Journal of Monetary Economics 000 (2018) 1–16

Contents lists available at ScienceDirect

Journal of Monetary Economics

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

A simple general equilibrium model of large excess reserves☆

Huberto M. Ennis

Research Department, Federal Reserve Bank of Richmond, 701 East Byrd Street, Richmond, VA 23219, USA

ARTICLE INFO

Article history:
Received 15 June 2017
Revised 12 April 2018
Accepted 13 April 2018
Available online xxx

JEL classification:
E40
E50
G21

Keywords:
Banking
Monetary policy
Central bank

ABSTRACT

In a general equilibrium macroeconomic model with a banking system that can hold large excess reserves and is subject to (possibly binding) capital constraints, I study how the quantity of government-provided monetary assets is related to the price level in steady state. When the central bank does not pay interest on reserves, the price level moves one-for-one with the monetary base. If, instead, the central bank can pay interest on reserves at market rates, the price level can decouple from the quantity of monetary assets in the economy: a larger monetary base need not imply a higher price level. However, for large enough levels of reserves, the capital constraint binds and the tight link between money and prices reemerges.

1. Introduction

Macroeconomic models typically generate a tight long-run relationship between the amount of government-provided monetary assets and the price level in the economy. This is true even when the model is sophisticated enough to distinguish between currency and reserves, the two main components of the monetary base (e.g., Ireland, 2014; Lucas and Nicolini, 2015). Until recently, this tight relationship captured the data well (Lucas, 1996).

In the years since the financial crisis, however, the link between base money and prices has weakened considerably in many advanced economies. For example, in the U.S. the monetary base grew at an average annual rate of 16% in the last ten years, while prices have grown at only 1.8% on average. The growth of bank reserves accounts for most of the growth in monetary assets during that period, and have pushed the U.S. banking system to operate, now for several years, with an extremely large amount of *excess* reserves.[1] The objective in this article is to study a relatively simple monetary macroeconomic model that can simultaneously account for the more traditional, tight relationship between money and prices and also for situations like the ones experienced more recently in some advanced economies where reserves are plentiful (that is, their demand as a liquid financial instrument is fully satiated) and the link between monetary assets and the price level has become more tenuous.

☆ I would like to thank Philippe Bacchetta, Marco Bassetto, Petra Gerlach, Marvin Goodfriend, Todd Keister, Eric Leeper, Ed Nosal, Ricardo Reis, Martin Schneider, Neil Wallace, Alex Wolman, and participants at several seminars and conferences for comments. All remaining errors are mine. The views expressed in this article are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Richmond or the Federal Reserve System.

E-mail address: huberto.ennis@rich.frb.org

[1] The implied annual average growth rate of reserves in the last ten years in the U.S. is roughly 50%. Keister and McAndrews (2009) provide a good discussion of the process of buildup of bank reserves that resulted from the various Federal Reserve programs (lending facilities and asset purchases) put in place as part of the policy response to the financial crisis.

https://doi.org/10.1016/j.jmoneco.2018.04.008
0304-3932/

Beyond the response to the financial crisis, it seems clear at this point that active management of the balance sheet should be counted as an additional policy tool for many modern central banks. In light of that situation, understanding how large purchases of assets by the central bank impact the economy has become an area of intense research (see, for example, Curdia and Woodford, 2011; Foerster, 2015; Gertler and Karadi, 2011, and Christensen and Krogstrup, 2016). Within that broader effort, but more in the spirit of Reis (2016), this paper focuses particularly on the liability side of the central-bank's balance sheet and investigates its relationship with the behavior of prices.

The model integrates a banking system into an otherwise standard dynamic monetary macro model. As an asset, reserves (deposits at the central bank) can primarily be held by banks. Given the role played by reserves in explaining the recent evolution of monetary aggregates in many countries, it is critical to extend the workhorse model, as I do here, to include a banking system with a non-trivial balance sheet. To this end, the model includes four types of agents and a central bank. Households consume and make deposits in the banking system. Entrepreneurs take loans from banks to fund productive projects. Expert investors provide bank capital to banks, and banks intermediate funding between households, expert investors, and entrepreneurs. The central bank sets the rate of growth of monetary assets in the economy, may or may not pay interest on reserves, and can impose lump-sum taxes/subsidies on households.

Aside from the goods produced by entrepreneurs undertaking their projects, households and expert investors receive an endowment of goods every period. There is also an endowment of productive assets every period which yield goods the following period. The claims on the productive assets play the role of securities on agents' balance sheets. All agents can, in principle, hold securities.

Households do not consume from their own endowment and, instead, trade goods with other households using currency (Lucas, 1990). The monetary assets issued by the central bank are *endogenously* divided every period between currency and bank reserves. Banks maximize profits and face three constraints: (1) a bank capital constraint, (2) a reserve requirement constraint, and (3) a liquidity constraint. There is free entry in banking and, hence, banks make zero profits in equilibrium.

I study the model's stationary competitive equilibrium.[2] The main results in the paper are as follows. When the central bank pays low (or no) interest on reserves, banks hold no excess reserves, the demand for reserves is pinned down in equilibrium and the price level moves one-to-one with the quantity of monetary assets. Instead, if the central bank pays interest on reserves at market rates, excess reserves can be large and, as long as bank capital in the economy is not scarce, the price level may decouple from the behaviour of total monetary assets. There are limits, however, to the quantity of reserves consistent with such situations. If the quantity of reserves is sufficiently large so that attracting extra bank capital requires paying abnormal returns, then the bank-capital constraint becomes binding and the price level moves again in close parallel with the quantity of base-money. These results suggests that it is possible for the central bank to purchase securities using nominal reserves with no intention to induce increases in the price level, but that there are limits to such policy: After some point, if excess reserves become large enough, more nominal reserves come together with higher prices.

Three features of the model are of special importance for these results. First, the central bank can pay interest on reserves. Second, the central bank only controls the total amount of monetary assets (currency plus reserves) but does not control the split between the two (an endogenous variable in the model). And third, the quantity of bank capital in the economy is potentially large but limited. When the central bank is paying interest on reserves at market rates and bank capital is plentiful, banks are basically indifferent between holding more or less reserves funded with deposits, as the cost and benefits of doing so are effectively the same. This indifference and the flexibility provided by the endogenous split of currency and reserves, allows for adjustments in the quantity of reserves without significant changes in the price level. Eventually, though, as excess reserves (and, with them, the banking system) become sufficiently large, the amount of bank capital in the economy turns into the limiting factor, breaking down the aforementioned indifference – the cost of funding reserves is higher than the return associated with holding them. At that point, higher monetary assets in the economy can only be accommodated with higher values of the price level.

The questions in this paper involve mainly long-run trends and large, relatively persistent changes in various aspects of monetary policy. For this reason, I work with a non-stochastic, perfect foresight model. However, as will become clear in the analysis, a stochastic extension of the model could be useful to theoretically investigate, for example, the short-run effects of central bank asset purchases. This subject is left for future research.[3]

The rest of the paper is organized as follows. In the next section, I describe the baseline model. In Section 3, I define equilibrium and discuss price-level determination in the model. In Section 4, I turn the attention to stationary equilibrium. There are three parts to this section. First, I consider the case when the central bank pays low or no interest on reserves, which aligns well with the situation in the U.S. before the financial crisis. Second, I consider the case when the central bank pays interest on reserves at market rates, similar to what the Fed has been doing during the last few years. Finally, I consider a situation where banks hold excess reserves, the central bank pays interest on reserves that are higher than the rates on deposits and interbank loans, and the banking system faces non-trivial balance-sheet costs induced by the scarcity of bank capital. In each case, I discuss the link between money and prices in equilibrium. In Section 5, I provide a brief conclusion.

[2] Woodford (1994) study non-stationary monetary equilibria in a cash-in-advance economy with cash and credit goods. He shows that self-fulfilling hyperinflations can happen even when the central bank is controlling the quantity of monetary assets in the economy. While the tight link between prices and monetary assets breaks down in such situations, the implied evolution of prices is at odds with the recent experience in advanced economies.

[3] Ireland (2014), for example, studies quantitatively the short-term responses to shocks of an economy where the central bank pays interest on reserves.

Please cite this article as: H.M. Ennis, A simple general equilibrium model of large excess reserves, Journal of Monetary Economics (2018), https://doi.org/10.1016/j.jmoneco.2018.04.008