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Pricing decisions in an experimental dynamic stochastic general equilibrium economy☆

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ABSTRACT

We construct experimental economies, populated with human subjects, with a structure based on a nonlinear version of the New Keynesian dynamic stochastic general equilibrium (DSGE) model. We analyze the behavior of firms' pricing decisions in four different experimental economies. We consider how well the experimental data conform to a number of accepted empirical stylized facts. Pricing patterns mostly conform to these patterns. Most price changes are positive, and inflation is strongly correlated with average magnitude, but not the frequency, of price changes. Prices are affected negatively by the productivity shock and positively by the output gap. Lagged real interest rate has a negative effect on prices, unless human subjects choose the interest rate, or firms sell perfect substitutes in the output market. There is inertia in price setting, firms integrate wage increases into their prices, and there is evidence of adaptive behavior in price-setting in our laboratory economy. The hazard function for price changes, however, is upward-sloping, in contrast to most empirical studies.

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1. Introduction

Any accurate model of the macro-economy must be able to generate the stylized facts that characterize empirical data. One important feature of the macroeconomy is the existence of consistent patterns in how firms set and update their prices over time. Motivated by the importance of micro-level pricing behavior for generating business cycles, a number of studies

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have documented clear empirical patterns in price setting decisions (for a survey see Klenow and Malin, 2010). In this paper, we consider which environments best reproduce a number of stylized facts about pricing. We explore the implications of different assumptions on the structure of the economy for the pricing decisions of individual firms. The environments we study all have the dynamic stochastic general equilibrium (DSGE) structure, which is currently the workhorse paradigm for macroeconomic policy making.

We employ an experimental approach. The use of an experiment allows us to specify and vary the structure of the economy as desired, while permitting complete freedom for the individuals placed in the role of firms to make their pricing, production, and factor purchase decisions. The key difference between employing experimentation with human subjects, as we do here, and conducting simulations, is that we leave agents' decision making uncontrolled. For the questions of interest here, we do not wish to impose any structure exogenously on the strategies agents use. The experimental design consists of four different environments. Each environment differs from one of the others in terms of exactly one feature. This structure allows the effect of that one feature on pricing behavior to be isolated.

Our experimental economy is based on a New Keynesian DSGE model. In the DSGE framework, inertia in output prices can generate persistence of demand and supply shocks. In turn, macroeconomic events, such as shocks to demand, productivity, or monetary policy, affect pricing behavior of individual firms. There are four treatments, that vary in terms of frictions, which may potentially create price inertia, that are present in the economy. Pairwise comparisons of our treatments isolate the effect of the presence of monopolistic, rather than perfect, competition, as well as the existence of menu costs, in the output market. Another comparison between two treatments isolates the effect of discretionary interest rate setting versus strict adherence to a Taylor-type policy rule. Note that this treatment introduces another layer of uncertainty in the economy that could potentially change pricing behavior. Additionally, the shocks in the economy could be propagated in a different manner in the case of human central banker.

In our analysis, we compare pricing patterns in our data to those described in Nakamura and Steinsson (2008), Bils and Klenow (2004), and Klenow and Malin (2010), and test the hypotheses that the stylized facts they document appear in our data.[4] We then compare the behavior of the four environments. Specifically, we measure the average frequency and magnitude of price changes, and how these correlate with overall inflation. We evaluate whether positive changes are more frequent than negative changes, and by what percentage. We check how the frequency and size of price changes covary with inflation. We consider whether the hazard rate of price changes is decreasing or increasing over time. The hazard rate of price changes indicates the probability of a price change, as a function of the length of time that the same price has been in effect.

In addition, we conduct some exploratory analysis on the data. We estimate the markup that producers charge. We analyze the effect of macro variables such as productivity, output gap, and interest rate on prices set by firms in our economy. We also evaluate how micro level variables influence prices, in particular how past prices, current wage costs, and past profitability affect the prices set by firms in different treatments. We also check whether the behavior of human central bankers is in line with the Taylor principle, i.e., the response of the nominal interest rate to inflation must be greater than 1 in the long-run.

The principal findings, which are presented in Section 4, are the following. Pricing patterns mostly conform to empirical stylized facts. Which treatment conforms most closely to field data depends on the specific variables considered. Most price changes are positive, with the percentage of positive changes remarkably close to that observed in field data. Inflation is strongly correlated with the average magnitude, but not the frequency, of price changes. The hazard function for price changes, however, is upward-sloping. This means that the likelihood that a firm changes its price in a period is greater the longer it has kept its price constant. This stands in contrast to most empirical studies, but is consistent with the DSGE model with menu costs (see e.g., Alvarez et al., 2011).

Our data analysis yields a number of other basic relationships between macroeconomic variables, as well as between these variables and institutions that would be difficult to isolate in non-experimental economies. Menu costs reduce the variability of inflation. Prices are affected negatively by productivity shocks and positively by the output gap under most regression specifications. The lagged real interest rate has a negative effect on prices, unless the output market is very competitive. There is inertia in price setting, firms integrate wage increases into their prices, and there is evidence of adaptive behavior in price setting. Results regarding "central bankers" suggest that they set the nominal interest rates where they respond more than one-to-one with respect to changes in the inflation.[5]

2. Experimental design

In this section, we describe the DSGE model that is the basis for the experimental design. Additional details about the implementation are described in the online appendices. The analysis of the macroeconomic data in the economy is reported in a companion paper (Noussair et al., 2013).

Subjects were all undergraduate students at Tilburg University. Four sessions were conducted under each treatment for a total of sixteen sessions. Six subjects participated in each session (three consumers and three producers), with the exception

[4] These studies use product-level data from the US.

[5] Engle-Warnick and Turdaliev (2010) also study the monetary policy decisions of inexperienced human subjects. They find that the sensitivity to inflation is, on average, close to or above 1 in their interest rate decisions.