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## Money, liquidity, and the structure of production

Joshua R. Hendrickson <sup>a,\*</sup>, Alexander William Salter <sup>b</sup><sup>a</sup> University of Mississippi, Department of Economics, 229 North Hall, University, MS 38677, United States<sup>b</sup> Rawls College of Business, Texas Tech University, 703 Flint Avenue, Lubbock, TX 79410, United States

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### ABSTRACT

We use a model in which media of exchange are essential to examine the role of liquidity and monetary policy on production and investment decisions in which time is an important element. Specifically, we consider the effects of monetary policy on the length of production time and entry and exit decisions for firms. We show that higher rates of inflation cause households to substitute away from money balances and increase the allocation of bonds in their portfolio thereby causing a decline in the real interest rate. The decline in the real interest rate causes the period of production to increase and the productivity thresholds for entry and exit to decline. This implies that when the real interest rate declines, prospective firms are more likely to enter the market and existing firms are more likely to stay in the market. Finally, we present reduced form empirical evidence consistent with the predictions of the model.

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## 1. Introduction

Time can be an important element of the production process. For example, for those who produce lumber or bottle wine or raise livestock, time is an important factor of production. Trees and livestock grow over time. Wine needs to mature before bottling. For these types of production, it is important to consider the optimal point in time to convert a tree into lumber or a pig into bacon. An important characteristic of this type of production is that it is irreversible. Once one cuts down a tree, bottles the wine, or slaughters a pig, this decision cannot be reversed.

Other types of production decisions are similarly either irreversible or entail large fixed costs, such as the decision to build or shut down a factory. There is an extensive literature that examines these types of decisions. [Dixit and Pindyck \(1994\)](#), for example, have labeled investment problems of this sort as part of the “option theory” of investment. According to this view, firms facing these types of investment decisions possess something like a financial options contract. In other words, firms have the opportunity, but not the obligation to exercise the option to undertake the particular type of investment (e.g. cut down the tree or build the factory). This option to invest has value. However, once a firm exercises the option, this value is gone. Thus, the investment decision of firms is really just a decision about the optimal time to exercise the option.

Many of the decisions analyzed in this literature are similar to those considered by earlier economists, such as [von Bohm-Bawerk \(1891\)](#) and [Wicksell \(1898\)](#). For these economists, capital goods were defined as goods-in-process. Central to their

\* Corresponding author.

E-mail addresses: [jrhendr1@olemiss.edu](mailto:jrhendr1@olemiss.edu) (J.R. Hendrickson), [alexander.w.salter@ttu.edu](mailto:alexander.w.salter@ttu.edu) (A.W. Salter).

analysis was the idea that changes in the rate of interest would alter the structure of production, or what Bohm-Bawerk called the period of production (i.e. the length of time from the start of production until the time of completion).

Building on the work of Bohm-Bawerk and Wickcell, Hayek (1931, 1933) developed a theory of the business cycle that emphasized the structure of production and, in particular, the role of changes in the money supply. Hayek argued that increases in money growth lead to corresponding increases in the length of production and therefore capital accumulation. However, since the change in the length of production was inconsistent with consumers' rate of time preference, this would ultimately result in lower consumption and a necessary reallocation of resources.

The purpose of this paper is to examine the effects of monetary policy on the structure of production. What we mean by this is that we want to consider how monetary policy affects the production decisions of firms when time is an important element of the production process. We consider decisions at both the intensive and extensive margins. On the intensive margin, we want to consider how monetary policy affects the decision regarding the optimal point in time to cut down a tree, or bottle the wine, or slaughter a pig. On the extensive margin, we want to consider how monetary policy affects a firm's decision about the optimal point in time to enter or exit a market.

We begin by developing a framework in which the length of the production process is an important choice variable for firms. We do so within a framework in which a medium of exchange is essential. Two possible media of exchange exist in the model, currency and bonds. When the bonds issued by firms to finance production have some degree of liquidity (i.e. can be used as a medium of exchange), an increase in inflation causes the period of production to increase. The Friedman Rule is optimal in this framework both because it eliminates the opportunity cost of holding money and because it ensures that the length of the production process in the centralized market is consistent with the time preferences of households.

We also consider the effect of monetary policy on the entry and exit decisions of firms. Decisions to enter and exit a market are also decisions that involve determining the optimal time to engage in a particular activity (and therefore fall within our definition of the structure of production). We show that expansionary monetary policy encourages more prospective firms to enter the market and less existing firms to exit the market. This effect is the result of prospective firms with lower productivity entering the market and existing firms with low levels of productivity remaining in the market longer than they otherwise would. We present reduced form empirical results consistent with the model's predictions.

## 2. Relation to previous work

This paper is related to three strands of literature. The first strand of literature is concerned with the role of competing media of exchange.<sup>1</sup> Bonds are assumed to be imperfectly liquid in our model. This assumption could be motivated by some sort of legal restriction consistent with the theory of Bryant and Wallace (1980). However, since the bonds in the model are used to finance goods in process in our model and capital is defined as the volume of these goods in process, the bonds are similar to claims to capital. Using this interpretation, this model is perhaps most similar to Lagos and Rocheteau (2008) who consider money and capital as competing media of exchange. They show that lower rates of return on money (higher inflation) cause the rate of return on capital to decline. This decline in the rate of return coincides with an increase in the capital stock. Our model combines this sort of logic with the additional time elements of the production decision, such as the period of production and the thresholds for entry and exit. In particular, our model shows that higher rates of inflation cause the real interest rate to decline, which increases the period of production, or time-to-build, of firms and lowers the thresholds for entry and exit. Thus, in our model, capital increases because the value of the goods in process increase and existing firms are less likely to exit.

Within the monetary search literature, Berentsen and Waller (2009) develop a model with endogenous firm entry and consider the implications for policy. In their model entry generates a congestion externality in the decentralized market and it is therefore optimal for policymakers to deviate from the Friedman Rule. In our model, the Friedman Rule is optimal. The difference between the two frameworks is that we assume that entry and exit occur in the centralized market rather than the decentralized market and therefore there is not a congestion externality.

The model is also related to a second strand of literature by Bilbiie et al. (2007, 2012), who examine endogenous entry over the business cycle. In particular, Bilbiie et al. (2007) consider endogenous entry and product variety in a model with sticky prices. Their model suggests that expansionary monetary policy results in increased entry (and thereby greater product variety), which is consistent with the prediction of our model. Our approach differs from their approach in few important respects. First, we consider a model in which media of exchange are essential for trade. As a result, the mechanism by which monetary policy works is through changes in the rate of inflation and a no arbitrage condition for money and bonds in the household's portfolio decision. Thus, in our model the influence of monetary policy on entry, exit, and the period of production is a function of the liquidity of bonds and therefore the degree of financial development. This latter emphasis on the period of production is also unique to our model. This adds an important element about the adjustments made to the structure of production on the intensive margin that is absent from this earlier work. This is also important because our model features an interaction between decisions on the intensive and extensive margin. Specifically,

<sup>1</sup> There is an extensive literature on this subject. In what follows we discuss the paper most closely related to our approach, both in methodology and results. For a sizable list of citations related to money and competing media of exchange, see the discussion in Nosal and Rocheteau (2011).

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