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Counterfeit quality and verification in a monetary exchange☆

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ABSTRACT

Recent studies on counterfeiting in a monetary search framework show that counterfeiting does not occur in a monetary equilibrium. These findings are contrary to the observation that counterfeiting of bank notes in some countries has recently experienced rapid increases. In this paper, we construct a model of counterfeiting in which counterfeiting can exist as an equilibrium outcome. A competitive search environment is employed in which sellers post offers and buyers direct their search based on posted offers. When sellers are uninformed, their offers are pooling and thus buyers can extract some rents by using counterfeit money. Therefore, counterfeit notes can coexist with genuine notes under certain conditions. We also explicitly model the interaction between sellers' verification decisions and counterfeiters' choices of counterfeit quality. This allows us to better understand how policies can affect counterfeiting.

1. Introduction

Counterfeiting of bank notes had been a serious problem in Canada in the early 2000s. To reduce counterfeiting and to keep it at a low level, the Bank of Canada has implemented a number of anti-counterfeiting measures. [1] In order to study the effectiveness of these measures, we develop a search model of money in which money is not perfectly recognizable and thus can be counterfeited. The model incorporates relevant decisions such as counterfeiting, verification, and government policy. First, we show that counterfeiting can exist as an equilibrium outcome and characterize the conditions under which such an equilibrium will exist. Then we study how policies affect counterfeiting. [2]

The literature on theoretical models of counterfeiting of bank notes is relatively small. [3] In recent years, a few papers have studied counterfeiting in the context of monetary search models. [4] For example, Kultti (1996) studies the conditions under which a monetary equilibrium can be sustained by extending the search models of Kiyotaki and Wright (1993) while Green and Weber (1996) look at how the introduction of new issue of bank notes affect counterfeiting. Cavalcanti and Nosal (2011) argue that it is optimal to tolerate counterfeiting when transactions are difficult to monitor and their values are small. Nosal and Wallace (2007) show that counterfeiting is only a threat and does not exist in a monetary equilibrium. However, such a threat could potentially result in the collapse of a monetary equilibrium if the cost of counterfeiting is sufficiently low. Li and Rocheteau (2011), with a basic set up similar to Nosal and Wallace, argue that despite the threat of counterfeiting there always exists a monetary equilibrium. However, the threat of counterfeiting will instead affect real allocations and thus social welfare. In the base model, Li and Rocheteau also find no monetary equilibrium with counterfeiting. [5] However, the experiences in Canada discussed above and in other countries suggest that counterfeiting is more than just a threat. Indeed, many countries have experienced a rapid increase in counterfeiting of bank notes followed

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[1] For a brief discussion of the Canadian experience of counterfeiting, see for example Bank of Canada (Fung and Shao, 2011).

[2] For example, Green and Weber (1996)) examine whether a policy of introducing a new style of currency that is harder to counterfeit but not immediately to withdraw from circulation all of the old issues would be able to reduce counterfeiting. Monnet (2005)) studies whether inflation would reduce the value of counterfeiting activities.

[3] For a comprehensive review on the subject matter, please see our survey in Fung and Shao (2011).

[4] Another strand of literature studies counterfeiting using game-theoretical models, for example, Lengwiler (1997) and Quercioli and Smith (2015).

[5] Li and Rocheteau consider two extensions in which counterfeiting can exist in equilibrium.

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by a gradual decline over the last decade or so. To explain such a phenomenon, it requires a model in which counterfeiting of bank notes exists as an equilibrium outcome.

Our model differs from existing models of counterfeiting in several aspects. First, money is divisible as in Lagos and Wright (2005). In Kultti (1996), Cavalcanti and Nosal (2011) and Williamson (2002), however, money is indivisible and thus counterfeit notes can improve welfare by acting as private money in alleviating the money shortage problem. In Canada and other industrialized countries, however, money shortage is less likely to be an issue. Second, the market structure in our model is such that sellers post their offers to buyers and thus buyers can direct their search based on the posted offers. [6]Unlike Nosal and Wallace, and Li and Rocheteau, buyers cannot signal to the sellers their types. In this case, there will always be a monetary equilibrium. Third, buyers have to pay a cost to produce counterfeit notes, and in the extended version of our model a higher quality counterfeit note is more costly to produce. In turn, higher quality counterfeit notes are more difficult for the seller to detect. In addition, sellers can invest in a verification technology that can detect counterfeit notes with a probability. If a seller does not invest in the technology, she will not be able to tell between genuine and counterfeit notes. The seller's decision may or may not be known to the buyer. Thus it allows us to explicitly model the interaction between counterfeiters and sellers.

We begin with a baseline model of counterfeiting which is very similar to Nosal and Wallace (2007), except that we consider divisible money and competitive search. Buyers decide whether to produce counterfeits or not at a cost. Sellers will receive a signal which will inform them whether the notes they will receive are genuine or counterfeit at some positive probability. We then characterize the conditions under which a monetary equilibrium with counterfeiting will exist in such an environment. We find that counterfeiting can exist in a monetary equilibrium if the cost of producing counterfeits is sufficiently low. Next we consider an extension to the baseline model in which a counterfeiter decides on counterfeit quality and a seller decides whether to verify the notes they receive or not. Such decisions will influence the probability that the signal is informative. A buyer's decision regarding counterfeiting is always private information. However, a seller's verification choice may or may not be observable. In these cases, the conditions for the existence of counterfeiting in equilibrium are related to the money growth rate and the cost of verification. We also find that a higher rate of inflation tends to reduce counterfeiting. This is consistent with the observation that counterfeiting is less likely to be a serious problem in high inflation countries and that most countries experiencing a high level of counterfeiting have relatively low and stable inflation. Interestingly, we find that a higher cost of verification tends to reduce counterfeiting. This seems counter-intuitive. However, when the cost of verification is higher, a seller will enter the market only if there is a higher fraction of buyers using genuine money so that he can make enough money by selling to a buyer.

The rest of the paper is organized as follows. The next section describes the model environment. In Section 3, we consider the baseline mode of counterfeiting in a competitive search environment and derive conditions under which counterfeiting can exist in a monetary equilibrium. In Section 4, we consider an extension which includes decisions regarding counterfeit quality and verification. We first consider the case that the seller's verification decision is public information. We again derive conditions under which counterfeiting can exist in a monetary equilibrium and then study how changes in inflation and the cost of verification will affect counterfeiting and the quantities traded. In Section 5, we allow the seller's verification decision to be private information and study whether the results in the previous section will be affected. Section 6 concludes.

[6] Competitive search is also a more realistic description of most transactions at the retail level. A buyer usually can observe the price listed for the goods or services she wants to buy and then decides which store to go to.

2. The environment

The basic economic environment is similar to Rocheteau and Wright (2005). Time is discrete and runs forever. Each period is divided into two sub-periods, 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. 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 on 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 Walrasian market. We restrict attention to policies where $\gamma \geq \beta$, where $\beta \in (0, 1)$ is the discount factor, since it is easy to check that there is no equilibrium otherwise. To examine what happens when $\gamma = \beta$, which is the Friedman rule, we can take the limit of equilibria as $\gamma \to \beta$.

Money is perfectly recognizable in the Walrasian market but imperfectly recognizable in the search market. The recognizability problem of fiat money gives a buyer an incentive to produce counterfeits and extract more surplus in the bilateral trade. Buyers can produce counterfeited notes in any quantity at a fixed cost g and this decision is private information. In any trade meeting, the trading pair will receive a signal regarding the quality of the money used by the buyer. With probability π, this signal reveals the type of money used by the buyer and with probability $1 - \pi$, the signal is uninformative. We will consider two different cases regarding this signal. In the first case, the baseline model, the probability of this signal being informative is exogenous, as in Nosal and Wallace (2007). Studying this case is important because Nosal and Wallace (2007) find no equilibrium with counterfeiting when the buyer makes a take-it-or-leave-it offer to the seller. It is thus of interest to study whether counterfeiting can exist in equilibrium under a different trading mechanism such as competitive search. In the second case, the probability depends on the actions of the counterfeiters and the sellers. We will describe the second case in more detail in Section 4 below. Counterfeits are assumed to be 100% disintegrated or confiscated at the end of each period as in Nosal and Wallace (2007). [7]

[7] We maintain this assumption for three reasons. First, this assumption is used in the existing literature such as Nosal and Wallace (2007) and Li and Rocheteau (2011). In order to make a sound comparison with existing studies, we want to have an economic environment as close as possible and highlight the trading arrangement as a key to generate different results. Second, this assumption implies a pooling equilibrium of counterfeiting meaning that counterfeit notes coexist with genuine notes only when people think the counterfeit note as a genuine one. The emphasis on pooling is that, in reality, sellers do not accept or recirculate counterfeits if they know the notes are fake. Thus, if counterfeiting occurs, it must be a pooling outcome. Third, in our setup, counterfeits are always detected in the day market since there is no private information problem in this market. Therefore, it is natural to assume that counterfeits do not circulate across periods. This assumption is close to reality where counterfeit notes do not tend to circulate for too long before they are detected and removed from circulation (see (Quercioli and Smith, 2015)). If we allow the possibility that counterfeits can circulate across periods, then counterfeits may have future values. In this case, as Li and Rocheteau (2011) point out, there can exist a separating equilibrium in which counterfeit notes and genuine notes trade with different prices and people accept counterfeits knowingly. Counterfeit notes are very similar to private money which is along the line with Kultti (1996), Cavalcanti and Nosal (2011) and Williamson (2002). The issue of private money is out of the scope of this paper, and one can consult the paper by Sanches (2014) for details.