Journal of Macroeconomics 34 (2012) 1020–1033

Contents lists available at SciVerse ScienceDirect

Journal of Macroeconomics

journal homepage: www.elsevier.com/locate/jmacro

On model ambiguity and money neutrality

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ARTICLE INFO

Article history:
Received 12 January 2012
Accepted 6 August 2012
Available online 6 September 2012

JEL:
E40
E31
E48
E52
O42

Keywords:
Money neutrality
Dynamic monetary equilibrium
Model misspecification
Preference for robustness
Risk aversion
Stochastic money supply process
Stochastic capital growth process

ABSTRACT

We solve for the equilibrium of a stochastic neo-classical continuous time model without and with money under model ambiguity. We show that: (i) the correction for ambiguity stemming from the money supply is nil at equilibrium; (ii) money is neutral with respect to the stock market equilibrium (the equity risk premium); (iii) money is not neutral with respect to consumption and capital accumulation, and its effect may be quantitatively substantial; (iv) the preference for model robustness affects all the real economic variables as well as the expected inflation rate and the nominal interest rate.

1. Introduction

We investigate the issue of money neutrality within a neo-classical continuous time framework where the capital accumulation and money supply processes are stochastic and where private agents face model ambiguity and exhibit preferences for robustness. Under certainty, Reis (2007) studied the dynamics of Sidrauski's (1967) model of a neo-classical monetary growth model with money in the utility function. If money demand is interest rate elastic *and* money affects the marginal utility of consumption, a nominal interest rate policy, although neutral, is not super-neutral.[1] Lioui and Poncet (2008) extended Reis' analysis to the uncertainty case. They showed that even when utility is separable in consumption and real balances, money is not super-neutral, as the real interest rate is affected by the re-allocation of wealth between capital and money that takes place when monetary policy affects the market price of output risk.

Unlike what is traditionally assumed, however, the parameters of the random processes driving the model are in general unknown. This leads to model ambiguity in the sense associated with Knight (1921). Lacking information as to these parameters, economic agents may fear that the ones they use to optimize their choices are not accurate and thus desire to hedge

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[1] A policy variable is neutral (super-neutral, respectively) if a change in its level (in its growth rate, respectively) does not affect consumption, capital or output. This paper investigates neutrality.

0164-0704/$ - see front matter
http://dx.doi.org/10.1016/j.jmacro.2012.08.003

against this possibility. They will therefore adopt decision rules that are somehow robust to model misspecification, i.e. choose strategies that perform reasonably well under (not too severe) deviations from the adopted model.

This paper departs from most of the macroeconomic literature dealing with money and model ambiguity in at least three respects.[2] First, when model uncertainty has been introduced, it has always been assumed to affect the decision rules of the *central bank* itself. In contrast, in a micro-founded general equilibrium approach, we deem more appropriate to assume that *private agents* are unsure about the parameters to be used when deriving their optimal demands. We thus consider private agents not having sufficient information as to the random processes driving the accumulation of capital and the money growth to make their decisions rest on a unique probability measure. Their optimization problem thus reflects their concern for model misspecification, or, equivalently, their preference for robustness. Second, the economic equilibrium that is impacted by model uncertainty is generally not derived from private agents' optimization behavior, but is exogenously given as a set of structural equations. We do not posit such equations but instead derive the fully general equilibrium of the economy. Third, existing models are usually built in discrete time, which is natural since they are essentially designed to address empirical issues. To benefit from the theoretical insights allowed by closed form solutions, however, we use instead the powerful tools of continuous time.

Incorporating a concern for model uncertainty is the natural extension to propose after Lioui and Poncet (2008) highlighted the importance of economic uncertainty, as model misspecification is intimately related to the randomness of the economy. However, while a reduced form approach, positing the stochastic discount factor as the marginal utility of consumption, was sufficient in Lioui and Poncet (2008) to address the role of economic uncertainty in money (super) non-neutrality, a full-fledged general equilibrium model is required to assess the influence of model uncertainty on key macroeconomic aggregates. We need here to develop a framework that allows us to derive explicitly the equilibrium consumption and capital accumulation rates, the nominal and real interest rates as well as the equilibrium risk premium and inflation rate dynamics in order to capture that influence.

Our key findings can be summarized as follows: (1) the premium that compensates for model uncertainty in the monetary economy is identical to the one that prevails in the real economy, as monetary uncertainty does not affect the level and volatility of real wealth. This strong result is due to lump sum transfers being designed so as to respect the (implicit) government budget constraint. If holding real balances exposes individuals to inflation risk, rebating lump sum transfers provides them with a perfect hedge against this exposure. (2) Consequently, money is neutral with respect to financial asset prices in the sense that risk premia are left unaffected by the parameters governing the money supply process. (3) Risk premia, however, depend positively on the private agents' preference for robustness, which plays in that respect a role similar to risk aversion. (4) Irrespective of the presence of nominal rigidities, money is generically not neutral with respect to consumption and capital accumulation. Monetary impulses are transmitted to the real side of the economy through changes in the optimal tradeoff between money and consumption, which in turn impinges on capital growth. Simulations suggest that the quantitative effects of money non-neutrality may be substantial. (5) Preference for model robustness affects the expected inflation rate and the nominal interest rate essentially through its influence on the consumption to capital ratio.

The rest of the article is structured as follows. Section 2 presents the stochastic real economy that serves as the benchmark economy, and derives the general equilibrium under model misspecification. The stochastic monetary economy is examined in Section 3 and its competitive equilibrium compared to that of the real economy. Section 4 provides a numerical illustration from realistic sets of parameters. Section 5 concludes. Most proofs are gathered in a technical appendix.

2. The real competitive equilibrium

We consider a representative agent who maximizes her expected lifetime utility from her consumption stream $\{c_t\}$. She can invest in the available technology so as to accumulate real capital k. She has also access to two financial claims in zero net supply, a risky asset denoted by S and a safe one yielding the real rate r. The laws of motion of real capital and the risky asset write respectively

$$dk_t = (Ak_t - c_t)dt + k_t\sigma_k dZ_{k,t}, \tag{1}$$
$$dS_t = S_t(\mu_s dt + \sigma_s dZ_{k,t}), \tag{2}$$

where σ_k and σ_S denote the volatility of the return on real capital and of the return on the risky asset, respectively, μ_S is the average return rate on the risky asset and Z_k is a one-dimensional Brownian motion defined on the appropriate filtered probability space that reflects technological shocks. It is the only source of risk in this real economy. We thus adopt the simplest version of the 'AK' growth model with exponent one for tractability. Note that, for simplicity and without loss of generality, the rate of capital depreciation is (implicitly) included in the constant A, and that $A - \frac{c_t}{k_t}$ is the net investment rate.[3]

[2] For the application of robustness methods pioneered by Hansen and Sargent (1995) to portfolio theory and asset pricing, see Epstein and Schneider (2007). Wada (2007) attacked the equity premium and riskfree rate puzzles evidenced by Mehra and Prescott (1985) by introducing Knightian uncertainty in a discrete time, two-state Markov model. Leitemo and Söderström (2008) studied the effects of model uncertainty in a simple New-Keynesian discrete time model where the central banker exhibits a preference for robustness. Dennis et al. (2009) show that in small open economies the domestic and import sector Phillips curves are especially susceptible to model misspecification. Kimura and Kurozumi (2007) use a forward-looking model where an adjusted New-Keynesian Phillips curve equation includes the lagged inflation rate and the central bank is uncertain about both the degree of inflation persistence and the social loss function to be minimized.

[3] A useful reference to the AK model is Kotlikoff (2000).