-determined from the beginning, and as such not particularly informative (for example, the saddle path adjustment). It was argued above that a meaningful analysis of the transition may add substantial information to our understanding of the economy, notably as regards the *viability* of the out-of-equilibrium path undertaken following a structural change of the economy. This section aims at discussing the building blocks of out-of-equilibrium models, without reference to any specific set of equations. Some examples may be found in the appendix.

Out-of-equilibrium analysis shows that once we release some simplifying assumptions of standard equilibrium theory, ongoing

processes of change become interesting to study because, far from being pre-determined, they are shaped by the interaction of agent's behavior, institutional factors, and environmental characteristics.

The starting point is a standard general equilibrium model, with households and price-setting firms using labor and capital. Typical examples of this type of models may come from the New Keynesian literature (see e.g., Woodford, 2003).

It is important to notice that the use of capital is not strictly necessary, as it can be substituted by dated labor as was for the example the case in classical analysis (see the discussion in Garegnani, 1984).

A sequential analysis focuses both on the supply and on the demand side of the economy. As for the supply side, the standard hypothesis to be dropped is the perfect substitutability of factors (usually embedded in a Cobb-Douglas production function) and the instantaneous utilization of labor and capital. In out-of-equilibrium models, production takes time, and is characterized by complementarity rather than substitutability of the production factors. This complementarity can be modeled through the definition of a productive process as a scheme by which a flow of labor inputs is converted into a flow of output and the consideration of a construction period, with inputs but no final output, which is followed by a running-it period (Hicks, 1970; Hicks, 1973). It can also modeled by using a CES function with a sufficient degree of complementarity between capital/dated labor) and labor (the limit case would be a standard Leontief function).

Analytically, time-to-build and complementarity are both necessary, as they create sunk costs, and make choices at a certain moment in time depend on the stock of capital/dated labor available for the firm. Suppose for example that you had no complementarity. Then no matter what their past choices and the stock of capital/dated labor were, firms would always be able to choose the desired level of output through an appropriate choice of factor quantities.

A second simplifying assumption, rational expectations, also prevents fully-fledged transitional dynamics. In out-of-equilibrium analysis agents have bounded rationality, especially when facing complex environments. "Innovativeness raises uncertainties. The

future outcome of an *innovative action* poses ambiguity: the law of 'unanticipated consequences' applies (Merton, 1936) entrepreneurs have to act on their 'animal spirits', as John Maynard Keynes (1936) put it; in the view of Friedrich Hayek (2002), innovations are launched first, the benefit and the cost are 'discovered' afterward" (Phelps, 2007, p. 544). A backward-looking component of expectation formation is necessary for reasons analogous to time-to-build, *i.e.* to create a link between past and current actions, and hence to link periods into a sequence. While there is some ground for rejecting backward looking behavior in equilibrium models, it is much more difficult to do so in out-of-equilibrium contexts, in which "knowledge of the model" is of little use, and in which at least short term fluctuations, cannot be properly predicted. In these situations, agents usually resort to "rules of thumb" that resemble the adaptive behavior embedded in out-of-equilibrium models (see for example Hommes, 1998).

A third important simplifying assumption of standard theory is market clearing. Instantaneous price adjustments rule out, by definition, the possibility of disequilibrium. In sequential analysis, this assumption is released in order to allow the emergence of quantity constraints (the short side rule), and undesired stocks (both real and financial). These stocks contribute to link the periods in a sequence. This does not mean, of course, that prices do not change: "The fix-price method is a disequilibrium method [...] If flow demand is less than flow supply, a stock will have to be carried over; we say here that it has to be carried over, for the alternative policy of cutting price so as to dispose of them within the current period is not seriously considered. (And is not that, very often, realistic?) [...] In describing this model as a fix-price model, it is not assumed that prices are unchanging over time, or from one single period to its successor; only that they do not necessarily change whenever there is demand-supply disequilibrium." (Hicks, 1956, p. 232).

Finally, out-of-equilibrium agents may be constrained, in their transactions, by financial resources availability, strictly relevant in a context where costs are dissociated in time from receipts. This can be obtained by introducing missing markets, or more simply, through cash-in-advance constraints. The first road is necessary if the focus is on the working of credit and financial markets. The out-

of-equilibrium literature, so far, has been more concerned with a macroeconomic approach, and hence has made use of cash-in-advance constraint that emerges because markets open sequentially.

All the modifications to the standard approach listed above have been extensively used in the literature. As for price rigidity, the early reappraisal of Keynes's economics (Clower, 1965; Leijon-hufvud, 1968) or temporary equilibrium models (Hicks, 1939; Malinvaud, 1977; Bénassy, 1982), assume that prices only adjust between periods. Nevertheless, by releasing the hypothesis of full rationality, out-of-equilibrium analysis has to deal with the appearance of unsold stocks. The New Keynesian literature (Clarida, Gali and Gertler, 1999; Woodford, 2003) also makes reference to a monopolistic competition sticky prices environment, emphasizing short run quantity adjustments in response to shocks, even if in a context in which fluctuations are exclusively technology driven. Time-to-build has also been extensively studied (Kydland and Prescott, 1982), usually (but not only) in RBC type models, although not with reference to fully vertically integrated production processes. Finally cash-in-advance and credit constraints are rather commonly studied in the mainstream literature.

Nevertheless, to the best of our knowledge, these hypotheses were never considered jointly, so that their potential to analyze sequential economies has not been fully exploited (Saraceno, 2004). It is easy to see why their interaction is relevant when we are interested in analyzing out-of-equilibrium dynamics: each period begins with state variables determined in the previous one, and with imbalances that constrain agents in their subsequent decisions. Expectations and the structure of productive capacity further link the periods in a sequence. As a consequence, it is impossible to consider each period in isolation, as for example in the temporary equilibrium literature. A shock (no matter of what type) disrupts the coordination between agents and between phases of production (construction and utilization) that characterizes the equilibrium. *Ex ante* disequilibria (*i.e.* inconsistency of agent's plans) within the period are eliminated by rationing and stock accumulation rather than by price adjustments. The "success" of the subsequent transition lies in the ability of the system in recovering coordination.

In order to embed the assumptions above into a coherent framework, out-of-equilibrium models are usually built into a sequence. The sequential opening of markets (for financial resources, for labor, and for goods) creates binding constraints. The sequence broadly speaking consists of three different moments (the equation numbers refer to the equations in the appendix):

(A) At the end of every period we have a number of state variables:

— The productive capacity, represented by a population of processes, or by a stock of dated labour (see eqs A.3 and A.4) he stocks (of goods or financial means) in the hands of agents (that appeared as rationing in the previous period (eq. A.8). A set of prices and wages

— Some stock variables as labor supply or total money/credit supply.

(B) At the junction between periods

— If imbalances in the labor and goods markets appeared, wages and prices change (eqs. A.6 or A.7).

— The productive capacity 'ages': every productive process becomes one year older.

(C) In the new period things happen in the following order:

— On the production side firms determine, based on expectations (eq. A.5), and the stocks left from the previous period, both the desired quantity to be produced and investment.

— In the next step the desired production is compared with the productive capacity. This may either result in a constraint, or in a decision to keep part of productive capacity idle (equivalently, scrapping of processes can occur).

— Once desired/feasible production is determined, firms can compute the wage bill necessary to carry on production, and investment. The difference between the desired wage fund and available internal resources gives the amount of external financing required by firms.

— The short side rule (eq. A.8). then determines (given the supply from helicopter money or the financial sector) the equilibrium quantity of financial resources. If the demand side is rationed, investment and production are affected, and this alters the structure of productive capacity.

— After taking into account all the constraints affecting desired production, we can compute labor demand. The labor market opens, and demand and supply are matched. If rationing occurs (eq. A.8)., either unemployment or non desired money balances by firms appear

— Production takes place, and wages are paid. This allows computing aggregate demand for the goods.

— The matching of demand and supply in the goods markets is the final step, and the short side rule (eq. A.8). determines unsold stocks or non-desired money holdings by households.

While the details (on utility, technology, rationing, financial markets) may change, most out-of-equilibrium models share a sequential structure of this type that allows analyzing at each step the emergence of constraints affecting the subsequent choices (a *constraint-decision-constraint* sequence). Laying down the sequence allows to realize that problems in the matching of demand and supply may arise because of a number of constraints. A firm may fail to meet the demand it expects because it has not enough productive capacity, or because it faces a human resources constraint, or again because it fails to raise the funding needed to pay for wages and investment. In other words, problem of coordination may arise for a number of reasons, and the smooth functioning of the economy along a regular path appears to be the exception rather than the norm.

As a consequence of a change in the environment (the appearance of a new and superior technology, the degree of extent of the market due to a change in the distribution of income or to the globalisation of the economy), firms have to adapt their productive capacity, in fact they have to adopt a new one adapted to the new environment. In any case, the new productive capacity must be built before being used. And most of the time, there is a divorce between the investment in terms of capacity and the investment at cost. Whatever the reason for changing, the new capacity requires a higher construction cost more than compensated by a lower utilisation cost. This inevitably creates distortions in the structure of productive capacity, which engender fluctuations in output and employment. As a matter of fact, in absence of a change in the external resources available for carrying production processes, the investment in capacity decreases and, mechanically, after a while,

the final output decreases with the consequence of diminishing the level of employment as well as the level of productivity. This is the result of coordination failures due to both irreversibility of investment decisions and imperfection of market information. What really happens along the way is the consequence of the distortion in the structure of production capacity, which the main event associated with any structural change (and the main property of our model). It will depend on the reaction of agents, that is, the way in which firms reacts to successive market disequilibria and government reacts to global imbalances (unemployment, inflation pressures).

3. Macroeconomic controversies revisited

An out-of-equilibrium analytical perspective allows shedding a different light on issues that have been at the center of important debates in macroeconomics.

The prevailing policy consensus, reflecting the equilibrium view of the existence of unique attractors defined with respect to the properties of technological changes and/or other fundamentals, maintains that the long term must prevail over the short term, that the supply conditions are more important than the demand conditions.

In an out-of-equilibrium perspective—where short term oscillations appear no longer as deviations from a fixed trend but rather as the way in which a process of change takes shape and gets realised—the short term actually determines what the long term will be, supply conditions and demand conditions interact with each other and there is a strict relation between the distribution and the creation of wealth, that is, between equity and efficiency.

These are the general methodological conclusions that result from the analysis of some relevant theoretical issues and controversies, presented in the following sections: conclusions that provide a guide line for policy interventions quite different and sometimes opposite to those inspired by the prevailing equilibrium analytical approach. For all the controversies listed below, here we only want to give a sense of how the out-of-equilibrium approach allows gaining a different perspective from equilibrium analysis. While the structure of the models used broadly corresponds to

what we outlined in the previous section, we refer the reader to the cited papers for details on the specific choices made in each of the models.

3.1. Wage rigidity and keynesian unemployment

In an equilibrium construct in which markets are complete, the price vector conveys all the information necessary to fully coordinate agent's decisions. In this framework, unemployment can only stem from nominal rigidities in the relevant market, namely the one for labor.

The focus on flexibility comes from Neo-classical and New Keynesian models which both explain involuntary unemployment as the result of real wage rigidity. The Neo-classical analysis also postulates a positive correlation between nominal and real wages (generally confirmed by empirical observations), so that any cut in money wages should result in a cut in real wages. As a consequence, money wage rigidities associated with some specific institutional rules would be responsible for involuntary unemployment and should be reduced. The New-Keynesian analysis focuses on the bargaining arrangements on the labor market. In particular, entrepreneurs would fix a real wage rate above the equilibrium one—the efficiency wage—in order to induce the workers to reveal their actual level of productivity Stiglitz (1987). Once again, better information would result in a lower real wage and a higher employment level.

According to Keynes, the persistence of unemployment is due to a fall in the marginal efficiency of capital, which is not compensated by an equivalent fall in the real interest rate. In other words, it is due to capital market imperfections. "It was Keynes' position that it is the failure of the incomplete market mechanism to reconcile the implied values of forward demand and supplies [...] that is the source of the trouble. Unemployment of labor and other resources is a derivative phenomenon" (Leijonhufvud, 1968, p. 276). Co-ordination failures at the system level rather than failures in the labor market are responsible for unemployment, which will therefore be involuntary in the strict sense. In this context, disequilibria on the labor market call for wage adjustments, but a fall in the money wage and in the price level, far from leading to a decrease in the real wage and a re-absorption of unem-

ployment, results in a debt deflation process and a cumulative depression. The reason invoked by Keynes is that wage bargains between entrepreneurs and workers do not determine the real wage, and 'there may exist no expedient by which labour as a whole can reduce its *real* wage to a given figure by making revised *money* bargains with the entrepreneurs' (Keynes, 1936, p. 13).

If the "source of the trouble" does not lie in the labor market, whose disequilibrium is only a "derivative phenomenon", the hypothesis of fixed wages that stirred so much controversy acquires a very precise meaning. Keynes writes that "if money-wages were to fall without limit whenever there was a tendency for less than full employment, [...] there would be no resting place below full employment until either the rate of interest was incapable of falling further, or wages were zero. In fact, we must have some factor, the value of which in terms of money is, if not fixed, at least sticky, to give us any stability of values in a monetary system" (Keynes, 1936, p. 303). Keynes reverses the common wisdom on wage rigidity that, in his framework, becomes a necessary institutional feature to avoid the implosion of the system rather than a source of disequilibrium.

The crucial role of co-ordination, however, is better tackled by abandoning the equilibrium approach that also characterises Keynes' *General Theory*, and by seeing the working of the economy as a sequential out-of-equilibrium process (Amendola, Gaffard and Saraceno, 2004b; Saraceno, 2004). This is a complex process that originates on the production side of the economy, but involves all the relevant economic variables, as discussed in the previous section. Involuntary unemployment appears then as the result of a lack of co-ordination that emerges in the economy as a whole along the way, at each step, and cannot disappear simply by allowing price and wage flexibility. As a matter of fact, the standard treatment for taking care of unemployment, a reduction in wages, may result in a sequential process and in further distortions of productive capacity rather than in re-establishing co-ordination and hence re-absorbing unemployment.

Whatever the nature of the original shock experienced by the economy, it implies a distortion of its productive capacity, the dissociation in time of costs and proceeds, a reduction in the resources allocated to investments and hence in the demand for

labor. Consequently income earned by the workers and their demand is reduced. An excess supply appears in the market for final output, and undesired real stocks cumulate. The production demanded no longer matches the existing productive capacity, and the firms scrap some processes in the utilisation phase. As production drops, the excess supply on the labor market persists. An excess of demand may then appear on the market for final output so that we can have an alternation of excesses of supply and demand that, by amplifying the distortion of productive capacity, result in ever increasing fluctuations of the economy. These can be either reduced or amplified according to whether co-ordination is successfully re-established or less. The prevailing wage regime has an essential role in this. Flexibility interpreted as quick adjustment feeds over-reactions in one or the other direction that result in a stronger alternation of excesses of supply and demand, and amplify the distortion of productive capacity. The relation between employment and flexibility then appears under a completely different light. Employment is in fact the result of a complex adjustment process and depends on how this process actually evolves. Price variability implies trading at false prices that create constraints and incentives, which in turn induce firms to take wrong production and investment decisions. Thus the problem lies not so much in the persistence of a wrong price than in the effects of an excessive variability of prices on the structure of productive capacity. In this case a certain wage rigidity prevents the fluctuations from becoming too strong and representing a threat to the viability of the economy. However, as the source of the problem is not in the labour market but in the conditions under which the investment creates, amplifies or eliminates distortions in the productive capacity of the economy, the issue of flexibility versus rigidity should be viewed in the light of how the investment issue is taken care of. If the latter is properly dealt with, it does not matter how flexible wages are: the wage–employment dilemma does not exist.

Prices and wages volatility induces quantity and hence investment volatility, that is, distortions in the age structure of productive capacity, which are responsible for stronger and stronger fluctuations of final output. By the way, in case of technological change, reducing the real wage would be at the opposite of

what should happen as the consequence of a higher labour productivity level.

3.2. Financial constraints and monetary policy

The dissociation in time of inputs from output and costs from proceeds that characterizes every structural change calls for a central role of liquidity in ensuring the viability of the processes of change. Additional liquidity is required to build the bridge through time at the heart of the production process, destroyed by the distortion of productive capacity: and this can only be the outcome of an external intervention. Credit, or money creation, have the crucial role of re-establishing consistency over time of construction and utilization, investment and consumption, supply and demand. This is a general feature of out-of-equilibrium models, but was studied in detail in (Amendola and Gaffard, 1998; Amendola *et al.*, 2004b) where it is shown that the provision of liquidity must be articulated over time so as to properly interact with the modification in the structure of productive capacity which is taking place sequentially; which means, in particular, being harmonized with the time profile of internally generated financial resources during the process of change. Following a positive technology shock, although the natural rate of interest should finally increase, during the transition the lack of financial resources makes it necessary to conduct a loose monetary policy. It will be carried out through a reduction in the monetary interest rate, which will respond to the temporary reduction in the productivity growth rate of the economy[2]. This monetary policy allows minimizing both the output gap and the inflation rate over a given period of time, because it allows minimizing the distortions in the structure of productive capacity.

A policy dilemma is typical of economies that follow out-of-equilibrium paths (Amendola *et al.*, 2004b). Innovation requires "to transmute the capital that was embodied in the late stages of old production processes into capital embodied in the early stages of new processes, that is a disruption of other activities which is 'bound to be a strain'" (Hicks, 1989, p. 535). Then inflationary pres-

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2. The reasons why an initial fall in productivity is usually associated with a process of structural change will be explored in detail in the next section.

sures (and/or deficits in the trade balance in open economies) necessarily appear "because the goods in which the wages (...) will be spent (...) cannot be provided out of the product of the labour which is newly employed, for that is not yet ready" (*ibid.*). Central banks can try to bring inflation back to the target level as soon as possible, with the consequence of exacerbating the initial negative impact of the shock on output and employment. They can, alternatively, decide an accommodating monetary policy bringing inflation back to the target more slowly with the consequence of simultaneously reducing inflation and unemployment (Amendola, Gaffard and Saraceno, 2004a). The latter policy consists in accepting a transitory inflation in the perspective of reducing unemployment. Later on, when and if co-ordination of the production process and the flow of internally generated financial resources are re-established, a restrictive monetary policy may be required to hamper the arising of inflationary pressures. These results hence call for a conduct of monetary policy substantially more articulated than a simple inflation-targeting rule, or even a Taylor rule. Monetary policy needs by its very nature to be discretionary, because it needs to accommodate the changing needs of the economy during the transition process.

3.3. Appropriating the potential gains of technology: The productivity paradox

The standard representation of production and technology, forces to consider unemployment as an equilibrium phenomenon. Its natural rate is determined by 'fundamentals' in a wide (*i.e.* not only referred to labor market features) sense. Unemployment is seen "as shaped by the structure of the economy rather than its recent history: technology, individual preferences, social values and institutions" (Phelps and Zoega, 1998, p. 783). Shocks—including temporary productivity shocks—may in the short run produce disequilibrium transitory effects on employment due to adjustments failures or lags; but in the long run only changes in the fundamentals—e.g. in the productivity growth rate—may explain changes in the natural rate. This, among other things, should account for the fact that "unemployment rates viewed over the very long run...appear to be un-trended in most nations, despite tremendous increases in productivity" (Blanchard and Katz,1997, p.56).

In the equilibrium framework technological advances should be instantaneously mapped into increases in productivity, and the only way to explain the 'productivity paradox'—a fall in productivity, we remember, notwithstanding the introduction of a superior technique in terms of production coefficients—is to assume adoption delays (Amendola, Gaffard and Saraceno, 2005). This happens because in the standard representation of technology, productivity is built into the production function as a given relationship between inputs and output. Such a representation needs an equilibrium framework, in which the ratios between the factors and output are constant and corresponding to those dictated by the production function coefficients.

If productivity is seen instead as the outcome of an out-of-equilibrium process, triggered by a technological shock, then the potential gains of a superior technology may only be appropriated if agents succeed in reshaping the productive capacity (whose distinguishing feature is to be temporally articulated), and in recovering the intertemporal co-ordination disrupted by the introduction of the new technique. Physical, human, and financial capital are complementary in this process of reshaping, and may constrain each other. The outcome of the disequilibrium process depends then on the interaction of accumulation choices, learning, and money supply rules.

The out-of-equilibrium analysis, we have seen, makes it possible to show how a shock of any kind brings about first and foremost a distortion of the existing productive capacity due to a breaking of the intertemporal complementarity of the production process. This implies the appearance of disequilibria, and hence of problems of co-ordination that extend to all aspects of economic activity (resulting, for example, in inflation, unemployment, and so on). Reactions to these disequilibria stimulate a process of adjustment sketched out by sequentially interacting disequilibria, which will amplify or dampen the original deformation of the structure of productive capacity—and hence create or eliminate viability problems—according to the working of the co-ordination mechanisms along the way. If co-ordination is not re-established, this will result in particular in increasing levels of unemployment, and decreasing levels of productivity and real wages (Amendola *et al.*, 2005).

Consider the case of the introduction of a new technology characterised by higher construction costs, as it is typical of the new information and communication technologies. The costs come earlier, and hence cannot be financed out of current production This causes a distortion of productive capacity and the dissociation in time of inputs from output, and of costs from receipts, which puts a financial constraint on investment in capacity. The availability of financial resources *at the right time* is then essential to build a bridge over time between costs and revenues, so as to render the required restructuring of productive capacity viable while it is still on the way and does not yet deliver output and revenues. If these resources are not available, the necessary investment cannot be realised, which will further reduce final output and postpone (or even cast doubts on the effective obtainment of) the expected increases in productivity. What we shall have in the meantime is less production and less labor demand. Unemployment, lower revenues and the subsequent fall in final demand will further reduce receipts and financial resources. Insufficient investments will paradoxically result in excess supply, excessive productive capacity and in the scrapping of production processes. And so on, in a process that is a threat to the viability of the change undertaken. Viability that, therefore, calls for the kind of discretionary monetary policy described in the preceding section.

This process also occurs if the new technology requires a different gamut of skills. We shall immediately have the appearance of a human resource constraint, taking the form of a labour mismatch, which implies the co-existence of unemployment and unfilled vacancies (for lower and higher skills respectively). Once again this will result in lower investment and hence in a subsequent fall in revenues and final demand. Unemployment thus reveals the existence of co-ordination problems at the economy level. It cannot be reduced to a matching problem, to be solved thanks to appropriate changes in the regulations of the labour market or appropriate actions that would allow workers to learn new competencies.

Of course, with a fully rational behaviour making available the financial resources aimed at covering balanced investment expenses, equilibrium will be maintained or mechanically re-established. But this simply means wiping out by assumption the co-

ordination problems that arise along a process of qualitative change and the implied requirement of a macroeconomic management of the process itself.

The above scenario illustrates the productivity paradox, that is, a fall in productivity notwithstanding the introduction of a superior technique in terms of production coefficients. There is a divorce between the productivity of the technique, which can only be verified in an economy already in the equilibrium state associated with the technique itself, and the effective productivity of the economy resulting from how the out-of-equilibrium process of transition takes place. This divorce has nothing to do with the specific character of the technique concerned; it depends on the co-ordination problems that arise in the transition process from an old technique to a new one.

3.4. Trade and domestic distortions

Comparative advantages postulate that an increase of exchanges between countries is generally beneficial to all partners. Importing new goods and services, even when these goods were previously domestically produced, creates new opportunities and allows the use of productive resources in a more efficient way. The loss of manufacturing jobs due to the growing import penetration is generally offset by the job creation effect of growing exports. International trade is thus a positive sum game and cannot be held responsible for increasing unemployment, waste of resources, and low growth.

However, old as well as more recent analyses demonstrate the possibility of losses for some participants to the exchange. These losses would be essentially due to differences in productivity gains among countries, which result in differences in real income (Hicks, 1953; Krugman, 1985; Gomory and Baumol, 2000; Samuelson, 2004). These models deal with the welfare effects for a country when a part of domestic production is taken over by its trading partner, generally a less advanced country. Usually, changes in international trade result in widespread gains if there are no obstacles to prevent the redistribution of productive resources among sectors that allows the convergence toward the full employment equilibrium. Within the standard analytical framework, these considerations lead to focus on the role played by wage

adjustments and distortions associated with them. For the gains from trade and relocation to materialize, it is essential that no domestic distortion prevents the necessary adjustment (*i.e.* the convergence towards the full employment equilibrium). Changes in fundamentals (technology and preferences) must be accommodated by relative prices (in particular wages). In this case, relocation and outsourcing only correspond to a better allocation of resources at the international level without harmful consequences on employment. Increasing imports will be matched by increasing exports.

Out of equilibrium models are not concerned by the final welfare effects of changing trading patterns, but with the positive implications of the transition process. One cannot deny that changes in international trade entail social and distributional costs: "An irony that is not sufficiently appreciated in the public debate is that the economist's case for gains from trade relies heavily on the restructuring of national economies by the forces of trade: specialization requires restructuring. While re- structuring may take different forms, in most cases it is likely to have distributional impacts-both in the short term as a consequence of adjustment costs and in the long-term as a result of permanent changes in relative factor demands. One might even say that the dislocations and distributional consequences produced by trade are the flip side of the efficiency gains. No pain, no gain!" (Rodrik, 1998, p.6).

The restructuring mentioned by Rodrik is an intrinsic feature of globalization and of relocation processes. In fact, increasing openness is a form of structural change and, hence, analytically equivalent to technical progress; as such, it entails the destruction of existing productive capacity (and of the corresponding jobs), and the construction of something new to replace it. Changes in international trade go hand-to-hand with the breaking-up of the pre-existing industrial and spatial structure of productive capacity, which results in unavoidable disequilibria between supply and demand of final goods, all along the transition towards the new adapted structure of the economy. Thus, the supply side, in particular investment, becomes crucial for the transition to a new steady state. It is therefore pointless, when not harmful, to try to bypass the transition and the associated turbulence by eliminating

price distortions. Policy should rather accompany the process of change, progressively removing or softening the constraint faced by the economy.

The out-of-equilibrium approach allows to push Rodrik's argument even further, by arguing that this process of restructuring does not necessarily converge to the new equilibrium: the *ex ante* benefits from increased openness may *ex post* fail to materialize, if something goes wrong with the co-ordination process. Thus, the process of restructuring needs not to be successful. The viability of the transition and the recovery of coordination crucially hinge upon the right mix of institutional and policy factors, notably in access to credit.

A two sector oligopolistic model that is subject to an external demand shock (Gaffard and Saraceno, 2012). Firms can migrate between sectors, following relative profits, but need to adapt their productive capacity to the new sector of activity. The natural tendency of the system to converge to the new steady state equilibrium corresponding to a different demand structure may be hampered by excessive variations in wages and/or by too fast migration between sectors; these may trigger, via aggregate demand effects, an important drop in the investment capacity of firms. In turn, if this lack of resources is not compensated by the credit sector, the insufficient investment disrupts the productive capacity of the economy, and triggers a cumulative explosive process. Therefore, re-establishing the coordination between investment and consumption and reabsorbing unemployment requires an accommodating credit policy, and a sufficiently slow change in wages on the one side and on migration rates on the other. Excessive rigidity, on the other hand, will result in a new equilibrium permanently characterized by unemployment. The paper concludes therefore that there is a sort of "optimal" degree of flexibility for the economy.

4. The current crisis from an out-of-equilibrium perspective

As already stressed, any structural change is a process of development defined as "disturbance of equilibrium, which forever alters and displaces the equilibrium state previously existing" (Schumpeter, 1934, p. 64). The on-going crisis is clearly a moment

of such a process, and should be analysed in this perspective. Of course, financial (mis)behaviours have played an essential role in triggering the crisis. But, its roots are real. Technological shocks, growth strategies carried out by emergent countries, and, most important, dramatic changes in the income distribution, have generated large distortions in the structure of productive capacity in several countries. These have resulted in the involuntary accumulation of real and financial stocks.

Thus, the on-going crisis should have led to understand and address the policy mistakes that prevented the world economy from fully adjusting to the unavoidable structural changes, rather than to propose the same recipes that prevailed before the crisis. As a matter of fact, capitalism is submitted to recurrent structural changes and its survival depends on the way co-ordination takes place. Private (market) or public (policy) co-ordination will be successful when leading to the harmonisation between supply and demand at each moment of time and over time, that is, when smoothing adjustment processes. This co-ordination consists in arbitrages between conflicting objectives, but also requires a harmonisation of interests, which in turn is possible only through a fair distribution of income.

The sequence of events that have been observed can be explained with reference to the analytical construct described above, *i.e.* by focusing on the divorce between investment and consumption that characterized most countries.

The US crisis can be interpreted as the consequence of the way a deep structural change, mostly linked to technological advances, has been managed. During a first phase, financial markets and monetary policy have allowed investments in new technologies to be easily financed (Amendola *et al.*, 2005). But delayed reaction to the building up of disequilibria led to overinvestment and to the emergence of a stock market bubble that eventually burst. In the second phase, the indebtedness of households belonging to poor and middle classes compensated the increased income inequality that should have had a negative effect on final demand and on the potential growth rate (Fitoussi and Saraceno, 2010; 2011). Indebtedness would have created inflationary pressure and would have led the Federal Reserve to apply a tight monetary policy, if the gap between domestic supply and demand for final goods had not

been filled by imports from emerging countries. To summarize, imbalances in the structure of productive capacity have opened the way to cumulative disequilibria (both real and financial, domestic and foreign) that have resulted in a great contraction.

The EU crisis is a different story. During two decades large European countries have experienced a lower growth rate that has ended in increasing budget deficits. This has been the result of a restrictive monetary policy that compressed inflation, but also prevented adequate investments in new technologies. In other words, the transition to the new productive capacity that would have incorporated new technologies has not been completed (Amendola *et al.*, 2005). Nevertheless there were no strong imbalances between investment and consumption that would have rendered unviable this slow growth path. A serious problem arose during the 2000's, when Germany adopted a strategy that has consisted in stimulating exports while constraining its domestic demand with labor market reforms (Carlin and Soskice, 2008). This has resulted in a divorce between Germany and other European countries, that is, between a country with a current-account surplus and countries with deficits, that contributed to the crisis of the Euro in 2011. A strong imbalance between domestic investment and consumption in Germany required a high level of consumption in some other developed countries. Decreasing interest rates in the euro zone periphery and available funds in particular from German banks have fuelled housing bubbles, specifically in Spain, where a symmetric distortion has arisen: domestic consumption was no longer in line with investment in new productive capacity.

In China, excessive inequality, and an insufficient provision of welfare (in particular health care and pensions), led to the necessity of an export led growth and to the ensuing accumulation of assets. Given the large (and sometimes excessive) investment driving the fast growth carried out, only increased exports of goods have allowed absorbing the resulting supply. If this pattern of growth is to be reversed, the growth of investment must fall well below that of GDP and consumption must be dramatically augmented. In our framework, the economy should re-establish a balance between the construction and the utilisation of production processes at the domestic level. This transition to greater

reliance on internal consumption might be quite bumpy, and, it should be managed smoothly to be successful. The government response to the crisis, that took the form of increased public investment, and incentive to private capital accumulation, sustained the economy in the short run, but widened the imbalance between consumption and investment, making the long run adjustment harder and more necessary at the same time.

The global imbalances that result from the prevailing relations between advanced and emerging countries (mainly between the US and China), but also among advanced countries (e.g., between Germany and Spain), take the form of national current-account surpluses and deficits offset by net capital inflows. According to the international intertemporal trade agreement, these global imbalances should create no problems since surplus countries are foregoing goods and services today but expect, in return, to receive net goods and services tomorrow. This is what Corden (2011) calls 'the return journey'. In this scenario, borrowing is supposed to be aimed at financing sound investment, and to provide for the return journey. However, what has happened is that financial resources thus made available have actually been devoted to finance increased current consumption and unproductive investment (housing). As a consequence, a large imbalance has appeared between consumption and sound investment, which is not sustainable. This is an example of the paradox of thrift. We must stress that we are not only concerned with the divorce between saving and (sound) investment, but also with the imbrications of successive disequilibria that push economies out of their stability corridor.

Focusing on the distortions between investment and consumption as the engine driving the evolution of the economy, and identifying them as one of the main causes that pushed economies out of their stability corridor, helps to better understand the intrinsic complexity of the situation. This also reveals how difficult is to elaborate exit strategies for macroeconomic policies. Re-establishing a better co-ordination between investment and consumption will take time. Governments should be able both to smooth short-term fluctuations, and, at the same time, to favour a restructuring of the economy. It would then be a mistake to focus on fiscal consolidation and to ask to implement structural policies

as if the only problem were to re-establish a balanced public budget. Nevertheless, the old Keynesian recipes are also not enough, because as the case of China teaches, they may worsen the co-ordination problems the economy faces. The transition paths should take place in such a way as to correct existing distortions, which means obtaining greater reliance on investment in some countries, on consumption in other ones, while sustaining aggregate demand in the short run. In both cases, this requires adjustments in the structure of the productive capacity and eventually in the distribution of income and wealth. Such changes take time and must be managed in a way that prevents the economy to experiment too strong fluctuations in the meantime. The real challenge is to co-ordinate and harmonize short-term and long-term policies. This may require that inflationary pressures and budget deficits are accepted for a while, when not sought for. Structural policies should not be oriented towards more flexibility on the market, but, at the opposite, they should favor rigidities that permit smoothing the necessary adjustments. Indeed, "the crisis has also put to the test long-standing dogmas that blame labor-market rigidity for unemployment, because countries with more flexible wages, like the U.S., have fared worse than northern European economies, including Germany" (Stiglitz, 2011).

References

Amendola M. and J.-L. Gaffard, 1998. *Out of Equilibrium*. Oxford and New York. Oxford University Press Clarendon Press.

Amendola M., J.-L. Gaffard and F. Saraceno, 2004a. "Technological Shocks and the Conduct of Monetary Policy". *Revue Economique*. 55(6). 1241-63.

Amendola M., J.-L. Gaffard and F. Saraceno, 2004b. "Wage Flexibility and Unemployment: The Keynesian Perspective Revisited". *Scottish Journal of Political Economy*. 51(5). 654-74.

Amendola M., J. L. Gaffard and F. Saraceno, 2005. "Technical Progress, Accumulation and Financial Constraints: Is the Productivity Paradox Really a Paradox?". *Structural Change and Economic Dynamics*. 16(2). 243-61.

Bénassy J.-P., 1982. *The Economics of Market Disequilibrium*. New York. Academic Press.

Blanchard O. and L. F. Katz, 1997. "What We Know and Do Not Know About the Natural Rate of Unemployment". *Journal of Economic Perspectives*. 11(1). 51-72.

Carlin W. and D. Soskice, 2008. "Reforms, Macroeconomic Policy and Economic Performance in Germany". in *Economic Policy Proposals for Germany and Europe*. R. Schettkat and J. Langkau, Eds., Routledge, 72-118.

Clarida R., J. Gali and M. Gertler, 1999. "The Science of Monetary Policy: A New Keynesian Perspective". *Journal of Economic Literature*. 37(4). 1661-707.

Clower R., 1965. "The Keynesian Counterrevolution: A Theoretical Appraisal". in *The Theory of Interest Rates*. F. H. Hahn and F. P. R. Brechling. Ed.. MacMillan.

Corden W. M., 2011. "Global Imbalances and the Paradox of Thrift.". *CEPR Policy Insight*. 54

Fitoussi J.-P. and F. Saraceno, 2010. "Europe: How Deep Is a Crisis? Policy Responses and Structural Factors Behind Diverging Performances". *Journal of Globalization and Development*, 1(1). Article 17.

Fitoussi J. P. and F. Saraceno, 2011. "Inequality, the Crisis and After". *Rivista di Politica Economica*. III(1-3). 9-28.

Gaffard J.-L. and F. Saraceno, 2012. "International Trade and Domestic Distortions". *Journal of Evolutionary Economics*. 22(2). 275-301.

Garegnani P., 1984. "Value and Distribution in the Classical Economists and Marx". *Oxford Economic Papers. N. S.*. 36 2, 291-325.

Gomory R. E. and W. J. Baumol, 2000. *Global Trade and Conflicting National Interests*. Cambridge. Mass. MIT Press.

Hayek F. A., 2002. "Competition as a Discovery Procedure", *Quarterly Journal of Austrian Economics*. 5(3). 9-23. (Originally published as Der Wettbewerb als Entdeckungsverfahren". Kieler Vorträge. 56. 1968).

Hicks J. R., 1939. *Value and Capital*. Oxford. Clarendon Press.

Hicks J. R., 1953. "An Inaugural Lecture". *Oxford Economic Papers. New Series*. 5. 117-35.

Hicks J. R., 1956. "Methods of Dynamic Analysis". in *Collected Essays on Economic Theory. Vol. Ii: Money. Interest and Wages* Basil Blackwell. 1982. 217-35.

Hicks J. R., 1970. "A Neo-Austrian Growth Theory", *Economic Journal*, 80(3183. 257-81.

Hicks J. R., 1973. *Capital and Time*. Oxford. Clarendon Press.

Hicks J. R., 1989. *A Market Theory of Money*. Oxford. New York. Clarendon Press.

Hommes C. H., 1998. "On the Consistency of Backward-Looking Expectations: The Case of the Cobweb". *Journal of Economic Behavior and Organizatio*. 33(3-4). 333-62.

Howitt P., 1994. "Adjusting to Technological Change". *Canadian Journal of Economics*. 27 4. 763-75.

Kaldor N., 1985. *Economics without Equilibrium*. Cardiff. U.K. University College Cardiff Press.

Keynes J. M., 1936. *The General Theory of Employment. Interest. and Money*. London. MacMillan.

Krugman P. R., 1985. "A 'Technology Gap' Model of International Trade". in *Structural Adjsutment in Advanced Economies*. K. Jungenfelt and D. Hague. Ed McMillan. 35-49.

Kydland F. E. and E. C. Prescott, 1982. "Time to Build and Aggregate Fluctuations". *Econometrica*. 50(6). 1345-70.

LeBaron B. and L. Tesfatsion, 2008. "Modeling Macroeconomies as Open-Ended Dynamic Systems of Interacting Agents". *American Economic Review*. 98 2. 246-50.

Leijonhufvud A., 1968. *On Keynesian Economics and the Economics of Keynes; a Study in Monetary Theory*. New York. Oxford University Press.

Malinvaud E., 1977. *The Theory of Unemployment Reconsidered*. Oxford. Blackwell.

Mehrling P., 2006. "The Problem of Time in the Dsge Model and the Post Walrasian Alternative". in *Post Walrasian Macroeconomics : Beyond the Dynamic Stochastic General Equilibrium Model*. D. C. Colander. Ed. Cambridge University Press. 70-9.

Merton R. K., 1936. "The Unanticipated Consequences of Purposive Social Action". *American Sociological Review*. 1(6). 894-904.

Phelps E. S., 2007. "Macroeconomics for a Modern Economy. Nobel Lecture". *American Economic Review*. 97 3. 543-61.

Phelps E. S. and G. Zoega, 1998. "Natural-Rate Theory and OECD Unemployment". *Economic Journal*. 108 448. 782-801.

Rodrik D., 1998. "Symposium on Globalization in Perspective: An Introduction". *Journal of Economic Perspectives*. 12 4. 3-8.

Samuelson P. A., 2004. "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization". *Journal of Economic Perspectives*. 18(3). 135-46.

Saraceno F., 2004. "Wage Regimes, Accumulation, and Finance Constraints: Keynesian Unemployment Revisited." Observatoire Français des Conjonctures Économiques, *Document de Travail*. 2004-01. January.

Schumpeter J. A., 1934. *The Theory of Economic Development; an Inquiry into Profits. Capital, Credit, Interest, and the Business Cycle*. Cambridge. Mass. Harvard University Press.

Stiglitz J. E., 1987. "The Causes and Consequences of the Dependence of Quality on Price". *Journal of Economic Literature*. 25(1). 1-48.

Stiglitz J. E., 2011. "The Ideological Crisis of the Western Capitalism". *Project Syndicate*. July 6th.

Woodford M., 2003. *Interest and Prices : Foundations of a Theory of Monetary Policy*. Princeton. Princeton University Press.

Appendix:
Analytical Elements of an Out-Of-Equilibrium Model

A.1. Technology

The two elements of complementarity and time-to-build can be introduced via an Hicksian representation of technology (Hicks, 1970; 1973): Consider a sequential economy of a neo-Austrian type which uses a homogeneous labour resource. Labour is inputted for n periods to build the productive capacity, and used for the following N to operate it and obtain a final output. An elementary process of production is defined by input coefficients such that:

$$\mathbf{a}^c = \left[a_i^c \right] \qquad \forall i = 1,...,n$$

$$\mathbf{a}^u = \left[a^u \right], \quad \forall i = n+1,...,n+N,$$

(A.1)

and output coefficients

$$\mathbf{b} = \left[b_i \right], \qquad \forall i = n+1,...,n+N. \qquad (A.2)$$

We usually assume that $a_i^c = a^c$, $a_i^u = a^u$, and $b_i = b$, even if any time profile can be modeled through the appropriate choice of vectors. The productive capacity of the economy is given by the number of processes in use at the moment t, in construction, $x^c(t)$ and in utilization, $x^u(t)$:

$$\mathbf{x}(t) = \left[\mathbf{x}^c(t), \mathbf{x}^u(t) \right]. \qquad (A.3)$$

This capacity is subject to ageing and to modifications due to investment and scrapping of processes in case of financial constraints.

Alternatively, especially if the construction phase is short enough, it can be assumed that the production function takes the form of a Leontief function with dated labor input

$$q_t = min[\,\kappa l_{t-1}, \lambda l_t\,] \qquad (A.4)$$

with q denoting quantity produced, and l denoting labour imput either at time t or at t-1. Thus, dated and current labor (l_{t-1} and l_t) concur in fixed proportions to the determination of production q; this formulation is equivalent to assuming capital, built by labor in the previous period, that fully depreciates.

Both with an Hicksian and a Leontief technology, past "invest-ment" may constrain current production: if firms don't possess the appropriate amount of capital/dated labor, they will not be able to produce as much as they wish. The Leontief representation is analytically more treatable, whereas the Hicksian representation allows a finer description of the time structure of production.

A.2. Expectations

We discussed at length, above, why short term expectations (also called *intraperiod*) need to be anchored in past behaviour. A general formulation, for a generic variable x (usually expected demand) contains three terms:

$$x_t^e = \phi x_{t-1} + \gamma x^* + \delta \left(\frac{x_{t-1} - x_{t-1}^e}{x_{t-1}} \right) \qquad \text{(A.5)}$$

The first is the past value of the variable; the second is the 'normal' value, and the third is an error correction term. An appro-priate choice of the coefficients ϕ γ and δ allows to describe a wide range of adaptive behaviours. Steady state/ equilibrium values may anchor long term or *interperiod* expectations (for example those affecting variables like investment, in human and physical capital). In this case, in eq. expect, we would have $\phi = \delta = 0$ and $\gamma = 1$ so that $x^e = x^*$.

A.3. Prices

Out-of-equilibrium models borrow from the fix-price literature (Hicks, 1939; Malinvaud, 1977; Bénassy, 1982), the idea that disequilibria are absorbed by quantity adjustments (short-side rule), while prices only change discretely over time. Analytically, this is obtained by having wages and prices fixed within periods, and adjustments that take place only between the periods (the Hicksian 'weeks'). The adjustment can simply follow previous excess demand (D-S), for example

$$p_t = p_{t-1} \left(1 + \omega \frac{D_{t-1} - S_{t-1}}{S_{t-1}} \right). \qquad \text{(A.6)}$$

ω_j is an indicator of price flexibility that nevertheless, as the equation clarifies, has nothing to do with market clearing beha-

vior. Alternatively, one can have a formulation that echoes the Calvo (1983) partial adjustment scheme:

$$p_t = \psi p^* + (1 - \psi) p_{t-1}, \tag{A.7}$$

with ψ denoting the fraction of firms adapting their price to its optimal value at each period.

A.4. Quantity Adjustments

The short side rule applies to obtain equilibrium in most markets. The actual value of a variable is thus computed as

$$x_t = min[\, x_t^d, x_t^s \,]. \tag{A.8}$$

The markets subject to quantity adjustments may be goods, labour or financial markets.

A.5. The Sequence

We said before that the time structure of the model is generally obtained through a sequence of periods linked by state variables such as the quantity of (dated) labor embedded in production processes, the stocks that result from past disequilibria, and past prices and wages. The interperiod sequence is complemented by an intraperiod sequence that allows the emergence of disequilibria:

Prices and wages change in response to market disequilibria, even if we do not let them clear markets (eqs. A.6 or A.7).

Firms form expectations (eq. A.5), Given expectations, the technology (eqs. A.1, A.2 and A.3 or A.4), and the stock of dated labor l_{t-1}, firms decide desired demand (for labor and external funds, in case the internal funds from previous periods are not sufficient) and supply (of goods).

The first market that opens is the financial market, in which demand for external funds may be rationed (eq. A.8). Financial constraints cause a rescaling of labor demand.

Total labor employed is determined once the second market, the labor market opens, where once again eq. A.8 determines whether unemployment or a human resource constraint appears. Then wages are paid, and production is carried over. Households form their demand based on the actual wage perceived.

Finally, the product market opens; as in the other markets, rationing may appear. Rationing in the goods and labor market will determine the change in prices and wages between periods, as well the stocks carried on from period to period.