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Imperfect coordination in DSGE models: The resurgence of Keynes in mainstream macroeconomics

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ABSTRACT

The imperfect coordination of expectations and actions is a central theme running through Keynes's *General Theory*. Incorporating this theme into mainstream macroeconomics, however, has proved to be a difficult endeavour. In particular, attempts to accommodate coordination failures within Dynamic Stochastic General Equilibrium (DSGE) models through multiple equilibria and "dynamic" indeterminacy, while promising in the 1990s, were gradually abandoned in the 2000s. Since then, the "New Keynesian" framework has come to dominate macroeconomic modelling. And since the coordination of agents is not at issue in this latter framework, mainstream macroeconomics has seemed to leave the coordination theme out of its focus, if not its scope. In this paper, we challenge this perception and argue that the coordination theme is actually alive and well. We especially present two recent research programmes which, while belonging to the DSGE paradigm, give pride of place to coordination failures and share a common objective: providing, within the class of DSGE models, an alternative to the New Keynesian framework that would involve the most important ideas emerging from Keynes's *General Theory*.

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1. Introduction

In 1991, the MIT Press published a two-volume book edited by Gregory Mankiw and David Romer entitled *New Keynesian Economics* (Mankiw and Romer 1991). The first volume gathered contributions dealing with "Imperfect Competition and Sticky Prices," while the second volume gathered articles focusing on "Coordination Failures and Real Rigidities." Besides significant differences, all of these papers shared a common feature: they were all of a qualitative nature, at a time when the new paradigm in macroeconomics was the quantitatively-oriented Real Business Cycle (RBC) model. Soon after the publication of the Mankiw-Romer book, however, a large body of work started to introduce some key ingredients of each volume into models of the

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RBC variety. For instance, Hairault and Portier (1993), Kimball (1995), King and Wolman (1996), and Yun (1996), incorporated monopolistic competition and nominal price rigidities into a RBC model augmented with monetary policy shocks, in order to investigate the quantitative responses of output and inflation to these latter shocks. Almost simultaneously, Rotemberg and Woodford (1992), Farmer and Guo (1994), and Benhabib and Farmer (1996), considered increasing returns to scale production technologies (either internal or external to the firm) within otherwise standard RBC models, and stressed that some parameter configurations could lead to the emergence of multiple equilibria and dynamic indeterminacy – "dynamic" in the sense that there was a continuum of equilibrium paths converging to a unique steady state.

The first decade of the twenty first century, however, witnessed a growing discrepancy in favour of the development of quantitative models involving elements of the first volume of Mankiw and Romer (1991). In particular, monopolistic competition and nominal price stickiness are at the core of what has been called, after Clarida et al., (1999), the "New Keynesian" (NK) framework – namely the vintage of Dynamic Stochastic General Equilibrium (DSGE) models which have become the workhorse for the study of business cycle fluctuations, the transmission mechanism of monetary policy, and the optimal monetary policy. The publication of Woodford's *Interest and Prices* treatise (Woodford 2003a) played a significant role in the promotion of this framework at the theoretical level, as did the applied work of Christiano, Eichenbaum, and Evans (2005)[1] and Smets and Wouters (2003, 2007) at the empirical one.

On the other hand, the development of quantitative models based on the insights from the second volume of Mankiw and Romer (1991) considerably slowed down in the 2000s. On top of notorious technical issues characterising these models, two main reasons, summarised by Schmitt-Grohé (1997), may explain this decline. First, the degree of increasing returns to scale required for multiple equilibria to exist very often lied in the upper range of available empirical estimates, thereby questioning the plausibility of this important source of coordination failures. Second, the degree of persistence displayed by the responses of output to the kind of "extrinsic disturbances" – such as self-fulfilling shocks to the "beliefs" of agents – allowed by the existence of multiple equilibria seemed to be highly sensitive to the value selected for most of the additional free parameters involved by these models, thereby questioning their robustness along a central dimension of business cycle fluctuations.

Hence, by the mid-2000s, the NK framework came to dominate macroeconomic modelling – to such an extent that "New Keynesian" and "DSGE" models became nearly synonymous. Since the coordination of agents is not at issue in this framework, mainstream macroeconomics seemed to leave the coordination theme out of its focus, if not its scope. And since the NK framework still dominates macroeconomics nowadays – despite strong criticism dealing with its inability to adequately address some crucial aspects of the Global Financial Crisis (GFC) – it could easily be concluded that coordination failures, at the end of the day, remain of interest only from a history-of-thought perspective.

[1] A reference to this paper, in its *Federal Reserve Bank of Cleveland W.P.* version (2001), is included in Smets and Wouters (2003).

In this paper, we argue that such a conclusion is highly premature. We especially present two recent research programmes which, while belonging to the DSGE paradigm, give pride of place to coordination failures. The proponents of these two programmes share a common objective: providing, within the class of DSGE models, an alternative to the NK framework that would involve what they perceive as the most important messages delivered by John Maynard Keynes in the *General Theory*. They therefore aim at accommodating, through imperfect coordination,[2] a "truly Keynesian" representation of the functioning of the economic system within the current mainstream in macroeconomics. The approaches to coordination failures considered, however, are quite distinct from the dynamic indeterminacy which characterised the attempts of the 1990s.

The first of these research programmes has been initiated in 2006 by Roger Farmer, who remains its leading figure. This programme allows for coordination failures within DSGE models through the lens of *steady-state indeterminacy*. This approach shares with the dynamic indeterminacy one – of which, as mentioned above, Farmer was one of the main exponents in the 1990s – the fact that the imperfect coordination between agents manifests itself by the existence of multiple equilibria. Contrary to this latter approach, however, steady-state indeterminacy involves a continuum of steady-state equilibria rather than a continuum of equilibrium paths (converging to a unique steady state). In this context, the steady-state level of employment that finally emerges depends on the beliefs, or "animal spirits," of agents regarding their wealth. An important implication of steady-state indeterminacy is that even highly transitory shocks (and notably temporary shocks to the beliefs of agents) can have permanent effects on employment. This stands in sharp contrast with models featuring dynamic indeterminacy, but also with the NK framework. In the words of Farmer (2016b): "The difference is between models in which the economy can be pushed away temporarily from its steady state and models in which it can be pushed into an entirely different steady state. In the first case, the economy is self-stabilizing and, most of the time, the allocation of resources is "almost" Pareto efficient. In the second case, the stabilisation mechanism is broken and the allocation of resources is very far from being Pareto efficient most of the time. In my opinion, the idea that economic equilibrium can be Pareto inefficient, most of the time, is *the* most important idea to emerge from Keynes' General Theory" (p. 29, italics in the original).

The second programme has been launched by George-Marios Angeletos and his co-authors in the early 2010s. Contrary to both steady-state and dynamic indeterminacy, this programme accommodates imperfect coordination within DSGE models without resorting to multiple equilibria. Coordination failures can actually emerge in an environment of equilibrium uniqueness as a result of the combined assumptions of heterogeneous information about economic fundamentals (such as technology and preferences) and strategic interactions across agents. Models featuring these two assumptions have often been referred to as *beauty contest games* since, as in Keynes's parable, agents need to form expectations not only about the current value of

[2] Throughout the paper, we use the terms 'imperfect coordination,' 'lack of coordination,' and 'coordination failures' interchangeably. The term 'imperfect coordination,' though less usual, is now widely used in the recent literature.

fundamentals, but also about the expectations and actions of all other agents. This "higher-order" uncertainty opens the door to what Angeletos and La'O (2013) called "sentiment shocks," i.e., shocks affecting the expectations of each agent regarding the expectations of all other agents.[3] These shocks, taking the form of waves of optimism or pessimism, generate demand-driven fluctuations through self-fulfilling variations in expected demand. Moreover, sentiment shocks can induce positive co-movements in employment, output, consumption and investment, even when nominal prices are *fully flexible*. By contrast, the other types of demand shocks considered by the DSGE literature usually need sticky prices to replicate the observed co-movements. Thus, by allowing for sentiment shocks, beauty contest games make DSGE models consistent with one of the central Keynesian messages: business cycle fluctuations originate from aggregate demand shocks, and the propagation of these shocks is alien to nominal rigidities.

Our paper belongs to the large, and still growing, literature dedicated to the history of recent macroeconomics that has developed over the last decade. For instance, the essays collected in Duarte and Lima (2012) – and especially Hoover (2012) – challenge the standard narrative of microfoundations told by practicing macroeconomists. De Vroey and Duarte (2013) question the label "new neoclassical synthesis" (initially put forward by Goodfriend and King, 1998) to identify the NK framework, and shows that the link between the "old" and the "new" synthesis is rather weak. Young (2014), examining unpublished drafts of key papers in the RBC literature, describes the intellectual process by which the RBC programme was developed in the 1980s. De Vroey (2016) proposes a history of macroeconomics (from Keynes to pre-GFC NK models) written through the lens of the Alfred Marshall/Léon Walras divide. Ingrao and Sardoni (2020) provide a historical account of the various attempts, from the late 19th century to the post-GFC period, to integrate banking and finance into macroeconomic theory. Sergi (2020) argues that the narrative told in technical reports on DSGE models published by central banks conveys a rhetoric which aims at promoting the use of these models in policy institutions. Arnon (2022) provides another history of macroeconomics (from Wicksell to pre-GFC NK models), explaining the inability of DSGE models to have anticipated the 2007–2009 crisis from their "simplistic" character, i.e., the strong knowledge macroeconomists are supposed to have about the future path of the economy and the feasibility of policy options. Trautwein (2022) examines the DSGE models which have been developed since the GFC – namely NK models incorporating significant financial frictions – and questions their ability to account for financial instability and deep recessions. Cherrier et al., (2023) trace the emergence and development of heterogeneous household models in mainstream macroeconomics – and notably in the RBC paradigm.

Most of the above-mentioned work, however, essentially deals with DSGE models (either in their RBC or NK varieties) for which there are no coordination problems. By contrast, Cherrier and Saïdi (2018) discuss the most important studies on multiple

[3] It is worth mentioning here that, since the mid-2010s, Jess Benhabib and his co-authors have also investigated the implications of 'sentiment shocks.' However, we will not consider this work in the present paper since it does not introduce beauty contest games and sentiment shocks into quantitative models: Benhabib and his associates therefore do not aim at restating central Keynesian conclusions within the current mainstream in macroeconomics.

equilibria and dynamic indeterminacy in the 1980s and 1990s. Drawing on archives, interviews and bibliometric evidence, the authors first explain why the "first generation" of sunspot theorists came to use several modelling strategies – such as overlapping generations models, game theory, or chaotic dynamics. They then describe the efforts by the "second generation" of theorists to correct the flaws of the initial models (explaining why those models remained on the fringe of macroeconomics during the 1980s) by switching to RBC modelling and calibration. They conclude by briefly mentioning the two research programmes we focus on in the present paper.

We believe that these two research programmes are worth investigating, for at least two reasons. First, their existence illustrates that the main Keynesian ideas can be accommodated into DSGE models without relying on nominal rigidities – the cornerstone of the NK framework. Second, and perhaps more important, by showing that the kind of coodination failures stressed by Keynes in the *General Theory* (and further deepened by Axel Leijonhufvud in his 1968 classic piece) can play a central role even in a framework which has not been built for this purpose, these programmes make a strong case for the introduction of such coordination failures into any macro model.

The paper is organised as follows. In the next section, we detail the major coordination issues considered in the *General Theory*, principally those associated with the allegories of animal spirits and the beauty contest, confronting Keynes's position with the classical approach adopted by the standard RBC model. Section 3 presents the main results induced by DSGE models involving steady-state indeterminacy and animal spirits, while Section 4 illustrates the main implications stemming from the accommodation of beauty-contest games and sentiment shocks within the DSGE paradigm. Section 5 concludes. Throughout the paper, we frame the most important arguments in mathematical terms. Given the complexity of the material reviewed, we believe that an all-literary presentation would generate much confusion and misinterpretation. However, each equation will be explained in plain English, and each mechanism will be described in the most intuitive way.

2. Coordination issues in the *General Theory*

Keynes's *General Theory* may be seen as a book devoted to coordination issues. Let us recall the three most significant of them:

i. It is because the labour market participants cannot easily coordinate on an overall reduction of money wages, which "could only be accomplished by administrative decree and is scarcely practical politics under a system of free wage-bargaining" (Keynes 1936, 265), that "the effect of combination on the part of a group of workers is to protect their *relative* real wage" (*ibid*, p. 14, emphasis in the original) and not to influence the *general* level of real wages. As a consequence, high *involuntary* unemployment can persist without promptly triggering the required real wage adjustment, even if this adjustment is, by definition, *acceptable to labour as a whole*.

ii. It is because futures markets are severely incomplete that a decision to postpone consumption and a compensating decision to invest cannot be appropriately coordinated. Under complete futures markets, should consumption be postponed, "the expectation from some future yield from investment would be improved, and the resources released from preparing for present consumption could be turned over to preparing for the future consumption"(Keynes 1936, 210–211).
iii. It is because "the energies and skill of the professional investor and speculator are mainly occupied […] with foreseeing changes in the conventional basis of valuation a short time ahead of the general public" and with "anticipating what average opinion expects the average opinion to be" (Keynes 1936, 154 and 156), in other words with coordinating on the same arbitrary target (in the manner of the competitors in a *beauty contest*), that the market value of financial assets can be disconnected from their fundamental value and become the source of wrong signalling.

The first of these coordination issues, due to the absence of an auctioneer in the labour market, led Keynes to reject what he called the "second fundamental postulate of classical economics," meaning to put aside labour supply as an equilibrium determinant, if not as a constraint bounding feasible labour demand. In the classical representation of the labour market, the intersection of the demand and supply curves determines the equilibrium values of the employment and the real wage. This *full* employment, which does not exclude *voluntary* unemployment (unemployment at its natural rate), is made compatible with *effective* output demand by an appropriate adjustment of the money wage. If this adjustment does not take place and the money wage remains too high, equilibrium employment is determined (together with the real wage) by output and labour demands, at a too low level associated with extra (*involuntary*) unemployment. Now, in the classical assessment of Keynes's analysis, this outcome is just the plain consequence of money wage rigidity, whatever the reason for that rigidity may be.

What does the *General Theory* add to this triviality? First, in the dynamic analysis sketched in Chapter 19, it adds the conjecture that money wage adjustments may be destabilising, a decrease in effective demand being the unwelcome consequence of a money wage reduction. Second, and this is the point we will retain here, it adds the fact that the same money wage may be associated with very different employment levels at equilibrium, including full employment. In other words, involuntary unemployment is not inevitably, or fully, attributable to money wage rigidity, since it results, at any given money wage, from equilibrium indeterminateness coupled with inefficient equilibrium selection, in other words from a *coordination failure* in the sense of Cooper and John (1988).

To make things precise, let us go formal and, for the sake of further comparisons, refer to the canonical RBC (Real Business Cycle) model.[4]

[4] See the presentation given by Farmer (2016a). A more complete formalisation of the essentials of the *General Theory* in terms of a temporary general equilibrium model, alternative to the present one (based on the RBC model), is suggested by Dos Santos Ferreira (2014).

- The (inverse) labour demand function, resulting from the first order condition for profit maximisation by a competitive representative firm, endowed with a technology described by the Cobb-Douglas production function $Y_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha}$, is expressed as

$$\frac{w_t}{p_t} = (1-\alpha) A_t \left(\frac{K_{t-1}}{L_t}\right)^{\alpha}, \tag{1}$$

where Y_t, p_t, w_t, $L_t \in (0,1)$, K_{t-1} and A_t denote the output quantity and price, the money wage, the rate of employment, the pre-determined capital and the random total factor productivity, respectively, and where $\alpha \in (0,1)$ is the production elasticity of capital.

- The (inverse) labour supply function, resulting from the first order condition for current utility maximisation by a competitive representative consumer, is expressed (for a log-linear utility function in consumption C_t and leisure $1 - L_t$) as

$$\frac{w_t}{p_t} = \frac{\lambda C_t}{1 - L_t}, \tag{2}$$

where λ is the relative weight on leisure.[5]

- Assuming that total utility is the sum of current utilities at all dates, discounted at factor $\beta \in (0,1)$, the first order condition for intertemporal utility maximisation is expressed by the Euler equation:

$$\frac{1}{C_t} = \beta \mathbf{E}_t \left[\frac{1}{C_{t+1}} \frac{p_t}{p_{t+1}} (1 + i_t)\right], \tag{3}$$

where i_t is the money rate of interest and $\mathbf{E}_t$ is the expectation operator, conditional on information at date t. Assuming full capital depreciation (in order to obtain an explicit solution), capital employed at date $t+1$ is equal to investment at date t, itself equal to saving, by the output market equilibrium condition: $K_t = I_t = Y_t - C_t$, hence

$$K_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha} - C_t. \tag{4}$$

- A crucial assumption allows to close the model within the classical approach: saving and investment decisions are supposed to be perfectly coordinated, either because they are made by the same representative agent or because they are coordinated by an efficient financial market. In the first case, investment is decided by the consumer, who is also the firm owner, and only current employment decisions

[5] This is Equation (2) in Farmer (2020), the corresponding current utility function being specified in footnote 10 (p. 681). Log-linearity is assumed for convenience, but it expresses the peculiar property that income and substitution effects cancel each other out. More generally, constant elasticity of substitution with separability in consumpton and leisure (or labour) is usually assumed (as in Dos Santos Ferreira and Dufourt 2006, Farmer 2013 or Angeletos, Collard, and Dellas 2018, just to refer to articles examined in this paper).

are left to the firm manager. In the second, a perfect financial market equalises, by a no-arbitrage condition, the expected real interest factor $\mathbf{E}_t\left[(1+i_t)p_t/p_{t+1}\right]$ and the expected real return on capital $\mathbf{E}_t\left[\alpha A_{t+1}K_t^{\alpha-1}L_{t+1}^{1-\alpha}\right] = \alpha\mathbf{E}_t[Y_{t+1}]/K_t$. In any case, the Euler equation can then be rewritten as

$$\frac{K_t}{C_t} = \alpha\beta + \alpha\beta\mathbf{E}_t\left[\frac{K_{t+1}}{C_{t+1}}\right], \tag{5}$$

with solution $K_t/C_t = \alpha\beta/(1-\alpha\beta)$, leading to the equilibrium values:

$$L_t = \frac{1-\alpha}{1-\alpha+\lambda(1-\alpha\beta)} = L^* \text{ and } K_t = \alpha\beta A_t K_{t-1}^{\alpha} L^{*1-\alpha}. \tag{6}$$

We obtain a constant natural rate of employment and a path for capital given by the solution of a first-order stochastic log-linear equation.

Now, take Keynes's position, denying the perfect coordination of saving and investment decisions. Inexistence of appropriate futures markets translates into a future price p_{t+1} unobservable at date t. The optimising behaviour of the investing firm will still ensure the equality of the expected real return on capital and the expected real rate of interest or, equivalently, of the marginal efficiency of capital and the money rate of interest $\alpha\mathbf{E}_t[p_{t+1}Y_{t+1}]/p_tK_t - 1 = i_t$, but the expectation $\mathbf{E}_t[p_{t+1}Y_{t+1}]$ is conditional on the information of the investing firm, which may well differ from that of the saving consumer.

Moreover, once we accept the possibility of involuntary unemployment, that is, the possibility that the household is off its labour supply curve, its programme must be modified to take into account the labour rationing, both current and expected in the future, as well understood since Robert Clower (1965) and the so-called macroeconomic disequilibrium literature initiated in the following decade. Since the rationed household cannot choose the level of its current wage income, current real consumption will partially depend on some imposed value of *current* income. In our specification of the utility function, current real consumption will have a component $(1-\beta)Y_t$, the coefficient $1-\beta$ corresponding to Keynes's marginal propensity to consume. Investment decisions, very much influenced by the firm *long-term expectations*, are then called to play a leading, although not exclusive, role in the determination of the equilibrium income.

Contrary to short-term expectations, continuously revised "in the light of realised results" and hence treated in the *General Theory* as always fulfilled, "it is of the nature of long-term expectations that they cannot be checked at short intervals in the light of realised results. Moreover, […] they are liable to sudden revision" (Keynes 1936, 51). The latter property suggests them to be determined by an exogenous stochastic process which rules the entrepreneur's *animal spirits* and ultimately selects at each date, through the marginal efficiency of capital, a particular equilibrium in a continuum of potential equilibria. These equilibria are, in Hicksian terms, *temporary equilibria*, not *equilibria over time*, since Keynes does not impose, as an equilibrium condition, that long-term expectations be fulfilled.

We should not ignore a possible stabilisation channel reacting, through the money market, to a money wage adjustment. Consider the money market equilibrium condition assumed by Keynes (1936, ch. 15):

$$M_t = p_t Y_t / v + L\left(i_t; \mathbf{E}_t[p_{t+1} Y_{t+1}], i_t^e\right), \tag{7}$$

where M_t is the money supply, $p_t Y_t / v$ is the money demand responding to the transactions and precautionary motives (v being the income-velocity of money), $L(\cdot; \mathbf{E}_t[p_{t+1} Y_{t+1}], i_t^e)$ is the (decreasing) liquidity function the value of which represents the money demand responding to the speculative motive. This function depends upon two kinds of expectations: those, represented by $\mathbf{E}_t[p_{t+1} Y_{t+1}]$, affecting the yield of capital which ultimately rules the *fundamental* value of the rate of interest and those, represented by i_t^e, affecting its *conventional* value, namely what is considered to be its "safe" level at date t. Indeed, "what matters is not the *absolute* level of i but the degree of its divergence from what is considered a fairly *safe* level of i" (Keynes 1936, 201; our notation). And Keynes notices that "it might be more accurate, perhaps, to say that the rate of interest is a highly conventional, rather than a highly psychological, phenomenon. For its actual value is largely governed by the prevailing view as to what its value is expected to be. Any level of interest which is accepted with sufficient conviction as likely to be durable will be durable" (Keynes 1936, 203).

So if, in spite of the coordination issue pointed out in the labour market, involuntary unemployment does trigger a money wage reduction and, by Equation (1), an accompanying price decrease, some money becomes available, by Equation (7), to satisfy the money demand required by speculation. This induces a decrease in the rate of interest and a consequent investment increase – the so-called *Keynes effect*. Unfortunately, the decrease in the rate of interest may be slowed down and eventually stopped as i_t approaches i_t^e. It is the combination of a largely uncoordinated and volatile state of long-term expectations $\mathbf{E}_t[p_{t+1} Y_{t+1}]$ determining investment decisions and of strongly coordinated, undispersed and steady, expectations of some arbitrary level of the interest rate i_t^e, considered to be safe, that blocks stabilisation towards a full employment equilibrium: "The difficulties in the way of maintaining effective demand at a level high enough to provide full employment, which ensue from the association of a conventional and fairly stable long-term rate of interest with a fickle and highly unstable marginal efficiency of capital, should be, by now, obvious to the reader" (Keynes 1936, 204).

The coordination theme was at the centre of Leijonhufvud's reading of Keynes and received a formal acknowledgment in some New Keynesian models of the early 1980s collected in part IV of Mankiw and Romer (1991). One common characteristic of these models is that they exhibit multiplicity of *rational expectations equilibria*. Obtaining equilibrium indeterminateness by just making individuals' actions depend upon animal spirits is not enough: long-term expectations are now required to be fulfilled at equilibrium. Behind the conceptual shift from a temporary equilibrium to an equilibrium over time, there is the idea that "changes in expectations were not invoked simply as a *deus ex machina*" but that a change in expectations, "once begun, produces effects that confirm and strengthen that very belief" (Woodford 1991, 77). Furthermore, because they are self-fulfilling these changes in expectations can be a

rational response to an extrinsic event, affecting *sunspots* and leaving unchanged the fundamentals.

An important literature on endogenous macroeconomic fluctuations relating equilibrium *local* indeterminacy and self-fulfilling prophecies under extraneous uncertainty started with Costas Azariadis (1981) in the context of overlapping generations and then with Benhabib and Farmer (1994) in the context of an infinitely lived representative consumer.[6] In spite of its undeniable Keynesian flavour, this literature tended to support the idea that shocks on expectations can make the economy fluctuate around (possibly close to) a single dynamically stable steady state, itself observing all the requirements of a classical equilibrium, full employment included. Another step remained to be made in order to reconcile rational expectations and steady state indeterminacy or other forms of *global* indeterminacy, allowing the economy not to be riveted to a full employment steady state. Although tempered by the incursion of rationality in the context of long term expectations, this is clearly a line of Keynes revival, which will be considered in Section 3.

Let us further recall Keynes's association of "a fickle and highly unstable marginal efficiency of capital" making effective demand respond to *animal spirits* and leading to steady state indeterminacy with "a conventional and fairly stable long-term rate of interest" blocking effective demand adjustments through the Keynes effect. Because of the conventional nature of the long-term rate of interest illustrated by the parable of the *beauty contest*, we have seen that for Keynes "*any* level of interest which is accepted with sufficient conviction as likely to be durable will be durable" (our emphasis). Indeterminateness may thus be the consequence not only of missing financial markets allowing to coordinate intertemporal decisions, but also of liquid while inefficient financial markets estranging coordination from fundamentals. An important stream of literature initiated by Morris and Shin (2002) has been devoted to the beauty contest theme but, very much as the animal spirits literature added rational expectations to Keynes's original idea, the beauty contest literature focused on equilibrium uniqueness (although subject to coordination frictions), discarding Keynes's suggestion of equilibrium indeterminacy in this context. In spite of this qualification, the theme of frictional coordination building on the beauty contest appears as a further line of Keynes revival that will be considered in Section 4.

3. *Animal spirits*: steady state indeterminacy

The theme of steady state indeterminacy in the context of an otherwise standard DSGE model has been simultaneously introduced by Farmer (2006), exploiting the consequences of the lack of coordination in the labour market, and by Dos Santos Ferreira and Dufourt (2006), proposing a coordination game between firms acting in the output markets.

[6] See Benhabib and Farmer (1999) and Lloyd-Braga, Modesto, and Seegmuller (2014) for a synthetic view of this literature.

3.1. An uncoordinated labour market with large search costs

Farmer's starting point is essentially the one we attributed to Keynes in the preceding section: in a labour market without an auctioneer, supply and demand cannot be adequately coordinated to implement the equilibrium values of employment and the real wage. This is the first step in the way of dispensing with labour supply as an equilibrium determinant or, to use Keynes's terms, in the way of rejecting the second fundamental postulate of classical economics.

The consequences of the absence of an auctioneer in the labour market had already been drawn by search theory. First, workers and firms match randomly according to the matching function (often specified as Cobb-Douglas) $m(v,u)$, where v is the number of vacancies and u the number of unemployed workers. Second, when workers and firms match, they are assumed to engage in a (generalised) Nash bargain to share the surplus generated by the job creation. In terms of the whole macroeconomic model, we can say that the matching function rules *frictional* unemployment, neglected in both the classical and Keynesian approaches, and that the Nash bargain rules Keynes's *voluntary* unemployment, by replacing the labour supply function in the determination of the real wage.

Farmer (2006), prolonged by Farmer (2012, 2013, 2016a and 2020), takes the matching function but explicitly discards the Nash bargain and, implicitly, Keynes's money wage bargain with workers targeting their relative wage. Actually, he comes back to the classical competitive view of price- and wage-taking agents. However, search costs are now made explicit, at least on the firms side, since L employed workers are assigned either to production (X) or to recruitment (V) as mutually exclusive tasks: $L = X + V$. Accordingly, instead of a matching function proper, Farmer assumes a *search technology* $m(V,u)$ where V does no more represent the number of vacancies but rather the number of workers assigned to the recruitment task. By further assuming that labour does not carry disutility and that job separation is exogenous at rate δ, he obtains in a steady state, in which job destruction must be equal to job creation,

$$\delta L = m(V, 1-L) = \sqrt{\Gamma V(1-L)}, \tag{8}$$

using the specification he adopts for the function m. From this equilibrium condition we deduce that the steady state value of labour assigned to production is

$$X = L\left(1 - \frac{\delta^2 L}{\Gamma(1-L)}\right). \tag{9}$$

As a consequence, the equilibrium real wage is equal to marginal labour productivity $\partial Y/\partial X$ now multiplied by the derivative

$$\frac{dX}{dL} = 1 - \left(\delta^2/\Gamma\right)\left(\frac{1}{(1-L)^2} - 1\right), \tag{10}$$

which vanishes at $1 - L = 1/\sqrt{1 + \Gamma/\delta^2}$, sort of natural rate of unemployment with very specific foundations, neither classical nor Keynesian. When unemployment is

too low, the correspondingly prohibitive search costs leave no place for a production activity, all employed workers having to be assigned to the recruitment activity.

This model specificity is, however, by no means the crucial point in Farmer's approach. The significant point is that labour can be assigned to two rival tasks and that there is no market ruling the way to split it between them, thus keeping employment and the real wage undetermined. This indeterminacy opens the way to the determination of these two variables by *animal spirits* or *beliefs*,[7] which rule asset valuation in financial markets. To put it simply, "beliefs determine wealth, wealth determines the demand for produced goods, and the demand for produced goods determines employment" (Farmer 2020, 687).

Formally, Farmer closes its model by *a belief function*.[8] Beliefs, defined in Farmer (2013) as the expected price of capital in wage units

$$x_t \equiv \mathbf{E}_t\left[\frac{p_{kt+1}}{w_{t+1}}\right], \tag{11}$$

are determined as the geometric mean of the previous beliefs and the present observation of the price of capital, modified by a random shock s_t^b with zero mean:

$$x_t = x_{t-1}^{\rho}\left(\frac{p_{kt}}{w_t}\right)^{1-\rho} e^{s_t^b}. \tag{12}$$

This is an *adaptive expectations* process that can be approximated in logarithms by the equation

$$lnx_t = lnx_{t-1} + (1-\rho)\left(ln\left(\frac{p_{kt}}{w_t}\right) - ln\mathbf{E}_{t-1}\left[\frac{p_{kt}}{w_t}\right]\right) + s_t^b, \tag{13}$$

where the second term on the right hand side is the *error adjustment* weighted by $1-\rho$, with $\rho \in [0,1]$ measuring the *persistence*.

A crucial implication of this specification of the belief function is that temporary shocks on beliefs have permanent effects on endogenous variables, and especially on unemployment. For instance, suppose that, starting from the steady state characterised by the natural rate of unemployment derived above (from Equation (10)), a purely transitory negative shock on beliefs – i.e., a one-time negative realisation of s_t^b reflecting a bout of pessimism – occurs. This shock triggers a downward revision of the expected price of capital which, according to Equation (13), is permanent. Feeling permanently poorer, households are induced to reduce their consumption in every period. Since firms decide how many workers to hire based on the demand for the goods that they produce, the permanent fall in consumption generates a permanently lower hiring rate (at a constant firing rate). The economy thus reaches a new steady state featuring lower levels of consumption, output, and employment, and a lower

[7] The two terms are used interchangeably by Farmer (see Farmer 2020, p. 6867, n. 17).

[8] According to Farmer, this latter function "is a new fundamental that determines wealth, and should be accorded the same methodological status as technology shocks and preference shocks in conventional DSGE models" (2016b, p. 84).

price of capital (validating the pessimistic expectations). If no new shocks on beliefs happen, the actual unemployment rate will remain permanently higher than its natural counterpart: no market forces will bring unemployment back to any natural rate (however defined). Hence, echoing a key conclusion drawn by Keynes in the *General Theory*, the economy can be stuck for a very long time in an equilibrium with less than full employment.

An important additional remark is that adaptive expectations are not replacing rational expectations: the belief function "anchors beliefs in a world of multiple rational expectations equilibria" (Farmer 2013, 329). Adaptive expectations are used "as a fundamental structural equation that replaces the labour supply equation in a model with incomplete factor markets" (*ibid*). Actually, adaptive expectations as such are not an indispensable ingredient of Farmer's approach in general. Indeed, in Farmer (2020), he assumes that beliefs Z^B about the discounted present value of the return to capital, as valued in the stock market, follow the stochastic process

$$Z_t^B = \rho_B Z_{t-1}^B + (1-\rho_B)\bar{Z}^B + \varepsilon_t^B, \tag{14}$$

with unconditional mean $\bar{Z}^B$, persistence $\rho_B \in (0,1)$ and a belief random shock ε_t^B with zero mean. This belief formation is again backward-looking, but *regressive* rather than adaptive. Of course, it is still rational as far as beliefs are self-fulfilling, a consequence of the model being closed with beliefs. The non-stochastic steady state (with $\varepsilon_t^B \equiv 0$ for any t) is indeed determined by $\bar{Z}^B$, whatever it may be, provided feasibility is assured. This is not essentially different from Keynes's equilibrium being ultimately determined by the state of long-term expectations, as expressed in the marginal efficiency of capital.

To be exact, while the various belief functions proposed by Farmer are consistent with rational expectations in the sense of "self-fulfilling expectations" – an *equilibrium* concept – they are not congruent with the standard forward-looking approach to rational expectations *formation* which makes them be "essentially the same as the predictions of the relevant economic theory" (Muth 1961, 315). Hence, Farmer's models are less akin to mainstream macroeconomics than their author tends to suggest.[9]

3.2. Output markets with large firms playing a coordination game

By contrast with Farmer (and with Keynes himself), Dos Santos Ferreira and Dufourt (2006) take a conventional approach to the labour market, ignore the financial market and focus instead on the output markets, assumed to be oligopolies. It is well known that oligopolistic competition is a source of indeterminacy, as far as the same market structure can support different conducts, hence different degrees of competition,

[9] To the best of our knowledge, it seems that there were no reactions from the mainstream to Farmer's concept of belief function. It would be interesting to investigate whether Farmer's argument could be reproduced with the standard approach to rational expectations. This is however a theoretical rather than a historical issue, and not a straightforward one. Beliefs should be seen as part of the "relevant economic theory" the predictions of which depend upon them through their influence on agents' decisions, conferring anyhow an equilibrium, self-fulfilling, status to rational expectations.

susceptible of variations along the cycle. These variations were acknowledged by Keynes (1939) as one of the possible explanations of the Dunlop-Tarshis observations of the relative movements of real wages and output. The authors suppose however that market structure can itself be indeterminate, in a context of free entry of firms exhibiting *internal* economies of scale induced by a fixed cost.

They assume a large number of identical industries with an arbitrarily large number of identical firms in each one of them. These firms compete *à la* Cournot to serve unit-elastic demand for a homogeneous good,[10] by producing with a constant marginal cost and a fixed cost, not incurred when they decide to be inactive. Such configuration may lead to multiple free entry Cournot equilibria,[11] with different numbers of active firms. Equilibria are symmetric with respect to all active firms, so that the price is determined by applying to *marginal* cost c the usual Cournot mark-up factor $1/(1-1/n)$, decreasing in the number n of active firms. Two additional conditions, involving the *fixed* cost φ, must be satisfied by definition at equilibrium: *profitability* (the profit of an active firm cannot be negative) and *sustainability* (an inactive firm cannot make a positive profit by becoming active).

Suppose a free entry Cournot equilibrium exists for any $n \in \mathbf{N}$, the set of all integers in $[\underline{n}, \bar{n}]$ (if $n < \underline{n}$, the equilibrium candidate is unsustainable; if $n > \bar{n}$ it is unprofitable). By varying the distribution of equilibria with different numbers of active firms across the industries we obtain existence of a large number of equilibrium mean prices (a continuum in the limit case of a continuum of industries) belonging to the interval $[c/(1-1/\bar{n}), c/(1-1/\underline{n})]$. This is the basis for steady state indeterminacy.

Given this indeterminacy, how are observed equilibria selected? At the industry level, in the absence of any intrinsic uncertainty, every firm has a perfect knowledge of all the fundamentals (demand and symmetric costs) and would easily coordinate on the Cournot equilibrium if this equilibrium were unique (meaning that the firm would be able to rationally conjecture the equilibrium actions of its competitors). However, given the multiplicity of Cournot equilibria (symmetric with respect to the active firms), firms are involved in a coordination game. They lack a crucial information: the number of active firms that will emerge from their actions. Their conjectures must be somehow coordinated. It is assumed that this coordination takes place by referring to some extrinsic stochastic process (without alteration of the fundamentals), possibly with both systemic and idiosyncratic components.

An example of such a stochastic process, the one used in the numerical simulations performed in the paper, assumes that all firms in each industry i receive the same signal $s_{it} \in \mathbf{S} \equiv \{1, \ldots, \#\mathbf{N}\}$ coordinating their conjectures on the number of firms that are going to be active at date t. All industry signals are received according to the same probability distribution π_ω over $\mathbf{S}$, conditional on the state $\omega \in \mathbf{\Omega}$ prevailing in the economy. An idiosyncratic noise ε_{it}, specific to industry i, is added to

[10] The goods produced in the different industries become at the economy level a composite good by applying a Cobb-Douglas aggregator.

[11] Entry is free because there are no sunk costs associated with a preliminary decision to enter and because the game is symmetric, offering equal opportunities to all players. Equilibria are however asymmetric relative to the two categories of active and inactive firms (there is no equal treatment of all the players at equilibrium).

this systemic component. If the signal is too noisy, with a precision smaller than some threshold $\rho \in [0, 1]$, the firms in industry i, not entailing a sufficient degree of confidence, prefer to coordinate on the past observed signal s^*_{it-1}, a behaviour which creates persistence. Aggregation across the industries allows then to describe the process by the dynamic stochastic equation in the variable n_t (the weighted arithmetic mean of the numbers of active firms in all the industries):

$$n_t = \rho n_{t-1} + (1 - \rho) n_\omega, \tag{15}$$

with $n_\omega = \sum_{s \in \mathbf{S}} \pi_\omega(s) n(s)$, the expected value of the number of active firms in the economy, conditional on the realisation of state $\omega \in \Omega$ at the economy level.

This AR(1) process, the equivalent of Farmer's dynamic stochastic Equation (14), is thus obtained without the involvement of either the labour or the financial markets, in a somewhat un-Keynesian way, yet by still referring to Keynes's *animal spirits* – "a spontaneous urge to action rather than inaction" (Keynes 1936, 161). In both approaches, rationality of expectations or conjectures is added to Keynes's original approach: it is not the case that "'animal spirits' are supposed to play the role of exogenous random shocks […], but rather that they may act as a stochastic selection mechanism in the presence of indeterminacy" (Dos Santos Ferreira and Dufourt 2006, 312). Moreover, in both approaches this indeterminacy concerns the steady state, not the trajectories converging to an asymptotically stable steady state, thus opening the way to large endogenous fluctuations without requiring extreme characteristics of the fundamentals.

4. The *beauty contest*: frictional coordination

The literature investigated in the previous section assumes perfect information on the economic fundamentals (in every period, any individual agent knows their current value) and, if imperfect, at least homogeneous information on the determinants of the actions made by all other agents. Imperfect coordination is thereby completely divorced from potential informational issues. By contrast, heterogeneous information is at the core of the coordination problem raised by what has been commonly referred to, after the pioneering contribution of Morris and Shin (2002), as the "beauty contest" literature.

4.1. Dispersed information, strategic interactions, and unique equilibrium

The beauty contest literature makes two crucial assumptions: a) information is dispersed, in the sense that different agents receive different pieces of information about economic fundamentals; b) there are strategic interactions, in the sense that the optimal action of one agent depends on the actions made by the other agents. As a result, and exactly as in Keynes's parable, agents need to form expectations not only about the current value of fundamentals, but also about the expectations and actions of all other agents. Coordination is therefore imperfect since aggregate outcomes will diverge from the values pinned down by the fundamentals. Importantly, models belonging to the beauty contest class involve a unique equilibrium, which implies that

coordination failures are by no means confined to models exhibiting multiple equilibria and indeterminacy. Angeletos (2018) notably coined the term "frictional coordination" to designate the coordination problem arising in models featuring equilibrium uniqueness.

To illustrate these ideas, let us assume (following the general framework suggested by Morris and Shin 2002) that there is a continuum of agents, indexed by the unit interval [0, 1]. Agent i chooses an action $a_i \in \mathbf{R}$, and her loss function is given by:

$$l_i = -(1-r)(a_i - \theta)^2 - r\int_0^1 (a_j - a_i)^2 dj,$$

where r is a constant, with $0 < r < 1$, and θ is the underlying fundamental of the economy.

This loss function is made of two components. The first component is the standard quadratic loss in the distance between the underlying fundamental and the action of agent i. The second component is the "beauty contest" term: the loss of agent i is increasing in the average distance between her action and the action profile of the whole population.

Three cases could be distinguished.

i. Information is perfect: all agents know the actual value of θ. In this case, the optimal action of agent i is simply $a_i = \theta$.
ii. Information is imperfect but commonly shared: agents do not know the actual value of θ, but they all share the same information about this value. Moreover, this fact is common knowledge. In this case, the optimal action of agent i is $a_i = \mathbf{E}[\theta]$, where $\mathbf{E}[\theta]$ is the common expectation of θ.
iii. Information is dispersed:[12] agents do not know the actual value of θ, and each agent receives a private information about this value. In this case, the optimal action of agent i is:

$$a_i = (1-r)\mathbf{E}_i[\theta] + r\mathbf{E}_i[\bar{a}], \tag{16}$$

where $\mathbf{E}_i[\theta]$ denotes agent i's expectation of θ, and $\mathbf{E}_i[\bar{a}]$ her expectation of the average action in the population.

Several remarks are in order.

First, the constant r represents the degree of *strategic complementarities* in the actions of individual agents: Equation (16) makes it clear that the optimal action of agent i is an increasing function of the actions of the other agents in the economy, which is the very definition of strategic complementarities in actions.

Second, the existence of strategic complementarities – and more generally the existence of strategic interactions (i.e., the fact that $r \neq 0$) – implies that individual agents need to form expectations about the beliefs of others when information is heterogeneous. This can be seen by rewriting Equation (16) as follows:

[12] The terms 'dispersed' and 'heterogeneous' will be used interchangeably in the rest of the text.

$$a_i = \mathbf{E}_i\left[\sum_{h=0}^{\infty}(1-r)r^h\mathbf{E}^h[\theta]\right], \tag{17}$$

where $\mathbf{E}^h[\theta]$ denotes the hth order average expectation of the fundamental. Hence, in addition to "first-order" expectations (her own expectations of the fundamental, i.e., $\mathbf{E}_i[\theta]$), agent i has to form "higher-order" expectations (forecasts of the forecasts of others).[13,14] The fact that agents need to form higher-order expectations is called *higher-order uncertainty*.

Third, higher-order uncertainty induces imperfect coordination. Indeed, while agents may be individually very well (but not perfectly) informed about the actual value of the fundamental (so that $\mathbf{E}_i[\theta]$ is very close to θ), they will nevertheless choose an action that can be very different from this actual value if they believe that other agents are only poorly informed about it. Moreover, coordination will be all the more imperfect as the degree of strategic complementarities increases: as can be seen from Equation (17), the higher r, the higher the order of expectations agents have to consider, and the larger the weights they have to attach to expectations of higher orders.

Fourth and last, the assumption that $r < 1$ – so that strategic complementarities are "weak" – ensures equilibrium uniqueness. The fact that optimal actions are weak strategic complements implies that the equilibrium is unique when information is perfect. Equilibrium uniqueness is preserved as we move from perfect to imperfect but commonly shared information, and then to heterogeneous information. By contrast, multiple equilibria appear when strategic complementarities are strong (i.e., when $r \geq 1$), which characterise models displaying dynamic and/or steady-state indeterminacy.[15]

It is worth emphasising here that the famous "islands model" put forward by Robert Lucas in his 1972 seminal paper, while involving dispersed information, does not belong to the beauty contest class of models. This is because there are no strategic interactions between islands: even though producers on different islands receive different pieces of information regarding the actual value of the money supply, the lack of trade linkages between islands implies that producers do not need to form higher-order expectations. Potential coordination issues are therefore swept under the rug.

[13] For instance, second-order expectations are agent i's expectations about the average expectation of the fundamental; third-order expectations are agent i's expectations about the average expectation of the average expectation of the fundamental; and so on.

[14] The importance of higher-order expectations has been initially raised by Phelps (1983) and Townsend (1983), but it had already been foreshadowed by Keynes: "It is not a case of choosing those [faces] which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth and higher degrees" (Keynes 1936, 156).

[15] The strength of strategic complementarities is also what differentiates beauty contest games from 'global games.' In beauty contest games, dispersed information is combined with weak strategic complementarities, while in global games dispersed information is combined with strong strategic complementarities. Beauty contest games thus feature equilibrium uniqueness, while global games feature multiple equilibria and indeterminacy. See Angeletos and Lian (2016) for a survey of the global games literature.

The equilibrium uniqueness characterising beauty contest games makes them especially well suited to the task of introducing imperfect coordination into the DSGE research programme. This line of research was initially pursued by Woodford (2003b) and Angeletos and La'O (2010). Both contributions used the fact that higher-order expectations display more inertial behaviour than economic fundamentals to explain two important regularities at business cycle frequency. First, Woodford (2003b) showed that higher-order uncertainty would make price adjustment particularly sluggish after aggregate demand shocks, thereby providing an explanation for the persistent effects of monetary shocks on output. Second, Angeletos and La'O (2010) showed that higher-order uncertainty would considerably dampen the response of output to productivity shocks in an otherwise standard RBC model, thereby helping this model to reproduce the initial fall in employment observed after identified positive productivity shocks.[16] Hence, "frictional coordination" seemed to be a promising ingredient to make DSGE models consistent with the responses of actual economies to fundamental – monetary as well as real – shocks.

4.2. Sentiment shocks and demand-driven fluctuations

Most of the recent literature accommodating frictional coordination within the DSGE paradigm, however, has shifted attention towards the implications of shocks unrelated to fundamentals. Higher-order uncertainty, indeed, opens the door to the emergence of shocks affecting the expectations of each agent regarding the expectations and actions of all other agents. These extrinsic disturbances have been commonly referred to as "sentiment shocks" after Angeletos and La'O (2013). In their framework – as well as in the subsequent developments on the same track – sentiment shocks directly affect higher-order expectations: each agent, while being well aware that no fundamental shock has occurred, suddenly believes that the other agents expect such a shock to have actually taken place. Sentiment shocks therefore take the form of waves of optimism or pessimism. As such, they can be associated with forces akin to "animal spirits." They also generate demand-driven fluctuations through self-fulfilling variations in expected demand: a positive sentiment shock induces individual agents to expect a higher level of aggregate demand, and thus more demand for the item they sell; each agent accordingly raises production and spending, pushing up aggregate demand and validating the initial expectation. Moreover, sentiment shocks trigger positive co-movements in employment, output, consumption and investment, *even when prices are fully flexible*. This is in sharp contrast with the other types of demand shocks considered by the DSGE literature, which need sticky prices to replicate the observed co-movements. Hence, sentiment shocks allow for the accommodation of key Keynesian insights within mainstream models of the business cycle.

In order to illustrate these points, let us consider the baseline RBC model outlined in Section 2 (and summarised by Equations (1)–(6)). Moreover, let us introduce the following set of assumptions (taken from Angeletos, Collard, and Dellas 2018).

[16] This negative response of employment, at odds with the predictions of the standard – perfect information – RBC model, was initially stressed by Jordi Galí (1999).

First, there is a continuum of islands, indexed by i, and a mainland. Each island is inhabited by a firm and a household, interacting in local labour and capital markets. The firm uses the labour and capital provided by the household to produce a differentiated intermediate good. A centralised market for these goods operates in the mainland, alongside a market for a final good. The latter is produced with the use of the intermediate goods and is itself used for consumption and investment. All markets are competitive, and all prices are flexible.

Second, each period contains two stages. The labour and capital markets of each island operate in stage 1. At this point, the firm decides how much labour and capital to demand – and, symmetrically, the household decides how much of these inputs to supply – *on the basis of incomplete information regarding the choices made in other islands*. In stage 2, the centralised markets for the intermediate and the final goods operate, the actual level of economic activity is publicly revealed, and the households make their consumption and saving decisions on the basis of this information.

Third, there is a single fundamental shock in the economy, hitting the total factor productivity (TFP), A_t. This shock is *not observed* by the islands in the first stage of each period, which means that TFP is not known when production decisions are made. Information about productivity shocks is dispersed: in stage 1 of any period t, island i observes only a private signal of the form:

$$z_{it} = lnA_t + \varepsilon_{it}, \tag{18}$$

where ε_{it} is an island-specific error.

Fourth, we assume that each island believes that the signals observed by the other islands are biased: the prior of island i is that ε_{it} follows a Gaussian white noise process with variance σ^2, and that ε_{jt} follows a Gaussian process with mean ξ_t and variance σ^2 (for all $j \neq i$), where ξ_t is a random variable that represents the perceived bias in one another's signals. We assume that ξ_t follows an AR(1) process:

$$\xi_t = \rho\xi_{t-1} + \zeta_t, \tag{19}$$

where $0 \leq \rho < 1$ and ζ_t follows a Gaussian white noise process with variance σ_ξ^2. Innovations in ξ_t are called "sentiment shocks."

It can be shown that the general equilibrium of the model reduces to the solution of the following fixed-point relation:

$$Y_{it} = (1-\omega)\mathbf{E}_{it}A_t + \omega\mathbf{E}_{it}Y_t, \tag{20}$$

where Y_{it} denotes the level of output produced in island i in period t, Y_t the aggregate level of output, and $0 < \omega < 1$ a reduced-form parameter measuring the degree of strategic complementarities between islands. Since strategic complementarities are weak, the model features a unique equilibrium.

Let us now consider what happens after a positive innovation in ξ_t. Such a positive sentiment shock means that, while they are observing a signal indicating no shock on current TFP, individual islands suddenly believe that the other islands are observing wrong signals indicating a positive shock on current TFP. As a result, they keep their

own expectations of current TFP unchanged (i.e., $\mathbf{E}_{it}A_t$ is not affected), but adjust their higher-order expectations upwards. This upward adjustment leads individual islands to become optimistic about the level of aggregate output (i.e., to raise $\mathbf{E}_{it}Y_t$).[17] According to Equation (20), the optimal response of each island is to raise its own level of output – since an increase in the expected level of aggregate activity means an increase in the expected demand for its product. Firms thus raise their demand for both labour and capital, pushing the wage and the rental rate of capital up. However, since $\rho < 1$, this wave of optimism is only short lived. Consequently, households experience only a transitory increase in the returns to labour and capital. Because this entails only a small increase in permanent income, the wealth effect on labour supply is dominated by the competing substitution effect. Hours worked therefore increase in equilibrium. Moreover, because the boom is expected to be only transitory, households find it optimal to consume only a fraction of the increase in their income, and to save the rest.

Angeletos, Collard, and Dellas (2018) introduced additional shocks into the above framework. They showed that, among the different demand shocks considered (and especially investment-specific shocks and discount-rate shocks), only sentiment shocks were able to replicate the positive co-movements in hours worked, output, consumption, and investment, observed at business-cycle frequencies. The other demand shocks actually require introducing sticky prices to reproduce these co-movements. Angeletos, Collard, and Dellas (2018) also found that sentiment shocks would account for the bulk of the volatility in real variables. Hence, by opening the door to sentiment shocks, frictional coordination makes DSGE models consistent with one of the central Keynesian messages: business cycle fluctuations stem from aggregate demand shocks, and the propagation of these shocks has nothing to do with nominal stickiness.

5. Conclusion

Three decades after the publication of the *General Theory*, Leijonhufvud (1968) brought to light how Keynesian economics had diverged from the economics of Keynes in the meantime. He did so by emphasising the coordination and information themes spanning the *General Theory*. Five decades later, New Keynesian economics has essentially restored the classical paradigm, just amended by the introduction of imperfections and frictions justifying its differentiation with respect to the *classical* label. We wanted to show that, in spite of the dominance of this conservative understanding of Keynes's contribution, it is possible to find within the core of mainstream macroeconomics some recent theoretical developments which delineate a resurgence of Keynes on the basis of the coordination theme.

We have identified in the *General Theory* two major coordination issues, illustrated by two celebrated allegories: (i) the coordination failure that results from financial market incompleteness and from the consequent steady state indeterminacy, ending

[17] A positive shock on TFP, indeed, induces an increase in aggregate output in the standard RBC model. Since individual islands believe that the other islands are acting upon the expectation that such a positive shock has occurred, they are naturally led to expect an increase in aggregate output.

up in the selection by *animal spirits* of equilibria characterised by permanent unemployment, and (ii) the misdirected coordination, in liquid financial markets, on speculative asset valuations, disregarding fundamentals and making those markets mimic a *beauty contest*.

The story of *animal spirits* ruling agents' actions when there are multiple steady states (not just multiple paths converging to a full employment steady state) appears in a series of Farmer's papers starting in 2006 and in a paper by Dos Santos Ferreira and Dufourt of the same year. In both cases – and this differs of course of Keynes's original idea – animal spirits are inserted in a standard DSGE model, with self-fulfilling beliefs about financial market values or self-fulfilling conjectures about others' actions, a property made possible by steady state indeterminacy. This indeterminacy is related to the working of an uncoordinated labour market in the first case or of an oligopolistic output market in the second case.

The story of the *beauty contest* in a context of heterogeneous information about fundamentals, hence about the determinants of others' actions, appears in a paper of 2002 by Morris and Shin, at the origin of an important literature. Strategic complementarity and higher-order uncertainty (implying the need for any agent to form forecasts not only about fundamentals but also about other agents' forecasts) reproduce Keynes's intuition while being the source of relevant coordination frictions even when there is equilibrium uniqueness, as already shown by Woodford (2003b). Moreover, higher-order uncertainty opens the way to purely extrinsic shocks affecting the expectations of each agent about those of all other agents. These *sentiment shocks*, to use the term suggested by Angeletos and La'O (2013), play a role similar to that of animal spirits but without appealing to equilibrium indeterminacy. As shown in a series of subsequent papers authored or co-authored by Angeletos, they can generate demand-induced fluctuations, the propagation of which is independent from any nominal stickiness, in contrast to the standard interpretation of Keynes's achievement found in both classical critics and New Keynesian followers.

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References

Angeletos, G.-M. 2018. "Frictional Coordination." *Journal of the European Economic Association* 16 (3): 563–603. doi:10.1093/jeea/jvy019.

Angeletos, G.-M., F. Collard, and H. Dellas. 2018. "Quantifying Confidence." *Econometrica* 86 (5): 1689–1726. doi:10.3982/ECTA13079.

Angeletos, G.-M., and J. La'O. 2010. "Noisy Business Cycles." *NBER Macroeconomics Annual* 24 (1): 319–378. doi:10.1086/648301.

Angeletos, G.-M., and J. La'O. 2013. "Sentiments." *Econometrica* 81 (2): 739–779.

Angeletos, G. M., and C. Lian. 2016. "Incomplete Information in Macroeconomics: Accommodating Frictions in Coordination." In *Handbook of Macroeconomics*, edited by John B. Taylor, and Harald Uhlig. 2nd ed., Amsterdam, Netherlands: Elsevier Science, North Holland.

Arnon, A. 2022. *Debates in Macroeconomics from the Great Depression to the Long Recession: Cycles, Crises and Policy Responses*. Cham: Springer.
Azariadis, C. 1981. "Self-Fulfilling Prophecies." *Journal of Economic Theory* 25 (3): 380–396. doi:10.1016/0022-0531(81)90038-7.
Benhabib, J., and R. E. A. Farmer. 1994. "Indeterminacy and Increasing Returns." *Journal of Economic Theory* 63 (1): 19–41. doi:10.1006/jeth.1994.1031.
Benhabib, J., and R. E. A. Farmer. 1996. "Indeterminacy and Sector-Specific Externalities." *Journal of Monetary Economics* 37 (3): 421–443. doi:10.1016/0304-3932(96)01257-3.
Benhabib, J., and R. E. A. Farmer. 1999. "Indeterminacy and Sunspots in Macroeconomics." In *Handbook of Macroeconomics*, edited by J.B. Taylor and M. Woodford, Vol. 1, 387–448, Amsterdam: Elsevier.
Cherrier, B., P. G. Duarte, and A. Saïdi. 2023. "Household Heterogeneity in Macroeconomic Models: A Historical Perspective." *European Economic Review* 158: 104497. doi:10.1016/j.euroecorev.2023.104497.
Cherrier, B., and A. Saïdi. 2018. "The Indeterminate Fate of Sunspots in Economics." *History of Political Economy* 50 (3): 425–481. doi:10.1215/00182702-7023434.
Christiano, L. J., M. Eichenbaum, and C. L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113 (1): 1–45. doi:10.1086/426038.
Clarida, R., J. Galí, and M. Gertler. 1999. "The Science of Monetary Policy: A New Keynesian Perspective." *Journal of Economic Literature* 37 (4): 1661–1707. doi:10.1257/jel.37.4.1661.
Clower, R. 1965. "The Keynesian Counter-Revolution: A Theoretical Appraisal." In *The Theory of Interest Rates*, edited by F. H. Hahn and F. P. R. Brechling, London, UK: Macmillan.
Cooper, R., and A. John. 1988. "Coordinating Coordination Failures in Keynesian Models." *The Quarterly Journal of Economics* 103 (3): 441–463. doi:10.2307/1885539.
De Vroey, M. 2016. *A History of Macroeconomics from Keynes to Lucas and Beyond*. Cambridge: Cambridge University Press.
De Vroey, M., and P. G. Duarte. 2013. "In Search of Lost Time: The Neoclassical Synthesis." *The B.E. Journal of Macroeconomics* 13 (1): 965–995. doi:10.1515/bejm-2012-0078.
Dos Santos Ferreira, R. 2014. "Mr. Keynes, the Classics and the New Keynesians: A Suggested Formalisation." *The European Journal of the History of Economic Thought* 21 (5): 801–838. doi:10.1080/09672567.2014.881896.
Dos Santos Ferreira, R., and F. Dufourt. 2006. "Free Entry and Business Cycles under the Influence of Animal Spirits." *Journal of Monetary Economics* 53 (2): 311–328. doi:10.1016/j.jmoneco.2004.12.003.
Duarte, P. G., and G. T. Lima, eds. 2012. "*Microfoundations Reconsidered*." In *The Relationship of Micro and Macroeconomics in Historical Perspective*. Cheltenham: Edward Elgar.
Farmer, R. E. A. 2006. "Old Keynesian Economics." Paper Prepared for a Conference in Honour of Axel Leijonhufvud, UCLA, August 30-31." In *Macroeconomics in the Small and the Large*, edited by R.E. Farmer, 23–43. Cheltenham: Edward Elgar.
Farmer, R. E. A. 2012. "Confidence, Crashes and Animal Spirits." *The Economic Journal* 122 (559): 155–172. doi:10.1111/j.1468-0297.2011.02474.x.
Farmer, R. E. A. 2013. "Animal Spirits, Financial Crises and Persistent Unemployment." *The Economic Journal* 123 (568): 317–340. doi:10.1111/ecoj.12028.
Farmer, R. E. A. 2016a. "The Evolution of Endogenous Business Cycles." *Macroeconomic Dynamics* 20 (2): 544–557. doi:10.1017/S1365100514000248.
Farmer, R. E. A. 2016b. *Prosperity for All: How to Prevent Financial Crises*. Oxford, UK: Oxford University Press.
Farmer, R. E. A. 2020. "The Importance of Beliefs in Shaping Macroeconomic Outcomes." *Oxford Review of Economic Policy* 36 (3): 675–711. doi:10.1093/oxrep/graa041.
Farmer, R. E. A., and J. –T. Guo. 1994. "Real Business Cycles and the Animal Spirits Hypothesis." *Journal of Economic Theory* 63 (1): 42–72. doi:10.1006/jeth.1994.1032.

Galí, J. 1999. "Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" *American Economic Review* 89 (1): 249–271. doi:10.1257/aer.89.1.249.

Goodfriend, M., and R. G. King. 1998. "The New Neoclassical Synthesis and the Role of Monetary Policy." *NBER Macroeconomics Annual* 12: 231–283. doi:10.2307/3585232.

Hairault, J. –O., and F. Portier. 1993. "Money, New-Keynesian Macroeconomics and the Business Cycle." *European Economic Review* 37 (8): 1533–1568. doi:10.1016/0014-2921(93)90121-P.

Hoover, K. D. 2012. "Microfoundational Programs." In *Microfoundations Reconsidered. The Relationship of Micro and Macroeconomics in Historical Perspective*, edited by P.G. Duarte and G. T. Lima, 19–61. Cheltenham: Edward Elgar.

Ingrao, B., and C. Sardoni. 2020. *Banks and Finance in Modern Macroeconomics: A Historical Perspective*. Cheltenham: Edward Elgar.

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

Keynes, J. M. 1939. "Relative Movements of Real Wages and Output." *The Economic Journal* 49 (193): 34–51. doi:10.2307/2225182.

Kimball, M. 1995. "The Quantitative Analytics of the Basic Neomonetarist Model." *Journal of Money, Credit and Banking* 27 (4): 1241–1277. doi:10.2307/2078048.

King, R., and A. Wolman. 1996. "Inflation Targeting in a St. Louis Model of the 21st Century." *Review* 78 (3): 83–107. doi:10.20955/r.78.83-107.

Leijonhufvud, A. 1968. *On Keynesian Economics and the Economics of Keynes*. Oxford, UK: Oxford University Press.

Lloyd-Braga, T., L. Modesto, and T. Seegmuller. 2014. "Market Distortions and Local Indeterminacy: A General Approach." *Journal of Economic Theory* 151: 216–247. doi:10.1016/j.jet.2013.12.004.

Lucas, R. E. Jr, 1972. "Expectations and the Neutrality of Money." *Journal of Economic Theory* 4 (2): 103–124. doi:10.1016/0022-0531(72)90142-1.

Mankiw, N.G., and D. Romer (eds.) 1991. *New Keynesian Economics. Vol. 1: Imperfect Competition and Sticky Prices. Vol. 2: Coordination Failures and Real Rigidities*. Cambridge, MA: MIT Press.

Morris, S., and H. S. Shin. 2002. "Social Value of Public Information." *American Economic Review* 92 (5): 1521–1534. doi:10.1257/000282802762024610.

Muth, J. F. 1961. "Rational Expectations and the Theory of Price Movements." *Econometrica* 29 (3): 315–335. doi:10.2307/1909635.

Phelps, E. S. 1983. "The Trouble with Rational Expectations and the Problem of Inflation Stabilization." In *Individual Forecasting and Aggregate Outcomes: 'Rational Expectations' Examined*, edited by Frydman, R., Phelps, E. S. Cambridge: Cambridge University Press.

Rotemberg, J., and M. Woodford. 1992. "Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity." *Journal of Political Economy* 100 (6): 1153–1207. doi:10.1086/261857.

Schmitt-Grohé, S. 1997. "Comparing Four Models of Aggregate Fluctuations Due to Self-Fulfilling Expectations." *Journal of Economic Theory* 72 (1): 96–147. doi:10.1006/jeth.1996.2195.

Sergi, F. 2020. "The Standard Narrative about DSGE Models in Central Banks' Technical Reports." *The European Journal of the History of Economic Thought* 27 (2): 163–193. doi:10.1080/09672567.2019.1651365.

Smets, F., and R. Wouters. 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area." *Journal of the European Economic Association* 1 (5): 1123–1175. doi:10.1162/154247603770383415.

Smets, F., and R. Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review* 97 (3): 586–606. doi:10.1257/aer.97.3.586.

Townsend, R. M. 1983. "Forecasting the Forecasts of Others." *Journal of Political Economy* 91 (4): 546–588. doi:10.1086/261166.

Trautwein, H.-M. 2022. "Financial Instability and Frictions: Can DSGE Models Finally Address the Critical Issues?." In *Financial Markets in Perspective*, edited by A. Arnon, M.C. Marcuzzo and A. Rosselli, 227–248. Cham: Springer.

Woodford, M. 1991. "Self-Fulfilling Expectations and Fluctuations in Aggregate Demand." In *New Keynesian Economics. Vol. 2: Coordination Failures and Real Rigidities*, edited by Mankiw, N.G., and D. Romer. Cambridge, MA: MIT Press.

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

Woodford, M. 2003b. "Imperfect Common Knowledge and the Effects of Monetary Policy." In *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*, edited by Aghion, P, Frydman, R., Stiglitz, J., Woodford, M. Princeton: Princeton University Press.

Young, W. 2014. *Real Business Cycle Models in Economics*. New York: Routeledge.

Yun, T. 1996. "Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles." *Journal of Monetary Economics* 37 (2–3): 345–370. doi:10.1016/S0304-3932(96)90040-9.