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State dependent price setting rules under implicit thresholds: An experiment

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ABSTRACT

How firms make their pricing decisions is a fundamental question of macroeconomics. We use a laboratory experiment to examine individual choices in a price updating task that provide insight into how well state dependent models reflect behavior. We find that in general subjects behave as if they recognize the importance of a state dependent pricing strategy, but they are unable to ascertain this threshold with precision and they also exhibit a substantial degree of time dependence. As a result, they update prices too frequently, and perform statistically significantly fewer real effort profit-generating tasks than theoretically optimal under full state dependence, which results in statistically significantly lower profits as well.

1. Introduction

How firms make their pricing decisions is a fundamental question of macroeconomics. The degree of price rigidity is commonly considered the main factor affecting the transmission of monetary policy to the real economy and, not surprisingly, an extensive literature has explored this matter over the years. A growing body of empirical work has tried to quantify the degree of flexibility of prices. The most recent empirical evidence seems to unanimously support the conclusion that price adjustments occur at higher frequencies than initially believed (see, for instance, Klenow and Kryvtsov, 2008; Nakamura and Steinsson, 2007; Bils and Klenow, 2004, who find durations between four and eight months). At the same time, many competing theories have been proposed to provide a micro-foundation of price rigidity and embed it in macroeconomic models, from the more simple staggered price model of Calvo (1978) to the menu costs of Mankiw (1985) and the state dependent models (also known as "Ss") introduced by Caplin and Leahy (1991). With so many alternative models still actively used in the theoretical work, economists seek to understand the intrinsic validity of the assumptions required by each, and controlled laboratory experiments provide a useful tool for doing so. In this paper, we investigate price rigidities relying on a

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fully experimental context. The purpose of our work is demonstrating to what extent a state dependent optimal pricing model has a legitimate *behavioral* basis.

Ss models hold at their core that agents should choose when to re-optimize solely based the state of the world ("state-dependent" adjustment) and not on time *per se* (i.e., "time-dependent" adjustment). In our experiment, we follow the approach of Magnani et al. (2016) to setup an experimental environment in which the subjects must adopt a state dependent pricing rule in order to maximize the profits of their production activity. The profits earned by the subjects are deleteriously affected by the deviation of the price charged at a point in time from an optimal reference price, which depends on the underlying economic fundamentals. Prices can be reset to the optimal price at any time, but the subjects face an adjustment cost that determines the standard optimal threshold for price adjustments of the Ss models. We depart from Magnani et al.'s (2016) design in how we model the adjustment cost, which entails two fundamental differences with respect to their basic framework. First, in our experiment subjects must complete a real effort task in order to produce a unit of output and make profits. Second, the subjects must complete a time-consuming task in order to adjust the price they charge, thereby foregoing profits to do so. As a result of the introduction of these two tasks, the cost of updating in our model reflects a real trade-off between production and price setting, and it is not exogenously given to the subjects as in Magnani et al. (2016). The trade-off relies on the perception of time cost of the subjects, which is an individual specific cost. By internalizing the updating cost and examining how this affects subjects' behavior, we are able to highlight a new dimension of the inability of price setters to accurately solve the problem facing them, which does not seem strictly related to economic uncertainty *per se*. This new dimension of the analysis provides additional insights on the role of attention and cognitive load in the price setting mechanism.

The main results of the experiment are essentially twofold. First, we find that subjects tend to respond in a way that is akin to state dependence. In each of the situations we examine, the average subject exhibits behavior consistent with the employment of a noisy decision rule for a threshold. They recognize the importance of an inaction region across treatments, although the precision of these regions is lower the higher the degree of uncertainty in the economy, and they exhibit some elements of time dependence in their pricing decisions. This first result is in line with the evidence documented by Magnani et al. (2016), who explain the large deviations of the subjects' decisions from the optimal thresholds with a model of bounded rationality. In their model, the limitations to rationality increase as a function of the cognitive load fundamentally caused by the volatility of the economic environment in which subjects find themselves operating. Second, subjects in our experiment make an additional systematic error in the identification of the optimal thresholds due to our implicit adjustment cost. Comparing the experimental results to the optimal thresholds obtained by simulation of the profit-maximizing decision rules that a fully rational agent should have followed, we find that subjects adjust their prices too "early" with respect to the state, in the sense that they reset prices when the profit from a unit of output sold is still higher than the optimal threshold point. Since this type of error does not seem to depend on the uncertainty of the environment, we link it to the form of the adjustment cost used in our experiment.

The results obtained from the experiment suggest that a state dependent model is insufficient to fully capture the price setting behavior. Rather, an hybrid model that mixes at the same time, state and time dependent elements would be necessary to adequately fit the data from the laboratory. Similar conclusions were suggested by the analysis of field data as well; for instance, Nakamura and Steinsson (2007) and Klenow and Kryvtsov (2008) show that the shape of the hazard functions of price adjustments in field microdata is not directly attributable to simple menu-cost models. Also Magnani et al. (2016) conclude that bounded rationality is the most plausible explanation of this hybrid dynamics of pricing decisions given their experimental setup. Subjects experience cognitive costs in assessing the state of the economy and formulating their optimal response, and higher cognitive loads decrease subjects ability to fully adopt state dependent rules by increasing these costs. While there are some exceptions, most studies have found negative effects of cognitive load on basic economic behavior (see Deck and Jahedi, 2015, for a recent survey).

We further explore this type of explanation with the introduction of the trade-off between production and price setting tasks. The purpose of this feature of our design is to have a simple and direct way to tamper with the cognitive capacity of the subjects; if the cognitive load explanation is valid, this additional burden should negatively affect the performance of subject across treatments. The implicit cost of adjustment achieves this goal in two ways: the first is by forcing subjects to infer their cost of resetting prices in terms of forgone profits while they accomplish the updating task; the second is by adding a real source of distraction for the subjects that diverts their attention from screening the state of the economy to executing the production task. While it is hard to precisely disentangle the two channels, they both operate in the same direction by increasing the likelihood of optimization errors. This implicit trade-off provides a simple micro-foundation of the attention allocation mechanism in the laboratory, but it can be considered fairly realistic for a large group of firms in which one or only very few workers are employed. The Small Business Administration (SBA), for instance, reports that over 75% of businesses in the US have no employees. Hence for most companies, pricing, production, and other tasks likely fall to a single person. Whilst experimentally adequate in general, this trade-off would be clearly much less realistic for larger and more sophisticated enterprises in which separate divisions are in charge of production and pricing decisions. However, other distracting factors would likely impact the pricing divisions of larger firms and hence our experimental set-up likely has relevance for them as well.

The effect of the endogenous cost of adjusting prices is a uniform shift of thresholds across decision environments. Sellers, pressured to actively engage in production, seem to systematically underestimate the actual cost they must bare to update prices, and as a consequence they end up updating relatively more often than optimal. This behavioral pattern can be