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Money, barter, and costly information acquisition

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Abstract

Endogenous information structure is analyzed in a search model of production and exchange under qualitative uncertainty by allowing agents to invest in an inspection technology at a fixed cost where incurring a higher cost permits quality to be recognized with higher probability. In any equilibria where agents acquire information, some bad commodities are always produced. The information acquisition promotes production and exchange of good commodities. As the information problem becomes severe, money can improve welfare by economizing on information costs. In the optimal monetary equilibrium, agents adopt trading strategies which contribute to the saving of information costs.

Key words: Money; Private information; Information acquisition

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1. Introduction

One of the main activities of a consumer in a market economy is the acquisition of goods and services. The provision of these goods and services requires not only the sale of income-yielding productive services but also the use

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of resources to acquire information about quality characteristics of goods and services. When the quality of a commodity is less certain, acquisition of information requires greater use of valuable resources. A rational consumer chooses optimal information by comparing the marginal cost of acquiring information to the marginal benefit from an improved trading position and reduced quality uncertainty. A similar idea was earlier noted by Stigler (1961) in the context of the search for the minimum price of an automobile.

Since Smith (1776) and Jevons (1875), traditional discussions of money have emphasized its function as a medium of exchange and its role in mitigating informational frictions associated with commodity transactions. Qualitative uncertainty can provide an incentive for some sellers to produce low-quality output and attempt to cheat uninformed buyers, and buyers have to decide whether or not to purchase a commodity of unknown quality. Brunner and Meltzer (1971) analyzed a partial equilibrium model to stress the idea that the institution of money exists because it serves to economize on the costly information production that would otherwise be necessary to mitigate moral hazard problems in the exchange of commodities. King and Plosser (1986) attempted to incorporate the Brunner–Meltzer hypothesis in a general equilibrium model of money.

This paper examines a search-theoretic model that captures costly information acquisition to study exchange both with and without fiat money, defined as an intrinsically useless but universally recognizable medium of exchange. Recently, Williamson and Wright (1994) analyzed a search-theoretic monetary model of production and exchange under private information concerning the quality of commodities or the 'lemons' problem.[1] They show that when the private information problem is severe, the use of a universally recognizable fiat currency leads agents to adopt trading strategies that ultimately increase the probability of acquiring commodity of good quality, because the seller recognizes money but may not recognize another commodity. This is the incentive effect through which money can increase welfare. However, because information structure was assumed to be exogenously given, they abstracted from the elements central to the development of a monetary theory that accords with the hypothesis of Smith, Jevons, and Brunner and Meltzer.

[1] It abstracts from the 'double coincidence problem' in order to isolate the impact of informational frictions. Many traditional discussions of money have emphasized its role in overcoming the double coincidence of wants problem with direct barter; see, for instance, Jevons (1875). Menger (1892) argues that natural media of exchange depend on their intrinsic properties such as a relatively low storage or exchange cost. Kiyotaki and Wright (1989, 1991, 1993) formalized some of these ideas using search-theoretic equilibrium models of the exchange process. In these models, commodity money or fiat money can arise endogenously as a medium of exchange, reducing the search and transactions costs associated with pure barter.

In this paper, the Williamson–Wright model is extended by allowing agents to invest in information. Now, agents, given their inventory holdings, can decide before trade whether to acquire a *verification* or *inspection* technology at a fixed cost; incurring a higher cost permits quality to be recognized with higher probability. The endogenous information structure leads to some interesting implications for the idea that monetary arrangements improve welfare by economizing on the information costs. Further, for a given specification of the inspection technology, it turns out to be lower information costs, instead of the incentive effect, that contribute to the highest welfare in the optimal monetary equilibrium.

For agents with bad commodities which can be produced at zero cost, having the inspection technology does not affect their decisions because there is no cost to giving up bad commodities. In any active nonmonetary equilibrium, only agents with good commodities acquire the inspection technology and some bad-quality commodities are always produced and traded. Hence, a type of nonmonetary equilibrium in Williamson and Wright (1994), in which no bad commodities are ever produced, is ruled out. The use of inspection technology leads to an increase in the probability of acquiring commodities of good quality, which is analogous to the unique role of money in Williamson and Wright.

There are four sets of parameters for which nonmonetary equilibria exist, including the one in which multiple Pareto-ranked equilibria coexist. The welfare ranking in the multiple equilibria depends on both the probability of acquiring a good commodity and the information cost in each type of equilibria. The higher the cost of acquiring an inspection technology, the more severe is the possible information problem. If the information problem is severe enough, the only nonmonetary equilibrium is the one without production of high-quality output.

When money is introduced as a generally recognizable object and attention is restricted to pure monetary equilibria where money is universally accepted, the marginal benefit of acquiring an inspection technology as a commodity trader is in general different from that of a money trader. For instance, an agent has a greater chance of getting good quality when he or she offers money rather than a commodity. Hence, in general, a trader with a good commodity acquires a different inspection technology from the one acquired by a money trader.

When the private information problem is serious, all the types of monetary equilibria yield higher welfare levels than active nonmonetary equilibria when they exist. Among the different types of monetary equilibria, it is the ones imposing a cash-in-advance constraint on the producers of bad commodities that imply higher welfare. More importantly, the significant welfare improvement of these types of monetary equilibria comes from lower information costs relative to nonmonetary equilibria, instead of higher probability of acquiring a good commodity in the monetary equilibria. Because money is universally recognizable while commodities are not, sellers of good output are more willing to trade for money than to engage in direct barter. The fact that agents buying with money have a greater chance of getting a good commodity in return contributes to the saving of costs of acquiring the inspection technology as a commodity trader and, hence, to higher welfare levels. This is much like what Brunner and Meltzer (1971) had in mind.

When the information problem gets sufficiently severe that the only nonmonetary equilibrium is degenerate, there still exist monetary equilibria with production and exchange of good-quality output. Further, in a region of the parameter space characterized by a high cost of the inspection technology, there exists a unique optimal monetary equilibrium which yields the highest welfare across all types of equilibria, while none of the other candidate monetary equilibria exist and the only nonmonetary equilibrium is degenerate.

The paper is organized as follows. In Section 2 the model is presented and in Sections 3 and 4 nonmonetary and monetary equilibria are characterized, respectively. Section 5 summarizes the findings with some concluding remarks. Appendices A and B contain the existence proofs of nonmonetary and monetary equilibria.

2. Model

There is a continuum of homogeneous and infinitely-lived agents, whose population is normalized to one. There are good and bad commodities that can be produced by all agents, with the cost in terms of disutility to producing one unit of the good commodity equal to $c > 0$ and the cost to producing the bad commodity equal to 0. Money cannot be produced by any private agent. At the beginning of the initial period, a fraction M of the agents in the economy are chosen at random and each is endowed with one unit of cash. Both money and commodities are indivisible, freely disposable, and storable at zero cost, but only one unit at a time. Consumption of either a bad commodity or money yields zero utility. Consumption of one unit of a good commodity yields utility $u > 0$ if it was produced by someone else, while consumption of one's own output yields zero utility. The latter assumption is an easy way to generate gains from trade.

Given agents' inventory holdings at the end of a period, they can acquire an inspection technology at a cost of $F(\theta)$, where $\theta \in [0, 1]$, $F(0) = 0$, $F'(0) = 0$, $F'' > 0$, and $F(1) = A$, where A is some positive constant. This technology will allow them in the succeeding period to recognize, with probability θ, the quality of a commodity held by another agent. The acquired inspection technology is assumed to become completely obsolete after one period. An agent's acquisition of an inspection technology is assumed to be private information; that is, it is unobservable to his or her would-be trading partner.

Each period, each agent is matched pairwise and at random with some other agent. Trade takes place if and only if mutually agreeable. Trade entails a one-for-one swap of inventories since commodities are indivisible. There are no private credit arrangements since agents who meet in one period will meet again in another period with probability zero. The following summarizes the sequence of events within a period:

1. In the beginning of the period, agents with their inventory holdings meet pairwise and at random. They inspect each others' inventories and simultaneously announce whether or not they wish to trade.
2. The agents separate, whereupon the quality of each object is revealed if it was previously unknown. Each trader then has the option of consuming the object, disposing of it, or storing it in inventory until the next period.
3. If the object is consumed or disposed of, then the agent can instantaneously produce a new commodity of either good or bad quality at the associated cost.
4. Agents decide whether or not to acquire an inspection technology for use in the next period.

Let p be the proportion of traders holding commodities that are good and $1 - p$ the proportion holding commodities that are bad. Agents choose production, acquisition of inspection technology, consumption, disposal, and trading strategies in order to maximize the expected discounted utility of consumption net of production cost where future utility is discounted at the rate of $r > 0$. In doing so, they take as given the strategies of others and the probabilities of meeting agents holding either good or bad commodities. In what follows, attention is confined to stationary symmetric Nash equilibria in which the strategies and meeting probabilities are time-invariant, expectations are rational, and agents holding same inventory acquire, if any, the same inspection technology.

3. Nonmonetary equilibria

An agent with a bad commodity is willing to trade at every opportunity since at worst he or she gets another bad commodity in return. Also, an agent with a bad commodity would never want to acquire the costly inspection technology because the individual will enjoy positive utility only by meeting someone with a good commodity who is uninformed but still willing to trade. That is, having the inspection technology would not affect his or her decisions. Essentially, there is no cost to giving up bad commodities.[2] Hence, only agents with a good commodity would be interested in acquiring the inspection technology. In this

[2] Using the notations in the best response problem, the value of holding bad commodity with and without an inspection technology can be written as $rV_b(\theta_b) = rV_b = p(1 - \theta_g')\sigma' u$ which implies that $V_b(\theta_b) - F(\theta_b) < V_b$ for $\theta_b > 0$. Hence, bad commodity holders never acquire an inspection technology.

section, attention is mainly confined to *active* nonmonetary equilibria in which at least some good commodities are produced, traded, and consumed, the inspection technology, θ_g, is acquired by agents holding good commodities at the end of each period, and utility is strictly positive.

Given that every agent with a good commodity acquires θ_g, the nontrivial decisions concern whether to produce output of good or bad quality and whether to accept or reject the commodity of unrecognized quality. Let σ' denote the probability with which an agent believes that those with good commodities will accept commodities of unrecognized quality, and let σ be an individual's best response. Note that $0 < p < 1$ in any active equilibrium where the inspection technology is acquired by agents in an equilibrium. If $p = 1$, no bad commodities are ever produced and nobody will find it in his or her interest to invest in an inspection technology. Then, however, everybody will produce bad commodities and this contradicts $p = 1$. Note also that $\sigma' > 0$ in any active nonmonetary equilibrium. If $\sigma' = 0$, unrecognized commodities are never accepted and so no bad commodities are ever produced, but then agents should always accept unrecognized commodities and this contradicts $\sigma' = 0$. Hence, $0 < \sigma' \leq 1$ in any active nonmonetary equilibrium.

Let $V_g(\theta_g; \theta'_g)$ denote the payoff or value function for an agent at the end of a period who holds a good commodity and has the inspection technology θ_g, given his or her belief that all other agents acquire the inspection technology θ'_g. Let V_b denote the value function for an agent at the end of a period who holds a bad commodity. Let $W = \max[V_g(\theta_g; \theta'_g) - F(\theta_g) - c, V_b]$ represent the value function for an agent with nothing in inventory who is deciding which quality commodity to produce.

An individual's best response problem is described as follows:[3]

$$rV_g(\theta_g; \theta'_g) = p\theta_g \Delta(u + W - V_g)$$

$$+ (1 - \theta_g) \max_{\sigma} \sigma[p\Delta(u + W - V_g) + (1 - p)(W - V_g)]$$

$$+ V_g - V_g(\theta_g; \theta'_g), \tag{1}$$

$$rV_b = p(1 - \theta'_g)\sigma'(u + W - V_b), \tag{2}$$

where $V_g = \max_\theta[V_g(\theta; \theta'_g) - F(\theta)]$ and $\Delta = [\theta'_g + (1 - \theta'_g)\sigma']$ is the probability that an agent with a good commodity is willing to trade. The first term in the right-hand side of (1) is the probability that the individual meets someone with a good commodity he or she can identify, $p\theta_g$, multiplied by the probability that the other agent is willing to trade, $\Delta = [\theta'_g + (1 - \theta'_g)\sigma']$, and multiplied by the *net* gain from trading, $u + W - V_g$. The second term is the probability that the individual meets someone with something he or she cannot identify, $1 - \theta_g$, multiplied by the *net* expected gain from choosing the acceptance probability σ. The last term, $V_g - V_g(\theta_g; \theta'_g)$, is equal to $-F(\theta_g)$ at the optimum, which is the cost incurred to acquire θ_g. A similar explanation applies to the return to holding a bad commodity, rV_b, in Eq. (2).

[3] The derivations of payoff functions follow Appendix A in Williamson and Wright (1994).

A symmetric Nash equilibrium consists of values for p, σ', and θ_g with the following properties. First, $0 < p < 1$ implies $V_g(\theta_g) - F(\theta_g) - c = V_b$. Second, given p and θ_g, $\sigma = \sigma'$ must solve the maximization problem in (1). Finally, every agent with a good commodity chooses an optimal inspection technology at the end of each period: that is,

$$\theta_g = \arg\max_{\theta_g} [V_g(\theta_g; \theta'_g) - F(\theta_g)] \quad \text{and} \quad \theta_g = \theta'_g.$$

There are two types of equilibria that may occur. A type-*b* equilibrium has $0 < p < 1$ and $\sigma' = 1$; in this case some bad commodities are produced but traders always accept commodities even when they do not recognize their quality. A type-*c* equilibrium has $0 < p < 1$ and $0 < \sigma' < 1$; in this case some bad commodities are produced and traders randomize between accepting and rejecting commodities that they do not recognize.

Consider the type-*b* equilibrium. First, any $p \in (0, 1)$ is a best response if $V_g(\theta_g) - F(\theta_g) - c = V_b$. After substituting $\sigma = \sigma' = 1$, $W = V_g(\theta_g) - F(\theta_g) - c$ into (1), and $W = V_b$ into (2), $V_g(\theta_g) - F(\theta_g) - c = V_b$ implies the following expression for p:

$$p = \frac{c(1 - \theta_g + r) + (1 + r)F(\theta_g)}{\theta_g(u - c)}. \tag{3}$$

After $W = V_g(\theta_g) - F(\theta_g) - c$ and $\sigma' = 1$ are inserted into (1), $\sigma = 1$ is a best response if and only if $pu - c \geq 0$.

Notice that the equilibrium value of p in (3) is a generalized characterization of the corresponding equilibrium in the Williamson–Wright model in the sense that choice of the inspection technology, θ_g, is now endogenous through agents' decision to invest in information at the associated cost of $F(\theta_g)$. Note that the free inspection technology, $F(\theta_g) = 0$, along with an exogenously given probability of recognizing the quality of a commodity implies the equilibrium characterization in Williamson and Wright (1994). Finally, the optimal choice of an inspection technology at the end of each period implies the following:

$$F'(\theta_g) = \frac{(1 - p)c}{1 + r}. \tag{4}$$

Consider the type-*c* equilibrium. First, any $\sigma \in (0, 1)$ is a best response if an agent is indifferent between accepting and rejecting an unrecognized commodity. After substituting $W = V_g(\theta_g) - F(\theta_g) - c$ in (1), this requires

$$p\Delta(u - c) = (1 - p)c,$$

which can be solved for p:

$$p = \frac{c}{[\theta_g + (1-\theta_g)\sigma'](u-c) + c} = \pi(\sigma', \theta_g). \tag{5}$$

Notice that $0 < \pi(\sigma', \theta_g) < 1$ for all $\sigma' \geq 0$. Second, from $rV_g(\theta_g) = p\theta_g\Delta(u-c) - F(\theta_g)$ and $rV_b = p(1-\theta_g)\sigma' u$, $V_g(\theta_g) - F(\theta_g) - c = V_b$ implies the following expression for σ' after substituting $p = \pi(\sigma', \theta_g)$ from (5):

$$\sigma' = \frac{c\{\theta_g(u-c) + (1-\theta_g)c - (1-\theta_g+r)[c+\theta_g(u-c)]\} - \kappa_1}{c(1-\theta_g)[c + (1-\theta_g+r)(u-c)] + \kappa_2}, \tag{6}$$

where $\kappa_1 = [\theta_g(u-c)+c](1+r)F(\theta_g)$ and $\kappa_2 = (1-\theta_g)(u-c)(1+r)F(\theta_g)$. This can be substituted back for σ' in (5) to obtain $p = \pi(\sigma', \theta_g)$. Again, notice that free information [i.e., $F(\theta_g) = 0$ in (6)] along with an exogenously given θ would imply the same equilibrium value of σ' as in Williamson and Wright (1994). Finally, analogous to the type-b equilibrium, the optimal choice of an inspection technology implies the following:

$$F'(\theta_g) = \frac{p\Delta(u-c)}{1+r} = \frac{(1-p)c}{1+r}. \tag{7}$$

In order to analyze the entire set of equilibria for a given parameter space, the following is assumed to simplify the analysis:

$$(1+r)F'(\bar{\theta}_g) = c \quad \text{for some} \quad \bar{\theta}_g \in (0,1). \tag{8}$$

This, along with the first-order conditions (4) and (7) which hold for any $p \in [0,1]$, further implies $0 < \theta_g < \bar{\theta}_g < 1$ and $0 < p < 1$ in both type-b and type-c equilibria. Then, it can be shown that finding active nonmonetary equilibria is reduced to solving the followings for θ_g^b and θ_g^c, respectively:

$$\Phi(\theta_g^b) \equiv (1+r)\left[F(\theta_g^b) + \left(\frac{u-c}{c}\right)\theta_g^b F'(\theta_g^b)\right] - \theta_g^b u + c(1+r) = 0$$
$$\text{in} \quad \theta_g^b \in (0, \theta^*], \tag{9}$$

or

$$\Psi(\theta_g^c) \equiv (1+r)\left\{F(\theta_g^c) + \left[\frac{u}{u-c} + \left(\frac{u-c}{c}\right)\theta_g^c\right]F'(\theta_g^c)\right\} - \theta_g^c u + cr = 0$$
$$\text{in} \quad \theta_g^c \in (\hat{\theta}, \theta^*), \tag{10}$$

where

$$(1+r)F'(\theta^*) = \left(\frac{u-c}{u}\right)c \quad \text{and} \quad 0 < \theta^* < \bar{\theta}_g.$$

Note that $\theta_g^b \in (0, \theta^*]$ for type-b equilibria is implied by $pu - c \geq 0$ which must be satisfied for $\sigma = 1$ to be the best response, and $\theta_g^c \in (\hat{\theta}, \theta^*)$, $0 < \hat{\theta} < \theta^*$, for type-$c$ equilibria comes from $0 < \sigma < 1$. Further, $\Phi(0) = c(1+r) > cr = \Psi(0)$, $\Phi(\theta_g) > \Psi(\theta_g)$ for $\theta_g < \theta^*$, $\Phi(\theta_g) < \Psi(\theta_g)$ for $\theta_g > \theta^*$, and

$$\Phi(\theta^*) = \Psi(\theta^*) = (1+r)F(\theta^*) - (u-c)\frac{c}{u}\theta^* + (1-\theta^*+r)c.$$

Proposition 1. Assuming $F(\theta_g) = A\theta_g^2$ *and as long as* u *is large relative to* c, *the following nonmonetary equilibria exist for the following four cases:*

1. *one type-b equilibrium for* $A_0 < A \leq A_1$,
2. *two type-b and one type-c equilibria for* $A_1 < A < A_2$,
3. *one type-c equilibrium for* $A_2 \leq A < A_3$,
4. *no active equilibrium for* $A \geq A_3$,

where $A_0 < A_1 < A_2 < A_3$, *and* A_0, A_1, A_2, A_3 *are functions of parameters, as determined in Appendix A. Further,* $\theta_g^b \leq \theta_g^c$ *and* $p^b \geq p^c$ *in the two type-b and one type-c equilibria.*

Proof. See Appendix A. ∎

With the endogenous information structure, the extent of the private information problem is captured in the magnitude of the inspection technology parameter, A. The greater A is in the model economy, the more severe the information problem. If A is large enough (e.g., $A \geq A_3$), barter exchange collapses due to the lemons problem and the only nonmonetary equilibrium is the one without production of any good-quality commodities.[4]

When active nonmonetary equilibria exist, type-c equilibrium requires larger values of A relative to type-b equilibrium.[5] That is, type-c equilibrium has the greatest chance of surviving when the private information problem is severe. This is because $\sigma' < 1$ imposes the greatest discipline on producers of bad commodities in the sense that not only do they have to meet uninformed agents, the latter also have to be willing to take a chance. Low values of σ' reduce the incentive to produce bad commodities. Further, as indicated in (4) and (7), an

[4] The lower bound A_0 is imposed by the auxiliary assumption (8) with $\bar{\theta}_g \in (0,1)$.

[5] This result generalizes the findings of Williamson and Wright (1994), where type-c equilibrium is the only one that exists when the private information problem is severe in the sense that an exogenously given probability with which agents can recognize the quality of commodities is very low.

agent's choice of the inspection technology, θ_g, decreases in p, the agent's belief on the proportion of traders holding good commodities.

Let Z_j be welfare in equilibrium j, where $j = b, c$. It is defined as the expected utility of the representative agent in the initial period before production takes place and the endowment of money is distributed. It can also be written as following:

$$rZ_j = p^j\Delta^j(u - c) \; - (1 - p^j)(1 - \theta_g^j)\, c - r[c + F(\theta_g^j)] - F(\theta_g^j). \qquad (11)$$

This is the probability of meeting with someone with a good commodity who is willing to trade, $p^j\Delta^j$, multiplied by the net gain from trade, $(u - c)$, minus the probability of meeting someone with a bad commodity that cannot be recognized, $(1 - p^j)(1 - \theta_g^j)$, multiplied by the loss from trading and producing, c, minus the capitalized initial cost of production and inspection technology, $r[c + F(\theta_g^j)]$, minus the current cost of inspection technology, $F(\theta_g^j)$.

Proposition 2. $p^b > p^c\Delta^c$ *and* $Z_b > Z_c$ *in the two type-b and one type-c equilibria.*

Proof. From Proposition 1, $p^b > p^c\Delta^c$ since $\Delta^c < 1$. Then it follows that

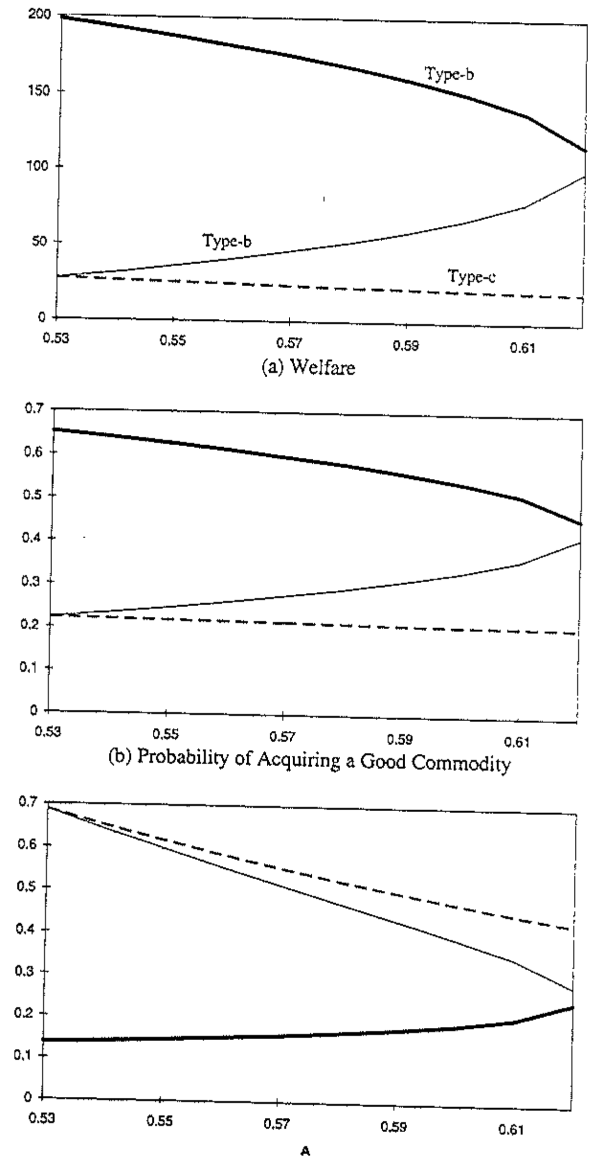
$$r(Z_b - Z_c) = (p^b - p^c\Delta^c)\,(u - c) + A[(\theta_g^b - 1)^2 - (\theta_g^c - 1)^2](1 + r) > 0, \qquad (12)$$

since $p^b > p^c\Delta^c$ and $\theta_g^c \geq \theta_g^b$. Therefore, $Z_b > Z_c$. ∎

Eq. (12) implies that the welfare differences between type-*b* and type-*c* equilibria arise from the two sources. The first is $p^b - p^c\Delta^c$, the difference in the probabilities of acquiring a good commodity, and the second is the difference in information costs. In the two type-*b* and one type-*c* equilibria, both factors are in favor of type-*b* equilibria. This is illustrated in the graphs of Fig. 1 where $u = 4.5$, $c = 1.0$, $r = 0.01$, and $A_1 < A < A_2$.[6] Type-*b* equilibria yield higher welfare levels than type-*c* equilibrium because of the higher probability of acquiring a commodity of good quality and the lower information costs.

Without the inspection technology ($\theta_g = 0$), everybody will produce bad commodities and, hence, $Z = 0$ in the only (inactive) nonmonetary equilibrium. As stated earlier, $0 < p < 1$ in any active equilibrium with $\theta_g > 0$. That is, the use of an inspection technology leads to active equilibria. However, if an inspection technology is to have a welfare-enhancing role in this economy, it cannot completely alleviate the private information problem. Any active (information) equilibrium has the property that some bad-quality commodities are produced

[6] Given the values of u, c, and r, $A_0 = 0.49505$, $A_1 = 0.52948$, $A_2 = 0.62034$, and $A_3 = 1.34$.



(c) Information Costs

Fig. 1. Two type-*b* and one type-*c* equilibria.

and traded. The inspection technology does not drive out all bad commodities. Instead, it allows agents to adopt trading strategies that ultimately increase the probability of acquiring high-quality goods. This is analogous to the unique role of money in Williamson and Wright (1994) where the information structure is exogenously given.

4. Monetary equilibria

It can be shown that, as in the nonmonetary equilibria, $0 < p < 1$ in any active monetary equilibria and an agent with a bad commodity never acquires the inspection technology. In what follows, attention is restricted to symmetric and pure monetary equilibria where money is universally accepted.

In a pure monetary equilibrium a money trader's marginal benefit of acquiring an inspection technology is different from that of a commodity trader. For instance, since good-commodity traders always trade for money, the probability that a money trade for an unrecognized commodity yields a good commodity is $(1 - M)\,p$, while the probability that a commodity trade for an unrecognized commodity yields a good commodity is $(1 - M) \times p[\theta'_g + (1 - \theta'_g)\sigma']$. Therefore, in general, a trader with a good commodity will want to acquire a different inspection technology from the one acquired by a money trader.

Let θ_m denote the inspection technology acquired by a money trader at the end of each period. Let $V_m(\theta_m; \theta')$ where $\theta' = (\theta'_g, \theta'_m)$ denote the value function for a money trader who has the inspection technology θ_m, given his or her belief that all other traders have θ'. Then, with $V_m = \max_\theta [V_m(\theta;\theta') - F(\theta)]$, the best response problem is described by[7]

$$rV_g(\theta_g; \theta') = (1 - M)p\theta_g\Delta(u - c) + M\bar{V}(V_m - V_g)$$
$$+ (1 - M)(1 - \theta_g)\max_\sigma \sigma[p\Delta(u - c) - (1 - p)c]$$
$$+ V_g - V_g(\theta_g; \theta'), \tag{13}$$

$$rV_b = (1 - M)p(1 - \theta'_g)\sigma' u + M(1 - \theta'_m)\omega'(V_m - V_b), \tag{14}$$

[7] Now, $V_g = \max_\theta[V_g(\theta;\theta') - F(\theta)]$, instead of $V_g = \max_\theta[V_g(\theta;\theta'_g) - F(\theta)]$. The derivations follow Appendix A in Williamson and Wright (1994).

$$rV_m(\theta_m; \theta') = (1 - M)p\theta_m(u - c + V_g - V_m)$$
$$+ (1 - M)(1 - \theta_m)\max_\omega \omega[p(u - c + V_g - V_m)$$
$$+ (1 - p)(-c + V_g - V_m)]$$
$$+ V_m - V_m(\theta_m; \theta'), \tag{15}$$

where ω' is the probability with which an agent believes that money traders will accept an unrecognized commodity, $\bar{V} = [\theta'_m + (1 - \theta'_m)\,\omega']$ is the probability that an agent with money is willing to trade, and ω is a money trader's acceptance probability of an unrecognized commodity.

Table 1 shows candidate monetary equilibria where $\phi \equiv (0, 1)$. The $(\sigma', \omega') = (0, 0)$ equilibrium cannot exist with $0 < p < 1$, because some agents have to accept commodities of unrecognized quality in order for bad commodities to be produced. Furthermore, it can be shown that monetary equilibria with $\sigma' = 1$ are always Pareto-dominated by a nonmonetary equilibrium (see Appendix B for the proof).

Consider the case $(\sigma', \omega') = (0, \phi)$. In addition to its analytical tractability, this equilibrium strategy imposes the greatest amount of discipline on the producers of bad commodities in the sense that bad commodity holders can never trade directly for a good commodity. The discipline is imposed not only by the endogenous choice of θ_g and θ_m, but also by a cash-in-advance constraint: the producers of bad commodities must trade for money (although this is not automatic since $\omega' < 1$) and then use this money to make a purchase in a later period. When $(\sigma', \omega') = (0, \phi)$, (13)–(15) can be simplified to

$$rV_g(\theta_g; \theta') = (1 - M)p\theta_g\theta'_g(u - c) + M\bar{V}(V_m - V_g) - F(\theta_g), \tag{16}$$

$$rV_b = M(1 - \theta'_m)\omega'(V_m - V_b), \tag{17}$$

$$rV_m(\theta_m; \theta') = (1 - M)p\theta_m(u - c + V_g - V_m) - F(\theta_m). \tag{18}$$

Table 1
Candidate monetary equilibria

	$\omega' = 0$	$\omega' = \phi$	$\omega' = 1$
$\sigma' = 0$	N	P	P
$\sigma' = \phi$	P	P	P
$\sigma' = 1$	D	D	D

N = monetary equilibrium does not exist, D = dominated by nonmonetary equilibrium, P = money potentially improves welfare.

To verify that $(0, \phi)$ is indeed a symmetric Nash equilibrium, the values for p, ω', θ_g, and $\theta_m \in (0, 1)$ should satisfy the following properties:

$$V_m \geq V_g, \tag{19}$$

$$V_g(\theta_g) - F(\theta_g) - c = V_b, \tag{20}$$

$$p\theta_g(u - c) - (1 - p)c \leq 0, \tag{21}$$

$$pu - c + V_g - V_m = 0. \tag{22}$$

First, (19) implies that accepting money is a best response, and $0 < p < 1$ implies (20). Any $0 < \omega < 1$ is a best response if a money trader is indifferent between accepting and rejecting an unrecognized commodity; that is, if (22) holds. Notice that $\sigma = 0$ is a best response if and only if (21) holds. Finally, the optimal choice of an inspection technology by an agent with a good commodity implies that

$$F'(\theta_g) = \frac{(1 - M)p\theta_g(u - c)}{1 + r}. \tag{23}$$

Similarly, a money trader's optimal choice of an inspection technology implies the following:

$$F'(\theta_m) = \frac{(1 - M)p(1 - p)u}{1 + r}. \tag{24}$$

Note that (19)–(24) determine the $(0, \phi)$ equilibrium values of p, ω', θ_g, and θ_m.

Proposition 3. *In $(\sigma', \omega') = (0, \phi)$ and $(\sigma', \omega') = (\phi, \phi)$ equilibrium,*

$$\theta_g \leq \theta_m.$$

Proof. Subtracting (24) from (23),

$$F'(\theta_g) - F'(\theta_m) = \frac{(1 - M)p}{1 + r}[\theta_g(u - c) - (1 - p)u].$$

Note that (19) and (22) imply

$$pu - c \geq 0. \tag{25}$$

Now, (21) can be rewritten as

$$\theta_g(u - c) \leq \left(\frac{1 - p}{p}\right)c \leq \left(\frac{1 - p}{p}\right)pu = (1 - p)u,$$

where the second inequality comes from (25). Hence, $F'(\theta_g) \leq F'(\theta_m)$ and, therefore, $\theta_g \leq \theta_m$ since $F'' > 0$. Analogous to the $(0, \phi)$ equilibrium, the equilibrium of the type $(\sigma', \omega') = (\phi, \phi)$ implies the following first-order condition with regard to the optimal choice of θ_g:

$$F'(\theta_g) = \frac{(1 - M)p\Delta(u - c)}{1 + r}, \tag{26}$$

and the optimal choice of θ_m implies the same first-order condition as (24). Then

$$\Delta(u - c) = \left(\frac{1 - p}{p}\right)c \leq \left(\frac{1 - p}{p}\right)pu = (1 - p)u,$$

where the first equality comes from $\omega \in (0, 1)$, while the inequality is due to (25). Hence, $\theta_g \leq \theta_m$ follows in the (ϕ, ϕ) equilibrium. ▮

Proposition 4. *Let $F(\theta_g) = A\theta_g^2$ and $F(\theta_m) = A\theta_m^2$. As long as u is large relative to c and $u - c$ is greater than but remains close to $2A(1 + r)$, the $(\sigma', \omega') = (0, \phi)$ equilibrium exists for a relatively small range of $M \in [\underline{M}, \bar{M}]$, where $0 < \underline{M} < \bar{M} < 1$.*

Proof. See Appendix A. ▮

As shown in Table 1, there are other qualitatively different types of monetary equilibria. However, these are not tractable for analytical characterizations and hence numerical results will be given for specific parameter values. For $u = 4.5$, $c = 1.0$, $r = 0.01$, and $A = 1.3$, panel (a) of Fig. 2 shows equilibrium welfare for a range of values of M for each of the equilibria when they exist. All types of the monetary equilibria other than $(\sigma', \omega') = (\phi, 1)$ exist, as does a unique type-c nonmonetary equilibrium.[8] As the private information problem gets more severe (e.g., $A = 1.35$), the only nonmonetary equilibrium is the degenerate or inactive one where no good commodities are produced, while there still exist different types of monetary equilibria with production of good-quality output. However, as the inspection technology becomes less costly, the lemons problem becomes less serious, and there is less room for money to enhance the welfare. When $A = 0.61$, for instance, monetary equilibria are dominated in welfare by nonmonetary equilibria.

[8] When u becomes larger relative to c (e.g., $u = 4.6$ and $c = 1.0$), all types of monetary equilibria exist for a range of values of M. In Fig. 2, for the given parameter values, no type of monetary equilibrium exists for $M \in [0.015, 0.033]$. This is because different types of equilibria require different sets of parameters. When $u = 5.0$, $c = 1.0$, $r = 0.01$, and $A = 1.3$, for instance, the $(\phi, 0)$ equilibrium exists for a wider range of $M \in [0.001, 0.072]$, while the $(0, \phi)$ no longer exists. Numerical investigations can show that the $(\phi, 0)$ equilibrium requires $u - c$ to be large relative to $2A(1 + r)$, while the $(0, \phi)$ equilibrium requires them to be close to each other. However, the qualitative results remain robust to different sets of parameter values. The details are available upon request.

As claimed in Proposition 4, Fig. 2 shows that the $(0, \phi)$ equilibrium exists only for a small range of values of $M \in [0.042, 0.05]$. Secondly, for the given parameter values, all of the existing monetary equilibria dominate the nonmonetary equilibrium for given values of M where welfare is measured by

$$Z_m = M[V_m(\theta_m) - F(\theta_m)] + (1 - M)[V_g(\theta_g) - c - F(\theta_g)].$$

Where does the welfare dominance come from? Unlike the multiple Pareto-ranked nonmonetary equilibria where the welfare ranking corresponds to the probability of acquiring a good commodity, Fig. 2 shows that the higher welfare levels do not necessarily correspond to better chances of obtaining a commodity of good quality in equilibrium. Indeed, the type-c equilibrium yields the lowest level of welfare while the corresponding probability of acquiring a good commodity is higher than that of the monetary equilibria of the type $(0, \phi)$ and $(0, 1)$. Instead, as illustrated in panel (c) of Fig. 2, the higher welfares in the monetary equilibrium $(0, \phi)$ and $(0, 1)$ relative to the type-c equilibrium are due to the lower information costs in each of the two types of equilibria.[9] In particular, it is commodity traders who contribute to information cost savings in both types of equilibria where bad-commodity holders must trade first for money in order to make any purchase of a good commodity.

For $(\phi, 0)$ and (ϕ, ϕ), higher welfare levels relative to the nonmonetary equilibrium come from the higher probability of acquiring a good commodity. However, these two types of monetary equilibria imply lower welfare levels than the other two types of monetary equilibria, $(0, \phi)$ and $(0, 1)$, where welfare improvements are due to information cost savings.

Let the *optimal quantity of money* be the value of M that maximizes welfare across all equilibria. Then the *optimal monetary equilibrium* is one that yields the highest welfare at the optimal quantity of money. As seen in Fig. 2, in this example the optimal monetary equilibrium is $(\sigma', \omega') = (0, 1)$. For a range of values of A, the optimal monetary equilibrium is of the same type.[10] Further, when the inspection technology becomes even more costly (e.g., $A = 4.5$), $(0, 1)$ is the only type of monetary equilibrim that exists with production of good-quality output, and the only nonmonetary equilibrium is degenerate.

Along with the equilibrium $(0, \phi)$, $(0, 1)$ imposes discipline on the producers of bad commodities by effectively subjecting them to a cash-in-advance constraint. Given a relatively high cost of inspection technology and a low waiting cost of holding money as captured by a low discount rate ($r = 0.01$), an agent holding

[9] The information cost in each type of the monetary equilibria is computed by $(1 - M)F(\theta_g) + MF(\theta_m)$.

[10] When $A = 0.61$, $(0, \phi)$ does not exist any more and the welfare ranking becomes $(0, 1) > (\phi, 1) > (\phi, \phi) > (\phi, 0)$ while $(0, 1) > (\phi, 1) > (\phi, 0) > (\phi, \phi)$ when A is further reduced to 0.5. However, they are all dominated in welfare by nonmonetary equilibria.

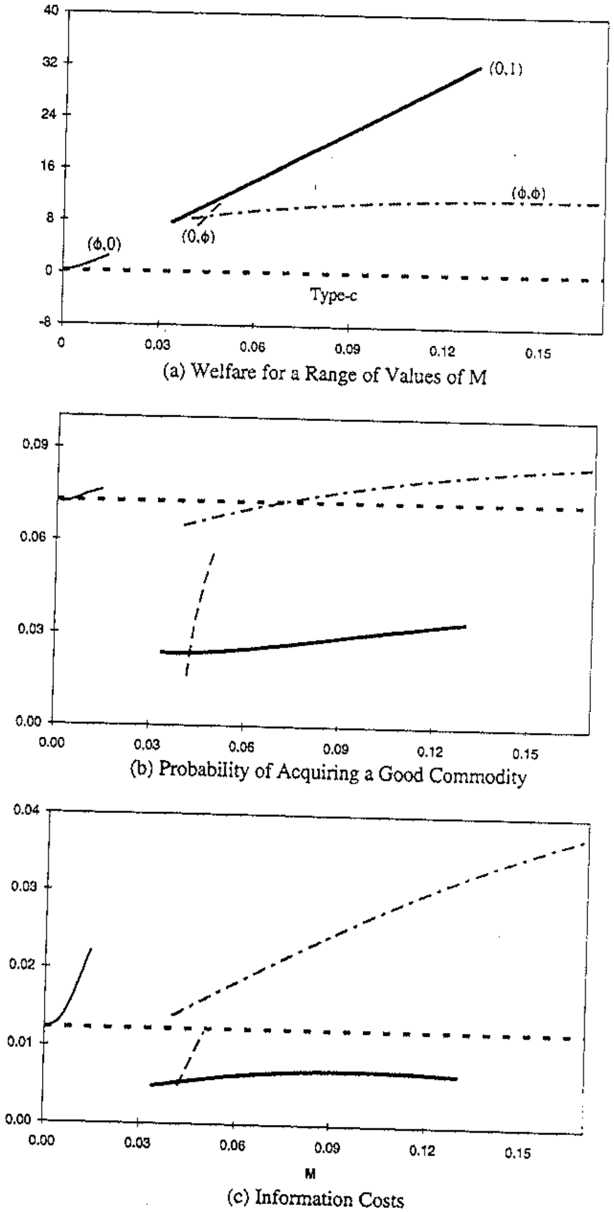


Fig. 2. Monetary equilibria.

a good commodity prefers to trade for money. Unlike the $(0, \phi)$ equilibrium, it is automatic to trade for money since $\omega' = 1$. Hence, instead of incurring a high cost of advanced inspection technology to engage in a direct barter, the good-commodity holder accepts money and holds out for the next period when he or she has a greater chance of acquiring a commodity of good quality. This allows a good-commodity holder to rely on a rather naive inspection technology, or a smaller θ_g in equilibrium. This intuition is also consistent with the larger number of monetary exchanges relative to direct barters in the $(0, 1)$ equilibrium than in the $(0, \phi)$ equilibrium.[11] Given $\omega = 1$, a money trader acquires an inspection technology for the purpose of 'commodity screening' where the equilibrium strategy of $\omega = 1$ is sustained by the higher p which then leads to the lower θ_m relative to the $(0, \phi)$ equilibrium for given values of M.

As illustrated in Fig. 2, the probability of acquiring a good commodity each period can be lower in the optimal monetary equilibrium than in the nonmonetary equilibrium. However, the *information cost* is always lowest in the optimal monetary equilibrium for a range of values of A. Money works by economizing on information costs, instead of just promoting useful production and exchange which was the case with an exogenous information structure, as in Williamson and Wright (1994).

5. Concluding remarks

This paper has analyzed an endogenous information structure in the Williamson and Wright (1994) model by allowing agents to choose information in the form of acquiring an inspection technology at a fixed cost; incurring a higher cost permits quality to be recognized with higher probability.

In any active nonmonetary equilibrium, some bad commodities are always produced and only agents holding good commodities acquire the inspection technology. The use of the inspection technology essentially promotes production and exchange of good commodities, which is analogous to the unique role of money with an exogenously given information structure as in Williamson and Wright (1994). When the private information problem becomes severe enough, there exists no active nonmonetary equilibrium. As in Williamson and Wright, for some parameter values, there exist multiple Pareto-ranked nonmonetary equilibria. The welfare differences among the multiple equilibria arise from their differences in the probability of acquiring a good commodity and the information cost associated with each type of nonmonetary equilibria.

[11] The number of barter trades is computed by $[(1-M)p\theta_g]^2$, while the number of monetary trades is computed by $M^2 + M\theta_m(1-M)p + M(1-\theta_m)\omega'(1-M)(1-p)$. With complete information where $M = 0$ and $\theta_g = 1$, for instance, $[(1-M)p\theta_g]^2 = 1$ since $p = 1$ and all trades are carried out successfully through direct barters. The actual numbers are available upon request.

As the lemons problem becomes more serious in the sense that information acquisition requires a substantial amount of resources, the introduction of money as a universally recognizable object can lead to active equilibria when the only nonmonetary equilibrium is degenerate. Even when active nonmonetary equilibria exist, the use of money can improve welfare. Unlike Williamson and Wright, however, the welfare dominance of monetary equilibria over an active nonmonetary equilibrium tends to come from lower information costs associated with monetary exchanges, rather than higher probability of acquiring a commodity of good quality. This is particularly true of the optimal monetary equilibrium which yields the highest welfare across all equilibria.

Finally, a possible productive path for future work would be to investigate the implications of endogenous information structure on price by incorporating bilateral bargaining in the model, as is done by Trejos (1994) in a search model with an exogenously given information structure.

Appendix A

Proof of Proposition 1

Given $F(\theta_g) = A\theta_g^2$ and as long as u is large relative to c, the followings are obtained:

$$\bar{\theta} = \frac{c}{2A(1+r)}, \quad \theta^* = \frac{c(u-c)}{2Au(1+r)}, \quad \hat{\theta} = \bar{\theta} - \frac{c}{u-c} \geq \tilde{\theta},$$

where $\tilde{\theta}$ is defined such that

$$\Phi(\theta_g) \equiv (1+r)\,A\left[1 + \frac{2(u-c)}{c}\right](\theta_g - \tilde{\theta})^2 - \frac{u^2}{4A(1+r)(2u-c)} + c(1+r)$$

and

$$\tilde{\theta} = \frac{cu}{2A(1+r)(2u-c)} < \theta^*.$$

Then, as illustrated in Fig. 3, Eqs. (9) and (10) imply four sets of parameters for nonmonetary equilibria.

Starting from panel (d) of Fig. 3, one type-b equilibrium exists if and only if $\Phi(\theta^*) = \Psi(\theta^*) \leq 0$ or

$$A \leq \frac{c(u-c)(3u-c)}{4u^2(1+r)^2} \equiv A_1.$$

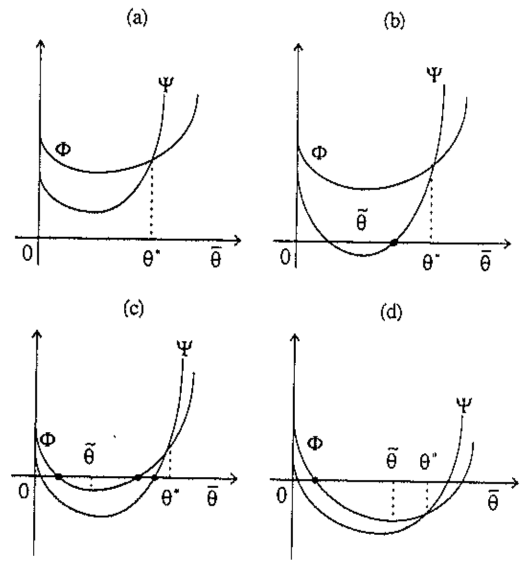


Fig. 3. Four sets of parameters for nonmonetary equilibria.

However, $\theta^* < \bar{\theta} < 1$ also implies the following lower bound for A:

$$A > \frac{c}{2(1+r)} \equiv A_0.$$

Hence, one type-b equilibrium exists if and only if $A_0 < A \leq A_1$. For panel (c), two type-b and one type-c equilibria exist if and only if $\Phi(\theta^*) = \Psi(\theta^*) > 0$ and $\Phi(\theta_g^b) = 0$ has two real roots. This holds if and only if $A_1 < A < A_2$ where

$$A_2 \equiv \frac{u^2}{4(1+r)^2(2u-c)}.$$

Panel (b) implies one type-c equilibrium which holds if and only if $\Phi(\theta_g^b) = 0$ has no real roots and $\hat{\theta} < \theta_g^c < \theta^*$. It can be shown that these two conditions are satisfied for $A_2 \leq A < A_3$ where A_3 is determined implicitly by $\hat{\theta} < \theta_g^c < \theta^*$. From panel (a) it can be shown that there exists no active nonmonetary equilibria if and only if $A \geq A_3$. Notice that panel (c) implies that $\theta_g^b \leq \theta_g^c$, which then implies $p^b \geq p^c$ by (4) and (7). Finally, it can be shown that as long as u is large relative to c, $A_0 < A_1 < A_2 < A_3$. ∎

Proof of Proposition 4

With $F(\theta_g) = A\theta_g^2$ and $F(\theta_m) = A\theta_m^2$, (23) and (24) can be solved jointly for p and θ_m:

$$p = \frac{2A(1+r)}{(1-M)(u-c)}, \tag{A.1}$$

$$\theta_m = \frac{u[(1-M)(u-c) - 2A(1+r)]}{(1-M)(u-c)^2}, \tag{A.2}$$

where $0 < p < 1$ and $0 < \theta_m \leq 1$ if and only if

$$1 - \frac{2Au(1+r)}{c(u-c)} \leq M < 1 - \frac{2A(1+r)}{u-c}. \tag{A.3}$$

In order for any such $M \in (0, 1)$ to exist, the following should hold:

$$u - c \geq 2A(1+r). \tag{A.4}$$

Now, subtracting (17) from (16), (20) can be solved for ω':

$$\begin{aligned}\omega' &= \frac{1}{Mc(1-\theta_m)}[M\theta_m(pu-c) + p(1-M)(u-c)\theta_g^2 - rc - A(1+r)\theta_g^2] \\ &= \frac{1}{Mc(1-\theta_m)}[M\theta_m(pu-c) + A(1+r)\theta_g^2 - rc],\end{aligned} \tag{A.5}$$

where the second equality comes from (A.1). Subtracting (16) from (18), (22) can be rewritten as following:

$$\begin{aligned}M(pu-c)(1-\theta_m)\omega' = {} & (1-M)p(\theta_m - \theta_g^2)(u-c) \\ & - [r + (1-M)p\theta_m + M\theta_m](pu-c) \\ & - (1+r)[F(\theta_m) - F(\theta_g)].\end{aligned}$$

This can be solved for θ_g:

$$\theta_g^2 = \frac{4A^2u(1+r)^2[M(u-c)+c] + \kappa}{2A^2u(1+r)^2(1-M)(u-c)}\theta_m,$$

where

$$\kappa \equiv (1-M)Auc(1+r)[(1-M)(u-c) - 2A(1+r) - 2(u-c)].$$

It can be shown that there exists $\theta_g > 0$ *as long as* $(u-c)$ *and* $2A(1+r)$ *are not too apart from each other*, while satisfying (A.4). And $\theta_g < 1$ follows from $\theta_g \leq \theta_m < 1$ as proved in Proposition 3. The condition (19) along with (22) implies $pu - c \geq 0$, which holds for M that satisfies (A.3). Note that (21) can be expressed as

$$\theta_g \leq \left(\frac{1-p}{p}\right)\frac{c}{u-c}, \tag{A.6}$$

where, using (A.1), the right-hand side can be written as

$$\theta_m \frac{(1-M)(u-c)}{2A(1+r)}\left(\frac{c}{u}\right) \leq 1,$$

since $(1-M)\,c(u-c) \leq 2Au(1+r)$ from $\theta_m \leq 1$. Notice, however, that $\theta_g > 0$ requires $(u-c)$ and $2A(1+r)$ to be not too apart from each other and, hence, a small range of values of M that satisfy (A.3). This then implies

$$\frac{(1-M)(u-c)}{2A(1+r)}\left(\frac{c}{u}\right) \simeq 1,$$

and (A.6) holds since $\theta_g \leq \theta_m$. Finally, it needs to be checked that $0 < \omega' < 1$. From (A.5), $\omega' > 0$ if and only if

$$\varphi(M) \equiv M\theta_m(pu-c) + A(1+r)\theta_g^2 - rc > 0, \tag{A.7}$$

and $\omega' < 1$ if and only if

$$\psi(M) \equiv (M+r)c - M\theta_m pu - A(1+r)\theta_g^2 > 0. \tag{A.8}$$

Fig. 4 shows the functions φ and ψ as the dashed curves, and both are positive if and only if $M \in [\underline{M}, \bar{M}]$ where $0 < \underline{M} < \bar{M} < 1$. As c becomes too large relative

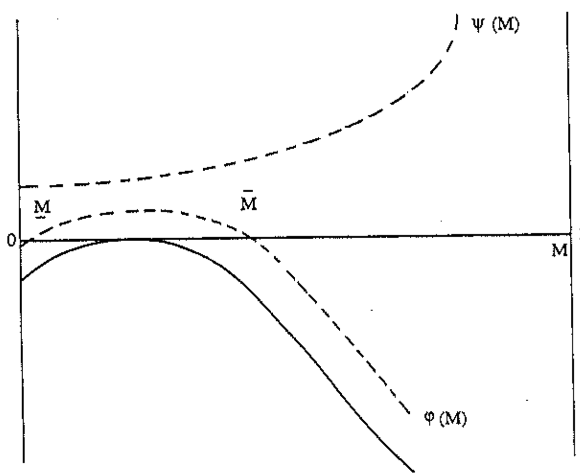


Fig. 4. The functions φ and ψ.

to u, the function φ shifts down as indicated by the solid curve. Hence, as long as $(u-c)$ and $2A(1+r)$ are not too apart from each other, and c is not too large relative to u, there exists the nondegenerate interval of $M \in (0,1)$ that satisfies (A.3), (A.4), $\varphi(M) > 0$, and $\psi(M) > 0$. ∎

Appendix B

Substituting $\sigma' = 1$ in (13) and (15),

$$rV_g(\theta_g) = (1-M)p\theta_g(u-c) + M\bar{V}[V_m(\theta_m) - F(\theta_m) - V_g(\theta_g) + F(\theta_g)] + (1-M)(1-\theta_g)(pu-c) - F(\theta_g), \tag{B.1}$$

$$rV_m(\theta_m) = (1-M)p\theta_m[u - K(\theta_g) + V_g(\theta_g) - V_m(\theta_m) + F(\theta_m)] + (1-M)(1-\theta_m)\max_{\omega}\omega[pu - K(\theta_g) + V_g(\theta_g) - V_m(\theta_m) + F(\theta_m)] - F(\theta_m), \tag{B.2}$$

where $K(\theta_g) = c + F(\theta_g)$.

Let's consider the case where $0 < \omega' < 1$. The welfare is

$$\begin{aligned} Z_m &= M[V_m(\theta_m) - F(\theta_m)] + (1-M)[V_g(\theta_g) - c - F(\theta_g)] \\ &= (1-M)\left[\frac{pu - c + (1-p)\theta_g c - F(\theta_g)}{r} - K(\theta_g) + \frac{M\bar{V}(pu-c) - M[pu - c + (1-p)\theta_g c]}{r}\right] \\ &\quad + M\left[\frac{(1-M)\theta_m p(1-p) - F(\theta_m)}{r} - F(\theta_m)\right]. \end{aligned} \tag{B.3}$$

On the other hand, the welfare in nonmonetary equilibrium with $\sigma' = 1$ is as following:

$$Z_b = \frac{pu - c + (1-p)\theta_g c - F(\theta_g)}{r} - K(\theta_g). \tag{B.4}$$

Hence, Z_m can be rewritten as

$$Z_m = (1-M)\left[Z_b - M\frac{(1-\bar{V})(pu-c) + (1-p)(\theta_m pu - \theta_g c)}{r}\right] - M\left(1 + \frac{1}{r}\right)F(\theta_m),$$

where $\theta_m pu - \theta_g c \geq 0$ if and only if

$$\frac{c}{pu} \leq \frac{\theta_m}{\theta_g}. \quad \text{(B.5)}$$

Note, however, the followings are true in the $(1, \phi')$ equilibrium:

$$F'(\theta_g) = \frac{(1-M)(1-p)c}{1+r}, \qquad F'(\theta_m) = \frac{(1-M)p(1-p)u}{1+r},$$

which then implies $\theta_g \leq \theta_m$ since $\sigma = 1$ implies $pu - c \geq 0$. Hence, (B.5) holds and Z_m is maximized when $M = 0$. Therefore, $Z_b \geq Z_m$. The cases where $\omega' = 0$ and $\omega' = 1$ can be proved similarly. ∎

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Was the worldwide shift to gold inevitable? An analysis of the end of bimetallism

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Abstract

This paper analyzes the causes and consequences of the universal switch from bimetallism to the gold standard in the early 1870s. It shows that the sole cause for the fall in silver prices after 1871 was the German demonetization of silver, and that the subsequent restriction of free silver coinage in Belgium and France was unnecessary: continued free silver coinage in the Latin Union would have reduced the share of gold in the Union's monetary system only marginally. Their continued adherence to bimetallism could have avoided much of the deflation in the gold standard world in the 1870s.

Key words: Bimetallism; Deflation; Gold standard; Latin Union

JEL classification: E42; F33; N1; N2

1. Introduction

Throughout most of the history of metallic monetary standards, both gold and silver played important roles. Starting in the renaissance, national mints generally allowed coinage of both metals. Their difference in value provided

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