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Classifying Monetary Economics: Fields and Methods from Past to Future

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Abstract

We propose a simple, yet sufficiently encompassing classification scheme of monetary economics. It comprises three fundamental fields and six recent areas that expand within and across these fields. The elements of our scheme are not found together and in their mutual relationships in earlier studies of the relevant literature, neither is this an attempt to produce a relatively complete systematization. Our intention in taking stock is not finality or exhaustiveness. We rather suggest a viewpoint and a possible ordering of the accumulating knowledge. Our hope is to stimulate an improved understanding of the evolving nature and internal consistency of monetary economics at large.

Key words: monetary economics, monetary theory, monetary policy, public finance, classification, methodology

JEL codes: E40, E50, E60

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Contents

> "The beauty of economics as an intellectual pursuit is its position at the intersection of formal theory, statistical analysis, and human events – coupled with its ultimate potential to improve peoples' everyday lives. A master economist must assume away the distracting inessential details of a situation in the interest of mathematical clarity. At the same time, he or she must see how relevant subtleties may affect the interpretation of the data and the applicability of different models in real life. Because the ultimate policy decisions at stake are so complex, with such vast potential to do harm or good in the world, economics (and especially macroeconomics) is perpetually unsettled, subject to constant questioning and reassessment." Obstfeld (2008)

1. Introduction

Monetary economics links closely with macroeconomics and it is both ultimately policy-oriented and perpetually unsettled. We here take stock of our current understanding of this particular subject area in its relation to the seminal papers of the past as well as the most promising avenues for future research. Moreover, our purpose is to propose a compact systematic classification scheme of monetary economics by main field and method of study. We hope that such a condensed and ordered restatement of the key themes and findings of earlier and recent work in monetary analysis would be useful in placing in perspective the essentials of our knowledge to date and the priorities for further inquiry.

There appears to be no commonly agreed or used explicit classification of monetary economics. The *Journal of Economic Literature* codes include monetary economics within macroeconomics at large, and separately from international, financial, or public economics. The *Handbook of Monetary Economics* (1990) edited by Friedman and Hahn, in two volumes, employs the following headings for the eight parts delineated in its structure: (1) money in the Walrasian economy, (2) money in non-Walrasian settings, (3) money in dynamic settings, (4) money demand and money supply, (5) pricing non-money assets, (6) money, other assets, and economic activity, (7) money, inflation and welfare, (8) monetary policy. In the preface to the handbook the editors begin by stating: "Monetary economics has always represented a symbiosis, albeit at times an uncomfortable one, between a priori theorizing and the development and exploitation of empirical evidence" (p. xi). They continue to embed this particular field, denoted as "formal theory describing an economy with money, and perhaps

other financial instruments" (p. xi), within the deeper structures of utility maximization and economic equilibrium, pointing to the tension ('handicap' in their words) arising because it has turned out difficult to accommodate money with general equilibrium. Stressing the interaction between theory and evidence, they also insist that it is hardly possible to separate these two aspects of monetary economics from a third one, of implicit or explicit evaluation of "actual policies carried out in the past or, correspondingly, judgments about potential future policies" (p. xi). Walsh's (2003) textbook on monetary theory and policy does not offer a uniform classification either, listing eleven chapters that are not organized in bulkier units. Woodford's (2003) treatise on the theory of monetary policy suggests a grouping of its eight chapters into two parts called respectively 'analytical framework' and 'monetary policy', but the focus in Woodford (2003) is in the narrower area of monetary policy, not the broader one of monetary economics.

The present synthetic contribution, therefore, seeks to propose a simple but also more structured and sufficiently encompassing classification that provides an overall perspective on monetary economics. We begin by elaborating on our scheme in the section that follows.

2. A Compact Classification Scheme of Monetary Economics

Our compact systematization of the monetary literature here focuses on three fundamental fields and six recent areas of work that expand within and across these fields. Neither the core fields nor the current trends we choose to highlight are found – at least altogether and in their relation among themselves – in earlier surveys of this literature. We visualize and streamline our discussion in what follows around a central diagram we now introduce, in Figure 1, which may be called a 'field-method map' of monetary economics. On this 'extended' Venn diagram, we first identify what we think are the three major fields/methods of monetary inquiry. We then summarize and evaluate, in turn, the ingredient subfields, topics and approaches in both what constitutes the more 'traditional' research (the three intersecting circles in Figure 1) and those of the 'innovative' extensions on the agenda nowadays that all hold the promise of a great potential (the six rectangles in the right-hand side of the same figure). We make clear the structure of the diagram, illustrating our main points, as this survey progresses on. With the help of Figure 1, we offer in the next sections a tour across monetary economics, revisiting the key issues and results as understood at

the turn of the millennium. This intellectual tour mostly focuses on some recurrent themes, at the same time expounding the basic terminology and delimiting the constituent elements of our proposed classification.

[Figure 1 about here]

With some prudent risk of oversimplifying and from perhaps the broadest perspective possible, one could identify, define or demarcate the subject area of 'monetary economics' as consisting of three fundamental fields that have traditionally occupied the interest of researchers (see the intersecting circles constituting the Venn diagram of Figure 1). We would call these three core fields as follows: monetary theory; monetary policy; and public finance. The numbering at this first-digit level in the diagram is rather arbitrary, although at the next, double-digit level (i.e. within each circle in Figure 1) it is intended to be roughly indicative of the chronology of the respective theories or approaches. Our distinction among the three core fields is based on the main issues of inquiry and the key techniques of analysis involved. The rationale for unifying these three fields under the label of monetary economics is that they all treat somewhat autonomous yet interrelated aspects of the same grand topic, namely, (general or macroeconomic) equilibrium in (models of) monetary economies. The common ground of all three fundamental fields from a theoretical viewpoint is that each tries to rationalize – i.e. to microfound, in a more modern language – an aspect of the demand for or supply of money or of the role of government policy in attempting to achieve certain socially desirable outcomes by partially controlling, by force of legislation, the money supply process.

The definition for monetary *theory* we would maintain throughout thus involves rationalizing and microfounding *money* itself as well as its *demand* in positive quantities by economic agents. Monetary *policy*, by contrast, will have to provide rationale and microfoundations to the *supply* of money and the unique role of the *central bank* in affecting it.[1] *Public finance* will have to rationalize and microfound the broader intervention of the government into the market mechanism: mostly *fiscal* policy in addition to monetary policy, but also other, structural (or supply-side) and social security policies. The main reason for linking monetary-fiscal (and other

[1] What is suggested in the text becomes obvious once the ideas in favor of free banking have historically ceded to the alternative of monopoly of note issue, granted by law to a non-profit-maximizing monetary authority acting in the national interest.

public) policies is that the consolidated general government would have to (eventually) comply with a *common* intertemporal budget constraint, such as those also faced – more tightly – by any other economic entity.[2] Moreover, as Samuelson (1958) and Diamond (1965) have demonstrated, the function of money as a store of value *alone* is sufficient for monetary policy to affect equilibrium allocations of resources, even assuming away any other functions (e.g. medium of exchange or unit of account) or services (such as liquidity) that money is also assigned to fulfill.

The three intersecting circles define a total area with seven regions. The unique central region where all three circles intersect represents topics and approaches that are pertinent to *all three* core fields. The three other regions where distinct *pairs* of the three circles intersect identify topics and approaches that are common to *only two* of the fundamental fields of monetary economics. Finally, the three regions with *no intersection* denote relatively autonomous territories of monetary (and fiscal) inquiry. Of course, the proposed classification is meant to be illustrative and, hopefully, convenient in offering an overall perspective on monetary economics, but with no claims for either exhaustiveness or high precision.

The six rectangles drawn to intersect the monetary policy and public finance circles in the right-hand side of Figure 1 are, rather, intended to be of relevance to *all three* core fields, including monetary theory proper. Their role in the diagram is to identify and (approximately) label six major recent trends in extending the 'traditional' area of monetary theory and policy to 'novel' issues and/or methods. Our focus later on will be precisely on these innovative approaches that update recurrent themes from past studies. But before moving to the present state of research, it would be useful to motivate and link in some systematic way the ingredients of the three circles of fundamental knowledge in monetary economics.

In structuring the paper we keep in line with the plan implicit in Figure 1. Accordingly, section 3 outlines the fundamental fields of monetary economics; section 4, in turn, discusses some important extensions in ongoing research; and

[2] Bloise and Polemarchakis (2006) define money and monetary policy as well as their link with fiscal policy in a similar way: "Money is a store of value that serves as a unit of account and medium of exchange. Monetary policy is the conduct of the monetary authority in the issuance and supply of money balances." Further down on the same page they stress that "it is not possible to consider monetary distinct from fiscal policy, and this is because of the accounting consistency required by general equilibrium: alternative specifications of the distribution of seignorage have different implications for the determinacy of equilibria, akin to the distinction, Woodford (1994), between Ricardian and non-Ricardian policies" (p. 1).

section 5 summarizes and concludes. Within each circle of traditional issues or rectangle of novel trends, we try to keep track – insofar possible and where relevant – of three aspects, namely, the most common (i) rationale, (ii) methods, and (iii) findings.

3. Fundamental Fields of Monetary Economics

The usual approach in most of monetary economics is to ignore or, rather, subsume the public finance literature within either or both of the remaining two core fields in our diagram. This would give rise to a grand field that can be denoted *microfounded macroeconomics* or *general equilibrium with money*. Various authors have recently termed versions of the fundamental fields we suggested in different ways.[3] Yet the precise concepts involved are not that crucial. What is more important is the apparent consolidation on how to split the broad domain of monetary economics into two subfields, theory and policy. We would instead prefer to treat here public finance as a distinct, third core field, often constituting in fact the intersection of the other two.

3.1 Monetary Theory

Looking first at monetary *theory* and applying a criterion of distinction that is both historical and methodological (or analytical) in nature, the major strands of literature could be classified in (at least) five approaches, explicit in the double-digit numbering in circle 1 of Figure 1.

Classical models of money demand comprise one such approach. Fisher (1911) first postulated and Friedman (1956) extended (1.1 in the diagram) such models, which led to the several versions of the quantity theory of money (QTM). These would be the earliest more or less well-specified models of money, although very much ad-hoc themselves.

Keynesian models of money demand, implicit in Keynes (1936) and developed more formally by Baumol (1952) and Tobin (1956, 1958), adding bonds as an alternative

[3] For example, our monetary *theory* circle in the diagram is referred to as 'models of money that meet certain *a prori* desiderata' (p. 847) or also 'matching models of money' (p. 851) in Wallace (2001), 'basic literature' (p. 715) in Kocherlakota (2005), and simply 'money' (p. 1) in Bloise and Polemarchakis (2006). Our monetary *policy* core field is then called by the same authors, respectively, 'money-is-productive models' (p. 847), 'applied literature' (p. 715) and 'monetary policy' (p. 1). The literature Kocherlakota (2005) classifies under the label 'applied' is not such in the usual sense, but the 'theory' in it does involve 'shortcuts' (p. 847), in the words of Wallace (2001), or 'simplifying assumptions' (p. 2), in the milder qualification of Bloise and Polemarchakis (2006).

asset to money and highlighting the role of the interest rate and transactions-technology costs (1.2 in Figure 1), are a second recurrent theme. Since these models allow for bonds, they are accounted for in our diagram in the intersecting region of monetary theory and public finance.

Models of money in general equilibrium (GE) with *only* (net) lump-sum transfers available have constituted a third field of research (1.3 in Figure 1), out of which the so-called Friedman (1969) rule has come out as a rather robust result. The Friedman rule says that the optimal policy (in such model contexts) would be to equalize the return on money and other assets by setting the nominal interest rate to zero and aiming at a mild deflation, thus guaranteeing a positive real interest rate. Chari, Christiano and Kehoe (1996) and Correia and Teles (1996, 1999) have further shown that Friedman's rule remains optimal even to extensions allowing for distortionary taxes in the *absence* of lump-sum transfers.[4] Moreover, Chari, Christiano and Kehoe (1996) have found it robust to three popular environments of modeling money, namely, those of Sidrauski (1967), assuming money balances entering the utility function, Kimbrough (1986), assuming a shopping-time model to motivate money, and Lucas and Stokey (1987) assuming a model with cash (hence, cash-in-advance constraint) and credit goods. Since Friedman's rule qualifies, in essence, what optimal monetary-fiscal policy should be, the literature of that kind is considered to occupy the intersection of the three fundamental fields in Figure 1. This central core of our diagram is, in that sense, perhaps the most relevant – or legitimate – subject-matter of monetary economics properly understood.

The same could be said of the type of models (1.4 in Figure 1) attempting to rationalize through shortcuts, yet not out of more primitive microfoundations, money in GE. Hahn (1965) has notably argued that money is redundant in *real* competitive GE because money cannot maintain a *positive* price. Since then, it has been hard to find and prove formally a role for money in such models. In *monetary* models that developed in response to Hahn's conundrum – e.g. by Clower (1967), involving a cash-in-advance (CiA) constraint, or by Sidrauski (1967) and Brock (1974, 1975), relying on a money-in-the-utility (MiU) function assumption – (i) transaction-technology costs (such as CiA or in the Keynesian tradition of Baumol, 1952 – Tobin, 1956, or, later, in Prescott, 1987) or (ii) shopping-time costs (where money and time

[4] Phelps (1973) has noted that Friedman's rule may hinge exactly on this restrictive assumption.

are substitutes) have been invoked to generate a *positive* money demand; alternatively and for the same purpose, real money balances have been directly embedded either (iii) in the utility function (hence, MiU approach to introducing money in GE models) or (iv) in the production function (sometimes referred to as money-as-intermediate-input approach). CiA versus MiU approaches to justifying a role for money in general equilibrium have been for some time lively debated, as they were often found to imply different analytical results and so, potentially, different policy recommendations, until Feenstra (1986) demonstrated their equivalence within a certain class of widely used models.

Finally, Kiyotaki and Wright (1989, 1991) and a large subsequent literature have delved into a deeper dimension of modeling monetary economies in a coherent way, beyond the 'shortcuts' rescuing money in GE and into the microeconomics of what has become known as search or random-matching models of money (1.5 in the diagram). The search literature focuses on formally microfounding money (and, thus, money demand) in GE and is, for that reason, classified in the non-intersecting region of circle 1. This may, however, be somewhat misleading insofar search models often come up with conclusions about the 'optimal monetary policy'. Nevertheless, characterizing the latter is not their main or direct objective, neither policy is derived within a relatively rich and realistic institutional set-up: so far it has been rare for these models, as Kocherlakota (2005) also points out, to go beyond other assets than money and into explicit modeling of the money supply process or its interactions with seignorage, taxation and other public finance issues.

Our analysis does not attempt to separate out what is sometimes called models of *exogenous* money, where money allocation is random or where the central bank controls perfectly the supply of money, versus models of *endogenous* money, where the supply of money arises endogenously, which is then adjusted accordingly and automatically to the demand for money to simply generate equilibrium in the money market. Even under systematic monetary policy there may be exogenous components, e.g. due to money velocity shifts or imperfect monetary control, which the empirical vector autoregression (VAR) approach has in fact employed in identifying monetary policy shocks. On the other hand, monetary policy can be neither purely exogenous, nor fully controlled, as the central bank responds only imperfectly to the current or expected future state of the economy, which has in turn provided rationale for the

theories and estimation of policy reaction functions. Real Business Cycle (RBC) models have ignored the role of money altogether as irrelevant.

3.2 Monetary Policy

The key differences in the set of assumptions between what we referred to as monetary *theory* and monetary *policy* (both potentially including aspects of public finance) have been summarized in a lucid way by Bloise and Polemarchakis (2006):

> "Simplifying assumptions facilitate the argument; in particular, it is often appropriate (1) to take for granted, and do not attempt to explain, the prevalence of monetary transactions, of exchanges of goods for money, and model the liquidity services of money balances as cash-in-advance constraints; (2) to restrict attention to fiat money, a zero-coupon bond of infinite maturity, whose quantity and value are not linked to any other commodity or asset, but for equilibrium relations; (3) to postulate, in a first instance, a complete asset market, so as to focus on money as a medium of exchange, independently of its role for purposes of intertemporal transfers of revenues and, possibly, insurance.", Bloise and Polemarchakis (p. 2).

Strangely enough, it is rare indeed to find monetary *theory* and monetary *policy* integrated or at least considered alongside in the same work. The surveys by Wallace (2001), Wright (2005), Kocherlakota (2005) or Bloise and Polemarchakis (2006) almost completely ignore[5] coverage of the themes and methods we classify in our monetary *policy* core field. Likewise, overviews from the 'other camp', such as those by Goodfriend and King (1997), Clarida, Galí and Gertler (1999), or Woodford (2003), tend to largely (if not absolutely) neglect the more 'fundamental' issues related to justification of the existence of money in competitive GE, i.e. monetary *theory* proper (1.5 in our diagram). Obviously, the disregard of each of those literatures to the other is *reciprocal*. A rare recent exception, at least in the title, is Lagos and Wright (2005); in essence, though, what the latter authors understand to be monetary policy is not what the mainstream nowadays Neo-Wicksellian or New Keynesian approach to the theory of monetary policy, e.g. expounded in the books by Woodford (2003) or Galí (2008), also defines and studies. In the remainder of this

[5] Unless to mention imperfections in the 'short-cut' approach to just accepting money, not 'fundamentally' proving its *raison d'être*.

subsection we sketch just a few among the numerous topics and methods in the literature on optimal monetary policy.[6]

The earliest, rather informal accounts of how monetary policy should be conducted relate to the practice of central banking and the corresponding debates on the appropriate monetary standard (or nominal anchor, in a modern sense). Discursive analysis of what is termed today stabilization policy has become more active once the gold standard (1776–1914) and, recently, the Bretton-Woods system (1944–1971) of fixed and convertible (into gold) parities between pairs of national currencies have been abandoned. Fisher (1896, 1911, 1923, 1930) and Wicksell (1898, 1907) are early classics, to which Khan, King and Wolman (2003) and Woodford (2003), respectively, have paid due tribute. Keynes's (1936) *General Theory* is another seminal work, which has given birth to macroeconomics. Hicks (1937) has ingenuously condensed the key messages of Keynes's book in the simple analytical and graphical apparatus[7] that has dominated academic and policy debates for almost half a century, the well-known IS-LM model.

Such macroeconomic stabilization topics have somewhat later, following World War II, been refined and conceptualized, mostly in terms of (long-run or ultimate) *goals* (called also *targets* and implying respective strategies of formulation) and (short-term or operating) *instruments* (called also *tools* and enabling relevant tactics for implementation) of monetary policy (2.1 in Figure 1). Tinbergen (1952) and Theil (1961, 1964) constitute the first authoritative formal treatment of economic policy. The development of *dynamic programming* by Bellman (1957) and followers and of *optimal control* by Pontryagin and colleagues (1962), as well as Muth's (1961) rational expectations (RE) formulation have further contributed to the methodological enhancement of earlier economic models and econometric approaches. Following work by Lucas (1972, 1976) and Sargent and Wallace (1975), applications of RE have become popular in the core fields of monetary economics we discuss here, together with applications of the theory of games developed by Von Neumann and Morgenstern (1944). Strategic interactions (in the 1980s) and incentive-contract

[6] Our own perspective on the new consensus recommending constrained policy discretion is developed in a companion paper, Arestis and Mihailov (2007). The references therein orient into the huge related literature.

[7] The 'hydraulic' model was considered to oversimplify Keynes's (1936) theory, and as "a retreat back inside the orthodox citadel" (Davidson, 2005, p. 451).

aspects (in the 1990s), to which we return later, have gradually been added to the optimal monetary policy problem, bringing in more realism and further developments.

These involve several dimensions, the most important ones being reflected in Figure 1. Kydland and Prescott (1977) established the dominance of rules over discretion (2.2 in Figure 1) because of the 'time-inconsistency' problem, implying ex-post incentives for a government to use 'surprise inflation' to reduce the real value of any outstanding fiat money, as Calvo (1978) pointed out, and what Barro and Gordon (1983 a) called 'inflationary bias' of discretion (potentially, under the influence of interfering politicians). Repeated interaction was seen by Barro and Gordon (1983 b) as a solution to the inflationary bias via the build up of *reputation* and, hence, *credibility*. The rules versus discretion debate led to the institution-design literature, launched in the monetary policy area perhaps by Lohmann (1992). It evolved into *targeting* rules as a particular modern type of a monetary regime. Such inflation(-forecast) targeting frameworks were initially adopted in the early 1990s, with Svensson (1997 a, b) and Bernanke and Mishkin (1997) being among the first academics to embrace, formally justify and popularize this new fashion in central banking. A growing number of papers and books has been accumulating since then, particularly within the empirical New Keynesian models (2.3 in Figure 1), presented exhaustively in Galí (2008), or the theoretical Neo-Wicksellian paradigm (2.4 in Figure 1), expounded coherently in Woodford (2003).

This New Keynesian or Neo-Wicksellian research essentially justified the *flexible* variant of inflation targeting, i.e. when the central bank responds to an *output* gap measure in addition to the (forecast) *inflation* gap relative to the inflation target, as *the* optimal monetary policy. Forecast-based targeting also allows for judgment to 'adjust' the conclusions from a number of alternative models central bankers use in decision making. There has not been so far a case where a country would abandon an inflation targeting framework, similarly to abandoning other monetary strategies in the past such as exchange-rate pegs or money growth guidelines. This fact itself speaks eloquently in favor of inflation targeting, yet it may be premature to deny any potential drawbacks of the apparently successful recent monetary regime.

3.3 Public Finance

The public finance core field in our classification scheme of monetary economics at large can be, in essence, identified by its joint consideration of *both* monetary and fiscal policies in their *interdependence*.[8] The modern, *dynamic* reinterpretations in Barro (1979) and Lucas and Stokey (1983) of the classic Ramsey (1927) problem of *statically* choosing optimal taxation brought the broader public finance literature, and in particular the strand within it focusing on the inflation tax, into optimal policy analysis. Since the early 1980s this approach has dominated GE macroeconomic models. Related work on the *optimal monetary-fiscal mix* could broadly be subdivided into (at least) four major strands.[9]

The original public finance literature (3.1 in Figure 1) begins with Ramsey (1927) on optimal taxation, Friedman (1948) on the role of policy for economic stability and Barro (1979) on the concept of Ricardian equivalence. The latter hypothesis implies that the intertemporal budget constraint of the government is always satisfied, which Sargent (1982) terms a *Ricardian regime*, also described by Leeper (1991) as *monetary dominance*, because monetary policy is active and fiscal policy is passive. Differently from the initial set-ups where only lump-sum transfers were assumed available and where the Friedman rule was found optimal, later research extended the so-called Ramsey problem of choosing the socially desirable policy by adding distortionary taxes and other assets in addition to money and bonds.

Most of the subsequent work follows the mathematical, optimization-based Ramsey approach that has become increasingly detailed and sophisticated over the years. Major papers in that line of research (3.2 in Figure 1) include Lucas and Stokey (1983), Persson, Persson and Svensson (1987, 2006), Chari, Christiano and Kehoe (1991), Chari and Kehoe (1999), Schmitt-Grohé and Uribe (2004 a, b, 2007), Benigno and Woodford (2003, 2006). All of these derive in a model-specific context certain optimal fiscal *and* monetary policy and, sometimes, also analyze the implied degree of monetary-fiscal coordination. Alternative approaches evolving since the 1980s

[8] Note, however, that a large body of the recent New Keynesian literature still largely ignores such interactions, mostly for reasons of tractability.

[9] It should be pointed out that our overview of the public finance literature here focuses on the more conventional and more closely related to monetary economics dynamic Ramsey approach to optimal taxation, including in particular the inflation tax. These models assume a representative agent, a benevolent government and availability of a credible commitment technology. Of course, the opposite assumptions of heterogeneous agents, political-economy strategic games and discretion are subject to ongoing explorations in various fields, to some of which we return in section 3.

have often considered the optimal monetary-fiscal mix within game-theoretic work on strategic interaction, policy conflict, coordination failures and, hence, the need for coordinated actions if policy effectiveness is to be increased, e.g. in Nordhaus (1994). Modern treatments extend further into the design of optimal incentive schemes, which could be thought of as contracts or institutions. Separation and delegation of powers from a principal to an agent and the related incentive-compatibility design and enforceability with view to some social optimum have been the key issues of focus in such studies.[10]

A third strand (3.3 in our diagram), concentrating on how fiscal policy ultimately plays a crucial role in determining the price level, could be classified under its usual label, the fiscal theory of the price level (or FTPL). Its major proponents are Leeper (1991), Sims (1994) and Woodford (1994, 1995) while McCallum (1999, 2001, 2003) and Buiter (1999, 2002) figure among its persistent critics. Notably, with Ricardian equivalence, McCallum and Nelson (2006) have claimed that monetary-fiscal coordination does not matter at all.

A fourth line of public finance literature (3.4 in Figure 1), particularly in the 1970s and the 1980s but also nowadays, has progressively developed more and more sophisticated overlapping-generations (OLG) models with money and has applied them to public policy and social security systems. Works widely cited in this subfield include Auerbach and Kotlikoff (1987) and Auerbach, Kotlikoff and Leibfritz (1999), among others.

Certainly, a lot is to be expected from future research at the intersection of optimal monetary and fiscal policies. In particular, Bloise and Polemarchakis (2006) claim that a solution to the conundrum by Hahn (1965) concerning the difficulty to generate a positive price for money in GE has been found in alternative formulations by Drèze and Polemarchakis (2000) and Dubey and Geanakoplos (2006) where both policies are explicitly modeled.

4. Recent Extensions of Monetary Economics

To put our attempt at a compact systematization in perspective, we next selectively sketch the rationale, main approaches and key results of the most influential recent

[10] These aspects are also well represented in the literature on monetary policy separately from fiscal policy, as will be noted further down.

and likely future trends of research in monetary economics. Our exposition continues to follow the logic of Figure 1, but now we concentrate on the rectangles in its right-hand side. As noted, the topics and methods listed as ingredients of these rectangles are in fact nowadays permeating all three core fields by providing relevant extensions and intersections within and across them.[11]

4.1 Richer Heterogeneity and Complexity (A in Figure 1)

Traditional models of monetary economies have remained until very recently limited within theoretical frameworks postulating a representative agent. Advances in computing have, however, eliminated the necessity of such simplification. More and more research has, consequently, engaged in modeling and simulating heterogeneity and complexity of various forms.[12]

The earliest and simplest forms of heterogeneous agents in monetary models appear to have been the overlapping-generations (OLG) models, where old and young generations interact (e.g. Samuelson, 1958), as well as search models of money where agents with money, willing to buy goods, interact with agents without money, willing to sell endowments (e.g. Kiyotaki and Wright, 1989). In both frameworks heterogeneity is reduced to only two types of agents. But these limitations have gradually been addressed by introducing further complexities (A.1 in Figure 1). Of particular relevance for monetary (and financial) models with positive and normative implications has been to study different kinds of informational asymmetries. These are often related to ways of learning, updating and forecasting or to other boundedly rational ways to acquire, process and use information (D in Figure 1) under uncertainty or ambiguity (F in Figure 1) by various agents and institutional sectors, including the central bank. We briefly review some of these concepts and results in the narrower contexts of the respective subsections further down.

[11] Describing in more detail the multiple aspects of the ongoing developments within this literature goes far beyond the purpose of the present study, but checking the papers quoted further down and the references therein would provide a good starting point for a deeper exploration.

[12] Present day computationally intensive algorithms allow efficient modeling of diverse interactions between agents and groups of agents that are heterogeneous across a considerable number of dimensions. For more on these developments and in a context much more general than that of monetary economies, including interactions of complex social or markets systems with evolutionary and computational algorithms related to physics, biology or neuroscience, one could refer to Ríos-Rull (1999), Markose (2005), Blume and Durlauf (2006), Gilbert (2007), Fagiolo, Moneta and Windrum (2007), Moss (2008).

We may note at this point that A.2 in Figure 1 is a particular implementation of richer heterogeneity with distributional implications, also incorporating individual as well as aggregate uncertainty yet simple enough to be analytically tractable. More importantly, this line of research proposed by Golosov, Tsyvinski and Werning (2006) under the brand of *new dynamic public finance* and as extension to Mirrlees (1971) has provided a novel alternative to the Ramsey approach in public finance outlined earlier. One rationale for it has been to relax the assumption of exogenously given tax instruments in the Ramsey framework. The new dynamic public finance thus studies *endogenous* tax instruments whose purpose is to redistribute across agents heterogeneous in their skills and risk attitudes under private information. Golosov, Tsyvinski and Werning (2006) derive a two-period 'workhorse' model of this kind and provide an overview of the field, challenging three of the standard results obtained in Ramsey set-ups. First, instead of recommending not to tax *capital* in the long run (e.g. as in Judd, 1985 and Chamley, 1986), it is argued that introducing an implicit distortion in savings to discourage them is optimal. Second, perfect *labor* income tax smoothing (e.g. as in Barro, 1979 and Lucas and Stokey, 1983) is not optimal either when agents have uncertain and evolving skills. Third, the *nature* of the time-consistency problem changes as well.

4.2 Game-Theoretic and Coordination Issues (B in Figure 1)

There are, broadly speaking, two strands of the game-theoretic and coordination literature that are closely related to topics in monetary economics. Both address optimal policy. However, one of them limits attention to strategic interactions between policymakers and the private sector or to coordination issues between fiscal and monetary policy within the same national economy, i.e. this is a problem of choosing and implementing the optimal macroeconomic policy mix. The other strand transfers the implications of strategic policies and social welfare spillovers beyond national borders, thus studying the international aspects of monetary and/or fiscal policy coordination. In this subsection we only give a flavor for the major results along each of these two dimensions, inviting the interested reader to go deeper into the works referenced in and referencing our two hopefully representative illustrations below.

In a *domestic* economy context (B.1 in Figure 1), Dixit and Lambertini (2003), among others, analyze monetary-fiscal interactions when the monetary authority is more

conservative than the fiscal authority. Their main finding is that joint commitment of the monetary and fiscal authorities achieves the social optimum, which they term 'the second best', the 'first best' being attainable only if a production subsidy financed by per-head taxes neutralizes the distortion of monopolistic competition in their model. Commitment of one of the authorities under discretion of the other is an inferior outcome. If no commitment is possible, the second best could be implemented in two alternative ways: either by assigning identical targets; or by completely separating the targets of the fiscal and monetary authorities, to avoid conflict of interest.

Building upon earlier work (including their own: Corsetti and Pesenti, 2001), Corsetti and Pesenti (2005), among others, develop a baseline GE model of optimal monetary policy among *interdependent* economies with monopolistic firms and nominal rigidities (B.2 in Figure 1). They find that an inward-looking policy of domestic price stabilization is not optimal when firms' mark-ups are exposed to currency fluctuations. Such a policy raises exchange rate volatility, leading foreign exporters to charge higher prices when facing increased uncertainty in the export market. As higher import prices reduce the purchasing power of domestic consumers, optimal monetary rules trade off a larger domestic output gap against lower consumer prices. Optimal rules in a world Nash equilibrium lead to less exchange rate volatility relative to both inward-looking rules and discretionary policies, even when the latter do not suffer from any inflationary bias. A key conclusion is that gains from international monetary cooperation are related in a nonmonotonic way to the degree of exchange rate pass-through.

4.3 Banking Sector, Macro-Finance and Financial Innovation (C in Figure 1)

Recent research in monetary economics has increasingly become interested in modeling explicitly a banking sector, macro-finance links and/or financial innovation. Earlier PE or GE monetary models have usually abstracted away from such realistic details. In this subsection we opt to illustrate two major strands of such work.

A first strand stresses the importance of *financial intermediation*, extending in various ways the microfounded but simple bank run set-up of Diamond and Dybvig (1983). Many papers have focused on modeling or estimating the credit channel of monetary policy transmission and the effects of liquidity or limited-participation constraints of agents in credit markets. Bernanke and Blinder (1988, 1992) developed and tested a

model where in addition to the standard, *money channel* (e.g. in earlier Keynesian or monetarist frameworks) a second, *credit channel* is operative. The money channel works via banking-sector liabilities (deposits), while the credit channel affects banking-sector assets (loans). The microeconomic justification Bernanke and Blinder (1988, 1992) suggest for the credit channel is that banks acquire expertise in screening loan projects and monitoring loan performance, which allows them to extend credit to customers unable to obtain credit in the financial market. Christiano, Eichenbaum and Evans (1996) provided early evidence from VARs based on the flow of funds accounts of the household sector in the US in favor of such *limited-participation constraints* that were being built within monetary business cycle models.[13] Bernanke, Gertler and Gilchrist (1996) further argued that worsening of the credit market conditions following adverse shocks can amplify the effects of these shocks on the economy, a mechanism they denote as the 'financial accelerator'.[14] One major difficulty in modeling credit in addition to money when the latter is essential in the sense of Kocherlakota (1998) and Wallace (2001), i.e. when its use expands the sets of allocations, is that credit requires record-keeping while money not. To address this problem and incorporate banking within a search framework, Berentsen, Camara and Waller (2007) extend the divisible money model of Lagos and Wright (2005) by introducing financial intermediation (C.1 in Figure 1). They find that, in general, financial intermediation improves the allocation and that the gains in welfare arise from the payment of interest on deposits, not from relaxing the liquidity constraints of borrowers. A novel result is also that increasing the rate of inflation can be welfare improving when credit rationing occurs in their model.

Another strand of the monetary literature has shifted the focus towards trying to understand the consequences of *financial innovation*. Since the late 1960s, concerns have increasingly been expressed in academia and policy circles that financial innovation, which spurred with the deregulation of banking and the advance of computing technologies, may have led to the break-up of econometric relationships among monetary aggregates and macroeconomic variables, e.g. between narrow

[13] This assumption more precisely means that households cannot adjust their financial assets and liabilities immediately after a monetary shock.

[14] Studies along these lines in the past decade have also dealt with the implications of adverse selection and moral hazard as major problems of asymmetric information which financial intermediation was meant to mitigate. Another related literature that has often become referred to as *macro-finance* integrates asset price dynamics in financial markets and, in particular, the term and risk structure of interest rates into theoretical or empirical models of monetary policy.

money and the price level. This was important insofar it affected the forecastability and controllability of the economy by the central bank. Moreover, the abundant spread and use of non-cash money across the globe by the late 1990s has led to debates on the trend towards cashless societies where credit and debit cards replace paper currency as well as on the impact of financial innovation (coupled with globalization) on inflation dynamics and monetary control. It is paradoxical to note that the dominant approach to monetary policy today has gone that far so as to deny the role of money in monetary policy. The motivation consists in the (alleged) theoretical inferiority of monetary aggregates to the respective interest rates as instruments of monetary policy and apparently reflects the trends towards cashlessness in the real world. This Neo-Wicksellian approach is most convincingly represented by what is termed 'models without money' or a 'cashless economy' (C.2 in Figure 1) in the sense of Woodford (1998, 2003). He has notably argued that money is not essential to modeling the effects of monetary policy under sticky prices, insofar these are transmitted via an interest-rate feedback rule which responds optimally to inflation and output gap forecasts summarizing the state of the economy.

4.4 Bounded Rationality, Learning and Rational Inattention (D in Figure 1)

We next only give a flavor for the main issues and findings of the huge and active literature at the intersection of bounded rationality with monetary economics.

A first, widely exploited approach at present relates learnability of equilibrium to policy feedback, as we briefly explain. Since Taylor (1993) reaction functions which specify how the monetary authority should set (ex ante), or has actually set (ex post), a short-term interest rate instrument in response to the present or expected future state of the economy has received much attention in the monetary policy literature. Empirical work has attempted to verify the *positive* perspective of simple Taylor-type rules for various countries and periods and with varying degree of success. The theoretical literature has, in turn, studied the properties of simpler or more complicated versions of instrument and related targeting rules from a *normative* perspective. In particular, the main concern has been that such rules intended to optimally guide the conduct of monetary policy and, as a consequence, to serve the crucial function of anchoring inflationary expectations should be carefully designed so as not to introduce additional instability in the economy. Accordingly, analytical work has examined extensively the existence, uniqueness and dynamic stability of

rational-expectations equilibria (REE) within the basic frameworks employed in modeling the effects of monetary policy. The study of real determinacy under a *boundedly* rational process of learning by agents, usually Bayesian (D.1 in Figure 1), has led to the concept of expectational stability (E-stability or learnability) of REE, introduced in Evans (1985) and expounded within broader context in Evans and Honkapohja (2001, 2003 a, b).

Along these lines, Bullard and Mitra (2002) consider interest-rate rules in a *closed*-economy *REE* model and show that if monetary policy is sufficiently aggressive the economy has an equilibrium that is not only unique but also learnable. 'Sufficiently aggressive' means consistent with the so-called 'Taylor principle' (see Woodford, 2001 referring to Taylor, 1999), which states that the central bank should increase its (nominal) interest rate instrument by more than one-to-one following an increase in (expected) inflation.[15] Bullard and Mitra (2007) furthermore investigate the consequences of policy inertia modeled as an interest-rate smoothing term in the standard Taylor rule equation, and find that this can increase the learnability of equilibrium. Llosa and Tuesta (2007) extend Bullard and Mitra (2002) to a small open economy (SOE), building as well upon the SOE set-up in Galí and Monacelli (2005). Their key finding is that, contrary to Bullard and Mitra (2002), expectations-based rules that involve the CPI and/or the nominal exchange rate limit the region of E-stability and the Taylor principle does not guarantee E-stability.[16] They also show that some forms of managed exchange rate rules can alleviate problems of both indeterminacy and expectational instability, yet these rules might not be desirable since they promote greater volatility in the economy.

Bullard and Schaling (2006) examine how determinacy and learnability of 'worldwide' REE may be affected by monetary policy in a simple two-country New Keynesian framework under both fixed and flexible exchange rates. The main result is that open-economy considerations may alter conditions for determinacy and learnability relative to closed-economy analyses, and that new concerns can arise

[15] I.e. that the coefficient to inflation in the monetary policy reaction function should be higher than unity, to ensure an increase in the real interest rate that helps reduce aggregate demand and, ultimately, the initial inflationary pressure.

[16] De Fiore and Liu (2005) and McKnight and Mihailov (2007) find analogous results concerning determinacy of REE in a SOE CiA model and in a two-country MiU model with nonseparability between consumption and real money balances, respectively.

when exploring classic topics such as the desirability of exchange rate targeting and monetary policy cooperation.

A second strand of monetary literature that builds upon bounded rationality is related to the notion of rational inattention (D.2 in Figure 1), introduced in economics by Sims (2003). Kasa (2006) presents a succinct background to this research, initiated by Shannon (1948) in the field of information theory. The key contribution of Shannon (1948) has been to view information as a stochastic process and quantify it in terms of the conditional probability distribution generating the data. He defined an *information transmission channel* as a mapping between inputs (e.g. a sound or signal) and observed outputs (what is heard or perceived, isolating the accompanying additive 'noise' as much as possible), and the *capacity* of such a channel as the maximum rate at which signals can be transmitted with a small detection error. Sims (2003) applied Shannon's (1948) concepts to describe individuals as finite capacity information transmission channels. He went on to stress that, if so, measurement error is unavoidable and rational, due to the constraints of the human brain to collect and process the information relevant in decision making. The problem of an economic agent is, hence, to minimize the sum of squared forecast errors subject to a lower bound on the variance of the measurement error decreasing with a given processing capacity. In such a context, *rational inattention* could be optimal: agents are 'inattentive' to small shocks in the sense that they ignore or do not react to them, and adjust their behavior only to bigger shocks, whenever the latter occur. Studying economic interactions that involve rational inattention is currently an active agenda, in particular in monetary and financial applications.

4.5 Incentives, Contracts and Mechanism Design (E in Figure 1)

Athey, Atkinson and Kehoe (2005) have broadly denoted the type of literature we consider in the present subsection as *legislative approach to monetary policy*. It has grown out of the seminal work of Kydland and Prescott (1977) and Barro and Gordon (1983 a, b) as well as the well-known extensions of Canzoneri (1985), Rogoff (1985), Lohmann (1992) and Walsh (1995), among others. However, the legislative approach differs from the one in the early literature on rules versus discretion, as does too the implied notion of discretion. The early literature assumes that society has no mechanism for committing to rules governing monetary policy, while the legislative approach, deemed more appealing for advanced economies, solves this dynamic

mechanism design problem. The papers we cited as well as recent work along similar lines[17] usually propose incentive schemes or contracts written between society and its representatives (parliaments and governments), on the one hand, and elected policymakers or appointed expert institutions (e.g. a central bank or a monetary policy committee), on the other, that are often viewed as institutional frameworks for policymaking. It is natural in this context to also think of the standard principal-agent problem and of certain mandates of policy delegation, hence, of issues of independence, transparency and accountability (E.1 in Figure 1).

A concise description of the general methodology of the legislative approach to monetary policy is provided in Athey, Atkinson and Kehoe (2005). It is assumed that society designs the optimal rules governing the conduct of monetary policy by the monetary authority via an agreed-upon social welfare function that depends on the random state of the economy. The monetary authority observes the state, while individual agents do not. Well designed rules trade off society's desire to give the monetary authority discretion to react to its *private information* against society's need to prevent that authority from giving in to the temptation to stimulate the economy with unexpected inflation, the *time inconsistency* problem. The solution the authors suggest to this apparently complex dynamic mechanism design problem (E.2 in Figure 1) is simple, and consists in legislating an inflation cap. The optimal degree of monetary policy discretion then shrinks as the severity of the time inconsistency problem increases relative to the importance of private information. In an economy with a severe time inconsistency problem and unimportant private information, commitment is optimal.

4.6 Uncertainty, Ambiguity and Robust Control (F in Figure 1)

The main rationale for introducing techniques of robust control in economic modeling and policy evaluation has been the acknowledgement of the pervasiveness of uncertainty in real-world economies and decision making. Its purpose has been the enhancement of optimal control methods, mostly deterministic until recently, used in studying macrodynamics and formulating policy, by more complex features involving uncertainty or ambiguity and the ensuing robust control approaches to economic policy in a stochastic environment, pioneered by Hansen and Sargent (2003, 2007).

[17] See, for example, the various formalizations in Beetsma and Bovenberg (2005), Castellani and Debrun (2005), Hughes Hallet and Libich (2006), Mihailov and Ullrich (2007); or Blinder (1997) and Wyplosz (2005), for a more general discussion.

Hansen and Sargent (2007) begin their book by stating: "Classical and modern control theory supplied perfect tools for applying Muth's (1961) concept of rational expectations to a variety of problems in dynamic economics" (p. 3). But more recently concerns about model misspecification, i.e. model uncertainty, led to extending these methods to robust control and estimation. Their contribution with this book, as they describe it concisely, is to extend robust control theory and estimation from engineering and physics into economics.

As early as Brainard (1967), economists have been attempting to appropriately characterize optimization problems that policymakers are bound to solve under *uncertainty*, distinguishing two types: (i) uncertainty about the *impact* of the realization of a shock on a single-variable target (F.1 in Figure 1), a type of uncertainty usually termed just *uncertainty* (or *risk*, in finance) or *shock* uncertainty (usually of an additive functional form, hence, *additive* uncertainty) in the recent research on robust control; and (ii) about the *response* parameter in the policy feedback model (F.2 in Figure 1), now called *parameter* uncertainty (of a multiplicative form, hence, *multiplicative* uncertainty). Two other types of uncertainty that are widely employed at present, including in work on optimal monetary policy are: (iii) the so-called *model* uncertainty, i.e. when the researcher has more than one model of the economy and is not certain which one of them is the 'true' model (F.3 in Figure 1); and (iv) what was known until very recently as *Knightean* uncertainty, after Knight (1921), but is now synonymously referred to instead as *ambiguity*, when the researcher is not able to assign even subjective probabilities to *all* possible stochastic events, so that he does not know (completely) the set of possible outcomes of one or more shock processes (F.4 in Figure 1). The earlier literature concerning decisions under uncertainty of type (i) above, i.e. such that has nothing to do with the actions of the policymaker, had commonly prescribed certainty-equivalence behavior, meaning that "the policy maker should act on the basis of expected values as if he were certain they would actually occur" (Brainard, 1967, p. 413).

More recent work has extended this prescription in various directions, and depending on the sophistication of the models involved. Novel monetary policy research on all these – and other[18] – types of uncertainty is currently very active, and likely to remain

[18] For example, *information* uncertainty and such related to combining information (e.g. observation window, disaggregate information, role of judgement) or *measurement* uncertainty (e.g. real time analysis).

so in the future. We close our discussion by an indicative illustration below of the major issues in a few recent and influential papers.

Among many others, Onatski and Williams (2003) have pointed out that the policy implications of uncertainty are strongly dependent on the underlying assumptions of how it is modeled. They have developed methods to analyze *parameter* uncertainty, in particular, concluding that the aggressiveness found in robust policy rules[19] is likely to be caused by overemphasizing uncertainty about economic dynamics at low frequencies. Building on this work, Levin, Onatski, Williams and Williams (2005) use a microfounded macroeconometric modeling framework to investigate the design of monetary policy when the central bank is uncertain about the true structure of the economy. They apply Bayesian methods to estimate the parameters of the baseline specification using post-war US data, and then determine the policy under commitment that maximizes household welfare. The main result is that the performance of the optimal policy is closely matched by a simple operational rule that focuses solely on stabilizing nominal wage inflation.[20] Giannoni (2007) adopts an extended framework where the policymaker faces uncertainty about model parameters *and* shock processes. The robust optimal policy rule in his forward-looking model, then, is likely to involve a stronger response of the interest rate to fluctuations in inflation and the output gap than in the absence of uncertainty. Thus, parameter uncertainty *alone* does not necessarily justify a weak response of monetary policy to perturbations, as found by some of the previous literature.[21]

Svensson and Williams (2008) go further in examining alternative monetary policies under a relatively general form of *model* uncertainty, so-called Markov jump-linear-quadratic systems extended to include forward-looking variables.[22] They provide an algorithm for finding the optimal policy as well as solutions for arbitrary policy functions, which allows computing and plotting consistent distribution forecasts – fan charts – of target variables and instruments. These methods extend certainty

[19] E.g. by Craine (1979), Sargent (1999) or Söderström (2002).
[20] Furthermore, this simple wage stabilization rule is remarkably robust to uncertainty about the model parameters and to various assumptions regarding the nature and incidence of the innovations. However, the characteristics of optimal policy are very sensitive to the specification of the wage contracting mechanism, thereby highlighting the importance of additional research regarding the structure of labor markets and wage determination.
[21] E.g. Brainard (1967), Rudebusch (2001) or Ellison, Sarno and Vilmunen (2007).
[22] This form encompasses simple i.i.d. model deviations, serially correlated model deviations, estimable regime-switching models, and more complex structural uncertainty about very different models, e.g. backward- and forward-looking models or time-varying central-bank judgment about the state of model uncertainty.

equivalence and 'mean forecast targeting' to more general certainty non-equivalence and 'distribution forecast targeting'. Finally, Kasa (2006) models robust control *and* rational inattention jointly. He claims that when considered separately these two features are observationally equivalent: a higher filter gain can be interpreted either as an increased preference for robustness or as an increased ability to process information. If considered simultaneously, he argues that an increased preference for robustness can be interpreted as an increased demand for information processing, whereas rational inattention models like the one in Sims (2003) can be interpreted as placing a constraint on the available supply. Kasa (2006) concludes that the way agents actually implement robust decision rules is by allocating some of their scarce capacity to process information to problems with high degree of model uncertainty and sensitivity to risk.

5. Summary and Conclusions

The objective of the present paper is to propose a compact systematic ordering of the major fields and methods in the subject area of monetary economics. In doing so, we have also strived to summarize selectively yet representatively (insofar possible) the rationale, approaches and findings of the most influential past and recent trends in this literature. Notably, we made an attempt to compress the logic of our classification into a straightforward referential diagram. The diagram comprised three fundamental fields, monetary theory, monetary policy, and public finance, and highlighted six areas of current research, expanding within and across the fundamental fields. The elements of our scheme are not found altogether and in their mutual relationships in earlier studies, neither are attempts for a simple but relatively complete systematization. Such a task is, no doubt, challenging, and we do not claim here exhaustiveness or finality. Our intention is rather to take stock of this active and diverse field by suggesting a synthetic viewpoint. We hope in this way to stimulate an improved understanding of the evolving nature and internal consistency of monetary economics at large.

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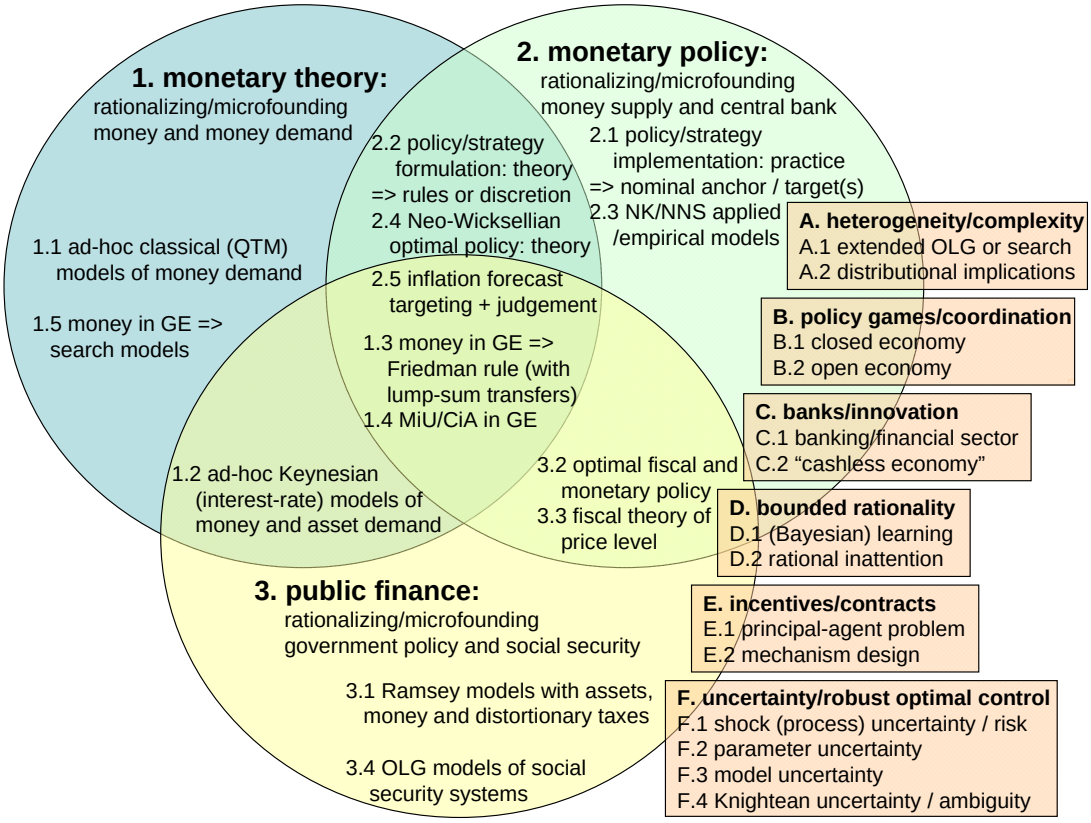

Figure 1:
A Field-Method Map of Monetary Economics