Behavioral economics and macroeconomic models[1]

John C. Driscoll*

Federal Reserve Board

and

Steinar Holden**

Department of Economics, University of Oslo

This version 26 May 2014

Abstract

Over the past 20 years, macroeconomists have incorporated more and more results from behavioral economics into their models. We argue that doing so has helped fixed deficiencies with standard approaches to modeling the economy—for example, the counterfactual absence of inertia in the standard New Keynesian model of economic fluctuations. We survey efforts to use behavioral economics to improve some of the underpinnings of the New Keynesian model—specifically, consumption, the formation of expectations and determination of wages and employment that underlie aggregate supply, and the possibility of multiple equilibria and asset price bubbles. We also discuss more broadly the advantages and disadvantages of using behavioral economics features in macroeconomic models.

Keywords: Behavioral macroeconomics, New Keynesian model

JEL Classification: E2, E3, D8.

* Federal Reserve Board, 20th and Constitution Ave. NW, Washington DC 20551, USA. John.C.Driscoll@frb.gov

** Corresponding author. Department of Economics, University of Oslo, Box 1095 Blindern, 0317 Oslo, Norway. Steinar.holden@econ.uio.no

[1] We are grateful to Gustav Horn, Kalle Moene, Ragnar Nymoen, Øistein Røisland, Sven Schreiber, Fredrik Wulfsberg and two anonymous referees for useful comments to a previous version. Steinar Holden acknowledges financial support from Hans Böckler Foundation for the project. The paper is part of the research activities at the centre of Equality, Social Organization, and Performance (ESOP) at the Department of Economics at the University of Oslo. ESOP is supported by the Research Council of Norway, through its Centres of Excellence funding scheme, project number 179552. The views expressed in this paper are those of the author and do not necessarily reflect the views of Hans Böckler Foundation.

1 Introduction

Over the past 20 years, researchers have incorporated an increasing number of results from behavioral economics into macroeconomic models. There are two main reasons for this change. First, it has become clear to macroeconomists that models based on assumptions of optimizing behavior in many cases have difficulty accounting for key real-world observations. Hence researchers have used behavioral economics assumptions with the aim of making their model predictions better fit the data. Early attempts to do this were criticized as being *ad hoc*. The force of this criticism has been reduced by the second reason for incorporating behavioral economics results into macroeconomics: cognitive psychologists and experimental economists have documented a number of systematic deviations between the decisions of human beings and those of the "economic man."

The economics profession has widely, though by no means universally, acknowledged the empirical support for puzzles that can be explained by behavioral features. Moreover, behavioral features have been introduced in many parts of macroeconomics. Where have these development led us? Which assumptions should one now make when analyzing macroeconomic questions? The aim of this paper is to provide a selective survey of the implications of insights from behavioral economics for macroeconomic models.

We argue that the insights from behavioral economics have led to important progress in our understanding of macroeconomic phenomena by allowing us to explain more aspects of real world behavior than we could with the more restrictive theoretical framework that most economists have been using. Some behavioral assumptions that have already been implemented in macroeconomic models, such as fairness considerations, seem especially promising to us. In other cases, we suspect that behavioral assumptions are needed for explaining macroeconomic puzzles—such as the inertial response of the economy to shocks—but are uncertain which assumptions are the best one. There are still other results from cognitive psychology whose macroeconomic implications have not been explored.

Incorporating behavioral assumptions into macroeconomic models is not without its problems. Even if there is considerable microeconomic evidence from cognitive psychology or experimental economics for certain behavioral features, it is often difficult to know which features are most relevant for macroeconomic models. For example, while there is strong evidence for inertia in macroeconomic consumption behavior, it is less clear whether this inertia should be viewed as the outcome of habit formation, rule-of-thumb consumption, or other alternatives. Another open issue is whether macroeconomic models should incorporate behavioral features or other deviations from the standard economic model, like financial frictions, limited information or agency problems. Thus, there is a need for more research to guide the choice of model specification.

Given the widespread impact of behavioral economics on macroeconomics, it has been necessary to narrow the discussion somewhat. We focus on economic fluctuations, unemployment and saving, as these are all core macro areas which have incorporated results

from behavioral economics heavily.[2] As an organizing principle, we use modifications to the New Keynesian model. Although that model is very widely used to analyze economic fluctuations and to evaluate the effectiveness of different approaches to monetary policy, it has some notable empirical deficiencies. Efforts to remedy those problems have been focused on different approaches to modeling consumption, expectations formation, and nominal wage and price setting. We will discuss those areas, and also use the discussion of consumption to study longer-run consumption and savings topics and the discussion of wage and price setting to study longer-run labor market issues. We will neglect issues related to finance, growth and happiness, although we will include a brief discussion of multiple equilibria, the effects of news, and asset market bubbles, because of their close association with economic fluctuations. Within each topic, we will discuss key innovations based on behavioral assumptions, as well as non-behavioral alternatives. Regrettably, space constraints will imply that the presentation will have to be selective also within the topics that are covered.

The rest of the paper is organized as follows. Section 2 provides a brief summary of the New Keynesian model and notes some of its key empirical failings. Section 3 discusses attempts to improve the model of consumption which underlies the New Keynesian model, and also discusses other attempts to better model longer-run consumption and savings decisions. Section 4 discusses efforts to improve models of aggregate supply, either by reconsidering how expectations are formed or by incorporating behavioral features of wage and employment determination. Section 5 discusses multiple equilibria, news, and asset market bubbles. Section 6 provides some broader critiques of behavioral economics. Section 7 concludes.

2 The New Keynesian model and its problems

The New Keynesian model is frequently used for analysis of economic fluctuations and macroeconomic policy. It shares many features with the older IS/LM-AD/AS framework still frequently employed in undergraduate textbooks, but has the advantage of being derived from an optimizing framework—which also facilitates comparisons with other dynamic stochastic general equilibrium (DSGE) models. Its simplest version has three equations.[3]

1. The *New Keynesian IS Curve*, which relates the output gap—the difference between the current and the natural rate of output —to the expected real interest rate and the expected future output gap. It is derived from the consumption Euler equation, usually with the additional simplifying assumptions that investment and government purchases are exogenous.

[2] This distinguishes this paper from several excellent recent related surveys, like Duffy (2012) on experimental macroeconomics, Chakravarty et al (2011) on experimental economics more generally, and Hommes (2011) on the formation of expectations.

[3] See Clarida, Gali and Gertler, 1999, Romer (2011), Walsh (2010), and Woodford (2003a) for more discussion and derivations.

2. A *Monetary Policy Reaction Function*, which relates the current nominal interest rate to inflation and the output gap. Often Taylor (1993)'s rule is used. When combined with the New Keynesian IS curve, it forms an aggregate demand curve relating the output gap and inflation.

3. The *New Keynesian AS Curve*, which relates current inflation to expected future inflation and the output gap. It can be derived in several ways, but the most common are to use the contracting models of Taylor (1980) or Calvo (1983), in which nominal wage or price schedules, respectively, are set several periods in advance.

These may be represented as:

$$\tilde{y}_t = E_t\tilde{y}_{t+1} - \alpha(i_t - E_t\pi_{t+1} - r_t^*) + \varepsilon_t^{IS}, \quad (1)$$

$$i_t = r_t^* + E_t\pi_{t+1} + \theta_\pi(\pi_t) + \theta_y(\tilde{y}_t) + \varepsilon_t^{MP}, \quad (2)$$

$$\pi_t = \beta E_t\pi_{t+1} + \gamma(\tilde{y}_t) + \varepsilon_t^{AS} \quad (3)$$

where $\tilde{y}_t$, the output gap, is the difference between current output y_t and the natural rate of output y_t^*; E_t is the conditional expectations operator as of time *t*, i_t is the nominal interest rate; π_t is inflation; r_t^* is the equilibrium real interest rate (labeled the "Wicksellian" real interest rate by Woodford, 2000); and ε_t^{IS}, ε_t^{MP}, and ε_t^{AS} are exogenous disturbances to the IS curve, monetary policy, and the AS curve, respectively.[4] The model has a steady state output gap and inflation rate of zero, and real interest rate equal to the Wicksellian level. In the short run, the model can be used to trace the effects of shocks on the output gap, inflation, and real and nominal interest rates.

While the model has been successful in explaining broad features of the response of real variables to monetary policy, it also has a number of deficiencies. One key problem is that the model displays a lack of inertia; shocks have immediate effects, which dissipate quickly. To see this, note that a shock in period *t* will only have effects in that period—in subsequent periods, the levels of the endogenous variables only depend on each other, current shocks, and expected future shocks. This complete lack of persistence arises from the absence of lagged inflation or output gap terms in the IS or AS equations—either directly, or indirectly through expectations which may depend on them. This prediction is strongly contrary to empirical evidence that, for example, the real effects of monetary policy shocks are both delayed and long-lasting.

A second problem, noted by Ball (1994) and Mankiw (2001), is that the aggregate supply schedule implies that inflation is expected to fall in a boom – according to (2), when the output gap $\tilde{y}_t > 0$, $\pi_t > E_t\pi_{t+1}$. This feature is inconsistent with evidence supporting the NAIRU, that inflation increases when output is high relative to the natural rate. Ball (1994) looks at this issue from the perspective of credibility of the central bank; he shows that the

[4] This is a version of the model linearized around a steady-state with zero inflation. The model may be extended to the case of having a positive rate of inflation.

New Keynesian models implies that credible disinflations should be accompanied by expansions, but provides evidence that actual disinflations have been associated with recessions.

These problems have led those who wish to use such models with an unappealing choice: use this model with theoretical support but empirical deficiencies, or alter the model so that it better fits the data. Some researchers have taken the latter course—e.g. Rudebusch (2002). A preferable solution would be to find models with microeconomic support which follow the macroeconomic data. Fuhrer and Moore (1995) suggested a model where agents care about relative real wages (for a critique, see Holden and Driscoll, 2003). A more common formulation is a hybrid model, where some agents are forward-looking and other agents are backward-looking (e.g. Gali and Gertler, 1999). While this model clearly has attractive elements, it has also been heavily criticized as being inconsistent with evidence; specifically, the forward-looking part is said to be empirically invalid (see Rudd & Whelan, 2007 Gali, Gertler and Lopez-Salido, 2005; Bårdsen and Nymoen, 2009).

Researchers have increasingly turned to behavioral economics to find microeconomic foundations that generate better macroeconomic empirical predictions. That has largely involved exploring different models of consumption (given the formulation of the New Keynesian IS curve), different ways of thinking of expectations formation, or different models of nominal wage determination.[5] We explore all three topics below in the next two sections, and further use the discussion of consumption to examine longer-run consumption and savings choices.

3 Consumption

3.1 The consumption Euler equation and short-run behavior

One of the areas where behavioral economics has had the greatest impact is in the study of consumption by households. The standard consumption Euler equation approach pioneered by Hall (1978) has been unable to explain key aspects of actual behavior. According to the permanent income hypothesis, consumption should be a purely forward-looking variable, depending on the net wealth of the consumer, including expected future labor income. Thus, consumption should respond instantaneously to new information about expected future income, but be much less responsive to changes in current disposable income, in so far as the latter does not reveal information about future income. However, empirical evidence shows that consumption respond much less to news, and that as result, consumption exhibits "excess smoothness" (Campbell and Deaton, 1989). Consumption also exhibits "excess sensitivity"

[5] This begs the question of why there are so few behavioral macroeconomic models of investment. The use of the consumption Euler equation as motivation for the New Keynesian IS curve is in part due to analytical convenience; it serves as a way of introducing interest sensitivity into the IS curve without having to invoke more complicated investment models.

to current income. Both of these results are largely confirmed by experimental evidence, as surveyed by Duffy (2012)—although it should also be noted that some experimenters find that other predictions of this theory, such as the response of consumption to changes in discount or interest rates, have support.

One traditional behavioral explanation for excess smoothness is habit formation among consumers, as in Pollak (1970), Abel (1990), and Fuhrer (2000). Habit formation may arise from the endowment effect—a result from cognitive psychology experiments in which individuals' possession of goods is shown to increase their valuation of them--, as shown in Loewenstein and Adler (1995). It is widely used in macroeconomics—its usage antedating the growth in behavioral economics in the past few decades-- and research has also shown that it has important implications also for other economic issues, like the equity premium puzzle (Constantinides, 1990). These models imply that the consumption Euler equation underlying the New Keynesian IS curve relate the ratio of consumption to the habit or reference level across adjacent periods, implying that equation (1) will have lagged output terms. Using this as the basis for an alternative New Keynesian IS curve has the effect of increasing the persistence of the effect of shocks on output, by changing the reference level of consumption. This is the approach taken by Fuhrer (2000), who finds that including habit formation, in the sense that consumers' utility in part depends on current consumption relative to past consumption, improves the empirical relevance of standard models for monetary policy. Smets and Wouters (2007) use the same approach for their model.

While habit formation plays a strong role in much of the recent research in macroeconomics, the empirical evidence is mixed. Dynan (2000) finds no evidence for habit formation among US households, while Alessie and Teppa (2010) find some evidence in favor of habit formation for Dutch households, but the magnitude is rather small. Fusaro and Dutkowsky (2011) analyze consumption behavior on the basis of checking accounts for US households, and the results give little evidence for habit formation. Rather, the authors interpret their findings as evidence in favor of "rule-of-thumb" consumption of the type suggested by Campbell and Mankiw (1990), with liquidity constraints.

Given the mixed evidence on habit formation, its use in macroeconomic models may be regarded as more of an analytically convenient way of generating inertia in the model than as a genuine reflection of the microeconomic foundations of consumption. And there are many alternatives. Pagel (2012, 2013) shows that models of expectations-based loss aversion can account for apparent excess sensitivity of consumption to current income. Gali, Vallés and López-Salido (2007) incorporate rule-of-thumb consumers into a variant of the New Keynesian model, and show that doing so improves the fit of the response of output to government spending. Akerlof (2007) emphasizes the role of norms as a key factor behind consumption decisions. Ljungqvist and Uhlig (2000) explore a model where households' utility functions exhibit the "catching up with the Joneses" feature—so that if others consume more today, our representative consumer will experience a higher marginal utility from an additional unit of consumption in the future

From a policy point of view, a key aspect of short-run consumption behavior is the effects of and implications for changes in tax policy. In the "catching up with the Joneses"-formulation of Ljungqvist and Uhlig (2000), optimal tax policy is procyclical. The idea is that in booms caused by a positive productivity shock, consumption will be higher than the socially efficient level (the economy is "overheated"), as consumers do not take into account the negative externality on others. Thus, in booms, taxes should be raised to dampen the "overheating" of the economy. In a survey of the evidence, Auerbach, Gale and Harris (2010) conclude that household consumption respond more vigorously to tax changes that are plausibly expected to be longer-lasting than to those expected to be shorter-lasting, consistent with the standard optimizing behavior. However, some studies show that the way tax cuts are described may affect behavior, suggesting a role for framing and default specifications. Hsieh (2003) finds that the source of income fluctuations matters. He shows that while households in Alaska use a considerable part (30 percent) of an income tax refund on non-durable consumption, the same households smooth their payments from the Alaska Permanent Fund, suggesting that households understand the nature of the payments from the Permanent Fund. Hsieh interprets the difference in consumption behavior as evidence in favor of bounded rationality, in the sense that household treat large and transparent income changes in a manner consistent with the permanent income hypothesis, but smaller or less transparent income changes in a hand-to-mouth manner.

In a survey of empirical consumption studies, Jappelli and Pistaferri (2010) conclude that liquidity constraints play an important role for why consumption responds more strongly to anticipated income increases than the standard model of consumption smoothing implies. A key argument for this conclusion is that consumption appears much less responsive to anticipated income declines, e.g. after retirement, when liquidity constraints have little bearing. There is also evidence of considerable heterogeneity in consumption behavior among income groups, which is consistent with liquidity constraints being more important for low-income and low-education households. Overall it seems reasonable to conclude that both behavioral features as well as credit constraints shape consumption behavior, although the importance of each factor remains open.

3.2 Consumption and saving in the longer run

The study of long term saving is another field where there is a discrepancy between traditional economic theory and empirical evidence. One such discrepancy is the existence of apparently time-inconsistent behavior; consumers reverse decisions they have previously taken. A popular formulation for this phenomenon has consumers exhibit hyperbolic discounting, according to which there is a systematic preference for the present moment (Phelps and Pollak, 1968; Ainslie and Haslam, 1992). The formal representation is often in the quasi-hyperbolic form used by Laibson (1997), where the utility function can be represented by

$$u(c_t) + \beta \sum_{i}^{\infty} \delta^i u(c_{t+i}) \tag{4}$$

where $0<\delta<1$ is the discount factor and the parameter $\beta\leq 1$ characterizes the consumer's bias for the present. A consumer who discounts hyperbolically ($\beta<1$) rather than exponentially ($\beta=1$) may exhibit time-inconsistent behavior (self-control problems) in the sense that s/he systematically may prefer to reverse earlier decisions. The time inconsistency arises because pairs of adjacent future periods are currently discounted at rate δ, but the next period is discounted at rate $\beta\delta$ with respect to the current one. Note that the Euler equation between consumption in adjacent periods is comparable in form to that underlying the standard Hall model, just with a discount rate with a slightly different interpretation—implying little change to the New Keynesian IS curve.

Quasi-hyperbolic preferences are an analytically convenient way of generating time-inconsistent and impatient behavior. But they are far from the only way of generating such behavior. Gul and Pesendorfer (2001, 2004) develop models of temptation and self-control. Fudenberg and Levine (2006, 2012) create models in which individuals have dual selves who may conflict with one another. Heidhues and Koszegi (2010) use a model with impatience to explain behavior in the credit card market. Benhabib, Bisin and Schotter (2010) present experimental evidence suggesting that the present bias in preferences is better characterized by a fixed cost associated with waiting, rather than variable cost implied by equation (4). Rubinstein (2003) provides experimental evidence for a new choice model in which decision makers separate comparisons across a money dimension with those along a time dimension.[6] Some of these approaches—Rubinstein in particular—represent more substantial departures from the standard choice framework. It is an open question which of these models, if any, best explains the data.[7] Perhaps because of its relatively small departure from the standard framework, the quasi-hyperbolic approach has so far been more extensively used in studies of the microeconomics and macroeconomics of savings; for that reason, we focus on it in the discussion below.

The time-inconsistent behavior that is implied by hyperbolic discounting involves difficult conceptual problems as well as important policy implications. Drawing upon earlier work by Ainslie (1992) and Schellling (1984), Bénabou and Tirole (2004) show that there is a conflict between the individual's successive "temporal selves," and that the individual may try to commit himself to specific actions that will not be chosen voluntarily at a later stage.[8] Diamond and Koszegi (2003) explore the implications when retirement is endogenous, and

[6] For other attempts, see, for example, Caplin and Leahy (2001), Bénabou and Pycia (2002), Ameriks et al (2007), Benhabib and Bisin (2005), Benhabib et al (2010), Dasgupta and Maskin (2005), Halevy (2008), Fernández-Villaverde and Mukherji (2006), Noor (2009), and Huang, Liu, and Zhu (2006). Duffy (2012) surveys experimental results on quasi-hyperbolic discounting.

[7] For an example of research which specifically finds evidence against quasi-hyperbolic discounting, see Andersen, Harrison, Lau and Rutström (2011).

[8] See Burger, Charness and Lynham (2009) for recent evidence on different models of willpower.

find that it may lead to over- or under-saving. Laibson, Repetto, and Tobacman (2003) argue that consumers appear to be of two minds; their large, voluntary, primarily illiquid retirement accumulations are consistent with a discount rate of 5 percent, while their frequent credit card borrowing is consistent with a discount rate of 18 percent.

In general, hyperbolic discounting gives rise to undersaving, and Laibson, Repetto, and Tobacman (1998) report that 77 percent of the respondents in a study of individuals between twenty-nine and forty-seven say that they save too little. Other studies, like Lusardi (2009), show that a large share of households do not plan for retirement, do not understand the basic concepts of financial decision making, and are not getting any help. Lusardi also shows that the lack of planning matters for US households, as nonplanners save less, implying that they hold about 20 percent less wealth close to retirement. Choi, Laibson and Madrian (2011) show that in the average firm, more than a third of the workers contribute too little in 401(k) pension plans, even if the firm would have matched their contribution, and even if the workers could subsequently withdraw savings without any penalty. Thus, workers are forgoing arbitrage profits that average 1.6 percent of their annual pay, or $507. Educating the employees did little to improve the problem. Laibson (2009) concludes that while one should try to promote financial literacy, other measures are also important. In particular, Laibson emphasizes the power of default options, referring to studies showing how this may increase savings (as Madrian and Shea, 2001, who find 401 (k) participation is significantly higher under automatic enrollment).[9]

A good example of the potential effect of intervention is the "save more tomorrow" program designed and tested by Thaler and Benartzi (2004).[10] In this program, employees were asked if they would increase their 401(k) contribution rates at the time of their next pay rise, implying that the increase in savings would not involve a reduction in the pay net of savings. Employees who sign up for the program remain enrolled until they reach the maximum contribution rate or they opt out. The results showed that 78 percent enrolled the plan, and virtually everyone (98 percent) remained in it through two pay rises, implying a dramatic increase in contribution rates, from 3.5 percent to 11.6 on average over the course of 28 months.

A policy alternative to this kind of "nudging" is the provision of public pensions when households are "behavioral" in some fashion. Imrohoroglu, Imrohoroglu, and Joines (2003) argue that social security programs are poor substitutes for commitment devices when households have quasi-hyperbolic preferences, a result reinforced by Caliendo (2011). Andersen and Bhattacharya (2011) establish conditions on asset returns and preferences under

[9] Of course, there are other behavioral models with strong implications for long-run saving. For example, Caliendo and Aadland (2007) look at the behavior of households with short planning horizons, and Caliendo and Huang (2008) examine households who are overconfident about the first or second moments of asset returns.

[10] This policy and other "nudges"—exploiting behavioral psychology to encourage people to undertake certain actions—are discussed in Thaler and Sunstein (2008).

which public pensions may optimally co-exist with private savings. Work surveyed by Cremer and Pestieau (2011) examine the interaction of a number of behavioral factors on social security design, including myopia and habit formation. Kumru and Thanopoulos (2011)) show that the optimality of social security is heavily dependent on the amount of temptation agents face.

4 Aggregate Supply

The standard New Keynesian AS curve may already be thought of as incorporating behavioral economics assumptions, through its justifications for infrequent wage or price adjustments. This makes it natural for attempts to improve the empirical fit of the AS specification to employ other behavioral assumptions. The two dimensions which have arguably been most explored are modifications to how agents form expectations and consideration of the effects of social conventions in the labor market. An important channel through which both dimensions work is by replacing $E_t\pi_{t+1}$ in equation (3) with expressions that depend on lagged inflation and/or output gap terms, which generate persistent responses to shocks.

4.1 Expectations and information

Since the 1970s, economists have principally assumed rational expectations. Rational expectations, or, more appropriately, model-consistent expectations, implies two key assumptions:

- Agents know the model and the probability distributions for the stochastic variables
- Agents are able to calculate the equilibrium of the model, and believe that all other agents will choose equilibrium strategies, in essence implying a coordination of expectations.

It is widely acknowledged within the economics profession that these assumptions are often not realistic; many behavioral economists would say they almost never are. Agents have insufficient knowledge about the economic model, and they have insufficient ability to understand it. In the literature many different approaches have been proposed on how to deal with this. Some of these have been applied to the modeling of aggregate supply.[11]

Ball (2000) suggests a model where agents use univariate forecasts based solely on lagged inflation. In contrast to the standard adaptive expectations assumption, this model allows agents' forecasts to depend on the stochastic properties of the variable. In historical periods when inflation was not persistent (as during the gold standard), agents did not predict it to be persistent in the future. On the other hand, in the post-war period when inflation was

[11] Fair (2014) has advocated the use of a "Cowles Commission" approach, in which the emphasis is on model fit, and economic theory is used more loosely to impose restrictions on structural models.

persistent, agents expected it to continue being so. Thus, this approach has the virtue that it explains data for both time periods.

Another proposal is the "sticky information" approach by Mankiw and Reis (2002), which is based on the assumption that agents update their information at intervals. This is a simple and attractive model that captures the notion that agents do not take all information into account immediately. Thus, firms may for some time change prices more mechanically without updating information, for then to make a more thorough revision based on updated information.

A third approach, suggested by Woodford (2003b) and Amato and Shin (2003), is based on the idea that there are limits to agents' ability of absorbing information. In these papers it is shown theoretically that noisy subjective perceptions by individual agents lead to greater uncertainty about higher-order expectations (that is, what one agent expects other to expect about his expectations concerning their expectations, and so on). One consequence of this feature is that inflation may be highly persistent. While this approach seems very promising, the complexity of the models has so far limited their use.

A fourth approach is taken by Mackowiak and Wiederholt (2011), who assume that decision makers have a limited amount of attention and thus must decide how to use it, as in the rational inattention model of Sims (2003). In Sims' model, players choose how much information to acquire and process, weighing the expected benefits against the costs of providing the information.[12] Mackowiak and Wiederholt derive a mix of fast and slow responses of prices to shocks in line with empirical evidence.

A different idea, suggested by Driscoll and Holden (2004), is that inflation persistence is a consequence of coordination problems under multiple equilibria, building on the model of Bhaskar (1990) discussed below. Driscoll and Holden show that wage setters' past behavior may work as an equilibrium selection device: among all the actions consistent with a possible equilibrium, agents expect other agents to play as they have played in the past. This focus on past actions can thus rationalize adaptive expectations, and therefore inertia in inflation, as a self-fulfilling prophecy, consistent with evidence on US post-war inflation.

In the learning literature (see Evans and Honkapohja, 2013, for a recent survey), the basic assumptions are that agents do not know the full model, and/or that they are not able to form rational expectations. Agents observe the outcome of the economic model, and update their expectations based on these observations (adaptive learning). An important result in the literature is that under many circumstances, the learning process may converge to the rational expectations equilibrium. In standard macroeconomic models, this will usually be the case provided that agents' environment remains stationary for sufficiently long time (Evans and Honkapohja, 2013). However, under other circumstances, the outcome is more complex than under rational expectations. For example, Branch and Evans (2011) show that adaptive learning may lead to endogenous stock market bubbles and crashes. Evans and Honkapohja

[12] Sims (2010) surveys recent work based on this idea.

(2013) explore the link between monetary policy and private sector learning, and find that policy should be conditioned on private-sector expectations.[13]

Duffy (2012) surveys experimental evidence on expectations formation in a macroeconomic context. Some experimental studies find that rational expectations appears to work better in univariate rather than multivariate settings, and when agents can learn from one another. Bao, Hommes, Sonnemans and Tuinstra (2012) present evidence from experiments indicating that while markets with negative expectation feedback (where agents have the incentive to do the opposite of what the others do) quickly converge to a new fundamental equilibrium, markets with positive expectation feedback do not converge. Adam and Woodford (2012) analyze robustly optimal monetary stabilization policy when the central bank recognizes that private-sector expectations need not be model-consistent.

Jaimovich and Rebelo (2007) explore the effect on business cycles of two psychological biases, optimism and overconfidence. They find that that overconfidence may increase business cycle volatility, while optimism does not appear to be a useful source of volatility in their model.[14]

In a series of papers and a recent book, de Grauwe (2010, 2012a, 2012b), develops a behavioral macroeconomic model, which he describes as "bottom-up" macroeconomics, where it is explicitly taken into account that agents experience cognitive limitations.[15] In this model, agents use simple rules or heuristics to forecast future output and inflation. More specifically, de Grauwe (2012a,b) considers two types of forecasting rule: a "fundamentalist" rule, in which expected output and inflation are equal to steady state levels; and an "extrapolative" rule, in which expected output and inflation are equal to past levels. Agents evaluate their forecast performance, and if one rule performs better than the other, an increasing share of the population will use the better rule. The model has the attractive features of generating inertia in output and inflation and allowing agents' sentiment to affect output. In periods where optimists, that is, agents who forecast a positive output gap, dominate, this will translate into above average output growth. Furthermore, de Grauwe (2012b) shows that the model endogenously generates non-normal disturbances, consistent with empirical regularities, while in the New-Keynesian model, the non-normal disturbances must be assumed exogenously.

---

[13] "Eductive stability" proposed by Roger Guesnerie (e.g. Guesnerie, 2005) and the theory of "rational belief equilibria" advocated by Mordecai Kurz (see e.g. Kurz, 1997) are other approaches which seek to explain behaviour consistent with intertemporal optimization and requirements of individual rationality, yet departing from the coordination of expectations that is implicit assumption of rational expectations.

[14] For microeconomic evidence that many individuals have an exaggerated view of their own abilities see De Bondt and Thaler, 1985 and Burks, Carpenter, Goette and Rustichini (2014).

[15] This is in contrast to standard macroeconomic models, called "top-down" models, where some or all agents are capable of understanding the whole picture and use this superior information to determine their optimal plans.

Fuster, Laibson and Mendel (2010) propose a model with what they refer to as natural expectations, which is a weighted average between intuitive and rational expectations. Agents with natural expectations will overestimate persistence, inducing overreaction to news, and thus also excessive volatility in asset prices.

4.2 Labor markets

Insights from behavioral economics have had profound impact on our understanding of several labor market issues. Some of these have been applied to the modeling of aggregate supply, yielding Phillips curves with a kink and also models with a range of equilibrium levels of output. We explore some of these approaches below, but start with a discussion of how even in long-run equilibrium labor markets appear to differ from predictions of neoclassical models. Most importantly, perhaps, is the question of wage rigidity (both real and nominal).Extensive evidence shows that wages are rigid, but standard models have had problems with explaining this result. In traditional neoclassical economics, labor is just an ordinary good, and the wage is just an ordinary price. Thus, the firm always benefits from paying the lowest possible wage that is sufficient to hire labor of the desired type and quality. In contrast, efficiency wage theories hold that workers' productivity depends on the wage that is paid. If workers find that they are paid too little, relative to some reference level, this may have a negative effect on their effort and productivity. In the "gift-exchange" theory of Akerlof (1982), firms give workers above market-clearing wages, and workers reciprocate by providing higher effort. In Akerlof and Yellen (1990), workers' effort depends on whether they find that the pay is fair. Whether the wage is found to be fair may also depend on how it relates to social norms for what the pay should be (see e.g. Akerlof, 2007).[16]

There is now strong support for the existence of fairness concerns and related effects. One important example is Fehr, Kirchsteiger and Riedl (1993).[17] The authors conduct an experiment to explore a two-player game illustrating an incomplete employment contract. The game occurs only once for each employer-worker pair, in the following way. The employer offers a wage and requests a certain level of effort from the worker. The wage is binding, but the requested effort is not enforceable. Workers can accept or reject the wage offer, and, upon acceptance, decide their effort. The employer's profit is equal to returns generated by the effort, minus the wage payment, while the worker's payoff is equal to his/her wage minus cost of effort. The experiments show a clear link between wage and effort, as workers who are paid more, on average provide more effort. However, there are huge differences across subjects: while there are many fair-minded workers who respond to a higher wage, there is also a substantial share of workers who do not.

The results change considerably in experiments with repeated interactions for each employer-worker pair. With repeated interactions, also selfish subjects have an incentive to cooperate,

[16] Efficiency wages may also be justified on the basis of asymmetric information, as in the shirking model of Shapiro and Stiglitz (1984), where firms pay high wages to reduce workers' incentive to shirk.

[17] See also Brown, Falk and Fehr (2004).

as this may give them higher payoff in subsequent rounds. Several studies show that such reputation effects can be sufficiently strong to sustain high levels of efficiency, even under adverse conditions (Fehr, Brown and Zehnder, 2009). Field evidence shows that "wage gifts" can lead to higher efforts by workers, as in Fehr, Goette and Zehnder (2009).

The importance of the labor-management relationship is also borne out by the study of Krueger and Mas (2004), who examined the quality of Bridgestone and Firestone tires produced in different plants. They found that a labor strife taking place after the company had announced lower wages for new hires and changed shift rotations unfavorably had a significant negative impact on the quality of the tires. Similar results have been found after a labor dispute at Caterpillar, a manufacturer of construction equipment and vehicles (Mas 2008). The evidence also shows that when employers' actions are considered unfair, the negative effect is stronger than the corresponding positive effect when the actions are thought to be fair, see Fehr, Goette and Zehnder (2009).

If workers reduce effort if they find that the wage is unfair and too low, firms may abstain from reducing wages even if external circumstances might imply lower wages. Akerlof and Yellen (1990) use this mechanism to explain the existence of involuntary unemployment. Traditional economic theory implies that unemployment would lead to lower wages, reducing supply and increasing demand, thus eliminating unemployment. However, as argued by Akerlof and Yellen, efficiency wage effects may prevent the reduction in wages, implying that wages remain above the market clearing level, thus causing involuntary unemployment.

Another possible implication of fairness considerations is the existence of internal and external labor markets, where workers may seem insulated from outside labor market conditions once they are employed in a firm. Kahneman, Knetsch, and Thaler (1986) provide evidence that in judgment about fairness, new workers compare the firm's offer to what they could otherwise earn in the labor market, while incumbent workers compare with the existing wages in the firm. This may explain the empirical fact that wages are rigid downwards (see e.g. Bauer, Bonin, Goette and Sunde, 2007, and Holden and Wulfsberg, 2009, for evidence of downward real wage rigidity; downward nominal wage rigidity is discussed below), and it may also explain the importance that relative wages are considered to be fair within the firm, see e.g. Bewley (1999). French, Kubo and Marsden (2002) analyze evidence from a survey on performance-related pay in the British public sector services. They find widespread de-motivating effects arising from difficulties of measuring and evaluating performance fairly.

Several authors have explored the effects of fairness consideration and related features on the cyclical properties of key macroeconomic variables. Shimer (2005) showed that the standard search model predicted a much too low volatility in unemployment as compared to data – the so-called "unemployment volatility puzzle", while Hall (2005) pointed out that if wages were rigid due to the existence of social norms, the model would be able to explain the empirical facts. However, other authors have been skeptical towards this explanation, arguing that wage rigidity for existing employees would not affect hiring decisions if the hiring wage were flexible (see e.g. Pissarides, 2009). Rotemberg (2008) presents a model where firms set

wages to retain workers, implying that even a slight altruism on behalf of the workers will affect wages. As workers' marginal utility of income is likely to increase in recessions, the model can explain the modest response of wages to changes in labor demand.

We now turn to research where behavioral features in the labor market are applied more directly to the modeling of aggregate supply. Akerlof, Dickens and Perry (1996) argue that wages are rigid downwards in nominal terms, due to the notion that employees, and in some cases also employers, think that nominal wage cuts are unfair; see Bewley (1999) and Dickens et al (2007) for additional evidence of downward nominal wage rigidity.[18] Akerlof et al. (1996) follow Tobin (1972) in pointing out that the combination of very low or zero inflation and downward nominal wage rigidity may lead to increased wage pressure, and thus also an increase in equilibrium unemployment. In this situation, an expansionary monetary policy allowing for higher inflation may involve a permanent increase in aggregate output.

Akerlof, Dickens and Perry (2000) take a slightly different approach, arguing that wage and price setters treat inflation differently from what most economists assume. First, when inflation is low, many people ignore it. Second, workers view nominal wage increases as a sign that they are appreciated, without taking into account that nominal wage increases also reflect a general rise in wage and price levels. More specifically, Akerlof et al. consider a model where workers' effort depends on their wage relative to a reference level. When inflation is low, near-rational firms and workers do not take it into account when updating their reference level, implying that wages are increased by less than they should. Thus, when inflation is low but positive, wage pressure is reduced, and equilibrium employment increased.

When inflation is high, however, it will be much more costly to neglect inflation. Thus, near-rational wage and price setters will take inflation fully into account when it is high. Hence, the reduction in wage pressure induced by inflation vanishes when inflation is high. Again, the upshot is that some inflation allows for higher equilibrium output than zero inflation, even if this latter explanation also implies that high inflation is associated with the same (low) output level as zero inflation.

While the detailed assumptions vary in the three stories above, the basic policy conclusion is essentially the same: a tight monetary policy may have a permanent negative effect on the economy by pushing output down to a low equilibrium level. This conclusion is consistent with the analysis of Ball (1999), who compares the monetary policy of North American and

[18] Downward nominal wage rigidity is often mentioned as an example of money illusion, where agents confuse real and nominal variables, see e.g. Shafir, Diamond and Tversky (1997). Note however that downward nominal wage rigidity can also be justified as the result of a nominal wage contract that can only be changed by mutual consent, consistent with the institutional setting in most OECD countries, see MacLeod and Malcomson (1993) and Holden (1994). As argued by Holden (1994), the fairness and contract arguments are complementary, in the sense that fact that the nominal wage is given in the contract, is likely to strengthen the feeling that it is unfair to cut the wage.

European countries in the 1980s and 1990s, and concludes that the tighter monetary policy in several European countries lead to long-lasting higher unemployment.

Bhaskar (1990) models the implications of workers who are concerned about fair treatment in the sense that they care disproportionately more about being paid less than other workers than they do about being paid more than other workers. This assumption can be defended by evidence suggesting that workers' effort is harmed if they are paid less than the "norm" (Akerlof, 1984), or if workers are loss averse (Kahneman and Tversky, 1979). Bhaskar shows that when the fair treatment assumption is incorporated into a standard wage bargaining model, it implies that there is a range of equilibrium wage growth rates, for which each wage setter will aim for the same wage growth as set by the others. Intuitively, workers will demand high wage growth if others get high wage growth, and low growth if others get low, implying that both alternatives are possible in equilibrium. The range of equilibria for the wage setting implies that there also is a range of equilibria for aggregate output. All output levels within the range may persist at a permanent basis. Furthermore, if e.g. a large negative shock has pushed the economy to the lower end of the range, an expansionary monetary policy moving the economy to the upper end of the range will in fact involve a permanent increase in aggregate output. Lye, McDonald and Sibly (2001) find empirical support for the existence of a range of equilibrium unemployment rates in Australia. As noted above, Driscoll and Holden (2004) use Bhaskar's framework to generate multiple equilibria and explain the persistence of inflation.

Some recent contributions integrate behavioral labor market features into dynamic stochastic general equilibrium (DSGE) models. Danthine and Kurmann (2010) use a gift-exchange framework to obtain real wage rigidity in an otherwise standard DSGE model with sticky prices. Danthine and Kurmann (2010) find that rent-sharing between workers and firms and wage entitlement effects based on past wages play important roles in explaining the dynamic responses of wages, inflation and output to various exogenous shocks. The results are consistent with notions of fairness and reciprocity in labor relations, but not with traditional efficiency wage models where wages mainly depend on aggregate labor market variables.

5 Multiple equilibria, news, and asset price bubbles

The New Keynesian model is a simplified version of arguably more accurate but also more elaborate DSGE models with nominal rigidities. One key simplification in the New Keynesian model from some DSGE models is that the effects of financial markets can be well captured by the sensitivity of output to the real interest rate (which in term comes from the consumption Euler equation). Financial markets may matter for the macroeconomy for "non-behavioral" reasons, such as the financial accelerator developed by Bernanke and Gertler (1989). But financial markets may also have macroeconomic effects through the generation of multiple equilibria, the effects of news on asset prices or expectations, or the possibility of

asset price bubbles, as the recent financial crisis strongly suggests. We discuss these three topics below.[19]

5.1 Multiple equilibria

A key feature of the New Keynesian model, as well as most mainstream economics, is the existence of a unique long run equilibrium. To many economists, this feature is a great advantage, as it yields clear predictions. Other economists are more skeptical, and have used behavioral assumptions to generate multiple equilibria. As explored in section 4 above, wage setting is a potential important cause of multiple equilibra, via wage rigidity or fairness considerations.[20] Multiple equilibria allow scope for the effects of beliefs and sentiments, which may decide which equilibrium prevails. In several papers (see e.g. Howitt and McAfee, 1992), the fluctuations are caused by random waves of optimism and pessimism, along the lines suggested by John Maynard Keynes, who argued that the animal spirits of entrepreneurs were an important determinant of investments and business cycles. These kind of models are often referred to as sunspot equilibria, because an essentially irrelevant factor may indeed move the economy if it works to coordinate agents' expectations. Azariadis (1981) consider the existence of sunspot equilibria within an overlapping generations setting, while Howitt and McAfee (1992) derive an animal-spirits cycle starting out from the multiple equilibria model of Diamond (1982). Farmer (2012) is a more recent version of this type of model, where market psychology plays an important role in selecting the equilibrium of the economy. Firms produce as many goods as are demanded, and the demand depends on self-fulfilling beliefs of market participants about the future value of assets. Duffy (2012) surveys the experimental evidence on how equilibria are selected in laboratory settings; the evidence is mixed, with some support for sunspot equilibria or the "global game" approach, in which there can be diversity of opinions about payoff-relevant variables.

5.2 News

A recent literature explores whether news about the economy may lead to business cycles. Jaimovich and Rebelo (2009) construct a model where good news about future technology may generate an economic expansion. The empirical model exhibits recessions that resemble those of the post war US economy. Milani (2011) explores whether expectational shocks may affect business cycle fluctuation, exploiting survey data on expectations. He finds that expectation shocks explain roughly half of business cycle movements. Surprisingly, the results indicate that the effect of expectations shocks is more persistent than the effect of structural demand shocks. Beaudry, Nam and Wang (2011) find that mood swings account for over 50 percent of business fluctuations in hours and output, and that these moods swings are strongly associated with long-run movements in total factor productivity. However, the results

[19] We omit discussion of other topics in behavioral finance, many of which could eventually also be incorporated into macroeconomic models. For a survey, see Thaler (2005).
[20] A multiplicity of equilibria may also arise from other, non-behavioral sources, like search complementarities (Diamond, 1982) or increasing returns to scale (e.g. Benhabib and Farmer, 1994).

cannot tell whether the mood swings are a reflection of the future growth (as suggested by the news shock literature) or cause the future growth (as suggested by the self-fulfilling equilibrium literature).

5.3 Asset price bubbles

One of the most contentious issues within macro finance has been the possible existence of bubbles in asset market. A bubble is a situation where the price of an asset is higher than its fundamental value, because the owners of the asset believe that they can sell at an even higher price at a later stage. Many economists have been skeptical to the existence of bubbles, partly because in most models with rational agents, bubbles cannot exist. In contrast, other economists argue that bubbles do exist, and find that this is an importance motivation for incorporating behavioral assumptions in macroeconomics.

In many cases rational behavior will prevent the possibility of a bubble. If the required rate of return on assets is higher than the growth rate of the economy, the market value of an asset bubble will sooner or later be greater than all other wealth in the economy, which is impossible. Rational agents will anticipate that the bubble will burst some time in the future, which will prevent the bubble from emerging. Note that this argument does not require that all agents are rational; a price bubble will involve the possibility of profitable arbitrage, so some agent will profit from selling the asset if the price is above equilibrium.

Most of the literature on asset bubbles is thus based on a behavioral foundation (see Brunnermeier, 2009 for a survey). As noted above, Branch and Evans (2011) explain bubbles within a model with adaptive learning. Agents are risk averse, and asset demand depends on their expectations of the mean and variance of stock market returns. Under adaptive learning, agents place greater emphasis on recent forecast errors, and occasional shocks may lead them to revise their risk estimates. This may affect the stock price so that subsequent revisions of the risk estimates place the economy onto a bubble-like path. The risk-estimate grows excessively along the bubble-path, paving the way for the eventual collapse of the demand for the risky asset, leading to a stock market crash.

Many studies with a behavioral foundation explain the existence of bubbles in settings with heterogeneous expectations. If some agents are better informed than others, the better informed may buy the asset in spite of a price above the fundamental value, because they expect to sell at a higher price to those who are less informed. Essentially, this is the “greater fool” idea discussed by Kindleberger (1978), that the last buyer was always counting on finding someone else to whom the stock or house could be sold.

Gilchrist, Himmelberg and Huberman (2005) emphasize that the combination of dispersion of investor beliefs and constraints on portfolio choice, e.g. on short selling, may lead to stock market bubbles. The authors find supporting empirical evidence, where increased dispersion leads to increased issuance of new equity as well as increased real investments.

Asset bubbles may have important implications. The recent financial crisis provides a recent and stark example (see, for example, the discussion in Akerlof and Shiller, 2009, and McDonald, 2009). Martin and Ventura (2011) argue that the crisis was due to a shock to investor sentiment that led to a collapse of a bubble or pyramid scheme in financial markets. Chirinko and Schaller (2012) explore whether bubbles in the US stock market lead to overinvestment, using a panel data set of over 50 000 firm-year observations from the US. The results indicate that firms with high stock price and poor investment opportunities accumulate between 15 and 45 percent too much capital, consistent with the hypothesis that bubbles affect economic activity by misallocating capital, in line with the argument of e.g. Shiller (2005), and with the findings of Gilchrist et al (2005) referred to above.

As alluded to above, asset bubbles may also arise with rational agents. Blanchard and Watson (1982) propose a theory of rational bubbles in which agents' rational expectations are influenced in part by extrinsic random variables whose properties accord to historical bubble episodes. More recently, Bacchetta, Tille and van Wincoop (2012) show how "risk panic" may emerge also with rational agents, if expectations of increased volatility in the asset price lead to a reduction in the demand for the asset. In this case the negative expectation is fulfilled, involving a self-fulfilling negative feedback effect.

In some studies, seemingly irrational behavior can also be viewed as a sort of agency problem. Scharfstein and Stein (1990) show that herd behavior among managers may arise as a consequence of rational attempts by managers to improve their reputation as decision makers. Brunnermeier and Nagel (2004) find that hedge funds contributed to the dot com bubble. On a stock-by-stock basis, the hedge funds analyzed by Brunnermeier and Nagel started to cut back their holdings before prices collapsed, switching to technology stocks that still experienced rising prices. Thus, hedge fund managers captured the upturn, but avoided much of the downturn. Brunnermeier and Nagel conclude that this is consistent with hedge fund managers being able to predict some of the investor sentiment that was arguably behind the wild fluctuations in valuations of technology stocks at the time. An important insight from the study of Brunnermeier and Nagel (2004) concerns the limits of arbitrage: If close substitutes are unavailable, risk aversion among rational investors will make them much less aggressive.

A common argument among proponents of the economic man assumption is that agents learn from their errors, so that their behavior becomes closer to that predicted by the economic man assumption. This feature is documented in a recent study of sportscards transactions (List, 2004), where it is shown that inexperienced consumers' exhibit the endowment effect predicted by prospect theory, while consumers with intense market experience behave largely in accordance with neoclassical predictions (i.e. the economic man assumption). However, there are also important decisions, like buying a house, making a large financial investment and changing workplace, which most people take much less frequently. In a study of the Boston housing market, Genesove and Mayer (2001) show that potential sellers who were facing a considerable loss, asked for higher prices than otherwise identical sellers who had bought at a lower price, i.e. consistent with the loss aversion hypothesis. This had a positive

impact on the sales price, but it also reduced the likelihood that the house was actually sold. Furthermore, there is also considerable documentation that in many cases even the behavior of "professionals" deviate from the standard economic man assumptions, see e.g. Shleifer (2000).

6 Critiques of the behavioral economics approach

In the foregoing, although we have argued that behavioral economics assumptions have considerable microeconomic empirical support and can help account for important aspects of macroeconomic behavior, we have also mentioned some problems with various specific behavioral economics assumptions introduced into macroeconomic models. However, there are more general critiques which apply to the use of behavioral models more broadly.

First, one can argue that behavioral economics is not needed to explain macroeconomic puzzles. The standard optimizing framework can be very expansive and elastic—it may be possible to find a "non-behavioral" optimizing explanation for every apparent fault in the standard New Keynesian models. We have noted this in some cases above—for example, in modeling consumption, the imposition of borrowing constraints can mimic some of the effects of behavioral models. Gul and Pesendorfer (2005) and Levine (2009) provide a number of examples where the standard models fit the data or when the standard framework offers other alternatives. Often, the behavioral assumption will be more parsimonious than the non-behavioral one or may otherwise provide greater analytical convenience, and may be preferable for these reasons.[21] Ultimately, however, the choice of assumptions should depend on empirical testing. A challenge is developing tests which will allow one to distinguish between behavioral and non-behavioral explanations.

Second, even were one to consider only behavioral explanations for problems with the standard model, distinguishing among such explanations has a similar "observational equivalence" problem. Since more than one behavioral assumption can generate the same macroeconomic facts—e.g. inertial responses to shocks—in order to determine which set of behavioral assumptions is correct, researchers need to find differences in other macroeconomic predictions of such assumptions. As noted above, Rubinstein (2003) provides experimental evidence for a different explanation for the same set of facts predicted by quasi-hyperbolic discounting. Fudenberg and Levine's (2006, 20012) dual self model provides another approach for explaining such facts and other paradoxes. Gul and Pesendorfer (2005), Levine (2009), and Rubinstein (2001, 2003, 2005, and 2006) also assert

[21] Rubinstein (2001, 2003, 2005, and 2006) has argued quite strongly against imposing functional forms motivated by evidence from cognitive science to otherwise standard optimization problems. He suspects that such evidence reveals more fundamental differences in the underlying decision-making process.

that particular behavioral explanations have not been subjected to the same level of scrutiny as have the standard models.[22]

Third, there are many potential results from behavioral psychology that can be applied to macroeconomics—as evinced by the multiplicity of topics discussed above. Are all of these behavioral effects true? Or are some mutually exclusive, which would be indicative of some more fundamental phenomenon causing the two? And which results matter at the macroeconomic level, and which do not—for example, some behavioral effects might lead to redistribution across different groups but have little effects on macroeconomic aggregates. This latter effect might mean that the application of some behavioral assumptions to representative agent models would produce misleading results.

Fourth, behavioral economics principles which are applied to one portion of a macroeconomic model would presumably be applicable to others. The considerable research on longer-run consumption and saving choices might matter for shorter-run choices, or for the price- or wage-setting decisions by firms. It makes sense for initial applications of behavioral principles to focus on one area, but consistency would make it desirable to cover multiple areas.

Fifth, one of the advantages of using micro-founded macro models is that it allows for welfare analysis. However, adopting behavioral features will often make welfare analysis problematic.

We should not careful not to overstate the force of these critiques. Many of them also apply to some degree to more conventional macroeconomic models. For example, and as noted above, there are several ways of delivering inertial responses to macroeconomic shocks that are arguably not behavioral; thus researchers face the problem of distinguishing among such explanations.

7 Concluding remarks

Simple macroeconomic models that assume agents behave rationally and have rational expectations often have stark predictions, some of which, as in the New Keynesian model, do not fit well empirically. Although more complicated purely rational models can improve the fit in some dimensions, they often do so at the expense of tractability and can still have counterfactual predictions in other dimensions.

It is much more difficult to say what should come instead. Akerlof (2002) and Akerlof and Shiller (2009), among others, have argued forcefully for including behavioral features in otherwise conventional macroeconomic models. The evidence provided by cognitive psychologists and behavioral economists strongly documents the existence of a number of important deviations from the economic man assumption. Incorporating such behavioral

[22] These papers are also to varying degrees critical of neuroeconomics, a topic we do not consider here, as it has not yet to our knowledge been applied to macroeconomics.

assumptions into macroeconomics thus has the potential to offer better microeconomic foundations as well as improving model fit.

In this paper, we have used the New Keynesian model as a framework to discuss the incorporation of behavioral economics features into macroeconomic models. We highlight the role of behavioral assumptions in the study of consumption—both short-term tradeoffs and longer-term decisions about consumption and savings; in the modeling of aggregate supply, with a focus on expectations formation and the labor market; and on the potential role of multiple equilibria, news, and asset bubbles. In all of these areas we find behavioral contributions have the potential to help explain macroeconomic puzzles.

In a few cases, we find particular explanations to be especially promising because of their empirical support within psychology and direct relevance to the macroeconomic phenomenon. For example, fairness considerations may interact with, and amplify, rigidities associated with labor market contracts, in particular downward nominal wage rigidity. This mechanism is probably also relevant for the existence of, and fluctuations in, unemployment. An interesting finding in the literature is the large variation in the importance of fairness considerations across individuals and settings (see e.g. the survey of Fehr, Goette and Zender, 2009). This variation might be one reason why economists traditionally have neglected fairness considerations. The finding that in a complex situation-- which often is true in macroeconomics--agents are not able to solve for or predict the equilibrium outcome also seems especially relevant. Thus, a rational expectations outcome is only plausible if it is the result of convergence of realistic behavior. The learning literature shows that this is may be the case if the circumstances are fairly stable, but it is less likely if large changes take place. Woodford (2012) suggests that one may accept that economic models deliver a range or plausible outcomes, rather than a unique prediction.

In other cases, a multiplicity of behavioral explanations has been offered for macroeconomic phenomena, but it is unclear to us which one is the most relevant. For example, a number of different assumptions about consumption behavior in the short-run can generate inertial responses to macroeconomic shocks.

Combining behavioral economics and macroeconomics—although promising and now done frequently—should be done with care. First, it is difficult to distinguish between behavioral and more "rational" explanations. For example, irrational investment decisions might be explained by irrational behavior among the investors, but it might also be a consequence of a inappropriate remuneration scheme for agents investing on behalf of others (see e.g. Rajan, 2005). Second, we often do not know the correct specification of plausible behavioral features. As observed by Blanchard (2009), when a weak assumption is first introduced, it [23]may quickly become standard and be passed on from model to model with little discussion. There is risk that behavioral features in simple models might in fact capture inertia

[23] Angeletos and La'o (2014) show that if frictions in communication prevent agents from reaching exactly the same expectations about economic activity, aggregate output may be affected by exogenous sentiment shocks.

in data that in reality reflects other mechanisms. Regrettably, we are still far away from knowing which approaches and assumptions are most appropriate (see Caballero, 2010, for a related view). Thus, there is need for more research to guide the choice of specification.

With these caveats, we note that there are yet other findings from cognitive psychology that have not yet been thoroughly explored in macroeconomic models, or explored at all, but seem promising. An important result from behavioral research is that many people—in some cases all—are affected by anchoring, framing, will-power problems and status quo. Thus, such features should be taken into account in the design of institutions, rules and regulations, e.g. when it comes to savings plans, consumer protection or the design of pension schemes, as discussed by Thaler and Sunstein (2008).

A related finding concerns the scope for sentiments and psychological factors, like optimism and pessimism. In the literature, such effects have been explained by behavioral features – direct assumptions on individual behavior – as well as arising from a multiplicity of equilibria or new information in models with more "rational" behavior. The vast uncertainty which exists about future trends and events provides room for large effects of fluctuations in agents' sentiment and expectations about the future. As expectations and sentiment both are affected by economic policy, such effects must also be taken into account in policy design.

Finally, it also seems worthwhile to explore more fundamentally different macroeconomic models, based on a broader framework and drawing upon insights from behavioral economics. De Grauwe (2012b) is a recent attempt of this. So called "agent based" models, see e.g. LeBaron and Tesfatsion (2008) are a further step away from the standard theory, which nevertheless seems like a promising avenue for future research, as it may allow us to explore the implications of much more complicated models and settings than we would otherwise be able to.

References:

Abel, A. B. (1990). Asset Prices under Habit Formation and Catching up with the Joneses. *American Economic Review*, 80(2), 38-42.

Adam, K. and M. Woodford (2012). Robustly Optimal Monetary Policy in a Microfounded New Keynesian Model. *Journal of Monetary Economics* 59(5), 468-487.

Ainslie, G. (1992). *Picoeconomics: The Strategic Interaction of Successive Motivational States Within the Person*. Cambridge University Press, Cambridge.

Ainslie, G. and Haslam, N. (1992). Hyperbolic discounting. In G. Loewenstein and J. Elster (eds.) *Choice over time.* Russell Sage Foundation, New York, pp. 57-92.

Akerlof, G.A. (1982). Labor contracts as partial gift exchange. *Quarterly Journal of Economics* 97(4), 543–569.

Akerlof, G.A. (1984). Gift exchange and efficiency wage theory: four views. *American Economic Review* 74(2), 79-83.

Akerlof, G.A. (2002). Behavioral Macroeconomics and Macroeconomic Behavior. *American Economic Review* 92(3), 411-433.

Akerlof, G.A. (2007). The Missing Motivation in Macroeconomics. *American Economic Review* 97(1), 5–36.

Akerlof, G.A., Dickens, W.T. and Perry, G. L. (1996). The macroeconomics of low inflation. *Brookings Papers on Economic Activity* 1996(1), 1-76.

Akerlof, G.A., Dickens, W.T. and Perry, G.L. (2000). Near-rational wage and price setting and the long run Phillips curve. *Brookings Papers on Economic Activity* 2000(1), 1-44.

Akerlof, G.A. and Shiller, R.J. (2009). *Animal spirits. How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism*. Princeton University Press, Princeton.

Akerlof, G.A. and Yellen, J.L. (1990). The fair wage-effort hypothesis and unemployment. *Quarterly Journal of Economics* 105(2), 255–283

Alessie, R. and Teppa, F. (2010). Saving and habit formation: evidence from Dutch panel data. *Empirical Economics* 38(2), 385-407.

Amato, J.D. and Shin, H.S. (2003). Public and private information in monetary policy models. Mimeo, London School of Economics.

Ameriks, J., Caplin, A., Leahy, J. and Tyler, T. (2007). Measuring Self Control Problems. *American Economic Review* 97(3), 966-972.

Andersen, T. M. and Bhattacharya, J. (2011). On Myopia as Rationale for Social Security. *Economic Theory* 47(1), 135-158.

Andersen, S., Harrison, G.W., Lau, M. and Rutström, E.E. (2011). Discounting behavior: A reconsideration. Mimeo, Department of Economics, Copenhagen Business School.

Angeletos, G-M. and La'O, J. (2014). Sentiments. Forthcoming in *Econometrica.*

Auerbach, A.J., Gale, W.G. and Harris, B.H. (2010). Activist fiscal policy. *Journal of Economic Perspectives* 24(4), 141-164.

Azariadis, C. (1981). Self-fulfilling prophecies. *Journal of Economic Theory* 25, 380-396.

Bacchetta, P., Tille, C. and van Wincoop, E. (2012). Self-Fulfilling Risk Panics. *American Economic Review*, 102(7), 3674-3700. Ball, L.S. (1994). Credible Disinflation with Staggered Price Setting. *American Economic Review*, 84(1), 282-289.

Ball, L.S. (1999). Aggregate demand and long-run unemployment, *Brookings Papers on Economic Activity*, 1999(2), 189-251.

Ball, L.S. (2000). Near-Rationality and Inflation in Two Monetary Regimes. *Proceedings*. Federal Reserve Bank of San Francisco.

Bao, T., Hommes, C., Sonnemans, J. and Tuinstra, J. (2012). Individual expectations, limited rationality and aggregate outcomes. *Journal of Economic Dynamics and Control* 36(8), 1101-1120.

Bauer, T., Bonin, H., Goette, L. and Sunde U. (2007). Real and nominal wage rigidities and the rate of inflation: evidence from West German micro data. *The Economic Journal* 117(524), F508-F529.

Beaudry, P, Nam, D. and Wang, J. (2011). Do mood swings drive business cycles and is it rational? NBER working paper 17651.

Bénabou, R. and Pycia, M. (2002). Dynamic Inconsistency and Self-Control: A Planner-Doer Interpretation. *Economics Letters* 77(3), 419-424.

Bénabou, R. and Tirole, J. (2004). Willpower and personal rules. *Journal of Political Economy* 112(4), 848-886.

Benhabib, J. and Bisin, A. (2005). Modeling Internal Commitment Mechanisms and Self-Control: A Neuroeconomics Approach to Consumption-Saving Decisions. *Games and Economic Behavior* 52(2), 460-492.

Benhabib, J., Bisin, A. and Schotter, A. (2010). Present-bias, quasi-hyperbolic discounting, and fixed costs. *Games Economic Behavior* 69, 205-223

Benhabib, J. and Farmer, R.E.A. (1994). Indeterminacy and increasing returns. *Journal of Economic Theory* 63(1), 19-41.

Bernanke, B.S., and Gertler, M. (1989). Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review* 79, 14-31.

Bewley, T.F. (1999). *Why wages don't fall during a recession*. Harvard University Press.

Bhaskar, V. (1990). Wage relatives and the natural range of unemployment. *Economic Journal* 100, 60-66.

Blanchard, O.J. (2009). The state of macro. *Annual Review of Economics* 1, 209-228.

Blanchard, O. and Watson, M. (1982). Bubbles, rational expectations, and financial markets. In *Crises in the economic and financial structure*, ed. Paul Wachtel. Lexington, Mass.: Lexington.

Branch, W.A. and Evans, G.W. (2011). Learning about risk and return: A simple model of bubbles and crashes. *American Economic Journal: Macroeconomics* 3(3), 159-191.

Brown, M., Falk, A., Fehr, E. (2004). Relational contracts and the nature of market interactions. *Econometrica* 72, 747–780

Brunnermeier, M. (2009). Bubbles. Entry in *The New Palgrave Dictionary of Economics*, edited by Steven Durlauf and Lawrence Blume, 2nd edition.

Brunnermeier, M. and Nagel, S. (2004). Hedge funds and the technology bubble. *Journal of Finance* 59(5), 2013-2040.

Burger, N., Charness, G. and Lynham, J. (2009). Field and online experiments on procrastination and willpower. Mimeo, Rand corporation.

Burks, S.V., Carpenter, J.P., Goette, L. and Rustichini, A. (2009). Overconfidence and social-signaling. *Review of Economic Studies* 80 (3), 949-983.

Bårdsen, G. and Nymoen, R. (2009). Macroeconomic modelling for policy. *Palgrave Handbook of Econometrics Vol 2*, Palgrave MacMillan.

Caballero, R.J. (2010). Macroeconomics after the crisis: Time to deal with the pretense-of-knowledge syndrome. *Journal of Economic Perspectives* 24(4) 85-102.

Caliendo, F. (2011). Time-Inconsistent Preferences and Social Security: Revisited in Continuous Time. *Journal of Economic Dynamics and Control* 35(5), 668-675.

Caliendo, F. and Aadland, D. (2007). Short-Term Planning and the Life-Cycle Consumption Puzzle. *Journal of Economic Dynamics and Control* 31(4), 1392-1415.

Caliendo, F. and Huang, K.X.D. (2008). Overconfidence and Consumption Over the Life Cycle. *Journal of Macroeconomics* 30(4), 1347-1369.Calvo, G. (1983). Staggered Prices in a Utility-Maximizing Framework. *Journal of Monetary Economics* 12(4), 983-998.

Campbell, J.Y. and Deaton, A.S. (1989). Why Is Consumption So Smooth? *Review of Economic Studies* 56(3), 357-373.

Campbell, J.Y. and Mankiw, N.G. (1990). Permanent income, current income, and consumption. *Journal of Business and Economic Statistics* 8(3), 265–279.

Caplin, A. and Leahy, J. (2001). Psychological Expected Utility Theory and Anticipatory Feelings. *Quarterly Journal of Economics* 116(1), 55-79.

Chakravarty, S., Friedman, D., Gupta, G., Hatekar, N., Mitra, S. and Sunder, S. (2011). Experimental Economics: A Survey. *Economic and Political Weekly* 46(35), 39-78

Chirinko, R.S. and Schaller, H. (2012). Do bubbles lead to overinvestment? A revealed preference approach. In Douglas D. Evanoff, George G. Kaufman & A.G. Malliaris (eds.), *New Perspectives on Asset Price Bubbles: Theory, Evidence, and Policy*, Oxford University Press, pp. 433-453.

Choi, J.J., Laibson, D. and Madrian, B.C. (2011). $100 bills on the sidewalk: Suboptimal investment in 401(k) plans. *The Review of Economics and Statistics* 93, 748-763.

Clarida, R., Galí, J. and Gertler, M. (1999). The Science of Monetary Policy: A New Keynesian perspective. *Journal of Economic Literature* XXXVII (December), 1661–1707.

Constantinides, G.M. (1990). Habit Formation: A Resolution of the Equity Premium Puzzle. *Journal of Political Economy* 98(3), 519-543.

Cremer, H. and Pestieau, P. (2011). Myopia, Redistribution and Pensions. *European Economic Review* 55(2), 165-17.

Danthine, J-P. and Kurmann, A. (2010). The business cycle implications of reciprocity in labor relations. *Journal of Monetary Economic*s 57(7), 837-850.

Dasgupta, P. and Maskin, E. (2005). Uncertainty and Hyperbolic Discounting. *American Economic Review* 95(4), 1290-1299.
De Bondt, W.F. and Thaler, R.H. (1985). Does the stock market overreact? *Journal of Finance* 40, 793-805.

De Grauwe, P. (2010). Top-down versus bottom-up macroeconomics. *CESifo Economic Studies* 56(4), 465-497.

De Grauwe, P. (2012a): Booms and busts in economic activity: A behavioral explanation, *Journal of Economic Behavior & Organization* 83(3), 484-501.

De Grauwe, P. (2012b). *Lectures on Behavioral Macroeconomics*. Princeton University Press.

Diamond, P. (1982). Aggregate demand management in search equilibrium. *Journal of Political Economy* 90, 881-894.

Diamond, P. and Koszegi, B. (2003), Quasi-Hyperbolic Discounting and Retirement. *Journal of Public Economics* 87(9-10), 1839-1872.

Dickens, W., Goette, L., Groshen, E.L., Holden, S., Messina, J., Schweitzer, M.E., Turunen, J. and Ward, M. (2007). How Wages Change: Micro Evidence from the International Wage Flexibility Project. *Journal of Economic Perspectives* 21(2), 195–214.

Driscoll, J. C. and Holden, S. (2004). Coordination, Fair Treatment and Inflation Persistence. *Journal of European Economic Association* 2(2-3), 240-251.

Duffy, J. (2012), *Macroeconomics: A Survey of Laboratory Research*. University of Pittsburgh.

Dynan, K.E. (2000). Habit Formation in Consumer Preferences: Evidence from Panel Data. *American Economic Review* 90(3), 391–406.

Evans, G.W. and Honkapohja S. (2013). Learning as a rational foundation for macroeconomics and finance. In Roman Frydman and Edmund Phelps (eds.) *Rethinking Expectations: The Way Forward for Macroeconomics*. Princeton University Press, Princeton, pp. 68-111.

Fair, R. C. (2014). Reflections on Macroeconometric Modeling. Yale University.

Farmer, R.E.A. (2012). Confidence, crashes and animal spirits. *The Economic Journal* 122, 155-172.

Fehr E, Brown, M. and Zehnder, C. (2009). On reputation: a microfoundation of contract enforcement and price rigidity. *Economic Journal* 119, 333–353.

Fehr, E., Goette, L. and Zehnder, C. (2009). A behavioral account of the labor market: The role of fairness concerns. *Annual Review of Economics* 1, 355-384.

Fehr E, Kirchsteiger, G. and Riedl, A. (1993). Does fairness prevent market clearing? An experimental investigation. *Quarterly Journal of Economics* 108, 437–460.

Fernández-Villaverde, J. and Mukherji, A. (2006). *Can We Really Observe Hyperbolic Discounting?* University of Pennsylvania.

French, S., Kubo, K. and Marsden, D. (2002) Why does performance pay de-motivate: financial incentives versus performance appraisal. In: Hanami, Tadashi, (ed.) *Universal wisdom through globalisation: selected papers from the 12th IIRA world congress, Tokyo.* Japan Institute of Labour Report (9). Japan Institute of Labour, Tokyo.

Fudenberg, D. and Levine, D. (2006), A Dual Self Model of Impulse Control. *American Economic Review* 96, 1449-1476.
Fudenberg, D. and Levine, D. (2012), Timing and Self-Control. *Econometrica* 80, 1-42.

Fuhrer, J. (2000). Habit formation in consumption and its implications for monetary-policy models. *American Economic Review* 90(3), 367-390.

Fuhrer, J and Moore, G. (1995). Inflation persistence. *Quarterly Journal of Economics* CX, 127-160.

Fusaro, M.A., Dutkowsky, D.H. (2011) What explains consumption in the very short-run? Evidence from checking account data. *Journal of Macroeconomics* 33(4), 542-552

Fuster, A., Laibson, D. and Mendel, B. (2010). Natural expectations and macroeconomic fluctuations. *Journal of Economic Perspectives* 24(4), 67-84.

Gali, J. and Gertler, M. (1999). Inflation Dynamics: A Structural Econometric Analysis. *Journal of Monetary Economics* 44, 195-222.

Gali, J., Gertler, M. and Lopez-Salido, J.D. (2005). Robustness of the estimates of the hybrid new Keynesian Phillips curve. *Journal of Monetary Economics* 52, 1107-1118.

Gali, J., Vallés, J. and López-Salido, J.D. (2007). Understanding the effects of government spending on consumption. *Journal of European Economic Association* 5(1), 227-270.

Genesove, D., and Mayer, C. (2001). Loss aversion and seller behavior: evidence from the housing market. *Quarterly Journal of Economics* 116, 1233−1260.

Gilchrist, S., Himmelberg, C.P. and Huberman, G. (2005). Do stock price bubbles influence corporate investment? *Journal of Monetary Economics* 52, 805-827.

Guesnerie, Roger (2005). *Assessing Rational Expectations 2: Eductive Stability in Economics,* MIT Press, Cambridge, Massachusetts

Gul, F. and Pesendorfer, W. (2001). Temptation and Self-Control. *Econometrica* 69(6), 1403-1435.

Gul, F. and Pesendorfer, W. (2004), Self Control, Revealed Preference and Consumption Choice. *Review of Economic Dynamics* 7, 243-264.

Gul, F. and Pesendorfer, W. (2005), *The Case for Mindless Economics*. Princeton University.

Halevy, Y. (2008). Strotz Meets Allais: Diminishing Impatience and the Certainty Effect. *American Economic Review* 98(3), 1145-1162.

Hall, R.E. (1978). Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence. *Journal of Political Economy* 86, 971-987.

Hall, R.E. (2005). Employment Fluctuations with Equilibrium Wage Stickiness. *American Economic Review* 95, 50–65.

Heidhues, P. and Koszegi, B. (2010), Exploiting Naivete about Self-Control in the Credit Market. *American Economic Review* 100(5), 2279-2303.

Holden, S. (1994). Wage bargaining and nominal rigidities, *European Economic Review* 38, 1021-1039.

Holden, S. and Driscoll, J. (2003). Inflation persistence and relative contracting. *American Economic Review* 93, 1369-1372.

Holden, S. and Wulfsberg, F. (2009). How strong is the macroeconomic case for downward real wage rigidity? *Journal of Monetary Economics* 56, 605-615.

Hommes, C.H. (2011), The heterogeneous expectations hypothesis: some evidence from the lab, *Journal of Economic Dynamics and Control* 35, 1-24.

Howitt, P. and McAfee, P. (1992). Animal spirits. *American Economic Review* 82(3), 493-507.

Hsieh, C-T. (2003). Do Consumers React to Anticipated Income Changes? Evidence from the Alaska Permanent Fund. *American Economic Review* 93, 397-405.

Huang, K.X.D., Liu, Z. and Zhu, Q. (2006), Temptation and Self-Control: Some Evidence and Applications. Minneapolis Federal Reserve Bank working paper.

Imrohoroglu, A., Imrohoroglu, S. and Joines, D.H. (2003), Time-Inconsistent Preferences and Social Security. *Quarterly Journal of Economics* 118(2), 745--784.

Jaimovich, N. and Rebelo, S. (2007). Behavioral theories of the business cycle. *Journal of European Economic Association* 5 (2-3), 361-368.

Jaimovich, N. and Rebelo, S. (2009). Can News about the Future Drive the Business Cycle? *American Economic Review*, 1097-1118.

Jappelli, T. and Pistaferri, L. (2010). The consumption response to income changes. *Annual Review of Economics* 2, 479-506.

Kahneman, D., Knetsch, J.K. and Thaler, R. (1986). Fairness as a Constraint on Profit Seeking: Entitlements in the Market. *The American Economic Review* 76(4), 728-741.

Kahneman, D. and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica* 47, 263-291.

Kindleberger, C. (1978). *Manias, Panics, and Crashes: A History of Financial Crises*, Basic Books, New York.

Krueger, A.B. and Mas, A. (2004). Strikes, scabs, and tread separations: labor strife and the production of defective Bridgestone/Firestone tires. *Journal Political Economy* 112, 253–289.

Kumru, C. and Thanopoulos, A. (2011), Social security reform with self-control preferences. *Journal of Public Economics* 95(7-8), 886-899.

Kurz, M. (1997). (Ed.), *Endogenous Economic Fluctuations: Studies in the Theory of Rational Beliefs,* Springer Verlag.

Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics* 62, 443-477.

Laibson, D. (2009). Comment on Household saving behavior in the United States: The role of literacy, information and financial education program. In *Policymaking Insights from Behavioral Economics*. C. Foote, L. Goette, and S. Meier (eds). Federal Reserve Bank of Boston.

Laibson, D.I.., Repetto, A. and Tobacman, J. (1998). Self-Control and Saving for Retirement. *Brookings Papers on Economic Activity* 29(1), 91-196

Laibson, D., Repetto, A. and Tobacman, J. (2003). A debt puzzle. In P. Aghion, R. Frydman, J. Stiglitz and M. Woodford (eds.) *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S Phelps*. Princeton University Press, Princeton.

LeBaron, B. and Tesfatsion, L. (2008). Modeling Macroeconomies as Open-Ended Dynamic Systems of Interacting Agents. *American Economic Review*, 98(2), 246-250.

Levine, D. (2009). *Is Behavioral Economics Doomed?* Max Weber Programme Lecture Series, European University Institute

List, J.A. (2004). Neoclassical Theory Versus Prospect Theory: Evidence from the Marketplace. *Econometrica* 72(2), 615-625.

Ljungqvist, L. and Uhlig, H. (2000). Tax policy and aggregate demand management under catching up with the Joneses. *American Economic Review* 90(3), 356-366.

Loewenstein, G. and Adler, D. (1995). A bias in the prediction of tastes. *The Economic Journal* 105, 929-937.

Lusardi, A. (2009). Household saving behavior in the United States: The role of literacy, information and financial education program. In C. Foote, L. Goette, and S. Meier (eds) *Policymaking Insights from Behavioral Economics*. Federal Reserve Bank of Boston.

Lye, J.N., McDonald, I.M. and Sibly, H. (2001). An estimate of the range of equilibrium rates of unemployment for Australia. *Economic Record* 77(236), 35-50.

Mackowiak, B. and Wiederholt, M. (2011). Business cycle dynamics under rational inattention. ECB working paper 1331.

MacLeod, W.B. and Malcomson, J.M. (1993). Investment, holdup, and the form of market contracts. *American Economic Review* 37, 343-354.

Madrian, B.C. and Shea, D.F. (2001). The power of suggestion. Inertia in 401(k) participation and savings behavior. *Quarterly Journal of Economics* 116, 4, 1149-1187.

Mankiw, N.G. (2001). The Inexorable and Mysterious Tradeoff Between Inflation and Unemployment. *Economic Journal* 111, C45-61.

Mankiw, N.G. and Reis, R. (2002). Sticky information versus sticky prices: A proposal to replace the New Keynesian Phillips curve. *Quarterly Journal of Economics* 117, 1295-1328.

Martin, A. and Ventura, J. (2011). Theoretical notes on bubbles and the current crisis. *IMF Economic Review* 59, 6-40.

Mas, A. (2008). Labor unrest and the quality of production: evidence from the construction equipment resale market. *Review of Economic Studies* 75, 229-258.

McDonald, I.M. (2009). The global financial crisis and behavioural economics. *Economic Papers* 28, 249-254.

Milani, F. (2011). Expectation shocks and learning as drivers of the business cycle. *Economic Journal* 121, 379-401.

Noor, J. (2009). Hyperbolic Discounting and the Standard Model: Eliciting Discount Functions. *Journal of Economic Theory* 144(5), 2077-2083.

Pagel, M. (2012), Expectations-Based Reference-Dependent Preferences and Asset Pricing. UC Berkeley.

Pagel, M. (2013). Expectations-Based Reference-Dependent Life-Cycle Consumption. UC Berkeley.

Phelps, E.S. and Pollak, R.A. (1968). On Second-best National Savings and Game-equilibrium Growth. *Review of Economic Studies* 35, 185-199

Pissarides, C. (2009). The unemployment volatility puzzle: Is wage stickiness the answer? *Econometrica* 77(5), 1339-1369.

Pollak, R. (1970). Habit formation and dynamic demand function. *Journal of Political Economy* 78, 745-763.

Rajan, R.G. (2005). Has financial development made the world riskier? Mimeo, IMF.

Romer, D.H., (2011). *Advanced Macroeconomics*, fourth ed. McGraw-Hill, New York

Rotemberg, J. (2008) Minimally altruistic wages and unemployment in a matching model with monopsony. *Journal of Monetary Economics* 55, S97-S110.

Rubinstein, A. (2001), A Theorist's View of Experiments. *European Economic Review* 45(4-6), 615-628.

Rubinstein, A. (2003). Economics and Psychology? The Case of Hyperbolic Discounting, *International Economic Review* 44, 1207-1216.

Rubinstein, Ariel (2005). *Modeling Bounded Rationality*. Zeuthen Lecture Book series, Massachusetts Institute of Technology.

Rubinstein, Ariel (2006). Discussion of "Behavioral Economics". In R. Blundell, W.K. Newey and T. Persson (eds.) *Advances in Economics and Econometrics: Theory and Application*, New York.

Rudd, J. and Whelan, K. (2007). Modeling inflation dynamics: A critical review of recent work. *Journal of Credit and Banking* 39 (2), 155-170.

Rudebusch, G.B., 2002. Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia. *Journal of Monetary Economics* 49, 1161-1187.

Scharfstein, D.S. and Stein, J.C. (1990). Herd behavior and investment. *American Economic Review* 80(3), 465-479.

Schelling, T.C. (1984). Self-Command in Practice, in Policy, and in a Theory of Rational Choice. *American Economic Review* 74(2), 1-11.

Shafir, E., Diamond, P.A. and Tversky, A. (1997). On Money Illusion. *Quarterly Journal of Economics* 112(2), 341–374.

Shapiro, C. and Stiglitz, J.E. (1984). Equilibrium Unemployment as a Discipline Device. *American Economic Review* 74, 433-444.

Shiller, R.J. (2005). *Irrational Exuberance*. Princeton University Press, Princeton.

Shimer, R.J. (2005). The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review* 95, 25-49.

Shleifer, A. (2000). *Inefficient Markets: An Introduction to Behavioral Finance.* Oxford University Press, Oxford.

Sims, C. (2003). Implications of rational inattention. *Journal of Monetary Economics* 50(3), 665-690.

Sims, C. (2010). Rational inattention and monetary economics. In B. Friedman and M. Woodford (eds.) *Handbook of Monetary Economics 3A*, Elsevier.

Smets, F. and Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review* 97, 586-606.

Taylor, J. (1980). Aggregate dynamics and staggered contracts. *Journal of Political Economy* LXXXVIII, 1-24

Taylor, J.B., (1993). *Discretion versus Policy Rules in Practice*. Carnegie-Rochester Conference Series on Public Policy 39, 195-214

Thaler, R.H. (ed.) (2005). *Advances in Behavioral Finance, Volume II*. Russell Sage Foundation, New York.

Thaler, R.H. and Benartzi S. (2004). Save Tomorrow™: Using Behavioral Economics to Increase Employee Saving. *Journal of Political Economy* 112(S1), 164-187.

Thaler, R. H. and Sunstein, C.R. (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Yale University Press.

Tobin, J. (1972). Inflation and unemployment. *American Economic Review* 62(2), 1-18.

Walsh, C.E., (2010). *Monetary Theory and Policy*, third ed. MIT Press, Cambridge, MA

Woodford, M. (2000). Monetary Policy in a World Without Money. *International Finance* 3, 229-260

Woodford, M. (2003a). *Interest and Prices*. Princeton University Press, Princeton.

Woodford, M. (2003b). Imperfect common knowledge and the effects of monetary policy. In P. Aghion, R. Frydman, J. Stiglitz and M. Woodford (eds). *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S Phelps*. Princeton University Press, Princeton.

Woodford, M. (2012). *What's wrong with economic models?* Institute for New Economic Thinking Research note #009.