The threat of counterfeiting in competitive search equilibrium

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ABSTRACT

This paper studies counterfeiting of bank notes in a monetary model under competitive search. The application of the refinement scheme proposed by Guerrieri et al. (2010) shows that there is no equilibrium with counterfeiting. However, due to the entry margin, counterfeiting poses a threat to the existence of a monetary equilibrium: there is no monetary equilibrium if the cost of producing counterfeits is low enough. Moreover, the threat of counterfeiting can generate an endogenous resalability constraint. An extension of the model is provided which allows the threat of counterfeiting to materialize, in that some buyers cannot observe the offers, and therefore search randomly. Counterfeit notes are produced by those buyers who randomly search.

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1. Introduction

This paper studies counterfeiting of bank notes in a monetary model under a competitive search environment where sellers make offers, and buyers see the offers and search toward sellers. The previous work on counterfeiting is typically done in the context of random search models where the terms of trades are determined by a signalling game in which an informed buyer makes an offer to an uninformed seller (see Green and Weber, 1996; Williamson, 2002; Nosal and Wallace, 2007; Hu, 2011).[1] These papers either put very restricted assumptions to generate the equilibrium with counterfeiting as in Green and Weber (1996) and Williamson (2002), or involve non-existence of counterfeiting equilibrium if the standard refinements are applied as shown in Nosal and Wallace (2007) and Hu (2011). In contrast to the existing studies, this paper considers the competitive search environment where agents' ability to signal is fully eliminated. This paper also explicitly models the entry of sellers, which opens the question how the cost of producing counterfeits affects the seller's entry decision, and hence, the monetary equilibrium. Compared to random search models, the competitive search environment is a more realistic description of most transactions at the retail level, because a buyer usually observes the price listed for the goods or services, and then decides which store to go to.

In the model, a seller who posts an offer needs to form a belief on how likely it is to meet with different types of buyers. To rule out unreasonable beliefs, this paper adopts the equilibrium concept proposed by Guerrieri et al. (2010) to refine sellers' out-of-equilibrium beliefs.[2] As a result, an equilibrium with counterfeiting does not exist due to the refinement

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[1] For a comprehensive review on the models of counterfeiting, please see the survey by Fung and Shao (2011b).
[2] A recent paper by Fung and Shao (2011a) argues that counterfeit notes and genuine notes can coexist in a pooling equilibrium under this environment. However, they show this result by not putting any restrictions on sellers' out-of-equilibrium beliefs, which leads to indeterminacy of equilibrium.

scheme that allows sellers to screen counterfeiters and discourage buyers from producing counterfeits. However, the possibility of counterfeiting poses a threat to the existence of monetary equilibrium.[3] For a given (positive) entry cost and inflation rate, if the cost of producing counterfeits is low, then there is no monetary equilibrium. The reason is that the potential counterfeiting problem can discourage sellers from entering the market so that the market may shut down. This threat distinguishes the counterfeiting of bank notes from other frauds – it can destroy confidence in using bank notes, leading to significant social costs. This result provides a rationale for why central banks should actively respond to the threat despite the extent of counterfeiting being small.

Moreover, this paper shows that the threat of counterfeiting can generate an endogenous resalability constraint. This resalability constraint, which is important in finance to understand asset liquidity and its prices, has been derived in Li and Rocheteau (2009) and Li et al. (2012) under some bargaining protocols. This paper contributes to the existing literature by showing that the constraint is robust and emerges under competitive price posting as well.

After establishing the no-counterfeiting equilibrium, this paper extends the model by introducing some randomness into the search process.[4] The idea is to assume that some buyers are uninformed about the offers posted by sellers, and thus they randomly search, while others still conduct directed search. In doing so, sellers cannot preclude all counterfeiters from visiting them, since some buyers always show up randomly. As a result, equilibrium with counterfeiting can exist when buyers are ex-ante heterogeneous. In this case, those buyers who randomly search may produce counterfeits. The existence of a counterfeiting equilibrium depends on the parameter values: if the costs of producing counterfeits and posting offers are low, and the fraction of uninformed buyers is high, the counterfeiting equilibrium more likely occurs.[5] The reason is that when more buyers are uninformed, sellers have a strong incentive to create a market with less-desirable terms of trade so that they can extract more rents from the uninformed buyers. At the same time, given the sellers' strategy, when the cost of counterfeiting is small, uninformed buyers find that producing counterfeits is at least as good as holding genuine notes. Hence, counterfeiting occurs in equilibrium. The existence of counterfeiting allows a discussion on related policies. For example, it can be shown that depending on the preferences, higher inflation results in lower counterfeiting. Given that counterfeiting occurs in this special environment, this paper discusses how to map these findings into the real world. The results resemble the phenomenon that foreigners produce and distribute counterfeits in the local community as observed in the past and current counterfeiting activities.

On the theoretical side, this paper follows the path of recent developments in the competitive search model with asymmetric information.[6] Guerrieri et al. (2010) and Chang (2011) study the adverse selection problem where the types are exogenously given and *principals* post offers to screen different types. In contrast to these papers, here the types are endogenously determined, which leads to a moral hazard problem. In the adverse selection problem with a similar setup, Guerrieri et al. (2010) show that the only equilibrium is no-trade. However, this result is not necessarily true in the moral hazard case as this paper shows. Yet, while Delacroix and Shi (2013) also investigate the private information problem which results when the types endogenously arise, they focus on signalling, rather than screening as in this paper. Therefore, this paper can be seen as a complement to the existing literature.

2. The baseline model

The basic economic environment is similar to Rocheteau and Wright (2005). Time is discrete and runs forever. Each period is divided into two subperiods, day and night, during which the market structure differs. During the day, there is a Walrasian market characterized by competitive trading, while at night there is a search market characterized by bilateral trading. There is a continuum of infinitely lived agents who differ across two dimensions. First, they have private information on some of their own characteristics that will be described in detail later. Second, they belong to one of two groups in the search market, called *buyers* and *sellers*. We normalize the measure of buyers to 1 and the measure of sellers is $N > 1$. In the Walrasian market all agents produce and consume, but in the search market a buyer can only consume and a seller can only produce. This specification of agents' trading roles in the search market generates a lack-of-double-coincidence-of-wants problem. Therefore, barter is ruled out. All meetings are assumed to be anonymous, which precludes credit. These frictions make a medium of exchange essential in the search market.

Goods are perishable, while (genuine) fiat money is storable, and thus money can potentially be used as a medium of exchange. Money is perfectly divisible and its stock at time t is given by M_t. The money stock grows at a constant gross rate γ, so that $M_{t+1} = \gamma M_t$. New money is injected ($\gamma > 1$) or withdrawn ($\gamma < 1$) via lump sump transfers to all agents in the

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[3] Nosal and Wallace (2007) were the first to propose the notion that "the threat of counterfeiting can eliminate the monetary equilibrium," however, their analysis is incorrect. After working out a proper belief system, Li and Rocheteau (2011) show that counterfeiting does not pose a threat to the existence of a monetary equilibrium.

[4] The idea of partially directed search is essentially to make contracts incomplete, i.e., the offers cannot be contingent on specific types of buyers. Similar idea has been explored by Li et al. (2012), in which the contract incompleteness comes from the assumption that the shock on the cost of counterfeiting is realized after the offers have been made.

[5] It is of interest to note that the counterfeiting rate in Canada rose considerably in the early part of the last decade. According to the existing reports (e.g., Chant, 2004 and RCMP Criminal Intelligence, RCMP Criminal Intelligence, 2007), one of the possible factors behind this development was the growing availability of low-cost ink-jet color printers and copiers, which substantially reduced the cost of producing counterfeits.

[6] There is also a growing literature on monetary search models with private information, including Williamson and Wright (1994), Berentsen and Rocheteau (2004), Faig and Jerez (2006), Ennis (2008), Shao (2009), Lester et al. (2011), and Dong and Jiang (2011).