



Modeling diverse expectations in an aggregated New Keynesian Model[☆]



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ABSTRACT

We explore a New Keynesian Model with diverse beliefs and study the aggregation problems in the log-linearized economy. We show the solution of these problems depend upon the belief structure. Agents' beliefs are described by individual state variables and satisfy three Rationality Axioms, leading to the emergence of an aggregate state variable named "mean market state of belief." In equilibrium, endogenous variables are functions of mean market belief and this state variable is the tool used to solve the aggregation problems.

Diverse beliefs alter the problem faced by a central bank since the source of fluctuations is not only exogenous shocks but also market expectations. Due to diverse beliefs the effects of policy instruments are not monotonic and the trade-off between inflation and output volatilities is complex. Also, monetary policy can counter the effects of market belief by aggressive anti-inflation policy but at the cost of increased volatility of financial markets and individual consumption.

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1. Introduction

The New Keynesian Model (in short NKM) has become an important tool of macroeconomics. Due to its assumption of monopolistic competition, prices are firms' strategic variables and price stickiness is a cause for money non-neutrality and

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efficacy of monetary policy. The model is inherently heterogeneous: it does not start with a representative agent and the large number of household-firms need not be identical. Up to now most research on the NKM has been done under the strong Rational Expectations (in short RE) assumption that all agents are identical and with policy implications that may be questioned. It is thus only natural to ask what is the effect of heterogeneity on the conduct of monetary policy and the exploration of this question is our long term goal. In this paper we focus on the narrow question of how to formulate an aggregate model when agents hold heterogeneous expectations. To that end we formulate a *microeconomic* NKM in which agents hold diverse beliefs and investigate whether the model can be aggregated. “Aggregation” means that we deduce from the microeconomic equilibrium, in a manner compatible with the probabilistic structure of agents’ beliefs, a *set of structural relations among macroeconomic aggregates* that constitute a dynamic macroeconomic NKM. Moreover, if such aggregation is possible, what are the implications of diverse beliefs to the resulting macroeconomic dynamics and policy?

Before proceeding we note that as the era of RE comes to a close, it is useful to keep in mind two points. First, the success of RE in disciplining macroeconomic modeling should not obscure the fact that the term “rational” is merely a label. Rationality of actions and rationality of beliefs have little to do with each other and using the term “rational” in RE has tended to brand all other beliefs as “irrational.” Rational agents who hold diverse beliefs do not satisfy the RE requirements but may satisfy other plausible principles of rationality. Indeed, the study of axioms of belief rationality is a fruitful area of research that can fill the wide open space between the extremities of RE and true irrational beliefs.

A second point relates to private information. Many scholars use the device of asymmetric private information as the “cause” of diverse beliefs. Indeed, some view diverse beliefs as *equivalent* to asymmetric information. This is theoretically and empirically the wrong solution and Kurz (2008, 2009) explains why. Suffices to say that market behavior of agents holding diverse beliefs with common information is very different from the case when they have private information. Under private information individuals guard their private information and deduce private information from prices. Without private information agents are willing to reveal their forecasts and use the opinions of others (i.e. market belief) only to forecast future prices and other endogenous variables, not as a source from which to deduce information they do not have. In addition, all empirical evidence associates diverse forecasts to diverse modeling or diverse interpretation of public information (e.g. Batchelor and Dua, 1991; Frankel and Froot, 1990; Frankel and Rose, 1995; Kandel and Pearson, 1995; Takagi, 1991). Finally, the volatility of RE models with private information is fully determined by exogenous shocks, consequently they cannot deliver the main dynamic implications of economies with rational and diverse beliefs with common information (see Kurz, 2009). This key implication is that diverse beliefs constitute a volatility amplification mechanism and excess economic fluctuations are *caused* by diverse beliefs. It is an economic risk which is generated *within the economy*, not by exogenous shocks, and is thus called *Endogenous Uncertainty* (See Kurz and Wu, 1996; Kurz, 1997). These properties are explored in Kurz (2009, 2011a) and discussed later in Section 4.

To explore problems of aggregation, we concentrate on the standard version of the NKM. With this in mind we follow developments in Woodford (2003), Walsh (2010) and Gali (2008). We note the axiomatic approach of Branch and McGough (2009) to the aggregation problem, a method adopted by others such as Branch and Evans (2006, 2011) and Branch and McGough (2011). The Branch and McGough’s (2009) axioms are made directly on the expectation operators, not on beliefs. As they are motivated by bounded rationality, they violate typical models with diverse beliefs. In contrast, we specify *rationality* axioms on beliefs and show they offer a natural route to a NKM with diverse beliefs where aggregation is attained in the log linearized economy. This last point is important since it will be clear a “representative household” does not exist in the model developed below and aggregation of the true economy is not possible in most cases. Instead, we study the aggregation problem in the log linear economy which is the standard economy used for virtually any policy analysis.

The source of our aggregation results is the structure of agents’ beliefs. To highlight this point note there is a growing literature on monetary policy with diverse beliefs which treats the problem of aggregation as follows. For any model developed denote the model’s expectations of x_{t+1} by $E_t x_{t+1}$ and suppose that in the model there are N types of agents in proportions n_i^t , each holding properly specified conditional expectation $E_t^i x_{t+1}$. All members of the same type hold the same expectations. Then, it is assumed that

$$E_t x_{t+1} = \sum_{i=1}^N n_i^t [E_t^i x_{t+1}]$$

where the aggregate expectations $E_t x_{t+1}$ is assumed a conditional expectation with respect to some probability. Examples for this approach are Adam (2007), Anufriev et al. (2008), Massaro (2012), Arifovic et al. (2007), Brazier et al. (2008) and De Grauwe (2011). We first note that it is well known (see Kurz, 2008) that as defined above $E_t x_{t+1}$ violates iterated expectations and, in general, there is no probability measure with respect to which it is a conditional expectation. Averaging probability measures does not yield a regular probability measure. Going beyond this technical issue, we show in this paper that the problem of aggregation is deeply connected to the problem of defining a concept of market belief. Hence, in order for the agents’ optimal decision functions to aggregate one must impose restrictions on the individual beliefs underlying the expectations $E_t^i x_{t+1}$ which cannot be arbitrary, as assumed above. We shall show in this paper that it is exactly the Rationality Axioms of individual beliefs that provide a set of sufficient conditions for aggregation to be attained.

Ideas about diverse beliefs we use here are drawn from the literature on the Rational Beliefs (in short RB) theory. Kurz (1994, 1997) are early work and Kurz (2009, 2011) are recent surveys. The work here extends results of Kurz (2008) and Kurz and Motolese (2011). As to monetary policy, Motolese (2001, 2003) shows that diverse beliefs cause, on their own, money non-neutrality. Kurz et al. (2005) and Jin (2007) offer the first formal models showing diverse beliefs constitute an

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