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# Inflation and optimal monetary policy in a model with firm heterogeneity and Bertrand competition<sup>☆</sup>

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## ABSTRACT

We study the joint implications of heterogeneity of total factor productivity and strategic price interactions between firms on the dynamics of inflation and the design of optimal monetary policy. In this setting, more productive firms respond less to shocks affecting their marginal costs than less productive firms. As a consequence, economies with a larger proportion of highly productive firms face a flatter Phillips curve. Moreover, when these two features concur, the Ramsey problem gives rise to an optimal non-zero long run inflation that amplifies the differences in relative prices between more efficient and less efficient firms, thus increasing the market share of the former. Nevertheless, in the presence of transitory technology shocks, optimal short term deviations from this positive long run inflation are negligible.

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## 1. Introduction

The productive structure of the economy determines the way output and inflation respond to disturbances. In this paper, we study the joint implications of heterogeneity of total factor productivity between otherwise identical firms and strategic interactions (Bertrand pricing) on the dynamics of inflation and the design of optimal monetary policy. In particular we show that when these two features concur in the productive structure, both the positive and normative properties of the economy regarding the inflation rate differ from what the standard New Keynesian model predicts.

The influence of several forms of firm heterogeneity on inflation has been analyzed in a series of recent papers. In their seminal work (Bilbiie et al., 2012) explore the role of endogenous firm entry in the market as a, potentially powerful, source of dynamics for markups, prices and quantities. Endogeneizing the number of firms in an economy opens up two additional channels through which the short-run dynamics of inflation can be affected. First, there is a *competition effect* whereby shocks that favor the entry of new firms intensify competition in the market. Secondly, the entry of new firms can be thought of as an expansion of the number of varieties available with a direct effect on the welfare-based aggregate price level; this is known as the *variety effect*.

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Much of the debate in industrial policy turns around measures to facilitate fast entry of new firms to foster market competition, thus relying on the *competition effect* to moderate markup and inflation fluctuations. Nevertheless, a number of papers have shown both theoretically and empirically that the *variety effect* is quantitatively more important and that the *competition effect* has a near negligible impact on market prices, unless one assumes a complex supply structure beyond entry and exit as in [Etro and Colciago \(2010\)](#); [Jaimovich and Floetotto \(2008\)](#), and [Lewis and Poilly \(2012\)](#), among others.

The importance of the competition effect is enhanced when firms are aware of the impact of their price decisions on their competitors'. [Etro and Rossi \(2015a\)](#) and [Guilloux-Nefussi \(2015\)](#) show that strategic interactions à la Bertrand flatten out the Phillips curve in a significant manner. However, for this mechanism to be quantitatively significant the number of firms must not be large, or there must be some differences in the elasticity of substitution across different sectors in the economy. When firms are homogeneous and the number of firms is large the market share of each individual firm is very small, the perceived impact of its price decisions on its competitors' is weak and the effective elasticity of demand under Bertrand competition gets very close to the standard case of Dixit–Stiglitz monopolistic competition.

In this paper we contribute to this literature by analyzing the joint effects of Bertrand competition and firm heterogeneity in productivity in an otherwise standard DSGE model. We show that more productive firms deliver more muted responses of inflation to exogenous disturbances. The reason for this is that price-setting firms with above-average productivity have larger market shares and take into account the fact that their pricing decisions have a non negligible impact on the aggregate price. Consequently, high-productivity (large) firms always change their optimal price level by less than low-productivity (small) ones.<sup>1</sup> In other words, highly productive firms absorb the effects of shocks to their marginal costs through significant countercyclical variations in their markups. This strategic effect is also present in less productive firms' pricing decisions, but the quantitative importance is of second order, since their market share is small and they expect that changes in their individual price will have at most a negligible incidence on the aggregate one. This mechanism weakens the connection between prices and current and expected marginal costs in large and most productive firms.<sup>2</sup>

Our results support the extended idea that the productivity and size distribution of firms in an economy has a close connection with the response of inflation to aggregate shocks. In our model this connection works naturally through a sizeable *strategic effect* that dominates the price decisions of large firms. This result has relevant policy implications as far as the dynamics of inflation and the competitiveness of economies is concerned.<sup>3</sup> Economies in which large firms predominate tend to display lower inflation volatility. In this sense, our mechanism can be considered another manifestation of the *granular hypothesis* developed in [Gabaix \(2011\)](#), according to which a large part of aggregate fluctuations can be attributed to the behaviour of large firms.

The presence of more productive firms affects the trade-off that monetary authorities face between output and inflation volatility to maximize welfare.<sup>4</sup> In the spirit of [Adam and Weber \(2017\)](#); [Bilbiie et al. \(2014\)](#) and [Etro and Rossi \(2015a, 2015b\)](#), among others, we study the implications of non-standard industrial structures for optimal monetary policy design. We find that the combination of TFP heterogeneity and strategic interactions delivers a novel result regarding optimal monetary policy. In particular, when these two features are present in the industrial structure, the Ramsey problem gives rise to an optimal non-zero long run inflation rate, as a device used by the monetary authority to amplify the differences in relative prices between more efficient and less efficient firms. Our industrial structure generates a long run trade-off between inflation and the average price markup in the economy. The non-zero optimal inflation rate balances the welfare gains of a lower markup (mitigating the labor distortion and increasing output and consumption) and the losses associated to price stickiness. Nevertheless, in response to transitory technology shocks optimal short term deviations from this non-zero long run inflation are negligible.

The rest of the paper is organized as follows, in the next section we briefly revise the empirical evidence. [Section 3](#) presents a simple model in which there are different levels of productivity, as well as the benchmark calibration. In [Section 4](#) we analyse the dynamic response of inflation and other variables to exogenous shocks, which we interpret with the help of the augmented Phillips curve derived from the model. [Section 5](#) studies the Ramsey solution to the optimal monetary policy, both in the long run and in response to technology shocks. [Section 6](#) concludes.

## 2. Empirical evidence

More productive firms are capable of setting lower relative prices and gaining market share. Since we abstract from differences across firms other than in TFP, productivity and size (market share) are closely related in our model. In this

<sup>1</sup> Since we do not consider differences other than those in TFP among firms, productivity, size and market share distributions are similar concepts in our setting.

<sup>2</sup> This result can be interpreted as an additional channel to reconcile the micro evidence of frequent price adjustments with the macroeconomic data indicating that inflation is rather inertial ([Bils and Klenow, 2004](#); [Nakamura and Steinsson, 2008](#), and [Altig et al., 2011](#)).

<sup>3</sup> Policy-makers are well aware of the importance of firm size, beyond firm creation, to understand aggregate economic performance. The Innova report in [European Commission, \(2014\)](#) report contains a wide set of proposals aimed at promoting firm growth and mentions that "...probably the newly designed aspects (... of European industrial policy...) focus more strongly on the growth processes of firms and are more selective in their specific support than many programs which focus mainly on the emergence of new firms".

<sup>4</sup> Departures from the standard industrial structure in the canonical New Keynesian model open up new channels for monetary policy beyond the one associated to the presence of nominal rigidities. As an example, [Bilbiie \(2017\)](#) has recently shown that, under some conditions, endogenous firm entry can reproduce monetary neutrality even in presence of sticky prices.

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