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Steady-state equilibrium with state-dependent pricing ☆

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Abstract

State-dependent pricing models are now an operational framework for quantitative business cycle analysis. The analysis in Ball and Romer [1991. Sticky prices as coordination failure. American Economic Review 81 (3), 539–552], however, suggests that such models may be rife with multiple equilibria, for in their static model, price adjustment is always characterized by complementarity, a necessary condition for multiplicity. We study existence and uniqueness of steady-state equilibrium in a discrete-time state-dependent pricing model. We find only weak complementarity and no evidence of multiplicity. However, nonexistence of symmetric steady-state equilibrium with pure strategies arises in the region of the parameter space between flexible and sticky prices.

JEL classification: E31; E32; C62

Keywords: Price adjustment; Menu costs; State-dependent pricing; Multiple equilibria

1. Introduction[1]

Dynamic models with monopolistic competition and sticky prices are at the forefront of quantitative research aimed at understanding the real effects of monetary policy; see, for example, Woodford (2003). Such models have emerged from two strands of the literature: the New Keynesian approach, whose hallmark is imperfect competition, and the real business cycle approach, whose hallmark is dynamic general equilibrium. Most recent work does not model the underlying source of stickiness, but fixed costs of price adjustment (''menu costs'') are a common explanation. Models in which monopolistically competitive firms face such

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[1]Most proofs and detailed derivations are omitted from the paper. They can be found in the companion technical reference, available on the Science Direct/Journal of Monetary Economics website.

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costs hold much promise for improving our understanding of business cycles and for evaluating monetary policy. Recent contributions by Dotsey et al. (1999), Burstein (2006), Devereux and Siu (2007), Golosov and Lucas (2007) and Dotsey and King (2005) show that such models are now operational for business cycle and policy analysis.[2]

Researchers using models with fixed costs of price adjustment have typically taken for granted that equilibrium exists and is unique, and have used common-sense algorithms to compute equilibrium. However, these models are not perfectly competitive and have nonconvexities, so standard existence and uniqueness results do not hold. Indeed, Ball and Romer (1991) argue that models with fixed costs of price adjustment are rife with multiple equilibria. It is an open question, however, whether their results carry over to the dynamic models currently being used to study real fluctuations and monetary policy.

In this paper we systematically study the existence and uniqueness of steady-state equilibrium in a benchmark discrete-time dynamic general equilibrium model with fixed costs of price adjustment. We have two main findings. First, multiplicity of steady-state equilibria is not a practical concern. Extensive numerical simulations, supported by analytical results, suggest that multiplicity does not occur for reasonable parameterizations of our dynamic general equilibrium model. Second—and unexpectedly—we find that for small regions of the parameter space, symmetric steady-state equilibrium does not exist, even though a natural computational technique would erroneously identify an equilibrium.

1.1. Relationship to previous literature

Although our work is motivated in part by Ball and Romer's finding, we do not present an exact dynamic generalization of their static model. Our aim is to study a model that fits into current mainstream work on equilibrium business cycles. Ball–Romer used preferences that are not standard: they assumed that utility was linear in consumption, whereas we use preferences that are logarithmic in consumption. Further, they used a "yeoman-farmer" model, in which households produce output using their own labor input.[3] We assume firms hire labor in an economy-wide market.

The model we analyze is a version of that in Dotsey et al. (1999). It is a discrete-time dynamic monopolistic competition model in which firms face a distribution of menu costs, so the frequency and timing of price adjustment are endogenous. It fits directly into the literature on equilibrium business cycles: if we set the fixed costs of price adjustment to zero, the model is a standard real business cycle model, simplified here by the elimination of capital. The seminal menu cost models of Caplin and Spulber (1987) and Caplin and Leahy (1991) and the more recent work by Danziger (1999) are set in continuous time, have a degenerate distribution of fixed costs, and are less amenable to business cycle analysis.

Ball and Romer (1991) argued that monopolistic competition models with menu costs tend to exhibit multiplicity in the degree of equilibrium price rigidity: if a firm anticipates that other firms will have sticky prices, then it may find sticky prices to be privately optimal, but if the firm expects others to have flexible prices, then price adjustment may be privately optimal. The extent of price stickiness—and hence the effect of aggregate demand shocks on prices and output—is then indeterminate.[4] Ball and Romer further argued that multiple equilibria enable these models to better explain phenomena such as the varying degrees of nominal

[2]Menu cost models are related to other models with fixed adjustment costs. Cooper et al. (1999) and Thomas (2002) look at investment in the presence of adjustment costs, while Fisher and Hornstein (2000) and Khan and Thomas (2004) analyze models of inventories with fixed costs.

[3]This has several implications. First, it effectively closes down a general equilibrium linkage in their model. In a world of yeoman farmers, the sole general equilibrium connection across firms is through aggregate demand, whereas in our setting, there is also a linkage through the real wage. A second and related point is that the behavior of marginal cost is affected. In the yeoman-farmer setting, marginal cost varies across producers, because it reflects the disutility of leisure. In our setting marginal cost is common across firms. Third, the yeoman-farmer approach allows Ball–Romer to model the cost of changing prices as a separable utility cost that has no connection to the rest of the model. In our setting, adjustment of prices requires labor, which means that the cost of adjustment is affected by changes in the real wage.

[4]The paper by Howitt (1981) is an important forerunner of the work of Ball and Romer. In his model, a firm can incur a fixed cost to observe the current value of an aggregate shock, in response to which it may adjust its price. Multiple equilibria can arise because of the feedback from the prices chosen by other firms who observe the shock to the value to an individual firm of observing the shock.