Friedman Meets the Joneses: A Model of Essential Money with Consumption Externalities*

Patrik Ryff†

April 30, 2010

Abstract

We extend a model with essential money similar to Berentsen, Camera, and Waller (2007) and Lagos and Wright (2005) to include a consumption externality. Specifically, we assume that agents have keeping up with the Joneses preferences, i.e. they evaluate their consumption relative to what others in the economy consume. We show that with the presence of such an externality the Friedman rule need not be the optimal policy anymore but that a benevolent planner might want to set a strictly positive interest rate. We quantify these effects and find that the welfare costs of inflation are lower than estimated in Lagos and Wright (2005). and more in line with results from the previous literature.

Keywords:	monetary policy, friedman rule, consumption externality, keeping up with the joneses
JEL Classification:	E40, E52

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*Highly preliminary and incomplete. For conference submission only. Do not cite or publish. All errors are mine. I thank Mariana Rojas Breu for helpful comments.

†Faculty of Business and Economics, University of Basel, Switzerland. patrik.ryff@unibas.ch

1 Introduction

The idea that individuals compare themselves to others when evaluating their utility or "happiness" seems very plausible and recent literature has developed both, theoretical and empirical support for this kind of behavior.

Especially the asset pricing literature has adopted concepts of relative comparisons to explain anomalies of the standard models, such as the equity premium puzzle. Gali (1994) uses a keeping up with the Joneses[1] (KUJ)-utility function in a multi-period asset pricing model. He finds that for any level of risk aversion, large enough negative consumption externalities can explain the equity premium puzzle. Kocherlakota (1996) also uses the idea of KUJ preferences as a possible explanation for the equity premium puzzle. The explanation these models offer is the following: If there is a significant negative externality then marginal utility of an agent is sensitive to changes in per capita consumption. Hence, even if the agent has a "normal" level of risk aversion towards individual consumption, she does not find risky assets attractive because she is averse to per capita consumption risk.

The way economic models, including those mentioned above, typically embed the idea of relative comparisons is through a consumption externality. Agents value not only their own consumption but also per capita consumption. Yet, when making decisions they do not take into account the effect of their own consumption on others. Dupor and Liu (2003) differentiate between two effects of such an externality: the effect that a raise of p.c. consumption has on the utility of the consumer and the effect a raise of p.c. consumption has on the consumer's marginal utility of own consumption. They call the former *jealousy*[2] and the latter *keeping up with the Joneses*[3] (KUJ).

The effect that will be relevant for our model will be the former. As in Ljungqvist and Uhlig (2000), however, we will refer to this simply[4] as KUJ.

As an alternative to p.c. consumption one can consider some form of past p.c. consumption that agents' preferences include. We then speak of *catching up with the Joneses* (CUJ) behavior, a concept closely related to habit formation. Such concepts have been used by Abel (1990), Constantinides (1990), Campbell and Cochrane (1995) and others to try to explain asset pricing puzzles. Abel (1990), for example, introduces a utility function, that can display habit formation

[1] *Keeping up with the Joneses* has first been introduced by Duesenberry (1952).

[2] Or *admiration*, depending on whether the effect is positive or negative.

[3] Or *running away from the Joneses*, depending on whether the effect is positive or negative.

[4] and perhaps somewhat sloppy

or catching up with the Joneses depending on certain parameters, in an asset pricing model. He then calculates the (unconditional) expected returns of bonds and stocks that are implied by his model, and finds that this specification does a better job at depicting the much higher return on equity compared to government bonds without requiring implausibly high risk aversion.

Ljungqvist and Uhlig (2000), more recently, introduced the idea of relative comparisons into the optimal taxation literature. In a representative agent model that is driven by productivity shocks where agents have keeping up with the Joneses preferences with respect to consumption, they find that the optimal (labor income) tax rate is equal to the fraction of individual consumption that does not count towards the agent's utility since it is offset by the consumption externality. A result which seems very plausible, as the externality distorts the intra-temporal tradeoff between consumption and leisure and an appropriate tax on labor income corrects this problem. In a second part of that paper they also analyze the effects of a catching up formulation of the utility function. Optimal tax policy then is countercyclical. Guo (2004) extends this model to allow for imperfectly competitive product markets.

In monetary economics the impact of keeping up with the Joneses preferences have not been studied widely[5]. Exceptions include Pierdzioch (2003) and Tervala (2007).

Tervala (2007) analyzes the effect of keeping up with the Joneses preferences on optimal monetary policy in a money in the utility type model with monopolistically competitive household-producers. Whether a (unanticipated) rise in money supply is welfare increasing or decreasing depends on the relative strength of the consumption externality. If the distortion created by the assumed preferences is large in comparison to distortions created by incomplete competition then a rise in the money supply is welfare decreasing because it adds to the overconsumption.

The increasing use of keeping up with the Joneses utility functions in asset pricing and other areas of economics has also prompted empiricists and "behavioral/experimental economists" to explore whether such behavior actually is relevant in decision making. In a recent paper Ravina (2007), using micro level data, estimates the effect of KUJ and habit formation and finds that both are relevant determinants of household decision making. Using data from the CCP panel data set on credit card accounts in California, he estimates a log-linearized Euler equation taking into account the current consumption of a reference group and past own consumption of the respective credit card holders.

[5]CUJ and habit formation have been used more often, as the breaking up of the intertemporal separability of utility helps explain the empirical observation that variables such as inflation, consumption spending etc. respond gradually to (monetary) shocks. See e.g. Fuhrer (2000), Jung (2004) or D'Amato and Laubach (2002).

Another interesting study is Daly, Wilson, and Johnson (2008). Viewing suicide as a revealed preference, i.e. as an individual's assessment of current and future utility, they relate a number of factors to the suicide hazard rate and find that suicide risk does move positively with the income of a reference group, suggesting that interpersonal comparisons are a relevant factor of decision making. These results suggest that keeping up with the Joneses is realistic aspect of individual decision making.

Based on the models of bilateral exchange with trading frictions by Diamond (1984), Kiyotaki and Wright (1989), Kiyotaki and Wright (1991) and Kiyotaki and Wright (1993) presented the first search theoretic model where a meaningful role for money arises due to a double-coincidence of wants problem. An analytically tractable version of these ideas was introduced by Lagos and Wright (2005). In their model, agents trade periodically in centralized and decentralized markets and the assumption of quasi-linear utility generates a tractable distribution of money holdings by eliminating wealth effects. Optimal monetary policy in Lagos and Wright (2005), as most other studies in the considerable literature on micro-founded models of money that developed following them, is the Friedman rule. In this paper we present a model similar to Lagos and Wright (2005) but where the optimal (nominal) interest rate can deviate from the Friedman rule due to a consumption externality created by the keeping up with the Joneses preferences of agents.

Our paper in that regard is similar to others who have considered extensions to the basic search framework that result in the Friedman rule not being the optimal interest rate, such as e.g. Andolfatto (2009), Williamson and Sanches (2009), Craig and Rocheteau (2006), Berentsen and Waller (2009) or to a lesser extent Berentsen, Camera, and Waller (2007).

2 The Basic Model

The framework of the model is similar to the one developed in Lagos and Wright (2005). Time is discrete and each period is divided into two non-overlapping subperiods. A discount factor $\beta \in [0, 1]$ exists between periods but no discounting is assumed between the first and the second subperiod of each period. There exists a $[0, 1]$-continuum of infinitely lived agents. All agents are anonymous, i.e. there is no record keeping technology. In subsection 2.1 perfect competition is assumed in both subperiods while in subsection 2.2 only the second subperiod is competitive. The first is characterized by random matching where prices are determined by asymmetric Nash bargaining.

2.1 Competitive Pricing

In this setting, a homogeneous and perishable good exists that is consumed and produced by every agent in the economy. Both subperiods are perfectly competitive.

In the first subperiod, which we'll refer to as market 1, idiosyncratic preference shocks determine whether an agent becomes a buyer or a seller in this market. Buyers wish to consume but cannot produce, sellers produce but do not consume. Let the probability of becoming a buyer be n and that of becoming a seller $1-n$. Agents incur utility costs $c(q_1)$ from producing q_1 units of the consumption good and get utility $u(q_1, Q_1)$ from consuming q_1 units of the consumption good when per capita consumption in the economy is Q_1. The agent's utility function, thus, depends on his individual consumption q_1 as well as on per capita consumption Q_1, i.e. he cares not only about his absolute own consumption but about his relative consumption. Assume that $u(\cdot)$ and $c(\cdot)$ are n times differentiable in their arguments, with $n \geq 2$. Also $u_q(q_1, Q_1) > 0$, $u_Q(q_1, Q_1) < 0$, $u_{qq}(q_1, Q_1) < 0$, $c'(q_1) > 0$ and $c''(q_1) \geq 0$. That is, utility is increasing in own consumption but decreasing in p.c. consumption. This second feature captures the keeping up with the Joneses preferences. Note that we make no assumption on the cross derivative $u_{qQ}(q_1, Q_1)$. The effect of p.c. consumption on the marginal utility of own consumption could be positive or negative.

In subperiod 2, which we'll refer to as market 2, all agents can consume and produce at the same time. Consuming q_2 yields utility $\upsilon(q_2)$. No keeping up formulation is assumed in market 2. Agents can transform one unit of labor into one unit of the consumption good[6]. Agents receive/pay lump sum transfers τ_2.

Symmetric Equilibrium

To calculate the symmetric and stationary equilibrium let ϕ be the real price of money in period t and let γ be the growth rate of the money stock in t, i.e. $\gamma = \frac{M_{+1}}{M}$. Let m_1 be the amount of money an agent takes into market 1 in period t and m_2 the amount of money an agent takes into market 2 in period t. Also, let $V_1(m_1)$ denote the expected value of trading in market 1 when entering the market with m_1 units of money and $V_2(m_2)$ the expected value of trading in market 2 when entering the market with m_2 units of money. We use subscripts b and s to refer to buyers and sellers respectively.

The representative agent then solves the following optimization problem in market 2:

[6] Another way to state it, is that in the second market an agent can produce according to a linear cost function $\zeta(q_2) = q_2$

$$\begin{aligned} V_2(m_2) &= \max_{q_{2b}, q_{2s}, m_{1,+1}} \{\upsilon(q_{2b}) - q_{2s} + \beta V_1(m_{1,+1})\} \\ &\text{s.t.} \qquad q_{2b} + \phi m_{1,+1} = q_{2s} + \phi m_2 + \phi \tau_2, \end{aligned}$$

which can be rewritten as

$$V_2(m_2) = \max_{q_{2b}, m_{1,+1}} \{\upsilon(q_{2b}) - q_{2s} - \phi m_{1,+1} - \phi(m_2 + \tau_2) + \beta V_1(m_{1,+1})\}.$$

The first order conditions for this problem are

$$\upsilon'(q_{2b}) = 1 \tag{1}$$

$$\beta V_1'(m_{1,+1}) = \phi \tag{2}$$

and the envelope condition is

$$V_2'(m_2) = \phi. \tag{3}$$

From the first order conditions above we see that the optimal choice of $m_{1,+1}$ is independent of m_1, and hence, the distribution of money holdings is degenerate.

In market 1 the representative agent's expected lifetime utility will be

$$V_1(m_1) = n\left[u(q_{1b}, Q_1) + V_2(m_1 - p_1 q_{1b})\right] + (1-n)\left[-c(q_{1s}) + V_2(m_1 + p_1 q_{1s})\right], \tag{4}$$

where p_1 is the competitive (nominal) price of the consumption good in market 1.

If the preference shock reveals the agent to be a seller, his optimization problem is

$$\max_{q_{1s}} \left[-c(q_{1s}) + V_2(m_1 + p_1 q_{1s})\right].$$

The first order condition is

$$c'(q_{1s}) = p_1 V_2'(m_1 + p_1 q_{1s}), \tag{5}$$

which we can rewrite, using the envelope condition from above, as

$$c'(q_{1s}) = p_1 \phi. \tag{6}$$

If the agent is a buyer instead, he solves the following optimization

$$\max_{q_{1b}} \left[u(q_{1b}, Q_1) + V_2(m_1 - p_1 q_{1b})\right] \quad \text{s.t.} \quad p_1 q_{1b} \leq m_1,$$

taking Q_1 as given. By taking Q_1 as given, the agent neglects the effect that his own consumption has on average consumption and thereby creates an externality on the others who want to "keep up".

The first order condition is:

$$u_q(q_{1b}, Q_1) - p_1 V_2'(m_1 - p_1 q_{1b}) = \lambda p_1, \tag{7}$$

which we can rewrite, using the envelope condition in (3) again, as

$$\frac{u_q(q_{1b}, Q_1)}{p_1} - \phi = \lambda, \tag{8}$$

with λ being the Lagrange multiplier on the agent's cash constraint, as he cannot spend more on goods than the money he takes into the market.

By the virtue of Kuhn-Tucker, we also need

$$\lambda(m_1 - p_1 q_{1b}) = 0. \tag{9}$$

This leaves us with two cases: when the cash constraint is binding, $\lambda > 0$, and when the cash constraint is not binding, $\lambda = 0$. We show in the appendix that in equilibrium the cash constraint will be binding.

For $\lambda > 0$ and thus $p_1 q_{1b} = m_1$, we can apply the envelope theorem on the Lagrangian of equation (4) accounting for the cash constraint (λ) of a buyer in market 1:

$$\frac{\partial V_1(m_1)}{m_1} = V_1'(m_1) = n\left[V_2'(m_1 - p_1 q_{1b}) + \lambda\right] + (1-n)\left[V_2'(m_1 + p_1 q_{1s})\right].$$

Using (3), this simplifies to

$$V_1'(m_1) = \phi + n\lambda. \tag{10}$$

To find the equilibrium quantity of the consumption good desired by an agent, note that in a (symmetric) equilibrium it must be that $q_{1b} = Q_1$. With that, we can combine (10) with the first order condition (8) to get

$$V_1'(m_1) = n\left[\frac{u_q(q_{1b}, q_{1b})}{p_1}\right] + (1-n)\phi.$$

Equation (6) tells us that $p_1 = \frac{c'(q_{1s})}{\phi}$. Also, from the first order condition (2) in market 2 we know that $\beta V_1'(m_{1,+1}) = \phi$ and thus it must be that $V_1'(m_1) = \frac{\phi_{-1}}{\beta}$. Plugging these two results into the above equation yields

$$\frac{\phi_{-1}}{\phi\beta} = n\left[\frac{u_q(q_{1b}, q_{1b})}{c'(q_{1s})}\right] + (1-n).$$

Now in a (symmetric) steady state real money holdings must be constant, i.e. $\phi M = \phi_{-1} M_{-1}$ and so $\frac{\phi_{-1}}{\phi} = \frac{M}{M_{-1}} = \gamma$. Using this property we can rewrite the above equation as

$$\frac{\gamma - \beta}{\beta} = n \left[\frac{u_q(q_{1b}, q_{1b})}{c'(q_{1s})} - 1 \right]. \tag{11}$$

Finally, define $q_1 \equiv q_{1b}$. Market clearing requires that $nq_{1b} = (1-n)q_{1s}$ and so $q_{1s} = \frac{n}{1-n} q_{1b} \equiv \frac{n}{1-n} q_1$. The consumption an agent chooses optimally, q_1^*, then is implicitly given by

$$\left[\frac{\gamma - \beta}{n\beta} + 1 \right] c'(\frac{n}{1-n} q_1^*) = u_q(q_1^*, q_1^*). \tag{12}$$

Social Planner's Solution

Unlike the individual agent, the planner takes the externality into account by setting $q_1 = Q_1$ in the agent's utility function in market 1 and then maximizing the following Welfare function

$$(1-\beta)W = \{nu(q_{1b}, Q_1) - (1-n)c(q_{1s})\} + \{\upsilon(q_{2b}) - q_{2s}\} \tag{13}$$

subject to the feasibility constraints

$$nq_{1b} = (1-n)q_{1s} \tag{14}$$

$$q_{2b} = q_{2s}. \tag{15}$$

Here, we implicitly assume that all agents are treated equally by the planner. The conditions for social optimum are then given by

$$[u_q(\tilde{q}_1, \tilde{q}_1) + u_Q(\tilde{q}_1, \tilde{q}_1)] = c'(\frac{n}{1-n} \tilde{q}_1) \tag{16}$$

$$\upsilon'(\tilde{q}_2) = 1. \tag{17}$$

The socially optimal consumption in market 2 is identical to the consumption an agent chooses in that market, which is to be expected as there is no externality in market 2. The consumption the planner optimally sets in market 1, however, is not the same as what the individual would choose on his own. Comparing equations (12) and (16), we can determine the optimal policy.

Optimal Policy

We think of the optimal policy as choosing the interest rate such that the social optimum is reached, i.e. the interest rate that sustains $\tilde{q}_1 = q_1^*$. This is given by

$$\frac{\gamma - \beta}{\beta} = n \left[\frac{u_q(q_1, q_1)}{u_q(q_1, q_1) + u_Q(q_1, q_1)} - 1 \right]. \tag{18}$$

Since $u_Q(q_1, q_1) < 0$, the optimal interest rate will be strictly positive. Thus, if agents exhibit keeping up with the Joneses behavior it is optimal to deviate from the Friedman rule and set a strictly positive (nominal) interest rate. The intuition behind this result is the following. An agent who increases his consumption does not take into account the effect his behavior creates for other agents who want to "keep up". This failure to internalize the social costs of his consumption leads to overconsumption in equilibrium, which in turn gives rise to beneficial policy intervention. The monetary authority can, by increasing the interest rate, discourage consumption and thereby lower it to the socially optimal level.

2.2 Bargaining

With an eye towards calibrating the model and comparing its results to previous work, we modify the model above slightly in this section. Market 2 is as in subsection 2.1, i.e. agents consume and produce at the same time and prices are determined by perfect competition. We assume that the utility function in market 2 is $v(q_2) = b \log q_{2b}$. This specification of the utility function is identical to Lagos and Wright (2005) and Cooley and Hansen (1989) which can be seen as benchmarks to which we want to compare our results. In the structure of market 1 we deviate a bit from the model above. Following Lagos and Wright (2005), we assume that it is characterized by random matching and generalized Nash bargaining, i.e. agents meet pairwise and randomly in decentralized markets according to a constant returns matching technology Σ. The number of buyers is n and the number of sellers is $1-n$. If an agent who is a buyer meets a seller and trade takes place, he receives utility $u(q_{1b}, Q_{1b})$ and will enter market 2 with money balances of $m_1 - x_1$, where x_1 denotes the amount of cash that changes hands in the meeting. If an agent who is a seller meets a buyer and trade takes place, he incurs utility cost $c(q_{1s})$ and will enter market 2 with $m_1 + x_1$. If an agent is a buyer and meets another buyer or if an agent is a seller and meets another seller, they part ways without a trade happening.

As in the previous section, we assume that $u_q(q, Q) > 0$, $u_Q(q, Q) < 0$, $u_{qQ}(q, Q) > 0$ and $u_q(q, q) > |u_Q(q, q)|$. Matching rates are given by the matching function and are denoted as $\sigma^b(n) = \Sigma(n, 1-n)/n$ and $\sigma^s(n) = \Sigma(n, 1-n)/(1-n)$. The quantities and cash changing hands in a meeting, q_1 and x_1, are determined by generalized Nash bargaining, i.e. they are the result of the following maximization problem

$$\max_{q_1,x_1} \quad [u(q_1,Q_1)+V_2(m_1-x_1)-V_2(m_1)]^{\theta}\,[c(q_1)+V_2(m_1+x_1)-V_2(m_1)]^{1-\theta} \tag{19}$$
$$s.t. \quad x_1 \leq m_1.$$

The first order conditions in market 2 are equal to equations (1) and (2) so the central result that the value function in market 2 is linear in m_2, i.e. $V_2(m_2) = V_2(0) + \phi m_2$ holds. This allows us to simplify equation (19) to

$$\max_{q_1,x_1} \quad [u(q_1,Q_1)-\phi x_1]^{\theta}\,[c(q_1)+\phi x_1]^{1-\theta} \tag{20}$$
$$s.t. \quad x_1 \leq m_1.$$

In the bargaining process, again, agents will take per capita consumption Q as given when optimizing.

The first order conditions then are

$$\theta u_{q_1}(q_1,Q_1)\,[-q_1+\phi x_1] = (1-\theta)\,[u(q_1,Q_1)-\phi x_1] \tag{21}$$
$$(1-\theta)\,[u(q_1,Q_1)-\phi x_1]-\theta\,[-q_1+\phi x_1] = \frac{\lambda}{\phi}\,[u(q_1,Q_1)-\phi x_1]^{1-\theta}\,[-q_1+\phi x_1]^{\theta} \tag{22}$$
$$\lambda(m_1-x_1) = 0. \tag{23}$$

As above there are two cases. First, if the cash constraint of the buyer is binding and second, if it is not. And as above, the cash constraint will be binding in equilibrium

For $\lambda > 0$, we can derive the marginal value of money by taking the derivative of the following equation with respect to m_1.

$$\begin{aligned} V_1(m_1) &= \sigma^b(n)\,[u(q_{1b},Q_{1b})+V_2(m_1-x_{1b})]+\sigma^s(n)\,[-c(q_{1s})+V_2(m_1+x_{1s})] \\ &\quad +[1-\sigma^b(n)-\sigma^s(n)]V_2(m_1). \end{aligned} \tag{24}$$

Thus,

$$\begin{aligned} V_1'(m_1) &= \sigma^b(n)\left[\frac{\partial u(q_{1b},Q_{1b})}{\partial q_{1b}})\frac{dq_{1b}}{dm_1}+(V_2'(m_1-x_{1b})+\lambda)\left(1-\frac{dx_{1b}}{dm_1}\right)\right] \\ &\quad +\sigma^s(n)\left[-c'(q_{1s})\frac{dq_{1s}}{dm_1}+V_2'(m_1+x_{1s})\left(1-\frac{dx_{1s}}{dm_1}\right)\right] \\ &\quad +[1-\sigma^b(n)-\sigma^s(n)]V_2'(m_1) \\ &= \sigma^b(n)u_{q_1}(q_1,Q_1)\frac{dq_1}{dm_1}+[1-\sigma^b(n)]\phi. \end{aligned} \tag{25}$$

To get an expression for the term $\frac{dq_1}{dm_1}$, we will first rewrite the optimality condition for q_1 from the bargaining process (equation (21)) and then plug it into the equation above.

Solving (21) for ϕx_1, we get

$$\phi x_1 = \phi m_1 = \frac{\theta c(q_1) u_{q_1}(q_1, Q_1) + (1-\theta) c'(q_1) u(q_1, Q_1)}{\theta u_{q_1}(q_1, Q_1) + (1-\theta) c'(q_1)} \equiv z(q_1, Q_1). \tag{26}$$

In equilibrium $q_1 = Q_1$ and thus

$$\phi m_1 = \frac{\theta c(q_1) u_{q_1}(q_1, q_1) + (1-\theta) c'(q_1) u(q_1, q_1)}{\theta u_{q_1}(q_1, q_1) + (1-\theta) c'(q_1)} \equiv z(q_1). \tag{27}$$

Then $\frac{dq_1}{dm_1} = \frac{\phi}{z'(q_1)}$ and hence we can rewrite (25) as

$$\frac{V_1'(m_1)}{\phi} = \sigma^b(n) \frac{u_{q_1}(q_1, q_1)}{z'(q_1)} + [1 - \sigma^b(n)]. \tag{28}$$

The term for the equilibrium interest rate is then given by

$$\frac{\gamma - \beta}{\beta} = \sigma^b(n) \left[\frac{u_{q_1}(q_1, q_1)}{z'(q_1)} - 1 \right] \tag{29}$$

with

$$z'(q_1)^{-1} = \frac{[\theta u_{q_1}(q_1, q_1) + (1-\theta) c'(q_1)]^2}{\Psi}$$

where

$$\begin{aligned} \Psi \quad = \quad & \left[\theta c'(q_1) u_{q_1}(q_1, q_1) + (1-\theta) c'(q_1) \frac{\partial u(q_1, q_1)}{\partial q_1} \right] [\theta u_{q_1}(q_1, q_1) + (1-\theta) c'(q_1)] \\ & + \theta(1-\theta) [u(q_1, q_1) - c(q_1)] \left[u_{q_1}(q_1, q_1) c''(q_1) - c'(q_1) \frac{\partial u_{q_1}(q_1, q_1)}{\partial q_1} \right]. \end{aligned}$$

Note that when $\theta \to 1$, i.e. when all bargaining power lies with the buyer, then $z'(q_1) \to c'(q_1)$ and the expression in equation (29) will converge to the expression in (11) with $\sigma^b(n) = n$. That is, with *buyer takes it all*-bargaining and respective matching rates the solution for the equilibrium interest rate in the bargaining version of the model is equivalent to the competitive pricing solution. Subsection 2.1 could thus be seen as a special case of subsection 2.2 where $\theta = 1$. We already established that the socially optimal interest rate in that case will be strictly positive. For $\theta < 1$, however things become a bit more complicated.

First, it is impossible to say anything about the behavior of $z'(q)$ without further assumptions on the utility and cost functions. Therefore, from here on we assume the following functional form for the representative agent's utility and costs.

$$u(q_{1b}, Q_{1b}) = \frac{(d + q_{1b} - \alpha Q_{1b})^{1-\eta} - d^{1-\eta}}{1-\eta} \tag{30}$$

$$c(q_{1s}) = q_{1s} \tag{31}$$

with $\alpha, d \in (0,1)$, $\eta > 0$. The parameter α in the utility function indicates the strength of the externality. The higher α, the more important becomes relative consumption as compared to absolute consumption. Note that, as assumed, we indeed have $u_q(q,Q) > 0$, $u_Q(q,Q) < 0$, $u_{qQ}(q,Q) > 0$ and $u_q(q,q) > |u_Q(q,q)|$. It is a "adapted" constant relative risk aversion utility function similar to the one in Lagos and Wright (2005). Parameter $d \approx 0$ is included to scale the utility function so that zero consumption yields the same utility level as the outside option[7]. It is also similar to the type of utility functions that have been typically used in the KUJ-literature such as Ljungqvist and Uhlig (2000) or Guo (2004)[8]. The interpretation of the cost function is the same as in market 2. Agents can turn one unit of labor into one unit of the consumption good. This is consistent with the formulation in Lagos and Wright (2005) or in Cooley and Hansen (1991).

Second, note that generalized Nash bargaining (with $\theta < 1$) creates an additional inefficiency in the sense that while the Friedmann rule is still the optimal monetary policy in the benchmark Lagos and Wright (2005)-framework, the first-best is not attainable anymore. This *hold-up* effect is present in our model as well, which implies that a) for certain parameter values the Friedman rule is optimal in our model as well and b) first-best may not be attainable. However we show, that for certain calibrations, the interest rate that induces agents to consume the socially optimal quantity will be positive.

We will now calculate the socially optimal interest rate given the utility and cost function discussed above and compare it to the no-externality case where the Friedman rule will be optimal.

Combining equations (29), (30) and (31) will yield the equilibrium relation between the nominal interest rate $\frac{\gamma-\beta}{\beta}$ and the quantity consumed q_1. For the moment we'll call this Ω.

Now remember that in the social optimum it must be that $c'(q_1) = \frac{\partial u(q_1,q_1)}{\partial q_1}$ or given (30) and (31) $q_1 = (1-\alpha)^{\frac{1-\eta}{\eta}}$. Combining this with Ω will yield the socially optimal interest rate:

$$i^* \equiv \frac{\gamma-\beta}{\beta} = \frac{(1-\alpha)^{-1}\left[\theta(1-\alpha)^{-1}+(1-\theta)\right]^2}{\left[\theta(1-\alpha)^{-1}+(1-\theta)\right]^2+\theta(1-\theta)\left[\eta^2(1-\eta)^{-1}(1-\alpha)^{-1}-\eta(1-\alpha)^{-\frac{1}{\eta}}\left[(1-\eta)^{-1}d^{1-\eta}+(1-\alpha)^{-1}d\right]\right]}. \tag{32}$$

If there is no externality then the term collapses to

$$i^{lw} \equiv \frac{\gamma-\beta}{\beta} = \frac{1}{1+\theta(1-\theta)\eta^2(1-\eta)^{-1}-\theta(1-\theta)\eta\left[(1-\eta)^{-1}d^{1-\eta}+d\right]}. \tag{33}$$

[7] If we restricted η to be between zero and one, we need not include such a parameter.

[8] Although it is different from the additive formulation that Gali (1994) uses.

and the Friedman rule will be optimal even though first-best is not attainable.

Note that equation (32) is strictly increasing in $\alpha \in (0,1)$ (for ≈ 0) and hence $i^* \geq i^{lw}$. The $\geq$-relation rather than a strict $>$ is due to the fact that the nominal interest rate is bounded from below by zero[9]. This implies that there exist parameter values for which both, i^* and i^{lw} are optimally set to zero. Yet, for certain parameters, as we show below, i^* becomes strictly positive. Furthermore, the presence of the externality potentially has significant effects on the welfare cost of inflation even if the parameters of the model are such that i^* is zero. The reason is that in this case the "optimum" is a constrained optimum and the further the zero interest rate is away from its "true" optimum the more severe will the effect on the welfare cost of inflation be.

3 Quantitative Analysis

To quantify the effects of the differences the preference structure implies for optimal policy we calibrate our model and calculate the welfare costs of inflation. We continue to keep our model from the previous section close to Lagos and Wright (2005) in the sense that their model can be seen as the limiting case of ours when $\alpha \to 0$.

In the first market we use the utility and cost functions specified in equations (30) and (31). For market 2 we specify the utility function to be $v(q_2) = D \log q_2$. This is consistent with the specification of preferences over the general good in Lagos and Wright (2005) as well as with the preference specifacation in Cooley and Hansen (1989).

To establish money demand we choose σ and the preference parameters to fit the following relationship to the data.

$$L = \frac{M/P}{Y}, \tag{34}$$

where M/P are the desired real balances and Y is total output from both markets. Nominal output in market 2 is $q_2^*/\phi = D/\phi$, nominal output in market 1 is $\sigma M$and hence total nominal output is $PY = D/\phi + \sigma M$. In equilibrium then total output is $PY = D + \sigma z(q)$ so that we have

$$L = \frac{M/P}{Y} = \frac{z(q)}{D + \sigma z(q)} \tag{35}$$

where $z(q)$ depends on the nominal interest rate i through equation (29).

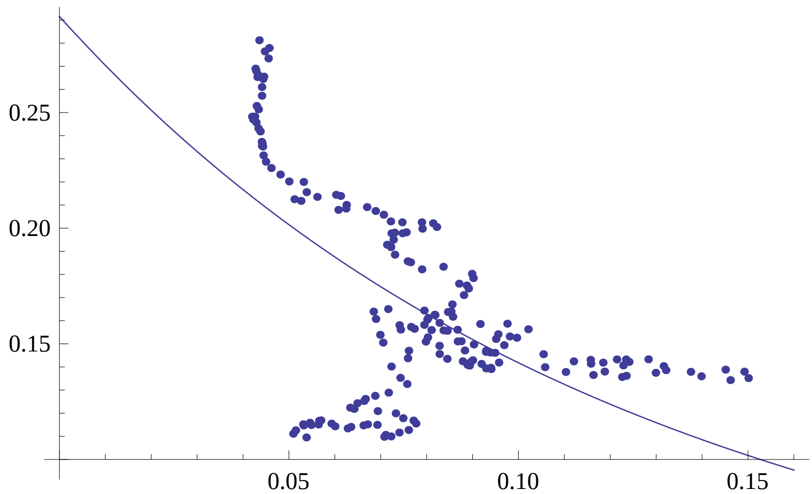
We fit (35) to the data, using quarterly Data on nominal GDP and the Moody's seasoned aaa corporate bond yield from 1959-2005. The data is derived from the Federal Reserve Economic

[9] A large literature on methods to overcome the zero lower bound on interest rates and their respective effectiveness exists. See e.g. Goodfriend (2000), Yates (2004) or Eggertsson and Woodford (2003).

Data (FRED) Database of the Federal Reserve Bank of St. Louis. For the $\theta = 1$, corresponding to the model in subsection 2.1, and $\theta < 1$, corresponding to the model in subsection 2.2, we fit our money demand equation to the data by choosing D, σ, η and α. σ is set to 0.5, to make our results comparable to Lagos and Wright (2005). We calculate the welfare costs of inflation implied by our model and compare it to previous results from the literature. The table below reports the results for $\theta = 1$ and $\theta = 0.5$.

	$\theta = 1$	$\theta = 0.5$
D	3.01736	
η	0.226553	
α	0.0289362	

These Parameter values are the nonlinear leat squares fit implied by the money demand equation that results from the model and the data given. The figure below shows the Scatterplot of the data and the implied money demand.



To evaluate the welfare cost of inflation, we ask the following question. How much consumption would an agent be willing to give up to have inflation of zero rather than 10%? The results are reported below

	$\theta = 1$	$\theta = 0.5$
D	3.01736	
η	0.226553	
α	0.0289362	
Welfare Costs	0.00538434	

The calculated welfare costs are therefore abot 0.5%. The corresponding estimate of the welfare costs in Lagos and Wright (2005) are in the neighborhood of about 0.5%, or triple of our estimates. Previous results by Cooley and Hansen (1989), Cooley and Hansen (1991) or Lucas (2000) have the costs of inflation in terms of forgone consumptions slightly below 1%. As Sinn (1999) suggests the welfare costs calculated by Lucas (2000) might actually be too high, depending on the exact method used for the calculations. Our result therfore seem to be mor in line with the result from the cash in advance-literature and less with those of the essential money framework.

We interprete these findings in the following way. The welfare costs of inflation that are supported by the framework in Lagos and Wright (2005) are too high. Appropriately correcting the essental money model too include a more realistic take on consumers preferences and therefore on optimal monetary policy leads to lower inflation costs.

4 Conclusion

The general equilibrium models that are commonly used in macroeconomics introduce money through some ad-hoc restriction as a cash in advance-constraint or by putting money in the utility function and thereby lack a proper foundation of money demand. Building on the work of Kiyotaki and Wright (1989), Lagos and Wright (2005) presented a framework that had both, an explicit microfoundation of money demand and is amenable to quantitative analysis. In their seminal work they find that the Friedman rule is the optimal monetary policy. A calibration of that model shows that the welfare cost of inflation is significantly higher than previous studies based on the cash in advance framework. This result stems mostly from a hold up problem resulting from the bargaining process that determines prices in the decentralized market. Even in the case where buyers have all the bargaining power, i.e. when the hold up problem does not matter, their estimations of the welfare costs of inflation are slightly higher than other authors have found.

In our model we extend the framework by Lagos and Wright (2005) to make policy implications more realistic. That is, in our model when considering competitive pricing or buyer takes all-bargaining (i.e. no hold up) the optimal monetary policy is to set a strictly positive interest rate. The reason for that is the introduction of keeping up with the Joneses preferences which create a consumption externality. Setting the interest rate to above zero can correct the effects from the externality. Such preferences are not only intuitively plausible but have also helped explain puzzles in financial market theory and other fields. Empirical estimations and evidence from experiments and happiness surveys strongly support the notion that such behavior is very present agents'decision making.

Even when we consider the model with Nash bargaining we find that depending on the values of the preference parameters the Friedman rule might no longer be the optimal policy. In both cases the we showed that the implications for quantitative analysis are important. We find that the welfare costs of inflation are lower than Lagos and Wright (2005) suggest and more in line with previous results by Cooley and Hansen (1989), Cooley and Hansen (1991) or Lucas (2000).

Appendix

If $\lambda = 0$¨,the first order condition in (8) becomes

$$\frac{u_q(q_{1b}, Q_1)}{p_1} = \phi, \tag{36}$$

which, using (6), will be

$$\frac{u_q(q_{1b}, Q_1)}{c'(q_{1s})} = 1. \tag{37}$$

Again, in a (symmetric) equilibrium it must be that $q_{1b} = Q_1$. Hence,the optimal consumption the individual would choose when he is not cash constrained is given by:

$$\frac{u_q(\hat{q}_1, \hat{q}_1)}{c'(\frac{n}{1-n}\hat{q}_1)} = 1. \tag{38}$$

The consumption an agent chooses when cash constrained is given in equation (12) as

$$\frac{u_q(q_1^*, q_1^*)}{c'(\frac{n}{1-n}q_1^*)} = \left[\frac{\gamma - \beta}{n\beta} + 1\right]. \tag{39}$$

Comparing equations (38) and (39), it is easy to see that $q_1^* < \hat{q}_1$ as long as $\gamma > \beta$. That is, except in the case where γ is exactly equal to β, the cash constraint must be binding in equilibrium.

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