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Abstract

The contribution of this paper is twofold. First, a thorough presentation of the state of the art of the New Keynesian Macroeconomic model is provided. A discussion of its empirical caveats follows and some recent extensions of the standard model are evaluated in more detail. Second, a key insight of Behavioral Economics, hyperbolic discounting, is used for the derivation of the IS Curve. It is argued that this approach is more appropriate than the usual praxis of allowing for a rule-of-thumb agent in an otherwise standard optimization framework.

Keywords: Behavioral Economics, New Keynesian Model, Rule-of-Thumbs, Hyperbolic Discounting

JEL classification: D91,E21,D8,D03

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1 Introduction

This paper follows the idea put forward by George Akerlof in his Nobel prize lecture of 2001, namely that in order to get "better" macroeconomic models, one should start dealing explicitly with the psychological and sociological dimensions of individuals' decisions and actions. He thus argues in favor of a "Behavioral Macroeconomics" in order to explain "Macroeconomic Behavior".[1] I will follow this approach by linking two recent strands in economic theory with regard to the concrete example of how agents discount the future. First, in the macroeconomic field, there has been the emergence of the "New Keynesian Model", or the "New Consensus Model".[2] A three equation macroeconomic model is derived from an explicit microeconomic optimization framework consisting of an IS-equation for the goods market, a Phillips Curve for the price formation block, and a Taylor-rule as the reaction function of the central bank. The results are then similar to the older Neoclassical Synthesis Model, i.e., one gets an effect of aggregate demand on output in the short run, due to price stickiness in the goods market, and a supply-side determined long-run equilibrium. This approach sees nominal price and wage rigidities at the heart of economic volatility. Assuming imperfect competition in the goods market and firms facing "menu costs" and thus being unwilling to adjust prices in response to a change in the demand for their product, it is shown that the economy does not react immediately to a shock. Hence, monetary policy gains the potential to stabilize the economy in the short run, which may justify calling this model (New) Keynesian.[3]

Besides these seminal advances in macroeconomic theory, the microeconomic field saw the incorporation of psychological insights into the standard framework, an approach which has become known under the name "Behavioral Economics". On the basis of empirical studies and experiments, it is shown that individuals mostly behave in a completely different way as it is usually assumed by the metaphor of the standard rational optimizing agent. Examples range, among others, from expectations formation to fairness motives, time discounting, and income framing.[4] However, this promising approach mostly stays in a microeconomic framework so far, or in a partial equilibrium context when it is used to address macroeconomic questions such as individuals' saving behavior. In general equilibrium models such

[1]See Akerlof (2002) and Akerlof (2007).

[2]Whether these kinds of models should be called "New Keynesian", "New Consensus", or "New Monetarist" has recently become controversial in the literature. Additionally, one also finds the names "New IS-LM model" (King, 2000) and "standard aggregate-demand- aggregate supply model" (De Grauwe, 2008). However, this question of taxonomy is beyond the scope of this paper, so I will use the name "New Keynesian Model" in what follows.

[3]The key reference is certainly Clarida et al. (1999), however, they do not provide an explicit derivation of the model. For this, they point to three central references: Walsh (2003), McCallum and Nelson (1999) and Goodfriend and King (1997), however, only the first provides a full derivation of both the IS- and the Philips-Curve. A collection of earlier papers is provided by Mankiw and Romer (1991), a more recent survey about the new IS-LM model is also given by King (2000). A variation including capital accumulation can be found in Yun (1996).

[4]See for an overview of Behavioral Economics Camerer et al. (2003).

as the New Keynesian Model, the assumption of the rational agent is maintained, which is puzzling given the extensive empirical evidence against it.

This paper takes hyperbolic discounting as one of the recently popularized models in Behavioral Economics and analyses its effects in a New Keynesian macroeconomic framework. I have chosen the question of discounting since this seems to be one of the most general assumptions of the standard model, whereas an effect of fairness, for example, only applies in some context. Before deriving the model, Section 2 will give a thorough discussion of the current state of the New Keynesian Model, some major critiques and extensions. This will also provide some motivation for the later argument. In section 3 of the paper, I will first explain the special features of hyperbolic discounting and discuss its implications for the appropriate time horizon. Emphasizing the role and modeling of consumption smoothing, I will then present a full derivation of the IS curve with hyperbolic discounting. Discussing implications, limitations and calling for future research, section 4 concludes.

2 New Keynesian Macroeconomics

2.1 The IS Curve and Extensions

2.1.1 The Standard New Keynesian IS Curve

At a first glance, the New Keynesian IS Curve looks fairly similar to its traditional formulation. In both cases, the goods market equilibrium depends negatively on the real interest rate. However, already King (2000) pointed to some key differences between the two formulations. First, the New Keynesian version stems from a microeconomic optimization decision of a representative consumer, and not from a firm's investment decision. Second, given the use of rational expectations, the consumer's life time optimization program is formulated in an entirely forward-looking way.[5] Third, whereas the traditional formulation was expressed in levels, the New Keynesian version delivers the optimal change in the variables. The result is an Euler equation, expressing both consumption smoothing in case of expected future income and intertemporal substitution of consumption with respect to changes in the interest rate. Log-linearizing around a steady state yields the New Keynesian IS-curve, interpreting the other goods market aggregates as exogenous demand shocks.

2.1.2 Problems of the Standard Approach

Recently, this approach has been criticized in various ways. A major point is the fact that the New Keynesian IS-curve cannot give rise to sufficient persistence, i.e. accounting for the high autocorrelation that is found in the data.[6] Attempts to validate Hall (1978)'s Random Walk hypothesis on an empirical basis show strong

[5] This can be seen by forwarding the standard equation (Clarida et al., 1999, p.1666).

[6] See Walsh (2003),p.240 and Fuhrer (1997) for empirical studies that suggest a significant role for lagged terms in the IS-equation.

evidence for a comovement of consumption and income and a significant role of predictable changes of current income, in contrast to the predictions of the standard consumption model. Already Campbell and Mankiw (1989) have provided evidence against a too large role designed to consumption smoothing in face of future expected income fluctuations. A further question concerns the problem whether one should include capital accumulation into the model. This is discussed in detail below.

2.1.3 Recent Extension Proposed in the Literature

Several extensions of the standard model have been proposed in order to cope with the observed lack of persistence in the goods market formulation.

A first strand of models uses habit formation for households' consumption decisions. The assumption of intertemporal separability of consumption goods is relaxed, i.e., the agent gets utility from one consumption good over more than one period which can be easily justified in the case of durable consumption goods. Models of habit formation can also be interpreted such that individuals have recurring consumption behavior, i.e. their decisions today also depend on their decisions in the past.[7]

In a second strand of models, sociological insights are used. In habit formation models, consumers base their decisions not only on their personal habits but also on the consumption of their social reference group.[8] It is an important feature of these models that individuals do not only consider changes in consumption, as in the standard Euler equation, but also take into account the level of consumption, which leads to a higher persistence in spending. In a similar vein, Akerlof (2000) and Akerlof (2007) has supported the importance of identity and social norms for people's behavior. If individuals deviate in their consumption decisions from established social norms, for example by increasing current consumption spending in anticipation of an inheritance in the future, they experience a loss in utility. Thus, these models derive a minor importance for consumption smoothing.

A third strand of models consists of introducing rule-of-thumb, or Non-Ricardian consumers into an otherwise standard optimization model. This approach assumes that under the conditions of a complex economic environment, for a fraction of agents it is too costly to make a decision using the optimization framework. Instead, if costs exceed a certain threshold they follow simple rule-of-thumbs.[9] A seminal contribution in this context is Gabaix and Laibson (2001)'s model of optimization costs, in which agents only adjust their consumption decisions from time to time. Galí et al. (2007), Galí et al. (2004) and Amato and Laubach (2003) have pro-

[7] A thorough presentation of the habit formation model can be found in Fuhrer (2000).

[8] See Falk and Knell (2004), who have also endogenized the reference standard.

[9] Amato and Laubach (2003) suggest that these rules should fulfill three requirements in order to be superior to complex optimization. The orientation variable should be easily observable, the rule should exhibit nearly no computation costs, and people should learn, i.e., the non-optimizing households always adjust to the behavior of the optimizing households. Mostly, it is also assumed that in the steady state, all agents behave in the same way, in order to simplify the analysis.

posed models with rule-of-thumb consumers. However, their rules differ. Galí et al. (2007) build on the findings by Campbell and Mankiw (1989) and state that one fraction of households only consumes its current labor income. On the contrary, Amato and Laubach (2003) suggest that the rule should simply be that a part of households in the current period mimic the behavior of all agents in the previous period, i.e., for rule-of-thumb consumers, consumption today simply equals consumption yesterday.

2.2 The Phillips Curve and Extensions

2.2.1 The Standard New Keynesian Phillips Curve

The New Keynesian Phillips Curve, as in the case of the New Keynesian IS curve, is based on microeconomic optimization assuming rational expectations and thus purely forward-looking agents. In order to get a sluggish response of the price level in response to a demand shock, nominal rigidities are introduced. These stem from the fact that firms act in a monopolistic environment thus having some price setting power and, in addition, face some costs of adjusting prices (”menu costs”) which make quantities react faster than prices.

There exists a number of different price setting models in the literature from which the New Keynesian Phillips Curve has been derived. Broadly, two approaches can be distinguished, namely time-dependent models, in which the period in which firms cannot change their prices is exogenously fixed and state dependent models in which the time period becomes an additional choice variable.

For the former approach, Roberts (1995), who has also introduced the name ”New Keynesian Phillips Curve”, has shown that the models of randomly price adjustment by Calvo (1983), of overlapping contracts by Taylor (1979), Taylor (1980) and of minimizing deviation costs by Rotemberg (1982) lead to a very similar outcome.[10] For the latter approach, note that state-dependent pricing makes it possible to avoid one of the main caveats of the widely used Calvo-model, namely the fact that there could exist a considerable fraction of firms that have not adjusted their price over a long period. Firms' price setting depends on the probability whether they can adjust their prices again in subsequent periods. However, in state-dependent models, these probabilities vary over time, thus changing the discount factor.[11] Specific features of state-dependent models are an influence of the functional form of demand on the price adjustment and the possibility of non-linearities and multiple equilibria. That time-dependent pricing models are more common in macroeconomic models results from their higher analytical traceability.

[10]See Dotsey (2002) for a discussion of the differences between these models.

[11]”A high probability of adjustment in some future period leads the firm to set a price that heavily discounts the effects on profits beyond that period.” (Dotsey and King, 2005,p.221)

2.2.2 Problems of the Standard Approach

The critique of the New Keynesian Phillips Curve has been even more severe than in the case of the goods market formulation and has lead Mankiw (2001) to talk about "an inexorable and mysterious tradeoff between inflation and unemployment".

The critiques of the short-run Phillips Curve can be summarized as follows. Time-dependent pricing models can generate persistence in the price level, since individual prices cannot always be changed immediately, but this does hardly affect the inflation rate. However, in a wide range of empirical studies following Fuhrer and Moore (1995), a high autocorrelation in the inflation rate has been found, pointing to the need of incorporating lagged terms into the inflation equation.[12] An additional objection has recently been raised by Rotemberg (2005). He quotes empirical evidence suggesting that prices do not fully react to changes of marginal costs or administrative costs. In Rotemberg (2008) he also quotes interviews with firm managers that mention "avoiding customer antagonism" and not costs of adjusting prices as the main reason for leaving prices unchanged.

Concerning the long-run Phillips Curve, its assumed verticality has been highly questioned. Even if already in the standard New Keynesian formulation the implied long-run neutrality of money does not hold entirely, this fact has often been concealed. As Woodford (2003), p.188, writes in his seminal book: "note that in Roberts (1995)'s presentation of the New Keynesian Phillips Curve, the discount factor β is set equal to one. This simplification may seem appealing, in that it implies a vertical "long-run" inflation-output trade-off. But correctly accounting for the presence of the discount factor (...) has important consequences for the analysis of optimal policy (...)." And as it has been put by Blanchard and Fischer (1989): "Most economists who came to accept the view that there was no long-run tradeoff between inflation and unemployment were more affected by a priori argument than by empirical evidence." Graham and Snower (2008) also quote a wide range of empirical studies questioning the long-run verticality of the Phillips Curve.

2.2.3 Recent Extensions Proposed in the Literature

Concerning the persistence in inflation, various attempts have been proposed to derive this phenomenon in a theoretically convincing way.

First, Fuhrer and Moore (1995) have suggested that firms' price setting should be modeled differently, arguing in favor of a relative real contract price instead of the usually adopted nominal one. In a similar vein, Christiano et al. (2005) have introduced price and wage indexation into an otherwise standard price setting model, in which non-optimizing firms have to stick with the price they had chosen before. In contrast, adjusting firms set prices optimally from time to time, whereas the actual price is automatically readjusted to changes in the aggregate price index in the meantime.

[12] See for further references also Amato and Laubach (2003) and Mankiw (2001).

A second proposition has been made by Sbordone (2002) and Galí and Gertler (1999) who argued that the persistence stems from the fact that firms' real marginal costs do not respond immediately to changes in output, thus importing inertia into the inflation equation from outside.

A third way of extending the standard model questions the assumption of rational expectations. Already Mankiw (2001) has admitted that using adaptive expectations gives the best empirical fit. Recent estimations by Rudd and Whelan (2006) show that adding lags to the forward looking Phillips curve indeed leads to a better empirical fit, however, they then find nearly no additional gain from including the forward looking term. They conclude that these results might be a hint to the weakness of the rational expectations hypothesis: "in the absence of any agreement among economists on what the correct models for inflation (or the rest of the economy) actually are, and given most individuals' limited ability to understand or model these uncertainties, a procedure in which agents base their expectations for future inflation on extrapolations of the recent past may itself constitute a form of optimizing behavior."[13] Also in this context, Mankiw and Reis (2006) suggest to replace the sticky price/wages Phillips Curve by a sticky information formulation. In this model, one fraction of agents sets prices according to the present information set, while another fraction bases its decision on outdated information, either because of costs of acquiring information or costs of reoptimization.

A fourth strand of dealing with serial correlation in the inflation rate has been the introduction of non-optimizing price-setters in an otherwise standard optimizing sticky-price model. It is assumed that firms do not only face "menu costs" that make them reluctant to change prices, but also optimization costs. Building on this idea, albeit without explicitly modeling different information sets, Galí and Gertler (1999) and Amato and Laubach (2003) assume that only a part of firms sets prices in an optimal manner whereas the remaining fraction follows a simple rule. This rule is the same in both papers: non-optimizing firms set their price according to the previously chosen price by both optimizing and non-optimizing firms and to the previous inflation rate, which serves as a proxy to forecast current inflation.

Fifth, Rotemberg (2005) has suggested incorporating fairness considerations into firms' price setting. He states that consumers judge price increases by firms as fair if they are linked to higher costs and as unfair if not. In the latter case, demand should decrease much more than it is actually suggested by the demand elasticity. However, firms try to avoid this reaction by taking into account consumers' fairness considerations which leads to fewer price adjustments. Rotemberg (2005) claims that this idea can also explain persistence in the inflation rate. In situations of high inflation, consumers start to think that firms' costs have been increased and thus accept further price increases as fair. This then provides a link from past inflation to current inflation.

With regards to the long-run nonverticality of the Phillips Curve, only a few

[13] Rudd and Whelan (2006), p.319

theoretical propositions have been made to account for this. Akerlof et al. (2000) have provided a "near-rational" model, in which price and wage setters ignore low inflation rates or only treat them as one factor among others. By building on these different behavioral assumptions, they show that the result is a long-run trade-off between inflation and unemployment. The most well know explanation are models of hysteresis which have been introduced first by Blanchard and Summers (1986). This approach claims that if policymakers do not react fast to a recession and thus extend it longer than necessary, the fraction of long-term unemployed workers increases leading to deteriorating effects on the human capital of the labor force. Through this channel, aggregate demand is also affected in the long-run by moving the non-accelerating-rate-of-unemployment (NAIRU).[14] Graham and Snower (2008) argue that the long-run Phillips Curve becomes non-vertical, if consumers discount the future hyperbolically. Assuming rigid wages but flexible prices, their model works as follows: if inflation rises, the marginal disutility of work increases over the wage contract period, whereas the marginal utility of consumption remains the same. Hyperbolic discounting reduces the present value of the marginal disutility of work relative to the marginal utility to consume. Then, the household raises his labor supply in order to balance the two values; rising inflation leads to higher labor supply and (in their model) also to more output.

2.3 Implications and Critique

The extensions of the New Keynesian models discussed so far are indeed able to derive serial correlation in both the IS and the Phillips curve. As it has been put recently by De Grauwe (2008), p.37, most of these approaches introduce inertia as an exogenous variable, meaning that the source of the restriction lies outside the model. For example, for the widely used Calvo-price setting, all firms would prefer to set their price optimally, however, by assumption, one fraction is simply not able to do so. The same is true for some of the habit formation models, in which individuals do not smooth consumption due to exogenously given social norms that are determined outside the model. Also the widely used rule-of-thumbs deal with inertia in an exogenous way. Even if this approach justifies the use of rule-of-thumbs by optimization costs, it is not explicitly specified when and how these rules are adopted. On the contrary, De Grauwe (2008) and also Mankiw and Reis (2006) present models that include "endogenous inertia". In this case, the persistence follows directly from the agents' optimal decisions and is thus fully developed within the model.

However, various critiques apply for the extensions discussed so far. In the case of the IS curve, models of habit formation and social norms are certainly worth following. However, Dynan (2000) runs a panel data estimation on the household level without finding strong empirical evidence for habit formation.

[14]See for an empirical investigation Gottschalk and Fritsche (2005).

In case of the Phillips Curve, no broadly accepted way of dealing with serial correlation from a theoretical point of view has emerged so far. The Fuhrer and Moore (1995) specification is an ad hoc assumption and not derived from an optimization framework, whereas for the price indexation of Christiano et al. (2005), no compelling empirical evidence has been found. The idea of sluggishly adjusting marginal costs by Galí and Gertler (1999) has been criticized by Fuhrer (2006), who has shown that the persistence in the inflation rate does not stem from "inherited persistence", i.e. from the sluggish adjustment of real marginal costs to the output gap, but from "intrinsic persistence", i.e. the lagged term in the Phillips Curve. The most fundamental critique can be raised in case of the widely used rule-of-thumbs raise for both the IS and the Phillips Curve. First, these rules are not derived from microeconomic decisions but are rather "ad hoc" and are thus subject to the same critique that has been raised earlier against the Neoclassical Synthesis models. Galí et al. (2007),p.238, themselves admit this, but see it as a minor problem: "as noted we do not take a stand on the sources of that behavior, though one may possibly attribute it to a combination of myopia, lack of access to financial markets, or (continuously) borrowing constraints." However, I do not think that this missing microeconomic foundation is a minor problem, namely because of a second critique of the rule-of-thumb models. Since they are assumed "ad hoc", they can be rather arbitrary, depending on the phenomenon the researcher wants to explain. Whereas Galí et al. (2004) and Galí et al. (2007) aim to explain the working of monetary and fiscal policy, Amato and Laubach (2003) are concerned with explaining the statistical significance of lagged terms in the IS and Phillips Curve. In both cases, a different rule is applied seeming to suggest that everything can be explained as long as one introduces an appropriate rule. As an extreme case, Amato and Laubach (2003) even assume a rule that mimics exactly the phenomenon they want to explain, namely a lagged term in both the supply and demand side of the economy.

Concerning the non-verticality of the long-run Phillips Curve, the recent proposition by Graham and Snower (2008) is not convincing either. First, they assume that firms act under conditions of perfect competition, i.e., they do not have any price setting power, which stands both in contrast to the standard New Keynesian Model and does not seem very plausible from an empirical point of view. Instead, Graham and Snower (2008) model inflation persistence solely by introducing staggered nominal wage contracts. Second, introducing hyperbolic discounting in this framework leads to a mechanism which seems at least at odds. As I have explained earlier, it attributes an entirely passive role to firms, whereas the work/leisure tradeoff becomes the main driving force of the model with the demand for labor adjusting independently of any possible lack of demand on the goods markets. To me, these features do not seem to fit with economic reality.

To sum up, even if there have been some promising extensions of the overly simplistic standard New Keynesian model, none of the recent approaches is fully convincing. I will thus try to tackle the problem from a different point of departure. Introducing hyperbolic discounting in the IS curve, I will highlight the resulting differences to the standard framework. This has the advantage that hyperbolic discounting is well grounded in microeconomic behavior, which makes it immune to the critique of being ad hoc.

Before proceeding, it is worth noting that two further important topics have not yet been dealt with convincingly in New Keynesian Macroeconomics. First, a still ongoing debate concerns the question whether and how to introduce money into the model. Already Sidrauski (1967) has pointed to the fact that under an additively separable utility function, money does not affect the steady state of the model even if it has been used in the utility function of the agent.[15] Additively separable utility also affects the second open question, namely the possibility of multiple stable and unstable equilibria.[16] Without downplaying the importance of these questions, I will not treat them further, since they do not affect the question of how individuals discount the future, which is the main purpose of this paper.

3 A Behaviorally Founded IS-Curve

3.1 Hyperbolic Discounting

I will now derive a Behavioral IS curve by introducing hyperbolic discounting instead of the traditionally assumed exponential discounting. Since it is not the aim of this paper to discuss the advantages and disadvantages of this approach in depth, I will simply give a short summary of the key features, referring to Angeletos et al. (2001) and the references cited therein for more details. Strotz (1956) was the first to emphasize problems with the standard exponential time discounting being used in life-time optimization models. The standard exponential discounting procedure implies a constant rate of decline in the utility of consumption, for example, in future periods. However, a wide range of psychological evidence has suggested that individuals are impatient in the short run and patient in the long run, hence, suggesting a higher discount rate in the present than in the future. This feature can be modeled by hyperbolic functions. Laibson (1997) in his seminal paper and Phelps and Pollak (1968) have introduced a discrete version of this, called the "quasi-hyperbolic" discount function, which also captures the empirical evidence that the discount rate drops sharply in the second period. For sake of simplicity, I will also use their quasi-hyperbolic model, with discount factors $1, \delta\beta, \delta\beta^2, \delta\beta^3, ...$, with δ as short run and β as long-run discount factors. Note that the quasi-hyperbolic discount model implies dynamic inconsistency, i.e., a decision maker in the current period will change his preferences in later periods. This is highlighted by a well known example: Being asked today whether they prefer one apple today or two apples tomorrow, most consumers choose the one apple. But when being asked whether they prefer one apple in one year or two apples in one year and one day, most consumers choose

[15] See Jones and Stracca (2008) for a recent empirical treatment of this assumption.

[16] See Obstfeld (1984) and Ono (2001) for a detailed discussion of this topic.

the second option.[17] This inconsistency leads to an intrapersonal conflict between the different current and future selves of an individual: An early self tries to impose his preferences on later selves whereas the later selves maximize their own interests. Already Strotz (1956) has modeled this situation as an intrapersonal game.

3.2 The Question of the Appropriate Time Horizon

It is an important implication of hyperbolic discounting in discrete time that one has to adopt a three period time framework in order to be able to capture time inconsistency. In the standard model, it is always assumed that the representative agent lives forever. This is justified by the following reasons. Technically, under an infinite horizon, one does not face the problem of being forced to specify what happens after the end of the time horizon is reached. Moreover, one does not have to be concerned with the time horizon as an additional exogenous variable, i.e. specifying the concrete length of the time period under consideration. Theoretically, one avoids running into the aggregation problem. As Blanchard (1985) has argued, if the agent lives only finitely, one cannot take him as a metaphor representing the entire differences between agents in the economy, but has to use an overlapping-generation-model instead. If individuals do not live forever, they will have different ages and remaining lifetimes, and thus different levels of wealth and different marginal propensities to consume, a fact that makes the use of the representative agent a very critical assumption.[18] Foregoing the differences between heterogeneous agents, I will adopt a finite time horizon for deriving the consumption decisions. In a standard discrete time model, it would be sufficient to use a two period framework. However, in order to be able to model hyperbolic discounting, it is necessary to adopt a three period framework, since only this makes it possible to get time inconsistency. Adopting hyperbolic discounting also leads to another dimension of the time horizon. Since the occurring time inconsistency is usually modeled as an intrapersonal game between the agent's different current and future selves, one has to use game theory to solve the optimizing decision. Under a finite horizon, it is principally possible to solve the game by backward induction, i.e. one gets a unique solution. By contrast, under an infinite horizon, multiple equilibrium paths are possible.[19]

3.3 The Role of Capital Accumulation

Introducing capital accumulation into the analysis does not only have effects on firms' price setting but also on the role of consumption smoothing. This has gained

[17] See for this example Thaler (1981).

[18] By contrast, assuming an infinite horizon is not a necessary condition for the existence of the Ricardian equivalence concerning the effects of fiscal policy, since this can also be derived under the assumption of a bequest motive of the finitely living agent.

[19] See Harris and Laibson (2001a) and Harris and Laibson (2001b). The authors claim that their results hold under an infinite horizon as well.

new prominence due to the introduction of rule-of-thumb consumers into the standard model and is also relevant for the model with hyperbolic discounting. The argument behind this goes as follows.

In neoclassical consumption theory, consumers smooth their consumption with regard to the expected growth of future income. However, this future income is considered to be non-risky, i.e., the risk of getting unemployed in the future and thus experiencing an income of zero is either not modeled at all or assumed to be idiosyncratic and thus diversifiable.[20] If labor income is not treated as diversifiable anymore and thus becomes an aggregate risk, this makes consumption smoothing less obvious. If a higher expected income growth comes along with a higher variance of future income, this leads to precautionary saving, i.e., the consumer tries to insure himself against this additional risk by consuming less today. This then works as a self-imposed credit restriction: the consumer is not borrowing against his expected future income due to its riskiness.[21]

In the New Keynesian approach, this topic has been dealt with in two ways. In the models by Woodford[22], perfect financial markets have been assumed, implying that labor income risk is diversifiable. In models where this assumption has not been made explicit, a first-order Taylor approximation around the Euler equation has been taken in order to derive the New Keynesian IS-curve.[23] By contrast, introducing rule-of-thumb consumers, Galí et al. (2004) claim that this makes it necessary to introduce capital accumulation in order to have an explicit distinction between a rational, optimizing and consumption smoothing agent when facing risk, and a non-optimizing, non-consumption smoothing rule-of-thumb consumer, who consumes his current income in every period.[24] To sum up, in order to get an important role for consumption smoothing, either one has to assume perfect financial markets, i.e. to assume that future labor income is diversifiable, or one has to introduce capital accumulation in order to have a means of consumption smoothing. In this derivation, I will adopt imperfect financial markets, leaving a thorough treatment of capital accumulation for further research.

[20] In the seminal paper by Hall (1978), this assumption is made explicit by using a quadratic utility function which makes the variance of future income drop out during the optimization process. The assumption of a quadratic utility function has been highly criticized by later authors (Blanchard and Mankiw (1988)) and has been replaced by CARA or CRRA utility functions with more adequate properties.

[21] See for an exposition of precautionary saving, or buffer stock models, Carroll and Kimball (2006).

[22] E.g. Woodford (1996) and Rotemberg and Woodford (1997)

[23] However, Kimball (1990) has shown that one needs a second-order approximation in order to model non-diversifiable risk.

[24] "Notice that in the absence of capital accumulation, the only difference in behavior across household types would be a consequence of the fact that Ricardian households obtain some dividend income from the ownership of firms. Yet, the existence of a market for firms' stocks would not provide a means to smooth consumption, since, in equilibrium, all shares would have to be held by Ricardian consumers in equal proportions." (Galí et al., 2004)

3.4 Consumers and Present Bias

I will introduce hyperbolic discounting in the consumption decisions of households trying to show the implications for the derivation of the IS curve. Introducing microeconomic insights from Behavioral Economics into general equilibrium macroeconomic models has been rare. Exceptions are Barro (1999) who is focusing on the implications of hyperbolic discounting in the Ramsey growth model, Graham and Snower (2008) who model the long-run Phillips Curve under hyperbolic discounting and less directly De Grauwe (2008), who deals with a different way of expectations formation. However, apart from Graham and Snower (2008) who locate the main analysis on the labor market, a thorough treatment of the New Keynesian model with hyperbolic discounting has not yet been done.

For deriving the IS-curve under hyperbolic discounting, I will make use of the results of Luttmer and Mariotti (2003) and especially Harris and Laibson (2001a), who have derived a Generalized Euler Equation under hyperbolic discounting. It is important to note that they start from a precautionary saving model as proposed by Carroll and Kimball (2006), i.e., labor income is non-diversifiable and thus households are liquidity constrained. Hyperbolic discounting makes individuals very impatient; they always prefer current consumption over future consumption. Adding liquidity constraints then prevents these impatient consumers from borrowing against all their future income, leading to a strong comovement between current consumption and current income which has often been found in the data.[25]

I do not include a labor market and I also do not put money in the utility function. The neglect of the first is due to the fact that the labor market only plays a role in deriving unemployment, which is not the aim of this paper.[26] Moreover, to simplify the analysis, I will use log-utility, thus neglecting precautionary saving.

The representative consumer's preferences can then be written in discrete time as:

$$U = E_t \left[\ln C_t + \delta \sum_{i=1}^{2} \beta^i \ln C_{t+i} \right] \tag{1}$$

for $t = t, t+1, t+2$, and with the hyperbolic discount factor $\delta \geq 0$ and the exponential discount factor $\beta \geq 0$. This contains the quasi-hyperbolic case, if both $\delta, \beta < 1$.

[25] The literature distinguishes between sophisticated agents, who anticipate that later selves will have different preferences and try to adopt strategies to prevent a change in behavior, whereas the naive agent does not take this into account. Commitment as one strategy of early selves leads to the fact that hyperbolic consumers hold a higher level of illiquid assets than exponential ones in order to prevent future selves to change their actions. Under full commitment, both exponential and hyperbolic consumer types behave fairly similar, even if in some cases there can be remarkable differences (Angeletos et al., 2001). For the purpose of this paper, these differences are not important.

[26] The New Keynesian model fails to explain involuntary unemployment without modeling some sort of real rigidities on the labor market.

The agent's budget constraint in period t is

$$C_t + \frac{S_t}{P_t} = \frac{X_t}{P_t}, \tag{2}$$

where $X_t/P_t \geq 0$ is "cash-on-hand", i.e. the agent's original endowments, liquid wealth, or initial real money balances.

In the subsequent periods $t+1$ and $t+2$, the agent receives labor income $\widetilde{Y}_t$, which is supposed to be stochastic i.i.d., symbolized by the tilde. Including savings given the nominal interest rate R_t from the first period, the subsequent budget constraints can be written as:[27]

$$C_{t+1} + \frac{S_{t+1}}{P_{t+1}} = \frac{R(X_t - C_t)}{P_{t+1}} + \frac{\widetilde{Y}_{t+1}}{P_{t+1}} \tag{3}$$

This problem can then be solved by using dynamic programming. This method, first introduced by Bellman, deals with solutions for discrete time optimization problems. Variables are split into state and control variables. The first one characterizes the state of a system, whereas its initial state X_t is historically given (= endowments or "cash-on-hand"). Since labor income is random, the only state variable of the system is liquid wealth X_t. The control variables are the choices of the decision maker (here: consumption). Assuming a value for X_t, the whole time path can be computed. The value function describes the time path which maximizes utility summed over the whole time period. Since one has to solve a game under time inconsistency, one has to slightly adjust the method. Considering a finite time horizon, one can solve the game by backward induction. Adopting the perspective of self t, two different value functions have to be specified, thus splitting the problem into two parts. This can be seen by spelling out the utility function (1) from the perspective of self t:

$$U = \ln C_t + \delta \left[\beta \ln C_{t+1} + \beta^2 \ln C_{t+2}\right] \tag{4}$$

Hence, self t faces two choices: He has to choose between today's consumption and the entire future consumption being additionally discounted by δ, and he has to choose between the different future periods. The first choice is the hyperbolic decision, the second choice is the standard exponential decision. Note that for the latter, self t uses the same exponential discount factor β for the subsequent periods $t+1$ and $t+2$. Thus, one can set up a continuation-value function $V(X_{t+1}/P_{t+1})$, i.e. the expected present discounted value of the utility stream beginning in $t+1$, depending on X_{t+1}/P_{t+1} which has been determined in t, as:

$$V\left(\frac{X_{t+1}}{P_{t+1}}\right) = \ln C\left(\frac{X_{t+1}}{P_{t+1}}\right) + E_{t+1}\beta VC\left(\frac{X_{t+2}}{P_{t+2}}\right) \tag{5}$$

[27] Woodford (1996), assuming perfect financial markets, shows that the flow budget constraint adopted here can be equally expressed as a set of intertemporal budget constraints, if a Non-Ponzi condition on borrowing is satisfied.

or, by plugging in $X_{t+2}/P_{t+2} = R(X_{t+1} - C(X_{t+1}))/P_{t+2} + \widetilde{Y}_{t+2}/P_{t+2}$:

$$V\left(\frac{X_{t+1}}{P_{t+1}}\right) = \ln C\left(\frac{X_{t+1}}{P_{t+1}}\right) + E_{t+1}\beta V\left[\left(\frac{R(X_{t+1} - C(X_{t+1}))}{P_{t+2}}\right) + \left(\frac{\widetilde{Y}_{t+2}}{P_{t+2}}\right)\right] \tag{6}$$

Note, that in an infinite time horizon model, this continuation-value function would be the same for all the periods following $t+1$, seen from the perspective of self t. In my three-period framework, however, the continuation-value function in $t+2$ is simply:

$$V\left(\frac{X_{t+2}}{P_{t+2}}\right) = \ln C\left(\frac{X_{t+2}}{P_{t+2}}\right) \tag{7}$$

In a second step, at time t, self t uses the discount factor $\beta\delta$, thus his current value-function $W(X_t/P_t)$ can be written as:

$$W\left(\frac{X_t}{P_t}\right) = \ln C\left(\frac{X_t}{P_t}\right) + E_t\beta\delta V\left[\left(\frac{R(X_t - C(X_t))}{P_t}\right) + \left(\frac{\widetilde{Y}_{t+1}}{P_{t+1}}\right)\right] \tag{8}$$

Since consumption is chosen by self t in the current period t, he maximizes utility out of consumption by choosing C. This gives the FOC of (8):

$$\frac{1}{C(X_t/P_t)} - E_t R\beta\delta V'\left[\frac{R(X_t - C(X_t))}{P_t} + \frac{\widetilde{Y}_{t+1}}{P_{t+1}}\right] \geq 0 \tag{9}$$

i.e., the marginal utility of consumption $U'(C_t) = 1/C(X_t/P_t)$ can be expressed as follows:[28]

$$\frac{1}{C(X_t/P_t)} = E_t R\beta\delta V'\left[\frac{R(X_t - C(X_t))}{P_t} + \frac{\widetilde{Y}_{t+1}}{P_{t+1}}\right] \tag{10}$$

Next, one can show a direct link between the continuation-value function V and the current-value function W. To do so, first forward the expression for the current-value function W in (8) by one period, divide by δ and rearrange:

$$E_{t+1}\beta V\left[\left(\frac{R(X_{t+1} - C(X_{t+1}))}{P_{t+1}}\right) + \left(\frac{\widetilde{Y}_{t+2}}{P_{t+2}}\right)\right] = \frac{1}{\delta}\left[W\left(\frac{X_{t+1}}{P_{t+1}}\right) - \ln C\left(\frac{X_{t+1}}{P_{t+1}}\right)\right] \tag{11}$$

Then, this expression can be plugged into the continuation-value function V in (6):

[28] In what follows, I will assume that this expression holds with equality, which is the case if $C(X_t) < X_t$, since then the term in the bracket becomes positive.

$$\begin{aligned} V\left(\frac{X_{t+1}}{P_{t+1}}\right) &= \ln C\left(\frac{X_{t+1}}{P_{t+1}}\right) + \frac{1}{\delta}\left[W\left(\frac{X_{t+1}}{P_{t+1}}\right) - \ln C\left(\frac{X_{t+1}}{P_{t+1}}\right)\right] \\ \delta V\left(\frac{X_{t+1}}{P_{t+1}}\right) &= W\left(\frac{X_{t+1}}{P_{t+1}}\right) - (1-\delta)\ln C\left(\frac{X_{t+1}}{P_{t+1}}\right) \end{aligned} \tag{12}$$

Finally, this expression linking the current- and the continuation-value function can be combined with the FOC in (10) to give the Hyperbolic Euler Equation:[29]

First, differentiate the "linked equation" (12) using the chain rule:

$$\delta V'\left(\frac{X_{t+1}}{P_{t+1}}\right) = W'\left(\frac{X_{t+1}}{P_{t+1}}\right) - (1-\delta)\frac{1}{C(X_{t+1}/P_{t+1})}C'\left(\frac{X_{t+1}}{P_{t+1}}\right) \tag{13}$$

and substitute this expression for $\delta V'(X_{t+1}/P_{t+1})$ in the FOC (10):

$$\frac{1}{C(X_t/P_t)} = E_t R\beta\left[W'\left(\frac{X_{t+1}}{P_{t+1}}\right) - (1-\delta)\frac{1}{C(X_{t+1}/P_{t+1})}C'\left(\frac{X_{t+1}}{P_{t+1}}\right)\right] \tag{14}$$

In order to replace $W'(X_{t+1}/P_{t+1})$, one can use the Envelope theorem: stating that any derivative of the current-value function W with respect to the choice variable C_t must be equal to zero, one gets the result that the derivative of W with respect to X_t is the same as the marginal utility of consumption:

$$W'\left(\frac{X_t}{P_t}\right) = U'\left(C\left(\frac{X_t}{P_t}\right)\right) = \frac{1}{C(X_t/P_t)} \tag{15}$$

Substituting and rearranging yields the Hyperbolic Euler Equation. If $\delta = 1$, one gets the standard exponential Euler equation.

$$\begin{aligned} \frac{1}{C(X_t/P_t)} &= E_t R\beta\left[\frac{1}{C(X_{t+1}/P_{t+1})} - (1-\delta)\frac{1}{C(X_{t+1}/P_{t+1})}C'\left(\frac{X_{t+1}}{P_{t+1}}\right)\right] \\ &= E_t R[\beta\frac{1}{C(X_{t+1}/P_{t+1})} - \beta\frac{1}{C(X_{t+1}/P_{t+1})}C'\left(\frac{X_{t+1}}{P_{t+1}}\right) \\ &+ \beta\delta\frac{1}{C(X_{t+1}/P_{t+1})}C'\left(\frac{X_{t+1}}{P_{t+1}}\right)] \\ &= E_t R\left[\left(\beta\delta C'\left(\frac{X_{t+1}}{P_{t+1}}\right) + \beta\left(1 - C'\left(\frac{X_{t+1}}{P_{t+1}}\right)\right)\right)\frac{1}{C(X_{t+1}/P_{t+1})}\right] \end{aligned} \tag{16}$$

Harris and Laibson (2001a) call the term in brackets the "effective discount factor", which is a weighted average of the short-run discount factor $\beta\delta$ and the long-run

[29] Harris and Laibson (2001a) call this the Strong Hyperbolic Euler Equation derived under the assumption of a continuous consumption function. They show that a more general expression also holds if this is not the case.

(exponential) discount factor β. The weights are the marginal propensity to consume (MPC) out of liquid wealth, and $1 - MPC$. Remember that the consumer is assumed to be liquidity constrained. This leads to the fact that a negative income shock reduces cash-on-hand, since the consumer cannot insure himself against this shock. And if he does so by keeping a buffer stock of precautionary savings, this works as a self-imposed liquidity constraint. In case of liquidity constraints, consumers will have a high MPC, since every increase in income acts as a relaxation of the (self-imposed) constraint and is thus nearly totally consumed. Hence, consumers with low level of cash-on-hand will have a high MPC. Changes in the future MPC affect the consumer as follows. Note that the effective discount factor is the higher the lower the future marginal propensity to consume. A rise in the future marginal propensity to consume signals to self t that the future self $t+1$ will consume more, thus reducing the planned saving of self t. However, self t values marginal saving in period $t+1$ more than marginal consumption, thus a rise in the expected MPC makes self t value the future less than the present.[30] And, given that low levels of cash-on-hand imply a high MPC, this leads to a stronger comovement of current consumption and income. This is exactly the behavior which has been assumed by Galí et al. (2007), though, by using hyperbolic discounting and liquidity constraints, it could have been derived from microeconomic optimization.

To derive an IS-curve from this Hyperbolic Euler Equation, the standard procedure of log-linearization can be applied. Under CRRA-utility ($U = C^{1-\eta}/(1-\eta)$), including prices, and defining $MPC_{t+1} \equiv C'(X_{t+1})$, $\phi \equiv 1-\delta$, and $\pi_{t+1} \equiv \ln P_{t+1} - \ln P_t$, one can rewrite the Euler equation as follows:[31]

$$\frac{C_t^{-\eta}}{P_t} = R\beta E_t \left[\delta MPC_{t+1} + (1 - MPC_{t+1})\right] \frac{C_{t+1}^{-\eta}}{P_{t+1}} \tag{17}$$

$$-\eta \ln C_t - \ln P_t = \ln R\beta + \ln E_t \left[(\delta - 1) MPC_{t+1} + 1\right] - E_t[\ln P_{t+1}] - \eta E_t[\ln C_{t+1}]$$

$$-\eta \ln C_t = \ln R\beta + \ln E_t \left[1 - (1 - \delta) MPC_{t+1}\right] - E_t[\ln P_{t+1}] + \ln P_t - \eta E_t[\ln C_{t+1}]$$

$$\ln C_t = E_t[\ln C_{t+1}] - \frac{1}{\eta}\ln R\beta - \frac{1}{\eta}\ln E_t \left[1 - (1 - \delta) MPC_{t+1}\right] + \frac{1}{\eta} E_t[\pi_{t+1}]$$

$$\ln C_t = E_t[\ln C_{t+1}] - \frac{1}{\eta}\left(\ln R\beta - E_t[\pi_{t+1}] + \ln E_t \left[1 - \phi MPC_{t+1}\right]\right)$$

Remember that I treat a closed economy without state and capital accumulation. In this case one can simply replace C_t by Y_t in the equation above in order to get the IS-curve. However, one can also model the other components of the goods market equilibrium as demand shocks. Let $X = I + G + EX - IM$, one can write for the goods market:

[30] Under commitment, this makes the self in t keep less liquid cash-on-hand, in order to prevent self $t+1$ from overconsuming.

[31] Note that I have not derived the role for prices explicitly. However, this can be done easily by allowing for bonds in the budget constraint (Luttmer and Mariotti, 2003).

$$C_t = Y_t - X_t = (1 - X_t/Y_t)\,Y_t \tag{18}$$

Then, taking logarithms, defining $-\ln(1 - X_t/Y_t) \equiv D_t$, one gets $\ln C_t = \ln Y_t - \ln D_t$ which can be substituted into the Euler equation to yield the IS-curve:

$$\ln Y_t - \ln D_t = E_t[\ln Y_{t+1} - \ln D_{t+1}] - \frac{1}{\eta}\left(\ln R\beta - E_t[\pi_{t+1}] + \ln E_t\left[1 - \phi MPC_{t+1}\right]\right)$$

$$\ln Y_t = E_t[\ln Y_{t+1}] - \frac{1}{\eta}\left(\ln R\beta - E_t[\pi_{t+1}] + \ln E_t\left[1 - \phi MPC_{t+1}\right]\right) + \epsilon_{d,t}, \tag{19}$$

where $\epsilon_{d,t} \equiv \ln D_t - E_t[\ln D_{t+1}]$ is defined as demand shock. The difference to the standard New Keynesian IS-curve is the last term, i.e. the appearance of the expected future marginal propensity to consume MPC_{t+1}. A rise in the expected MPC increases output today, since it reduces the role for intertemporal substitution of consumption. In case of higher real interest rates, the representative consumer would wish to postpone consumption to later periods. However, in case of hyperbolic discounting, he knows that his self in the next period will not stick to this plan, thus his current saving is reduced. One would thus expect a reduced effect of higher real interest rates on current output.

4 Conclusion and Outlook

To sum up, note that the contribution of this paper is twofold. First, it summarized the state of the art of the ongoing research in the standard New Keynesian Macroeconomic Model. It has been shown that a range of questions remains unanswered, concerning especially the explanation of serial correlation and the (long run) effects of macroeconomic policy. Second, hyperbolic discounting has been used for the derivation of the New Keynesian IS curve. It has been argued that for analytical simplicity, both a finite and an infinite time horizon can be useful. Indeed, apart from being able to forgo the distinctions between economic agents and the problem of multiple equilibria in the intrapersonal game, adopting an infinite horizon does not make a huge difference. Concerning the results, it has been shown that using hyperbolic discounting in a New Keynesian Macroeconomic Model can be promising and deserves further research. In contrast to rule-of-thumbs, which are usually assumed ad hoc, this first model builds on microeconomic evidence and is also able to give similar results, for example with respect to the comovement of income and consumption.

Several open questions remain for further research. First, note that I have not dealt with firm behavior and the question of general equilibrium. It would certainly be worth preceding this analysis and running simulations to examine whether the hyperbolic New Keynesian model can lead to greater persistency in the data than in the standard formulation. Second, with regard to consumption, it would be interesting to extend the model further by allowing for mental accounting. This has shown to be one way to deal with the commitment problem of agents and results in different marginal propensities to consume depending on the source of income. Third, I think it could be promising to analyze the effects of hyperbolic discounting in state-dependent models. In these models, the mark-up firms are able to change can be dependent on firms' price setting, which confronts firms with a double choice and thus possibly with a time inconsistency problem. In a broader context, one could link the topic of time discounting to institutional policy questions. Households can avoid the time inconsistency problem by committing themselves to savings schemes that can only be dissolved under high financial costs. However, in the course of the ongoing financial liberalization and flexibilization, one could imagine that it becomes much harder for households to gain access to self-committing financial products. In a similar vein, with respect to firms, one can imagine institutional arrangements, as financing investment by banks instead of financial markets for example, that overcome the present bias in management behavior. This would extend the "Varieties of Capitalism" research program[32] analyzing different institutional settings that have been developed in order to overcome coordination and principal agent problems.

Finally, it is worth noting that there are some authors who argue that adopting hyperbolic discounting in the way it has been done in this model is not enough. Rubinstein (2003) has claimed that the empirical and experimental evidence pointing against the standard exponential discounting can also be interpreted against its now widely used alternative. He suggests that the evidence cannot only be explained by changing the utility function slightly by adding a second discount factor, but can also be interpreted by a procedural approach, for which he provides further support by experiments. However, Rubinstein does not argue for a return to standard exponential discounting, but asks for a much more radical approach to deal with decision making: rather than "marginally modifying our models, we need to open the black box of decision making, and come up with some completely new and fresh modeling devices."[33] So far, however, applying hyperbolic discounting to macroeconomic models seems to do a rather good job as a first step to build a "Behavioral Macroeconomics".

[32]Hall and Soskice (2001)
[33]Rubinstein (2003), p.1215

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