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State-dependent pricing and the non-neutrality of money

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ABSTRACT

Golosov and Lucas (2007) have challenged the view that infrequent price adjustments by firms explain why money has aggregate real output effects. The basis of their challenge is the 'selection effect' – re-setting firms are not selected at random, they are those firms whose prices are furthest from the optimal reset price. Because of this the aggregate price level is sufficiently flexible for monetary neutrality. In this paper I add price review costs to an otherwise standard Golosov and Lucas model. This weakens the selection effect and restores monetary non-neutrality.

1. Introduction

In Golosov and Lucas (*GL* 2007) money is neutral even when firms, facing menu costs, adjust their prices intermittently. They attribute this to a 'selection effect' – the firms that are re-setting are those with prices furthest from the optimal reset price. In this paper I develop a discrete-time version of the *GL* model in which money is non-neutral. This is due to one very natural extension to the *GL* model: I allow *price review costs* and the *direct costs of changing prices* to play distinct roles in the pricing decision. The former are incurred when information is gathered and processed, and when decisions are made; the latter ('menu costs'), are incurred only when prices are changed. The distinction is important because there is substantial evidence that firms review their prices intermittently and change them less frequently than they review them.

The effect of review costs on the firm's pricing strategy has been analysed in an expanding number of recent papers (reviewed below). My aim in this paper is to embed both review costs and menu costs in an otherwise standard menu-cost model and examine the effect this has on the strength of the selection effect. I find that this extension to the standard model sufficiently weakens the selection effect to give a degree of money non-neutrality similar to that of Reis's (2006) 'inattentiveness' model.

Money is non-neutral when the *aggregate* price level is slow to adjust. Such price-level stickiness has been attributed to costs associated with changing prices. The presence of such costs provided new-Keynesians with the micro-foundation that earlier Keynesian models lacked. And yet the new-Keynesian analysis of monetary policy is usually based on the simplifying assumption of Calvo (1983): firms choose how much to change prices but not when.[1] Their timing is random.

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[1] Clarida et al. (1999) is a comprehensive survey of the new-Keynesian analysis of monetary policy based on the Calvo approach.

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New-Keynesians are left with the hope that the Calvo approach is close enough an approximation to a fully-specified menu-cost model to justify its use for the analysis of monetary policy. Unfortunately the standard menu-cost model, appropriately calibrated to match the micro-data, behaves rather unlike the Calvo model and the micro-foundations of Keynesian monetary policy would seem to be far from established.

In Caplin and Spulber's (1987) early menu-cost model, money is completely neutral because of the selection effect.[2] Firms that are re-setting are not drawn randomly – they are those with prices furthest from the optimal reset price. Consider the effects of a positive monetary shock. Those firms with initial prices well below their equilibrium will reset and, when they do so, make large adjustments (to catch up). Firms with prices nearer their equilibrium values or even some way above them are unlikely to reset. The aggregate price level is an average of the large price adjustments of the re-setters and the zero adjustments of others. In Caplin and Spulber's model the average price level exactly keeps pace with the monetary shock, neutralising any aggregate real output effects. They show that while there may be *firm-level* stickiness in prices, the *aggregate* price level is not and, because of this, money is neutral.

GL find that the selection effect is also present in their fully-specified menu-cost model with idiosyncratic productivity. Calibrating their model to match observed patterns of price setting (as described in Bils and Klenow (2004) and Klenow and Kryvtsov (2008)), they find that the selection effect blunts the real effects of money – not completely, but substantially so. Acknowledging that the menu cost model can explain price stickiness at the firm level, *GL* argue that it does not explain stickiness of the aggregate price level.

The standard menu-cost model can be challenged along two related lines. First it is simply not consistent with observed patterns of price changes in the micro data. And secondly, its description of the price-setting process and its associated costs is seriously incomplete. The first weakness concerns the failure of the standard model to account for the wide dispersion of price changes observed in the data. According to Klenow and Kryvtsov (2008), the average absolute change in those prices being re-set is around 10% and yet they find that 44% of price changes are less than 5% in absolute value. Since, in the standard menu-cost model, prices only adjust when they are some way from their equilibrium values, small price adjustments are only made if menu-costs are small – too small for the model to remain consistent with other features of the data.

Recent menu-cost models have been more successful in explaining the wide dispersion of price changes in the survey data. Several introduce some form of heterogeneity in menu costs. Dotsey et al. (1999) assume that menu costs are stochastic so that those firms with small menu costs will adjust prices even when current prices are close to the equilibrium. Dotsey et al. (2006) add idiosyncratic shocks to their earlier model, generating the large price changes observed in the data. Klenow and Kryvtsov (2008) assume fixed but different menu costs specific to 67 sectors. Small price adjustments will be made by firms in sectors with low menu costs. Similarly, Nakamura and Steinsson (2010) develop a multi-sector model in which menu costs (and therefore price-resetting frequencies and their size) vary by sector. Midrigan (2011) adds two extensions to the standard model: idiosyncratic productivity shocks are assumed to have fat-tailed distributions; and output is produced by multi-product firms so that there are 'economies of scope' in adjusting prices.[3] Firms re-set all prices when optimisation requires re-setting only one.[4] With the combination of fat-tailed productivity shocks and economies of scope, Midrigan explains both the large mean of absolute price changes and the frequency of small ones. This sufficiently weakens the selection effect to generate real effects of money similar to those in models with Calvo pricing. Finally Gertler and Leahy (2008) have developed a model with Poisson arrival of uniformly-distributed idiosyncratic productivity shocks and small menu costs, so that many price changes are small.

These 'second generation' menu-cost models (to borrow Klenow and Kryvtsov's term for them) have successfully modified the standard model to account for the mean size and wide dispersion of price changes in the data. And in doing so, they find that the selection effect is weak enough for money to have real effects comparable to those of the Calvo model.[5] Collectively they suggest that the new-Keynesian analysis of monetary policy, based as it is on Calvo pricing, may yet be a reasonable approximation to an analysis with sounder micro foundations.

The second weakness of the standard menu-cost model concerns its characterisation of the price-setting process and its associated costs. This is the focus of this paper. Standard menu-cost models typically assume that firms costlessly and continuously review their prices and change them only if the menu costs are justified. They largely ignore the costs of gathering and processing the relevant information and the costs of the pricing decision itself – collectively price review costs.[6] Firm surveys find two features which challenge the standard model. First, firms review their prices intermittently, not continuously,

[2] Golosov and Lucas (2007) first coined the phrase 'selection effect'. Caballero and Engel (2007) argue that the key distinction is that between the 'extensive' and 'intensive' margins. In the former a money shock raises the price level through its effect on the fraction of firms making price adjustments. The intensive margin is the additional price increases of those firms that were going to adjust anyway. Only the intensive margin is active in the Calvo model, while in menu-cost models both margins are strictly positive.

[3] Midrigan also seeks to explain the difference between 'regular' and 'posted' prices and the interesting observation that 86% of temporary nominal prices return to their original values. Although temporary price adjustments by firms may reduce the real effects of money, Midrigan finds this to be relatively unimportant.

[4] To support his use of scope economies, Midrigan cites Lach and Tsiddon (2007) who present evidence that economies of scope in price setting may account for the fact that some price changes are small.

[5] Indeed Gertler and Leahy obtain a closed-form solution that is identical to that of the new-Keynesian model based on Calvo pricing, though obviously the parameters have a different interpretation in their case.

[6] Alvarez et al. (2011), Woodford (2009) and others refer to these costs as 'information' costs. My preference is for the wider term 'review costs' to stress the fact that it covers information gathering, information processing, decision-making – the costs of *all* activities involved in pricing decisions.