A penalty function approach to occasionally binding credit constraints*

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Abstract

Occasionally binding credit constraints (OBC) have recently been explored as a promising way of modeling financial frictions. However, given their highly non-linear nature, most of the literature has concentrated on small models that can be solved using global methods. In this paper, we investigate the workings of OBC introduced via a smooth penalty function. This allows us to move towards richer models that can be used for policy analysis. Our simulations show that in a deterministic setting the OBC approach delivers welcome features, like asymmetry and non-linearity in reaction to shocks. However, feasible local approximations, necessary to generate stochastic simulations, suffer from fatal shortcomings that make their practical application questionable.

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Extended Abstract

Dynamic, stochastic general equilibrium models featuring financial frictions have recently become highly popular both at central banks and in the academic world. Their applications range from explaining the role of financial shocks during the crisis (Gerali et al., 2010; Iacoviello and Neri, 2010; Brzoza-Brzezina and Makarski, 2011), through analyzing optimal monetary policy in the presence of financial frictions (Curdia and Woodford, 2008; De Fiore and Tristani, 2009; Carlstrom et al. (2010); Kolasa and Lombardo, 2011) to the impact of macroprudential regulations on the economy (Angelini et al., 2010; Angeloni and Faia, 2009; Meh and Moran, 2010).

A substantial part of the literature features financial frictions in the form of credit constraints. In this concept, that can be traced back to the seminal paper of Kiyotaki and Moore (1997), some agents (entrepreneurs or households) are limited in their borrowing capacity by the amount of collateral that they can provide to the lender. The constraint is assumed to be eternally binding, which facilitates the model solution as standard perturbation techniques can be applied.[1] A number of papers followed Iacoviello (2005) and used this approach to model frictions in the housing market. However, while conceptually and computationally attractive, eternally binding constraint (EBC) setup suffers from a major shortcoming. As documented by Brzoza-Brzezina et al. (2011), the permanent nature of collateral constraints generates strong, short-lived and symmetric reactions of macroeconomic variables to shocks. This means in particular that the EBC modeling strategy does not allow to distinguish between "normal" and "stress" periods.

This model feature seems inconsistent with empirical evidence. Table 1 presents the skewness (i.e. the third standardized moment) for main variables related to the housing market. The reason for looking at this part of the economy is its important role in driving the business cycle as identified in the financial frictions literature (see e.g. Iacoviello and Neri, 2010). It is clear that residential investment, housing stock, change in mortgage loans and house price in inflation are all skewed downwards, i.e. left tail events are relatively more frequent. This suggests either that shocks affecting the housing market are asymmetric, or that it responds to symmetric shocks in a skewed fashion.

In this paper we follow the second option by considering a model in which asymmetries emerge endogenously from constraints facing the agents.[2] Such an approach has not only a

[1] It has to be noted, however, that this assumption does not necessarily hold globally. In particular, it may be violated for some shocks, making simulations with the model problematic.

[2] 2In terms of methodological approach, this paper is hence related to the literature on downward nominal rigidities (see e.g. Kim and Ruge-Murcia, 2009; Benigno and Ricci, 2011; Fahr and Smets, 2010). The alternative approach, generating asymmetry by feeding skewed shocks into a linearized models is followed

more structural flavor, but also seems to be supported by some recent empirical literature. In particular, Hubrich and Tetlow (2012) show that negative output effects of financial shocks are much more pronounced and long-lasting in times of high financial stress than in normal times. Kaufmann and Valderrama (2010) show that amplifying effects of loan shocks work in a highly nonlinear fashion. They identify periods during which loan shocks have only moderate effect on GDP and periods when they strongly amplify the cycle.

Collateral constraints are certainly important in real life and potentially useful for modeling purposes. However, the discussion presented above suggests that they should not be applied in a permanently and symmetrically binding fashion. A preferred specification would feature constraints that do not matter under normal circumstances (from the modeling perspective in the vicinity of the steady state), but become binding occasionally, i.e. during episodes of unfavorable economic conditions (e.g. after a series of negative macroeconomic or financial shocks).

The idea of occasionally binding constraints (OBC) is not new (e.g. Christiano and Fisher, 2000; Mendoza, 2010; Brunnermeier and Sannikov, 2011). However, given their highly nonlinear nature, they require global solution methods. Due to the curse of dimensionality, these can be applied only to relatively small models with a limited number of state variables. In particular, such techniques seem out of range for models of the size used for practical policymaking, i.e. featuring a number of real and nominal rigidities. At the same time, adding these frictions seems indispensable when the models are to be applied e.g. for analyzing business cycle consequences of macroprudential policies.

In this paper we thoroughly investigate a potentially attractive shortcut to approximate occasionally binding constraints that has been introduced by Luenberger (1973) and Judd (1998), and more recently advocated by De Wind (2008), i.e. the so-called barrier or penalty function method. This approach essentially consists in converting inequality constraints into equality constraints, making the use of standard perturbation techniques possible. It has been applied to a range of macroeconomic models e.g. by Rotemberg and Woodford (1999), Preston and Roca (2007) and Kim et al. (2010). To this end, we construct a DSGE model with a standard set of rigidities and collateral constraints in the spirit of Iacoviello (2005), except that the latter are introduced in the form of a penalty function. We parametrize the model in such a way that the constraint does not play an important role in the steady state, but becomes binding when the economy is hit by sufficiently large negative shocks. Next, we investigate the main features of the model both globally and using its local approximations of various orders.

All in all, while being practical for non stochastic models, the penalty function approach unfortunately fails to fulfill our expectations in a stochastic environment. This makes it an attractive way of introducing financial frictions into deterministic models like GEM (Tchakarov

e.g. by Grabek et al. (2011).

et al., 2004) or EAGLE (Gomes et al., 2010). However, a fully edged application in a realistic stochastic environment seems currently out of range.