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WHY SHOULD MONEY LOSE VALUE WITH TIME: BOOSTING ECONOMY IN THE ERA OF E-MONEY

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WHY SHOULD MONEY LOSE VALUE WITH TIME: BOOSTING ECONOMY IN THE ERA OF E-MONEY

We investigate new instrument of monetary policy which is able to stimulate economy in the age of electronic money. Demurrage (negative interest on money holdings) is a non inflationary monetary instrument that is able to boost the rate of economic transactions. We show with the search-theoretic model that the search effort of buyers is increasing in demurrage fees and higher search effort is associated with the lower price level and higher aggregate output. We find that aggregate welfare is higher when demurrage is imposed compared to quantitative easing policy. While demurrage is complicated to impose on banknotes it is easily set on electronic money which makes this unconventional policy measure more technologically feasible.

JEL Classification: E42, E50

Key words: demurrage, negative interest on money, monetary policy, government policy in recession

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1. Introduction

In the early twentieth century S. Gesell, a German merchant and theoretical economist, proposed the theory of money depreciation (Gesell, 1916). He argued that money should be used only as a medium of exchange but not the store of value. The main argument behind this statement was that money is costless to store so it can be easily hoarded and withdrawn from circulation which disturbs revenue flows in the economy. To return money into the cash flow Gesell proposed that money should pay negative interest he called demurrage[3]. This means that money holders should periodically pay some percentage of its value to the issuer (e.g. central bank). Gesell argued that demurrage would prevent stockpiling because money would automatically lose its value, resulting in accelerated monetary circulation and stable revenue flows.

Gesell proposed the following scheme of imposing demurrage. The holders of currency must periodically purchase stamps and attach them to banknotes in order to maintain their nominal value. The cost of these stamps should depend on the face value of the notes so that the mechanism is equivalent to the negative interest on money.

Money with demurrage stamps was first introduced in local communities as a complementary currency[4] during the Great Depression in the United States, Germany, Austria and Switzerland. These experiments resulted in liquidation of money deficit, lower unemployment level and increased tax payments (Blanc, 1998). Stamped money provided incentives to spend which accelerated local trade (Fisher, 1933). Government authorities, however, banned these local currency systems as they were hurting the issuing privilege of the central banks.

Because Gesell's theoretical ideas applied to local economies led to their recovery from the severe recession, there is the question of whether these economic principles can be applied on a larger scale. In recession periods economic agents prefer to hoard money which is withdrawn from circulation, and this worsens economic downturns. Demurrage is the instrument that could return money into economic circulation. We believe that demurrage is able to stimulate aggregate demand by encouraging economic agents to spend money on consumption or lend their excess money holdings which would accelerate monetary circulation and put downward pressure on interest rates. Demurrage fees also force economic agents to store wealth in property, equity securities and other capital goods instead of currency, thus enhancing demand for these goods which is especially beneficial in stagnation.

[3] The term 'demurrage' originally referred to charges that the charterer paid to the ship owner for delays in loading and unloading a shipping vessel, i.e. for the time when the ship was not functioning.

[4] Complementary currency, or alternative currency, is a currency used as an alternative to the national currency (not legal tender). Complementary currency systems are based on the agreement between the parties to use this currency as a medium of exchange and designed for specific purposes, for example, to increase local financial stability and reduce the need for national currency in recessions.

It is important to study unorthodox policy instruments. Currently applied methods of expansionary monetary policy require an increase in money supply growth which engenders high inflation risks. It is important that if monetary authorities impose demurrage, prices are stable as there is no need to raise the money supply. Inflation, however, is not a bad phenomenon itself. In an inflationary environment economic agents may purchase assets out of concern that prices will rise in future. Demurrage is similar to some degree to an inflation tax as it lowers the purchasing power of money with time, however, compared to demurrage, inflationary expectations involve more uncertainties, thus making decisions of economic agents complicated (Goodfriend, 2000). It is obvious that the fact that money is taxed if it is not spent or invested provides more incentives to economic agents than inflationary expectations.

The idea of imposing demurrage on national currencies is considered in the literature mainly as an alternative solution for the economy in liquidity trap. The liquidity trap occurs when changes in money supply does not induce changes in aggregate demand and is usually associated with zero interest rates (see Coenen et. al, 2004; Krugman, 1998). Some researchers argue that negative interest rates on bonds could mitigate negative demand shocks, and they argue that the lower bound on the risk free interest rate is determined by the return on money holdings due to the zero carrying cost and absolute liquidity of money. Hence, they propose imposing negative interest on money to eliminate the zero bound on the nominal interest on bonds. (see Buiter & Panigirtzoglou, 2003; Buiter, 2009; Fukao, 2005). We think of the liquidity trap as of the situation when agents hoard money and avoid investment in financial and real assets so that the growth in money supply does not stimulate the demand. The idea of setting demurrage fees on money is to give it an artificial carrying cost which may effectively prevent hoarding so that monetary policy becomes effective again. In our paper we consider demurrage as a general-purpose instrument of expansionary monetary policy but the fact that demurrage can be applied effectively when other monetary policy measures become powerless makes it even more advantageous.

When we consider the existing literature, it is evident that there are few studies on demurrage as an instrument of expansionary government economic policy. In contrast to the prior research that explored the impact of demurrage on interest rates (Buiter & Panigirtzoglou, 2003; Buiter, 2009; Fukao, 2005), we are interested in its effect on general economic welfare. Previous studies of demurrage fees applied in local currency systems showed that this instrument is able to stimulate trade and lower unemployment (Blanc, 1998; Fisher, 1933). However, when we consider the effects of government economic policy it is also important to take potential changes in the price level into consideration.

Therefore, the purpose of this paper is to investigate the impact of demurrage on major macroeconomic indicators, such as economic output, price level, money velocity and welfare.

To meet the goal of the paper we use theoretical analysis and study the process of trade with the search-theoretic model of money. Search theory investigates the exchange process of buyers and sellers who search for each other before transacting. Search theoretic approach is advantageous because it introduces trade frictions in the economy where search is required for all transactions, thus presenting a more natural economic environment compared to frictionless competitive equilibrium models[5]. While some economists attribute recessions to price stickiness, search theory emphasizes search frictions, i.e. costly exchange process and difficult coordination of trade, as an additional cause of economic downturns.

When we consider national currencies it is complicated to impose demurrage on banknotes because paper money is bearer bonds. However, it is technological feasible to set demurrage on electronic money, i.e. checking accounts in banks, and nowadays most of the currency is deposited in the banking system.

In Section 2 we apply search-theoretic model of money to investigate the effects of demurrage on economy. Section 3 compares demurrage with the quantitative easing policy. Section 4 considers the technological feasibility of imposing demurrage in national economies. Section 5 concludes.

2. Search-Theoretic Model

We investigate demurrage mechanism in a search-theoretic model where money holders search for the sellers to purchase consumption goods. In our model money is used for all transactions (no barter or credit).

Mortensen (1982) showed within the framework of matching theory that agents do not search for each other intensively enough because the search process is costly, and their search efforts are lower than the joint wealth maximizing equilibrium requires. The role of demurrage here is related to alleviating inefficiencies in the economy with search frictions. In particular, demurrage induces money holders to search for trading partners more actively which results in higher volume of transactions in the economy with fixed money supply.

We adopt the framework of Trejos and Wright (1995) which assumes endogenous prices and divisible commodities[6], and introduced the bargaining game that determines the quantity of goods traded in the exchange market.

First consider the economic environment of the model. The economy is populated by a large number of infinitely lived agents with the total population normalized to unity. Agents produce and consume differentiated non-storable commodities. It is assumed that agents cannot

[5] See Diamond (1982, 1984), Trejos and Wright (1995), Shi (1995, 1997), Lagos and Wright (2005).
[6] The assumption of divisible consumption goods means that one unit of fiat money could buy several units of consumption goods.

produce commodities for their own consumption. This restriction is necessary to stimulate the trade process because in this case producers must enter the exchange market to trade their products for money and then purchase goods for consumption with the money received. This assumption represents the advantage of specialization over self-sufficiency in a modern economy.

At each moment in time the fraction $M \in [0, 1]$ of the population holds one unit of fiat money, we call them 'buyers', and the fraction $1 - M$ produces and trades q units of consumption goods, we call them 'sellers'. Money is used only as a medium of exchange, and when agents with money trade they spend all their money holdings at once. Note that the fraction of money holders, M, is also the value of nominal money supply which we assume exogenous because it is fixed by the government.

Agents are heterogeneous in their preferences, so each agent who enters the production process is able to produce a variety of consumption goods demanded only by a fraction $x \in [0, 1]$ of the population. Therefore, x can be also interpreted as the probability of an acceptable trade, or that each money holder accepts and consumes the certain commodity. The smaller x makes the exchange process more complicated. We assume x as an exogenous parameter constant across all individuals.

Note that consumption goods in contrast to money are divisible and one unit of money can be exchanged for q units of real commodities. If p is the price of q units of consumption goods in every transaction, then the total cost of one transaction for the buyer is $pq = 1$ as individual buyer holds only one unit of fiat money. This implies that the price level is $p = 1/q$. If q increases then one unit of money would buy more units of consumption goods which means that the purchasing power of money also increases or, equivalently, the price level falls. One can see from the quantity theory of money equation that output growth has a natural deflationary effect:

$$p = \frac{Mv}{Y},$$

where Y is the aggregate output composed of the quantities of goods traded in all economic transactions, q, and v is the velocity of money[7].

When a buyer purchases q units of consumption goods, he enjoys utility $u(q)$ and the seller bears the production cost $c(q)$. The standard assumptions are that $u'(q) > 0$, $u''(q) \leq 0$ and $c'(q) > 0$, $c''(q) \geq 0$ and $u(q) > c(q)$ for all $q > 0$. Money has no intrinsic value in the model which means it yields zero utility when hold.

[7] This phenomenon can be observed in the technology sector, where innovations are growing faster than inflation, and as a result buyers enjoy falling prices.

The trade process occurs in the following way. There is the expected number of contacts made by each agent per unit of time, $\xi > 0$. Therefore, $\xi\Delta$ is approximately the probability of meeting another agent in a short time interval of the length Δ[8]. The frequency of interactions is naturally dependent on the search effort of traders. In Trejos and Wright (1995) it is assumed that buyers search for sellers while the latter remain at distinct locations because they need a particular place for production purposes. Therefore, ξ represents the search effort choice of the buyer in our model. We assume zero cost of search to the buyer because higher search effort results in a more rapid consumption.

It is assumed that the rate at which each buyer locates sellers is proportional to the number of sellers, $1 - M$, and the rate at which each seller locates buyers is proportional to the number of buyers, M. Given heterogeneous consumption preferences of agents we define the rate at which each buyer locates appropriate sellers as $\xi(1-M)x$, and the rate at which each seller locates suitable buyers as ξMx. When the appropriate trading partners meet, they bargain over q, and if they trade, the seller becomes the buyer, and the buyer enters the production process.

To introduce demurrage in the model we adopt the process of taxing money holders described in Kiyotaki and Wright (1991). There is the tax rate on money balances $\delta \in [0,1]$ which also indicates the probability that the government revenue agent meets a buyer and confiscates all her money holdings while the latter moves to production without consuming. There is also the probability $\gamma \in [0,1]$ at which the government purchasing agent meets a seller and purchases consumption goods. The government budget constraint can be written as

$$\delta M = \gamma(1-M),$$

where $\gamma = \delta M/(1-M)$.

This process of money taxation is consistent with the policy of imposing demurrage because the tax is paid only by those who hold money at the moment. This means that money holders are able to avoid the payment of interest if they purchase consumption goods and money is passed on.

Note that the there is no budget deficit in the model because tax collections are equal to the government spending, and the government budget constraint represents the interrelation of monetary and fiscal policies.

Kiyotaki and Wright (1991) assumed the fraction of money holders, M, as an endogenous variable and showed that in equilibrium it is a decreasing function of the tax rate on money, δ. One interpretation of this finding is that the policy of imposing demurrage motivates traders to

[8] See Mortensen (1982).

hold less money holdings and more consumption goods. Note that in our model we assume M as an exogenous variable because it is the value of nominal money supply fixed by the government.

To determine the payoff for each agent in different states at each point in time we need to introduce the value functions for seller and buyer, V_{st} and V_{bt} respectively. To derive the value functions for rational agents in search models, Bellman's principle of dynamic optimality is usually applied. To do so, we need to determine the payoffs of every event that could possibly occur during a short future time interval of the length Δ. Let $r > 0$ denote the discount rate, or the rate of time preference.

First consider the value function of a seller. In a short discrete time period Δ the probability that the appropriate buyer or the government purchasing agent will arrive is $(\xi Mx + \gamma)\Delta$, and the probability that the seller will not trade in these period is $1 - (\xi Mx + \gamma)\Delta$. Therefore, the seller's objective function at time *t* can be written as

$$\mathrm{V}_{st} = \frac{1}{1 + r\Delta}\{(\xi Mx + \gamma)\Delta[\mathrm{V}_{bt+\Delta} - c(q_{t+\Delta})] + [1 - (\xi Mx + \gamma)\Delta]\mathrm{V}_{st+\Delta}\}.$$

Simplification gives

$$r\Delta\mathrm{V}_{st} = (\xi Mx + \gamma)\Delta[\mathrm{V}_{bt+\Delta} - \mathrm{V}_{st+\Delta} - c(q_{t+\Delta})] + \mathrm{V}_{st+\Delta} - \mathrm{V}_{st}.$$

If we divide the above equation by Δ and take the limit as Δ → 0, we get

$$r\mathrm{V}_{st} = (\xi Mx + \gamma)[\mathrm{V}_{bt} - \mathrm{V}_{st} - c(q_t)] + \dot{\mathrm{V}}_{st}.$$

For the buyer the probability to meet the appropriate seller in a short time interval is $\xi(1 - M)x\Delta$ and the probability to meet the government revenue agent is $\delta\Delta$. Then, the value function of the buyer becomes

$$\mathrm{V}_{bt} = \frac{1}{1 + r\Delta}\{\xi(1 - M)x\Delta[u(q_{t+\Delta}) + \mathrm{V}_{st+\Delta}] + \delta\Delta\mathrm{V}_{st+\Delta} + [1 - (\xi(1 - M)x + \delta)\Delta]\mathrm{V}_{bt+\Delta}\}.$$

The similar derivation gives

$$r\mathrm{V}_{bt} = \xi(1 - M)x[u(q_t) + \mathrm{V}_{st} - \mathrm{V}_{bt}] + \delta(\mathrm{V}_{st} - \mathrm{V}_{bt}) + \dot{\mathrm{V}}_{bt}.$$

Therefore, we can define the steady-state value functions for seller and buyer when $\dot{\mathrm{V}}_{st} = 0$ and $\dot{\mathrm{V}}_{bt} = 0$ as

$$r\mathrm{V}_s = (\xi Mx + \gamma)[\mathrm{V}_b - \mathrm{V}_s - c(q)] \quad (1)$$

and

$$rV_b = \xi(1-M)x[u(q) + V_s - V_b] + \delta(V_s - V_b) \quad (2)$$

These equations are standard in search-theoretic models, and may have the following interpretation. Equation (1) denotes that the payoff for the seller is the product of the rate at which he trades his commodities either to buyers or to the government, $\xi Mx + \gamma$, and the gain from switching to the buyer's state less the production cost, $V_b - V_s - c(q)$. Equation (2) indicates that the payoff for the buyer is composed of the rate at which he meets the appropriate sellers, $\xi(1 - M)x$, times the gain from consuming and switching to the seller's state, $u(q) + V_s - V_b$, and the probability that he encounters the government revenue agent, δ, times the gain from switching to the seller's state without consuming, $V_s - V_b$. In our analysis we focus on the steady-state value functions, where all endogenous variables are constant with respect to time.

2.1. Search Effort Choice

The next step is to analyze optimal search effort choice of the buyer. Note that in the model it is buyers who search for sellers because sellers produce commodities at certain physical locations. We consider the bargaining solution when the buyer cannot maximize her expected utility without the seller acceptance to trade.

Before bargaining over q is introduced in the model we first fix the quantity and assume that agents treat q as given exogenously by the prevailing traded quantity in the market, Q[9].

When a buyer and a seller meet and complete transaction they generate joint surplus relative to the state of rejecting to trade, namely when they need to wait before they deal with the next trading partner. This joint surplus should be divided between buyer and seller which is the case of the bargaining problem. Kiyotaki and Wright (1993) and Diamond (1984) assumed that this trading surplus is equally shared between buyer and seller which mean that the utility gains from trade to the buyer and to the seller are equated whenever they trade[10]. Applied to our model the buyer's gain from consumption plus the gain from switching to the seller's state is equated to the seller's gain from the change of status and becoming a buyer less the production cost

$$u(Q) + V_s - V_b = V_b - V_s - c(Q) \quad (3)$$

From this split-the-surplus equilibrium condition one can derive the equilibrium level of search effort of the buyer.

Subtracting (1) from (2), we get

[9] See Trejos and Wright (1995)
[10] This is Raiffa bargaining solution that equalizes the surplus utilities of both players.

$$V_b - V_s = \frac{u(Q)\xi(1-M)x + c(Q)(\xi M x + \gamma)}{(\xi x + \gamma + \delta + r)} \quad (4)$$

Substituting (4) in (3) we derive optimal level of search effort as

$$\xi = \frac{[u(Q) + c(Q)](\delta + r) + \gamma[u(Q) - c(Q)]}{x(1-2M)[u(Q) - c(Q)]} \geq 0 \quad (5)$$

Substituting γ with $\delta M/(1-M)$ in (5) as stated by the government budget constraint and differentiating (5) with respect to δ, one can show that the optimal level of search effort is increasing in demurrage, $\partial\xi/\partial\delta > 0$, when $u(Q) > c(Q)$.

Our interpretation of this is that demurrage provides incentives for the buyers to increase their efforts to find trading partners because in other way they risk to lose their money holdings.

2.2. Price Level, Aggregate Output and Welfare

Now consider the bargaining process where prices are determined. Remember that we defined the price level as $p = 1/q$ because one unit of money buys q units of goods in each transaction. When the buyer locates an appropriate seller, they bargain over q. Note that when the government purchasing agent meets the seller, he purchases the quantity of consumption goods $q = Q$ prevailing at the market and does not participate in the bargaining process. Hence, only buyers and sellers bargain over the quantity of commodities in the model. Trejos and Wright (1995) showed that in the steady state $q_s = q_b = q$ where q_s and q_b are the proposals of the seller and the buyer respectively which also means that the supplied and demanded quantities are equalized. The solution to the bargaining problem in Trejos and Wright (1995) equates the agent's value of accepting the offer of counterparty to the discounted value of rejecting when during the short time interval of length Δ each of these agents gets to make the next offer with equal probability, and the offer in both cases is accepted[11].

The optimal condition for q is derived as

$$\frac{V_s + u(q) - V_b}{V_b - c(q) - V_s} = \frac{u'(q)}{c'(q)} \quad (6)$$

If agents treat V_s and V_b as the functions of Q prevailing in the market, condition (6) is equivalent to the Nash bargaining solution:

$$q = \arg\max[V_s + u(q) - V_b][V_b - c(q) - V_s]\ ^{12}.$$

[11] See also Shi (1995).

If we substitute (4) into (6) and set $Q = q$, we derive optimal output equation $T(q) = 0$, where

$$T(q) \equiv [u(q) - c(q)][u'(q)\xi(1-M)x - c'(q)(\xi Mx + \gamma)] - (\delta + r)[u(q)c'(q) + c(q)u'(q)] \quad (7)$$

One can show that $\partial T(q)/\partial q < 0$, hence, if $\partial T(q)/\partial \xi > 0$ it is sufficient to state that $\partial q/\partial \xi > 0$ because $T(q) = 0$. Differentiating condition (7) with respect to ξ it is clear that $\partial q/\partial \xi > 0$ stated that $u(q) > c(q)$ and $u'(q) > c'(q)$[13].

When the buyer and the seller trade higher search effort is associated with higher quantity traded in each transaction. This implies lower price level because one unit of money buys more units of consumption goods. Note that $\partial q/\partial \delta < 0$ as $\partial T(q)/\partial \delta < 0$ so demurrage has some direct inflationary effects.

Further we develop aggregate output equation. We can define aggregate output in the economy as

$$Y = q(\xi Mx + \gamma)(1 - M)$$[14].

To derive aggregate output equation, the quantity of goods traded in one transaction is multiplied by the rate of completed transactions which is the product of the rate at which each seller trades his commodities either to buyers or to the government and the number of sellers.

Substituting γ with $\delta M/(1-M)$, we can rewrite the flow of output as

$$Y = [\xi(1-M)x + \delta]Mq \quad (8)$$

It is clear from (8) that $\partial Y/\partial \delta > 0$ and $\partial Y/\partial \xi > 0$ which means that aggregate output is increasing in demurrage both directly and through the higher search effort.

Now consider the relationship between demurrage and money velocity in our model. According to the quantity theory of money, $Yp = Mv$. If the price level is $p = 1/q$, then we can define the velocity of money as

$$v \equiv Y/Mq.$$

If we substitute (8) in the money velocity equation we get

$$v \equiv \xi(1-M)x + \delta.$$

[12] One can see that the terms in brackets are the payoffs of the buyer and the seller from trade, and the bilateral Nash bargaining problem generally takes the form of maximizing the product of surplus utilities.
[13] Trejos &Wright (1995) showed that in equilibrium $u'(q) > c'(q)$.
[14] See Shi (1995).

Therefore, the velocity of money is strictly increasing in the tax rate on money by definition.

Along with individual value functions, we also introduce aggregate welfare criterion in our model. Define steady-state aggregate welfare as

$$W = M\mathrm{V}_b + (1 - M)\mathrm{V}_s \quad (9)$$

From (9) it is clear that aggregate welfare is simply the average value for buyers and sellers in the steady state.

Substituting (1) and (2) into (9) we derive

$$rW = \xi M(1 - M)x[u(q) - c(q)] - \delta Mc(q) \quad (10)$$

One can notice from (10) that demurrage has ambiguous effects on aggregate welfare. Demurrage could increase welfare through higher search effort of the buyer which means that the welfare I higher when the rate of transactions in the economy is higher. On the other hand, it engenders some welfare cost similarly to inflation because it erodes the purchasing power of money.[15]

Therefore, from the perspective of social efficiency there can be $\delta > 0$ if its influence on the rate of transactions exceeds the welfare cost. Note that this welfare cost is increasing in money supply and production cost.

In the next subsection we develop quantitative illustration of our model to compare macroeconomic effects of demurrage and quantitative easing as expansionary monetary policy tools.

3. Quantitative Easing

Quantitative easing means that the government increase money supply, M. It is clear from optimal output equation (7) that $\partial q/\partial M < 0$ when $u(q) > c(q)$ as $\partial T(q)/\partial M < 0$ on this interval. This implies that the price level increases in nominal money supply, $\partial p/\partial M > 0$, which corresponds to the monetarism concept of inflation.

Hence, quantitative easing policy is inflationary in our model while demurrage appears to be less inflationary – although it has direct inflationary effect it also lowers the price level through higher search effort.

[15] See Baily, 1956; Lucas, 2000.

It is clear from aggregate demand equation (8) that changes in money supply have oppositely directed effects on aggregate output which is the real variable and may have little influence on it which corresponds to the neutrality of money concept.

We could also compare welfare effects of demurrage and quantitative easing. Differentiating aggregate welfare equation (10) with respect to M it is clear that $\partial W/\partial M < 0$. Welfare cost of quantitative easing are composed of inflation cost because $\partial q/\partial M < 0$, or $\partial p/\partial M > 0$ (in the first term), and also of some cost associated with monetary taxation (in the second term).

To develop quantitative comparison of the model we specify consumption utility and production cost functions as

$$u(q) = \frac{q^{1-\sigma}}{1-\sigma}$$

and

$$c(q) = \theta q,$$

where $\sigma > 0$ represents the risk aversion, and $\theta > 0$ is the marginal production cost.

To illustrate effects of demurrage on major macroeconomic indicators we first determine different values of search effort by varying the tax rate on money. Then, we substitute these pairs of values into optimal output condition (7), and get values of the price level, aggregate output and welfare given fixed money supply.

To illustrate effects of quantitative easing on prices, aggregate output and welfare we set δ equal to zero and substitute different values of money supply in output equation (7) and determine the variables given fixed search effort[16].

We set parameters as $Q = 10$, $r = 0.1$, $M = 0.49$, $x = 0.3$, $\sigma = 0.5$, $\theta = 0.3$. To determine the value of search effort we use $M = 0.49$.

The illustration of effects of these two policy instruments is presented on Figures 1, 2 and 3. It is clear from Figure 1 that demurrage is noninflationary in contrast to money supply growth. From Figures 2 and 3 one can see that, in contrast to money supply growth, non-zero tax rate on money leads to higher aggregate output and welfare, and these variables begin to decrease when money supply grows above 0.3 and 0.5 respectively. We can also see that aggregate output is less sensitive to changes in money supply which reflects the neutrality of money.

[16] Although search effort is endogenous in our model and could be dependent on money supply as well as on the tax rate on money, we fix the value of search effort and assume that it does not change when negative interest on money is not applied by the government. The fixed value of search effort is set to 47.

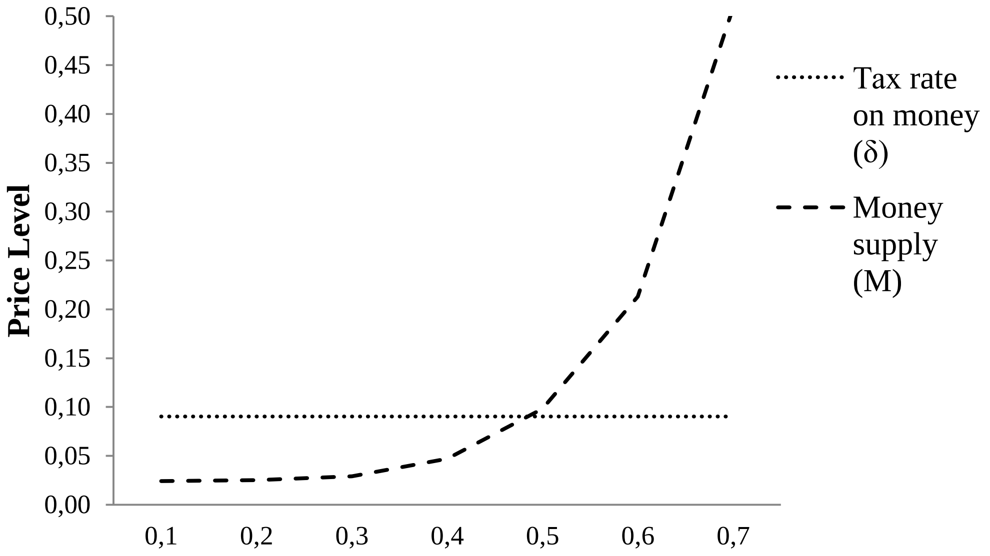

Fig. 1. Effects of Demurrage and Quantitative Easing on Price Level

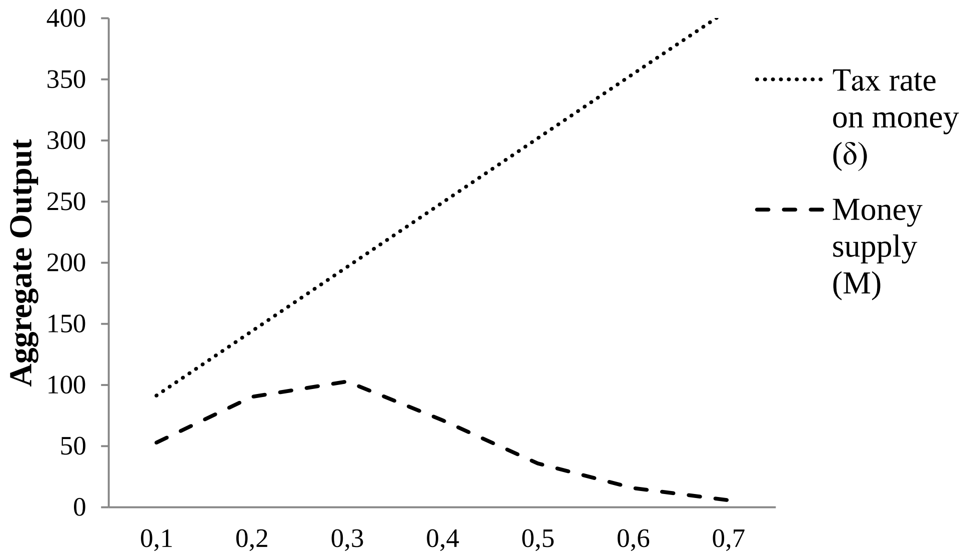

Fig. 2. Effects of Demurrage and Quantitative Easing on Aggregate Output

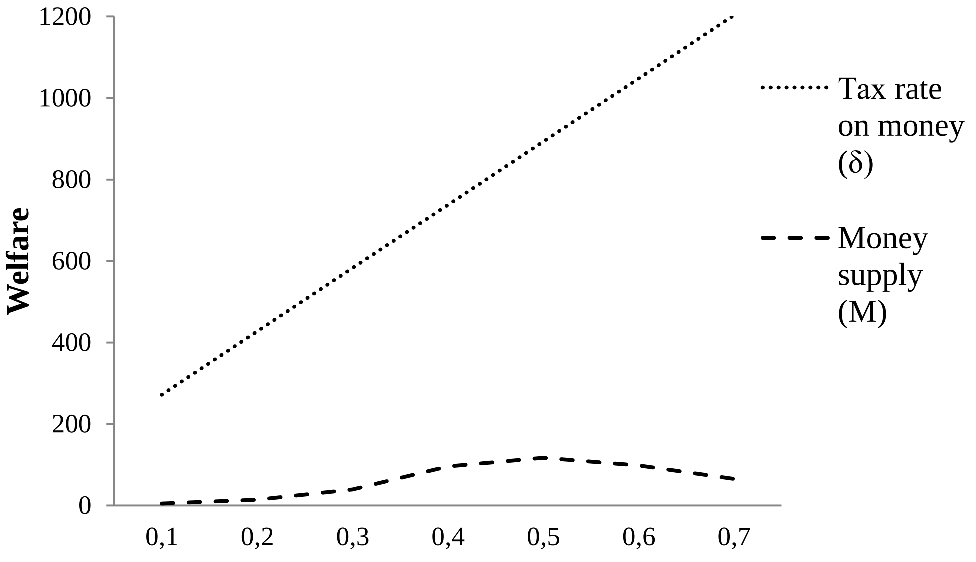

Fig. 3. Effects of Demurrage and Quantitative Easing on Welfare

It is clear that higher demurrage results in aggregate output growth and enhanced welfare. What important is that demurrage is not inflationary as the price level remains stable. It is even advantageous that prices do not fall because most economists regard deflation as a negative economic phenomenon. In the next subsection we discuss the ways of imposing demurrage on money holdings and give some recommendations to policy makers.

4. Technological Feasibility

In introduction we mentioned that demurrage is easily set on electronic money while it is complicated to impose it on banknotes. Goodfriend (2000) proposed to tax the vault cash in private banks. He argued that taxation of vault currency may propagate demurrage on checking accounts. We suggest that central banks could impose negative interest on demand deposit liabilities of private banks by taxing these liabilities periodically. We consider this procedure technologically feasible in a way monetary authorities impose reserve requirements to deposit liabilities. In this case private banks are likely to set demurrage fees on checking accounts.

The funds that monetary authorities obtain as a result of money taxation may be used to cover administrative costs of this policy and could also contribute to the general tax revenue thus making it possible for the government to lower other taxes or increase government spending. We suggest that when monetary transactions become purely electronic, governments could impose demurrage as part of regular fiscal policy. Note that the demurrage as an instrument of national fiscal policy should be set on money holdings of residents, not simply on national currency; otherwise, money is easily converted to foreign currencies to avoid paying the demurrage.

Finally, there is the problem of public discontent because new taxes are always opposed by the society even if they could improve the overall economic welfare. The annual tax on money holdings may be perceived as too high. The peculiarity of demurrage fees is that money holdings are taxed frequently to provide incentives, and economic agents are free from paying demurrage if they spend or lend their money holdings.

One should take into account that demurrage has been never applied in national economies, which means that quantitative effects of this policy are hardly predictable. It is important that real economic effects of money taxation are dependent not only on the value of demurrage fees but also on the frequency of payments which makes policy design even more complicated.

5. Conclusion

We showed in the framework of search-theoretic model that demurrage increases aggregate output through a more efficient monetary exchange process. What important is that demmurage is noninflationary in contrast to other expansionary monetary policy instruments such as quantitative easing that has been widely applied by central banks since the global financial crisis of 2007–2008. Moreover, aggregate output in our model is less sensitive to changes in money supply in contrast to demurrage which does not require changes in money supply and is likely to affect real variables, such as real GDP, through accelerated economic circulation.

Demurrage may be considered as a Pigovian tax as it mitigates trading externality associated with low search effort of traders. However, there could be some welfare cost of such policy. Demurrage induces agents to economize on money balances because their value deteriorates quickly which engenders 'shoe-leather cost' associated with holding small amounts of money.

The main limitation of the research lies in the absence of empirical data. One more limitation concerns the model we applied as it restricts the buyer's money holdings to be either zero or one. Lagos and Wright (2005) succeeded in eliminating this restriction by introducing endogenous distribution of money holdings. However, they found that all agents choose to hold the same amount of money which renders the distribution of money holdings degenerate.

Demurrage can be cosidered as the hybrid of monetary and fiscal policy. This instrument influences money market by accelerating monetary circulation and even lowering market-clearing interest rate on bonds (monetary policy), and also enables governments to raise additional revenue to fund government expenditures, or even replace some conventional income taxes (fiscal policy).

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