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Firm-specific capital, inflation persistence and the sources of business cycles



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ABSTRACT

This paper estimates a firm-specific capital DSGE model. Firm-specific capital improves the fit of DSGE models to the data (as shown by a large increase in the value of the log marginal likelihood). This results from a lower implied estimate of the NKPC slope for a given degree of price stickiness. Firm-specific capital leads to a better fit to the volatilities of macro variables and a greater persistence of inflation. It is also shown that firm-specific capital reduces the dependence of New Keynesian models on price markup shocks and that it increases the persistence of output to monetary shocks.

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1. Introduction

Despite being a more appealing choice of modelling capital (standard business cycle models assume that capital can be instantly and costlessly transferred across firms which is empirically unrealistic) there are still few examples of dynamic stochastic general equilibrium (DSGE) models with firm-specific capital and very little empirical work on the topic.¹

Altig, Christiano, Eichenbaum and Linde (hence ACEL, 2011) estimate the firm-specific and homogeneous capital DSGE models in terms of the reduced form New Keynesian Phillips curve (NKPC) and show how the assumption of firm-specific capital reduces the frequency of price re-optimization at the firm level.² This approach implies the two models to be observationally equivalent with respect to aggregate prices and quantities (and to differ only in terms of price frequency adjustment at the micro level). This is because only the mapping between the structural parameters and the slope of the NKPC is affected by the introduction of firm-specific capital.

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¹ One possible reason for this is that when capital is firm-specific it is no longer possible to solve the price setting problem without considering the firm's optimal investment behavior. This makes the model considerably less tractable but it turns out to still be possible to derive an aggregate-supply relation following the method developed in Woodford (2005).

² Other relevant empirical papers that have done this are Eichenbaum and Fisher (2007) and Matheron (2006).

In this paper I take the reverse approach. I fix the frequency of price adjustment at the firm level with values based on micro studies (such as [Klenow and Kryvtsov, 2008](#)). I then study the differences at the aggregate level of modelling capital as firm-specific rather than the more conventional homogeneous capital case. That is, in this paper, the parameter priors between the two models are assumed to be identical at the micro rather than at the macro level (and the models will differ in terms of the implied prior of the NKPC slope).

The estimated model in this paper is similar to that in [ACEL \(2011\)](#) but rather than using a limited information strategy I adopt a Bayesian estimation approach (which has become very popular in macroeconomics with [Smets and Wouters, 2003, 2007](#), as prominent references). This too is an important difference because the posterior distribution obtained from Bayesian estimation offers a particularly natural method of comparing models which enables me to show that firm-specific capital is important for DSGE models to achieve a better fit to U.S. macro time series data (as shown by a large increase in the value of the log marginal data density).³ This paper also extends the knowledge in the literature by looking at a wider range of shocks than those considered in previous studies of firm-specific capital models. Besides total factor productivity and monetary shocks the model includes discount rate, labor supply, government spending, capital-embodied technology and price markup shocks too.

My analysis suggests that the improved fit to the data of the New Keynesian model seems to be behind a better fit to the volatilities of macro variables observed in the data. Of particular interest is the finding that firm-specific capital substantially increases the persistence of inflation. This represents an important result since a major limitation of micro-founded models of dynamic price adjustment is that they do not imply inflation inertia ([Romer, 2011](#)). Previous approaches adopted to bringing inflation inertia into New Keynesian models have not been fully satisfying.⁴ The models, for the benchmark case, presented here are purely forward-looking, having no “intrinsic” inflation persistence (that is, all persistence is “inherited” from the driving variable in the NKPC). This shows that it is possible for price staggering models to account for the high reduced form persistence seen in the data without the presence of a lagged inflation term (as done in [Gali and Gertler, 1999](#), and [Christiano et al., 2005](#)) in their aggregate supply relation (intrinsic persistence). This has important implications for monetary policy (see [Fuhrer, 2010](#)).

The firm-specific capital specification is able to fit the data better because it implies a lower slope of the NKPC for a given degree of price stickiness. If in the homogeneous capital model one chooses a degree of price stickiness so that its implied prior NKPC slope is about the same as that of the firm-specific capital model, then the differences in fit between the models become negligible. The firm-specific capital, however, fits the evidence better for a plausible degree of price stickiness at the micro level. Empirical macro researchers who follow a Bayesian approach choose parameter priors mostly to be in line with micro studies. For those using this method, the results in this paper suggest it is beneficial to model capital as firm-specific. Researchers that prefer the more conventional homogeneous capital assumption may opt instead to allow the degree of price stickiness to be determined from macro estimates of the NKPC slope. The main difficulty with such an approach is that identification of the NKPC slope has been shown to be weak (see [Mavroeidis et al., 2014](#)).

Another relevant result is the significant reduction of the size of the volatility of price markup shocks, when firm-specific capital is assumed. This is of importance since it helps address the criticism of [Chari et al. \(2009\)](#) on the usefulness of New Keynesian models for policy analysis due to their reliance on these shocks in order to explain the data.

I also study how the model's responses to exogenous shocks are changed by the introduction of firm-specific capital. I find that the introduction of firm-specific capital has important dynamic implications. The impulse response functions show that firm-specific capital, by making firms change prices by less, aids considerably in propagating the responses of output, while dampening movements in inflation, to exogenous “demand” shocks (since these tend to move output and prices in the same direction) such as fiscal and monetary policy shocks. This is an important point since [Chari et al. \(2000\)](#) found the standard New Keynesian model to have difficulty in generating output persistence in response to monetary shocks.

Other related empirical papers in the literature include those on sectoral heterogeneity in price stickiness. Like firm-specific capital, heterogeneous price stickiness leads to more persistent effects on aggregate output of monetary shocks (see for example [Carvalho, 2006](#); [Dixon and Kara, 2011](#)) and affects the relative importance of exogenous shocks to cyclical fluctuations (see [Bouakez et al., 2014](#)). It is also worth mentioning other promising explanations for inflation persistence. [Sargent et al. \(2006\)](#) explain the historical movements in US inflation as the result of the monetary authority's learning about the state or structure of the economy. [Cogley and Sbordone \(2008\)](#) show how the introduction of a time-varying inflation trend allows for a purely forward-looking NKPC to fit the data well. In recent work, [Bianchi and Ilut \(2014\)](#) show

³ As I do, [de Walque et al. \(2006\)](#) and [Nolan and Thoenissen \(2008\)](#) analyze how firm-specific capital affects the aggregate behavior of economic variables. However, [de Walque et al. \(2006\)](#) assume Taylor contracts whereas I assume Calvo contracts (which is more conventional in the business cycle literature). [Nolan and Thoenissen \(2008\)](#) adopt a calibration methodology which makes it hard to assess which model fits the data better. With calibration the marginal likelihood is not computed, so in order to discriminate between models one would need to specify: (i) a distance to measure the difference between estimated and model moments, and (ii) a loss function that would determine which moments are the most important to match.

⁴ The most prominent approaches are as follows: rule-of thumb behavior ([Gali and Gertler, 1999](#)), indexation of price contracts ([Christiano et al., 2005](#)) and sticky information ([Mankiw and Reis, 2002](#)). [Gali and Gertler \(1999\)](#) introduce inertia by assuming that a fraction of firms raises prices mechanically in line with past inflation rates. This is unrealistic, since we do not observe micro prices that change automatically with lagged inflation (see the evidence shown in [Bils and Klenow, 2004](#); [Nakamura and Steinsson, 2008](#)). [Christiano et al. \(2005\)](#) and [Mankiw and Reis \(2002\)](#) assume some adjustment of prices between reviews. Again, this does not match the observations at the micro level (see [Bils and Klenow, 2004](#); [Nakamura and Steinsson, 2008](#)). Many prices are fixed for extended periods and there is little support that firms set price paths like those predicted by models of price indexation of contracts or sticky information.

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