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A Theory of Money and Banking

by David Andolfatto and Ed Nosal

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We construct a simple environment that combines a limited communication friction and a limited information friction in order to generate a role for money and intermediation. We ask whether there is any reason to expect the emergence of a banking sector (i.e., institutions that combine the business of money creation with the business of intermediation). In our model the unique equilibrium is characterized, in part, by the existence of an agent that: (1) creates money (a debt instrument that circulates as a means of payment); (2) lends it out (swapping it for less liquid forms of debt); (3) is responsible for monitoring those agents in control of the capital backing the illiquid debt; and (4) collects on money loans as they come due. Furthermore, the bank money in our model is a debt instrument that embeds within it important stipulations that are found in actual private money instruments. Thus, our model goes some way in addressing the questions of why private money takes the form that it does, as well as why private money is typically supplied by banks.

Keywords: money, banking, limited communication, limited information
JEL Codes: E40, G21, D82

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1 Introduction

This paper addresses a number of related questions concerning the activity of money creation and the business of banking. The first question concerns money; where by *money*, we mean any object (not necessarily fiat) that circulates widely as a means of payment. According to Townsend (1987) and Kocherlakota (1998), the key friction that generates a role for money stems from a technological restriction that limits the extent to which agents in an economy can communicate with each other to contract over the allocation of resources. The second question concerns intermediation. According to Diamond (1984), the key friction that generates a role for intermediation is a technological restriction on the structure of information that makes it difficult to enforce contractual contingencies. In such an environment, an intermediary may be able to mitigate incentive problems by issuing low-risk claims against a diversified portfolio of assets while serving as a delegated monitor. In this paper, we investigate the properties of a model that embeds both a limited communication friction and a limited information friction. Not surprisingly, we find that the equilibria that emerge must entail both money and intermediation. Less apparent, however, is whether the activity of money creation must in any way be related to the activity of intermediation.

We define a *bank* to be an intermediary that purposely designs its liabilities in such a way that renders them suitable for making payments.[1] Historically, bank liabilities in the form of banknotes (redeemable in specie) were often a prominent source of an economy's money supply. Even today, private bank liabilities in the form of electronic transactions balances (which are redeemable in government money) "circulate" from account to account and constitute the bulk of any well-developed economy's money supply. But, in principle, the business of money creation and the business of intermediation are conceptually distinct activities; it is not at all clear *a priori* why these two activities must necessarily be wedded, as appears to be the case both now and in the past. Indeed, some have gone so far as to advocate the legal separation of these two activities (Friedman, 1960). Hence, our final question concerns the relationship between money and intermediation. In particular, is there a rationale for money-issuing intermediaries and, if so, what are the likely consequences of a legal restriction that separates these two activities?

According to our theory, the emergence of money-issuing intermediaries is no accident: This institutional structure is the unique equilibrium outcome in our economic environment. As well, we find that this outcome is Pareto optimal. In our model a

[1] Thus, a bank is distinguished from other intermediaries in that the liabilities of the latter do not generally serve as money. The liabilities of mutual funds, for example, constitute simple claims against a diversified portfolio of assets. As well, the liabilities of insurance companies constitute claims against state-contingent events; while the liabilities of pension funds constitute claims that are redeemable on time-contingent events.

bank will turn out to be an agent that: (1) creates money (a debt instrument that circulates as a means of payment); (2) lends it out (swapping it for less liquid forms of debt); (3) is responsible for monitoring those agents in control of the capital backing the illiquid debt; and (4) collects on money loans as they come due. In addition, bank money in our model is a debt instrument that embeds within it important stipulations that are found in actual private money instruments. Any legal restriction that prevents intermediaries from issuing money is shown to generate two equilibria; one of which is Pareto optimal and the other which is not. Hence, if society imposes a legal restriction that prevents intermediaries from issuing money, it raises the prospect of a bad equilibrium outcome; i.e., the Friedman (1960) proposal may have undesirable consequences. The basic intuition behind this result is that a competitive intermediary that issues a liability that circulates as the medium of exchange has an incentive to design the liability precisely in the manner that is efficient in terms of its (equilibrium) redemption properties. An agent that issues a liability that circulates, but is not an intermediary, does not have a strict incentive to do so. As such, the economy may find itself in a bad equilibrium when the business of money creation and intermediation are legally separated.

We view our theory as building upon and extending existing models of intermediation, e.g., Diamond (1984) and Williamson (1986), and banking, e.g., Diamond and Dybvig (1983) and Peck and Shell (2003). Although the liability that the bank or intermediary issues in these models can be called a demand deposit, it is hard to interpret these liabilities as constituting money since they do not, strictly speaking, circulate. As well, although the institutions are sometimes called 'banks,' they can also be interpreted to be mutual funds or insurance companies, or even vending machines; see Wallace (1988). In contrast, our banks issue circulating debt instruments and the tasks that are performed by our banks look very much like the tasks that are performed by their real-world counterparts.

Our theory complements the recent work that extends search theories of money to include the activity of banking. In Cavalcanti and Wallace (1999a, 1999b) some agents have perfectly observable histories while others do not. Agents with unknown histories require some tangible object—for example, fiat money—in order to facilitate trade. Although agents with known histories do not require such objects for their own trade—since their behavior can be conditioned on their observable histories—they can issue "inside money" to the agents with unknown histories. Agents with unknown histories can use these objects in future trades. Along some dimensions, the agents with known histories resemble banks. An important result in Cavalcanti and Wallace (1999b) is that the set of implementable allocations using only fiat or outside money is a strict subset of allocations using only inside money. Hence, banking can improve the welfare of society. Cavalcanti (2002) extends Cavalcanti and Wallace (1999a, 1999b) by introducing capital and allowing agents with unknown histories to deposit their capital at a "bank," which can be withdrawn in the future. Finally, He, Huang and Wright (2003) develop a model that is consistent with the historical development of banks: Fiat money is subject to theft and banks arise as safe–keeping institutions. Agents can deposit their outside money at banks and can purchase goods with the liabilities of the bank—which are not subject to theft.

Our paper is also related to some recent models that attempt to introduce money-creating intermediaries. In Kiyotaki and Moore (2000), banks are agents endowed with a commitment technology that allows their liabilities to circulate. In Bullard and Smith (2001), the pattern in which agents meet endows the liabilities of intermediaries—an agent that follows a particular travel itinerary—with relatively low transactions costs, making these instruments the preferred medium of exchange. In contrast, our explanation does not hinge on endowing any one agent with some special capability. Furthermore, our environment implies a particular asset-liability structure for banks that broadly fits observation; in particular, our banks issue demandable debt instruments backed by the collateral obtained in the issuance of money loans.

The paper is organized as follows. The next section describes the model. Section 3 characterizes the equilibrium outcome when there are no information or communication frictions. Section 4 analyzes the model with only the limited communication friction and section 5 analyzes the model when there is only the limited information friction. Section 6 imposes both the limited information and limited communication frictions. The equilibria are characterized for when the Friedman proposal to separate money issuance and intermediation is imposed and when it is not. The section closes by arguing that the important results and insights continue to hold when a number of assumptions are relaxed. The final section concludes.

2 The Physical Environment

Our framework utilizes an intertemporal version of Wicksell's triangle along the lines of Kiyotaki and Moore (2000). Imagine an economy consisting of $3N$ individuals, where N is a large but finite number. The population is divided evenly among three "regions," which are labelled A, B and C. There are four time-periods, which are indexed by $t = 0, 1, 2, 3$.

As of date 0, each individual is endowed with a "project" that is scheduled to deliver output at some future date $t > 0$. Individuals (or regions) are specialized in production: type A individuals supply y_3; type B individuals supply y_1; and type C individuals supply y_2. Output is nonstorable and no effort is required in production. At each date $t > 0$, there are N projects that are scheduled to produce output. Assume that a fraction $0 < \lambda < 1$ of these projects "fail" (purely for technological reasons) and produce no output. Projects that do not fail each produce $y > 0$ units of output. Since λ is known beforehand, there is no aggregate risk; i.e., total output at each date $t > 0$ is given by $(1 - \lambda)Ny$. However, we assume that individuals do not know beforehand (i.e., as of date 0) whether they are endowed with a good or bad capital project. Individuals learn of the success or failure of their project at the very beginning of the period in which it is scheduled to produce output. Consequently, from an individual's perspective, there is risk associated with each project; in particular for each individual that produces at date t, his output will be,

$$y_t = \begin{cases} y & \text{with probability} \quad 1-\lambda; \\ 0 & \text{with probability} \quad \lambda; \end{cases} .$$

We will consider two information structures. In the *full information* case, individual project outcomes are costlessly observed by anyone who wants to observe it; in the *limited information* case, project outcomes are subject to a costly state verification. In particular, following the tradition of Townsend (1979), Diamond (1984), Gale and Hellwig (1984) and Williamson (1986), assume that when a project outcome is private information, it can be learned by another party following an audit (or monitoring) activity that costs the auditing party $\mu > 0$ 'utils' of expended effort per project. As is well known, this type of private information friction can give rise to a role for intermediation.

Individuals have preferences of the following form:

$$\begin{aligned} U_A &= c_1 + \epsilon c_3 - \mu e_A; \\ U_B &= c_2 + \epsilon c_1 - \mu e_B; \\ U_C &= c_3 + \epsilon c_2 - \mu e_C; \end{aligned}$$

where c_t is the (expected) consumption of the date t output and where e_i denotes the number of projects audited by agent $i = A, B, C$. Under these preferences, ϵ measures the weight that each individual places on the good that they produce. Individuals are assumed to value the good produced in their own region and a good that is produced in another region. We assume that $0 < \epsilon \ll 1$, which implies that individuals place a greater value on the good produced in outside of their region than the good produced in their own region. Hence, there are potential gains to trade. The table below describes, for each type of individual, the good that is highly valued in consumption (c_t) and the good that is produced (y_t):

	A	B	C
Good 1	c_1	y_1	
Good 2		c_2	y_2
Good 3	y_3		c_3

(1)

Note that in any pair-wise meeting between agents there is a complete lack of double-coincidence of wants: There are no gains from trade for any bilateral pairing of individuals. (There is still a complete lack of double-coincidence of wants even when one takes into account that each person attaches a small weight, ϵ, to the good that he produces).

We will have to precise about how individuals in different regions are able to interact or communicate with each one another. We envision that the three regions are located on one or more islands. There is no communication between islands: Individuals can only communicate with one other if they are on the same island. We consider two communication scenarios. In the *full-communication* scenario, all of regions are located on the same island. Here, individuals of all types can communicate with one another at all dates $t = 0, 1, 2, 3$. In the *limited-communication* scenario, each region is located on its own island: Individuals A live on island A; individuals B live on island B; and individuals C live on island C. In this scenario individuals from different islands meet only once in a pairwise fashion at each other's island. In particular, the sequence of meetings in the limited-communication scenario is as follows:

Date 0:	No travel;
Date 1:	Individuals A travel to island B;
Date 2:	Individuals B travel to island C;
Date 3:	Individuals C travel to island A.

Traveling individuals return to their own island at the end of their traveling date. We assume that project risk at each date is realized *prior* to the arrival of any travelling agents. In all scenarios, we assume that contracts can be costlessly enforced up to anything that is verifiable by a third party (e.g., a court of law) who permanently reside on each of the islands.[2] As is well known (Townsend (1987) and Kocherlakota (1998)), the limited-communication assumption coupled with a lack of double coincidence of wants creates a role for money.

Our analysis considers environments that embed various combinations of two key frictions: Limited information and limited communication. When these two frictions are combined, there is a role for both money *and* intermediation. However, *a priori*, it is not all evident that there needs to be any relationship between the activity of money-creation and the activity of intermediation. The key result of our paper demonstrates that the unique equilibrium outcome has these two activities combined within a single agency to form a money-issuing intermediary. Friedman's (1960) proposal—to separate money creation from intermediation—does not arise as an equilibrium. If, however, if Friedman's proposal is imposed on the economy, say by a government, then it is shown that multiple equilibria can exist, some of which are inefficient.

[2] Courts of law are also subject to the limited-communication assumption. That is, in the limited-communication environment there is no communication between a court of law on one island and a court of law on another island.

3 Full Communication and Full Information

In this environment all individuals—A's, B's and C's—will be in communication with one another at each date. As well, the success or failure of each of the individual's project will be costlessly observable to the entire population.

3.1 Arrow-Debreu Securities Market

We consider, as a benchmark, the allocation that would arise as a competitive equilibrium in an Arrow-Debreu securities market that opens at date 0. The securities that are issued by agents and brought to market take on a simple form:

> The bearer of this security is entitled to output y to be delivered at date t by agent i in the event of project success. If the project is unsuccessful, the bearer is entitled to nothing.

Type A agents will issue a security with $t = 3$ and will purchase a security with $t = 1$; type B agents will issue a security with $t = 1$ and will purchase a security with $t = 2$; and type C agents will issue a security with $t = 2$ and will purchase a security with $t = 3$.

It should be clear that all securities will trade at par and that the equilibrium allocation generates an expected utility payoff equal to $(1 - \lambda)y$ for each agent. This allocation also corresponds to the solution of a planner's problem that attaches equal weight to all individuals. There are, of course, many other Pareto optimal allocations. Note that the autarchic allocation (which places a lower bound on the welfare of each individual), generates an expected utility payoff equal to $(1 - \lambda)y\epsilon$.

In this kind of environment, there is no need for anything that resembles money. In fact, there is no need for a physical security of any kind. At date 0, each agent can make a "promise" to deliver output to another agent at a certain date if they are successful and the "court of law" on the island can enforce these promises.

4 Limited Communication and Full Information

In this environment the entire population is never simultaneously in communication with one another. At date 1 , the A's and B's are in communication with one another; at date 2, the B' and C's are in communication; and at date 3 the C's and A' are in communication. In terms of observability, the A's can observe the B's project outcome; the B's can observe C's project outcome; and the C's can observe the A's project outcome.

4.1 Private Money

Since agents are never simultaneously in direct contact with each other, an Arrow-Debreu securities market cannot function. Nevertheless, because pairs of agent-types meet at dates $t > 0$, spot market exchanges are a possibility. At date 1, all of the type A agents travel to island B in order to purchase output with the following security:

> The bearer of this security is entitled to output y to be delivered at date 3 by agent A at island A in the event of project success. If the project is unsuccessful the bearer is entitled to nothing.

Only successful type B agents will be able to acquire the security; unsuccessful type B agents will have nothing to trade for the security. Hence, in the event of trade, each successful type B agent will hold $(1-\lambda)^{-1}$securities. (We are assuming that securities are divisible.) But notice that successful type B agents are holding securities that represent claims against output (date 3 output) that they do not value directly. The only rationale for accepting A's security in exchange for date 1 output is the expectation that it will be useful in some future exchange. In particular, type B agents anticipate that they will be able to purchase claims against date 2 output (from the type C agents) using type A securities as a payment instrument in the date 2 spot market. But does it make sense for type B agents to hold such an expectation? The answer is yes; that is, as these securities represent enforceable (date 3) claims against the output that is highly valued by the type C agents, type B agents willingly accept these securities in exchange for claims against their output. At date 2, the successful type B agents travel to island C, where the former purchase output from the latter. At date 3, successful type C agents travel to island A. No spot market trades occur and type C agents simply present their securities for redemption. (Remember that with the full information assumption, the successful type A agents are legally obliged to make good on their debt.) Note that the equilibrium allocation differs slightly from that which occurred in the previous section; but the expected utility payoff of every agent remains equal to $(1-\lambda)y$.

Observe that in the equilibrium described above, efficiency is achieved by having a private security serve as a monetary instrument; i.e., type A securities end up circulating as a general means of payment. The role for money arises because the lack of double coincidence of wants can not be overcome by making promises of trade because of the limited communication friction.

5 Full Communication and Limited Information

Once again, in this environment all individuals—A's, B's and C's—will be in communication with one another at each date. But now, the success or failure of a project can only be costlessly observed by the producing agent.

5.1 Arrow-Debreu Securities Market

Since all agents can communicate with one another at all dates $t = 0, 1, 2, 3$, it seems natural to investigate first the outcome that would be realized in an Arrow-Debreu securities market. As of date 0, each agent in the economy possesses a stochastic claim against some future output. Since output is now costlessly verifiable only to the producing agent, each agent $i \in \{A, B, C\}$ will ultimately issue a security of the following form:

> The bearer of this security is entitled to output y to be delivered at date t by agent i in the event of project success. In the event of an announced failure, the bearer of this security *must* perform an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

Notice that this security embeds within it a stipulation that the bearer *must* perform an audit in the event of an announced failure. The purpose of this stipulation is to make the contract incentive compatible (i.e., so that the issuer has no incentive to lie in any state of the world).[3]

Once again, it should be evident that securities will be exchanged at par at date 0, with the terms of the contracts executed at subsequent dates $t > 0$. The expected utility payoff attained by each agent is now given by $(1 - \lambda)y - \lambda\mu$, since with probability $(1 - \lambda)$ the project will be successful and with probability λ, and agent will be compelled to undertake a costly audit.[4] The allocation is inefficient with economy-wide auditing costs totaling $\lambda N \mu$.

[3]Such a stipulation appears to be open to renegotiation and renegotiation may undermine the intent of the original contract. It can be shown, however, that if one allows the contract to be subject to renegotiation, then the intent of the original contract is not undermined. More specifically, Maskin and Tirole (1992) and Nosal (1988) demonstrate in the context of a finite game that the equilibrium allocation to a game that features renegotiation is identical to the equilibrium allocation in a game where agents are not able to renegotiate the initial contract. The interested reader can refer to Appendix 1 for an informal demonstration of this result. On a related note, if we change the above security so as to give the bearer the *option* to audit in the event of an announced failure, then it can be shown that in an Arrow-Debreu trading environment the equilibrium expected payoff associated with this contract will be strictly less than a contract that requires the bearer to audit in the event of failure.

[4]We assume that $(1 - \lambda)y - \lambda\mu > (1 - \lambda)\epsilon$ in order to insure that agents have an incentive to trade in the first place.

5.2 Intermediation

In this section, we demonstrate how the efficient allocation can be implemented with the aid of an intermediary, along the lines of Diamond (1984) and Williamson (1986). We imagine that at the beginning of date 0 there is a competition among agents to serve as the intermediary. In equilibrium, the net return to intermediation will be driven to zero.

At date 0, each agent in the economy possesses a stochastic claim against some future output. Since output is costlessly verifiable only to the producing agent, suppose that after the competition for the intermediary each agent $i \in \{A, B, C\}$ draws up a security of the following form:

> The bearer of this security is entitled to output y to be delivered at date t by agent i in the event of project success. In the event of an announced failure, the bearer of this security retains the *option* of performing an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

Notice that there is a subtle, but important, difference in the design of this security relative to the one described in the previous subsection. In particular, the security stipulates that conditional on an announced failure, the audit is now optional rather than mandatory.

As of date 0, the intermediary is in contact with all agents in the economy. Imagine that the intermediary purchases (accepts as "deposits") all such securities that are drawn up by all of the agents in the economy. In exchange, each agent receives a *risk-free* liability of the intermediary of the following form:

> Agent i is entitled to receive $(1 - \lambda)y$ units of output at date t from the intermediary.

For $i = A$ agents, $t = 3$; for $i = B$, $t = 2$; and $i = C$, $t = 3$.

We claim that the contractual structure described above implements a Pareto optimal allocation, with each agent receiving an expected utility payoff equal to $(1-\lambda)y$. To see this, suppose first that all agents exchange their securities for the intermediary's liability. Then it is indeed feasible for the intermediary to offer each depositor a risk-free return, since the asset side of the intermediary's balance sheet has completely diversified away all idiosyncratic risk. As in Diamond (1984) and Williamson (1986), the risk-free nature of the intermediary's liability arises for reasons of incentives (and not insurance). In particular, this contractual structure is necessary in order to prevent the intermediary from lying about the success or failure of *individual* projects. So, the proposed equilibrium has the intermediary offering this risk-free liability and all agents depositing their securities with the intermediary at date 0. As time unfolds, successful agents make their output available to the intermediary and the intermediary makes good on all its liabilities as they come due.

To confirm that this is indeed an equilibrium, we must check to see whether any agent has an incentive to deviate (conditional on the proposed equilibrium play of all other agents). Consider first an arbitrary agent whose project is successful: Does this agent have the incentive to make this output available to the intermediary? If such an agent defects from the proposed equilibrium—in hope of being able to consume his own output—then the intermediary will have strictly less than $(1-\lambda)Ny$ units of output to distribute in that period. Since the intermediary is contractually bound to deliver output to its liability-holders, a costly audit *must* be undertaken on all of those agents who declared failure for the period.[5] By assumption, such a process will recover all of the "hidden" output. Consequently, since a defecting agent must anticipate being unable to consume any hidden output, the agent will have no incentive to defect from the proposed equilibrium strategy.[6]

As for the intermediary, given the proposed play of all other agents, the intermediary is bound to make good on its liabilities. Since no auditing actually occurs in equilibrium, intermediation costs are equal to zero and the intermediary earns the same utility payoff as every other agent in the economy. Finally, note that as of date 0, competing intermediaries can offer no other feasible and incentive compatible contract that strictly dominates the proposed equilibrium contract.

5.3 A Note on Alternative Trading Arrangements

There are many different trading arrangements that can implement this Pareto optimal allocation. Here we examine one that is interesting and that will be relevant in what follows. In the trading arrangement described above, the intermediary looks more like a big department store contracting out with various customers and suppliers. Suppliers promise the (stochastic) delivery of inventory (in exchange for redeemable "coupons") and customers (suppliers acting in their role as consumers) subsequently arrive at the department store in order to redeem these coupons for output. This does not sound very much like "banking."

[5] Note that there is no scope for a successful renegotiation to take place at this stage of the game. That is, while the intermediary would at this stage of the game, prefer to renegotiate in order to economize on monitoring costs, the intermediary's debt-holders have no incentive to accept anything less than the full amount of the output owed to them.

[6] In fact, the intermediary is legally obliged to distribute $(1-\lambda)Ny$ units of output in only 2 of the three periods. In the period in which the intermediary consumes, he is legally obliged to distribute only $(1-\lambda)(N-1)y$ units of output since the intermediary himself is entitled to $(1-\lambda)y$ units of output. If in this period a successful producer hides his output, the intermediary would still be required undertake an audit, since, even if he foregoes his own consumption, the intermediary will still be short λy units of output on his contractual obligations.

But one could equally well imagine a slightly different trading arrangement. (Note: We are not changing the physical environment here). In particular, suppose that individuals are expected to purchase output using their "coupons" that are issued by the intermediary in a "spot market" that is open at dates $t > 0$. Suppose that these coupons are measured in units of "dollars" and that the intermediary exchanges M/N dollars worth of coupons for each security that it receives at date 0 (so that, in total, M dollars worth of coupons are issued to each class of individual). These coupons take on the following contractual form:

> Agent i has the *option* of redeeming p^* dollars for 1 unit of output at date t from the intermediary.

Note that this liability takes the form of a *nonbearer* note with a specific maturity date. An educated guess tells us that the equilibrium strike-price p^* for this option must equal:

$$p^* = \frac{M}{(1-\lambda)Ny}.$$

In effect, this option gives the coupon holder the option to redeem it at the intermediary for $(1-\lambda)y$ units of output on demand. Hence, if the bearer is unable to obtain a unit of output in the spot market for p^* dollars, this option will be exercised.

The proposed equilibrium play proceeds as follows at each date $t \geq 1$. At each date, all successful producing agents bring their output, y, to the spot market and agents wishing to purchase this output bring their M dollars to spot market. The posted price of exchange is p^* dollars per unit of output. Successful producers trade their output for coupons at this exchange rate. In total, M dollars will be exchanged for $(1-\lambda)Ny$ units of output. Agents who acquire output will ultimately consume it and agents that acquire coupons destroy them (since, being nonbearer notes, they are no longer of value). The equilibrium expected payoff to each agent in the economy is $(1-\lambda)y$.

But what incentive do successful producers have in bringing their output to the spot market? Suppose that a successful producer defects from proposed equilibrium play and withholds his output from the market. In this case, at the stated exchange rate, p^*, some of agents will be unable to purchase output their coupons. These agents will exercise their option with the intermediary. Notice that since the intermediary holds as "collateral" securities worth $(1-\lambda)Ny$ units of output in each period, the intermediary has the wherewithal (and legal obligation) to make good on its liabilities by undertaking a costly audit. The intermediary will ultimately find the "hidden" output and will payoff its obligation. Understanding all of this, successful suppliers can do no better than bring their output to market.

In the trading arrangement just described, the intermediary is starting to look more like a bank in that it is taking in deposits of securities and issuing a liability that serves as the economy's payment instrument. Two observations are order here. First, note that the payment instrument issued by the intermediary really doesn't circulate since it takes the form of non-bear debt; monetary instruments typically take the form of bearer debt. Second, the theory developed so far does not explain why either one of the trading arrangements described above (or any other arrangement) might emerge over the other: The institutional and contractual nature of the economy is indeterminate.

6 Limited Communication and Limited Information

In this environment the entire population is never simultaneously in communication with one another. At date 1 , the A's and B's are in communication with one another; at date 2, the B' and C's are in communication; and at date 3 the C's and A' are in communication. As well, the success or failure of a project can only be costlessly observed by the producing agent.

6.1 Private Money

It will be instructive to first investigate the outcome that would be realized in the absence of an intermediary. The physical environment is now such that a centralized Arrow-Debreu market cannot function. But there is a possibility that trade may occur in the sequence of spot markets. (Recall that producing agents learn of the success or failure of their projects before traveling agents arrive at their island).

The security issued by the type A agents of the following form:

> The bearer of this security is entitled to output y to be delivered at date 3 by agent A at island A in the event of project success. In the event of an announced failure, the bearer of this security *must* performing an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

This security is the same as is issued by the type A agents in the full communication and limited information environment when trade is mediated by Arrow-Debreu securities with the exception that the security is only valid at island A, see section 5.1. Without loss, assume that $(1-\lambda)^{-1}$ is an integer.[7]

For dates 1 and 2 the pattern of trade is identical to what was described in section 4.1, i.e., at date 1 successful type B agents give their output to type A agents

[7] Below, we explain what will happen if $(1-\lambda)^{-1}$is not an integer.

in exchange for $(1-\lambda)^{-1}$ units of the security, and at date 2 successful type C agents give their output to type B agents in exchange for $(1-\lambda)^{-1}$ units of the security. Note that despite existence of the private information friction, no monitoring needs to occur on spot market exchanges of money for goods at dates 1 and 2. The reason for this is that successful agents find it in their interest to voluntarily display their output (and hence their success) since the securities that they acquire by doing so will benefit them in future trades. Consequently, the expected utility payoff for type A and B agents is equal to $(1-\lambda)y$.

At date 3, however, without the threat of an audit, the type A agents have no incentive to voluntarily make good on their promises. As a result, type C agents are compelled to undertake a costly audit when a failure is announced. Since the above security is incentive compatible for the issuers, only actual failures will be reported. Hence, the type C individuals will receive an expected utility payoff equal to $(1-\lambda)y - \lambda\mu$.

What is interesting about this result is the following. If we relax the environmental restrictions to allow for full communication but restrict trades to take place on competitive markets without the aid of an intermediary, then monetary exchange Pareto dominates trade in Arrow-Debreu securities; see section 5.1. In a sense, this result can be thought of formalizing an oft-stressed notion that securities markets and monetary exchange are alternative, not complementary, arrangements for organizing economic activity (e.g., see Laidler (1988)).

6.2 Money and Intermediation: Friedman (1960)

We now open up the possibility of intermediation, but with a legal restriction (motivated by Friedman (1960)) that prevents intermediaries from issuing money. Since money is necessary in this environment—there is limited communication and a lack of double coincide of wants—and since money will be issued by type A agents, this legal restriction effectively prohibits any type A agent from becoming an intermediary. As well, remember that since there is limited communication, the intermediary that arises at date 0 can only contract with "local–island" agents. Ultimately, this implies that an intermediary will emerge among one of the type C agents and will contract solely with C agents.[8]

As it turns out, there are two equilibrium allocations in this setting. The equilibria are distinguished by how the type A agents go about designing their monetary instrument. In one equilibrium, type C agents have a competition for an intermediary at date 0 and at date 1 type A agents travel to island B with the following security:

The bearer of this security is entitled to output y to be delivered at date 3

[8] The insights gleaned from the private money equilibrium tells us that there is no reason for an intermediary to arise at date 0 on islands A or B.

> by agent A at island A in the event of project success. In the event of an announced failure, the bearer of this security retains the *option* of performing an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

At dates 1 and 2, this security will circulate in a manner identical to that described above, in section 6.1, where each security trades for $(1-\lambda)y$ units of output. At date three, the successful type C agents exchange these risky securities for a riskless claim issued by the intermediary: Each successful type C agent will receive a claim to $(1-\lambda)y$ units of date 3 output in exchange for their risky securities. The intermediary will then obtain output from the type A agents. Successful type A agents will exchange output for their liability: They understand that if they attempt to hide the output for their own consumption, the intermediary must exercise the option to audit them and will confiscate the output. In this equilibrium, no monitoring occurs and every agent earns an expected utility payoff equal to $(1-\lambda)y$.

There is, however, a second equilibrium. In this equilibrium the type A agents issue the following security:

> The bearer of this security is entitled to output y to be delivered at date 3 by agent A at island A in the event of project success. In the event of an announced failure, the bearer of this security *must* perform an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

It should be evident that the equilibrium here corresponds to the monetary equilibrium described in section 6.1. In particular, spot trades of the security for output occur on islands A and B without any auditing at dates 1 and 2, respectively. At date 3, successful type C agents travel to island A and to redeem the securities that they possess. If a type A agent announces failure, then the type C agent must undertake costly audit. This equilibrium is clearly inefficient as it entails monitoring costs to be incurred in equilibrium. In this equilibrium, the expected payoff to type A and B agents is $(1-\lambda)y$ while the expected payoff to a type C agent is $(1-\lambda)y-\lambda\mu$.[9] Note that the type A agent–the agent who issues the security that circulates and plays the role of money–is indifferent between the two equilibrium allocations.

[9] None of the trades or allocations at islands B and C are affected if $(1-\lambda)^{-1}$ is not an integer. However, if $(1-\lambda)^{-1}$ is not an integer, then there is a role for an intermediary to arise in island C in order to economize on monitoring costs (on fractional claims). The intermediary, however, will still have undertake some monitoring in equilibrium and the total monitoring costs will be $\lambda\mu N$. The expected payoff to a type C agent will be $(1-\lambda)y-\lambda\mu$, which is the expected payoff that a type C agent receives when it is assumed that $(1-\lambda)^{-1}$ is an integer.

6.3 Money and Banking

In this section, we remove the Friedman (1960) restriction that prohibits intermediaries from issuing money. What we intend to show here is that in such an environment, there is a unique equilibrium that necessarily involves money and intermediation being supplied by the *same* agency. For obvious reasons, let us refer to such an agency as a *bank*. Let us now describe the various activities and contracts that must be put in place.

At date 0, one of the A agents emerges as the bank. The bank is in a position to make money-loans to other type A agents. The terms of the loan contract are as follows. Each type A agent acquires M/N dollars in banknotes from the bank at date 0. Conditional on being a successful producer at date 3, the debtor is obliged to repay the loan with interest. The total amount that is owed is equal to $\frac{M}{N}(1-\lambda)^{-1}$ dollars.[10] If the type A agent turns out to be an unsuccessful producer at date 3, then he pays back nothing. Successful agents are expected to acquire the banknotes they need to pay back their loan by selling their output on the date 3 spot market.

The obvious question to ask here is whether these banknotes will end up circulating. In the end, the answer to this question depends upon whether or not the type C agents will be willing to exchange their output for banknotes. As it turns out, type C agents will be willing to exchange output for banknotes if they can be assured that if they are unable to obtain date 3 output in the spot market, they will be able to present the banknote to the bank for redemption. In the event of redemption, the bank must have the wherewithal to deliver the required amount of output. Let $1/\hat{p}$ denote the (yet to be determined) value of a banknote that is presented for redemption. If banknotes are to circulate, they must adopt the following contractual form:

> This banknote is redeemable on demand by its bearer for $1/\hat{p}$ units of output at any date.

Notice that the liability issued by the bank in this case constitutes a *bearer* note, redeemable on demand for a specific quantity of output at any date. As such, it strongly resembles the form that banknotes (or demand deposits) have taken historically. But how can the bank guarantee that will have the wherewithal to redeem a banknote? In particular, if a type C agent demands redemption at date 3, where will the bank acquire the output? In order to answer this question, note that as part of the loan

[10] Here, we anticipate that the equilibrium (gross) interest rate charged on each money loan is equal to $(1-\lambda)^{-1} > 1$ so that the net interest earned on the bank's loan portfolio is equal to zero. This zero interest rate reflects both the fact that zero banking costs will be incurred in equilibrium together with the assumption of free-entry into the banking business. This interest rate implies that all of the money that the bank lent out at date 0 is returned to the bank at date 3.

package to type A agents, the bank will require that each agent post collateral in the form of a security. In particular, the security must take the following form:

> If the agent A does not repay the loan at date 3, the bank retains the *option* of performing an audit. In the event that output is discovered, the bank shall retain the right to claim $1/\hat{p}$ units of output per dollar of the outstanding loan amount.

With the loan contract designed in this way, a type C agent can be guaranteed that any acquired banknote can at the very least be redeemed for $1/\hat{p}$ units of output.

We now describe how $\hat{p}$ is determined. An educated guess tells us that

$$\hat{p} = \frac{M}{(1-\lambda)N\epsilon y},$$

Note that, in equilibrium, the banknote must eventually end up in the hands of the successful type C agents. In order for these agents to willingly accept bank money as payment for their output, it must promise them a utility payoff equal to at least what they can generate in autarchy; i.e., ϵy. In the competition among the type A agents to become the bank at date 0, the collateral requirements for a loan of size M/N will be bid down to their lowest possible level, which entails the issuance of bank money that can be redeemed for ϵy units of output.

With the details of the monetary instrument and the loan contract all settled at date 0, type A individuals are now in a position to purchase the output that they desire on the date 1 spot market. At date 1, type A agents travel to island B. The successful type B agents willingly display their output in the spot market in order to acquire money that they anticipate will have value in some future exchange. The (equilibrium) posted price at date 1 is equal to $p^* < \hat{p}$. Note that, at date 1 no type B agent has the incentive to exercise the redemption option on the banknote after he receives it.

At date 2, the type B agents travel to island C with their recently acquired money (which are bearer notes) to purchase output from the type C agents. Once again, the successful type C agents have every incentive to display their output in their quest to acquire money that they anticipate having value in some future exchange. Once again, the (equilibrium) posted price is given by $p^* < \hat{p}$.

The question now is whether the successful type A agents have the incentive at date 3 to sell their output—which they value a little bit—for money—which they do not value at all and did not themselves issue. If the spot market price for output at date 3 is equal to $\hat{p}$, then the type A agents are indifferent between repaying their money loan or not. We claim that the date 3 price-level must be equal to $\hat{p}$. In equilibrium then, each successful type A agent supplies ϵy units of output to the market. To verify that this is an equilibrium, suppose that a successful A agent deviates from the proposed equilibrium and does not supply output to the spot market. (Successful agents who do not deviate sell their output on the spot market and pay off their loan to the bank.) Then at the posted market price of $\hat{p}$ some type C agents will be unable to purchase date 3 output with their money: These agents will exercise the redemption option on their banknotes. In the event that the redemption clause is exercised by an agent, the bank is legally obliged to audit those type A agents that did not pay off their loan in order to discover and seize any "hidden" output. As before, there are no renegotiation possibilities here, since the bank's note-holders will settle for nothing less than ϵy units of output. Understanding all of this, any successful type A agent has no strict incentive to deviate from truthfully revealing the outcome of his project. Consequently, the posted market price that "clears the market" at date 3 is $\hat{p}$ and the (successful) type A agents collectively acquire the M dollars that are necessary to discharge their debt obligations. In equilibrium, type A agents receive expected utility $(1-\lambda)(1+\epsilon(1-\epsilon))y$; type B agents receive expected utility $(1-\lambda)y$; and type C agents receive expected utility $(1-\lambda)\epsilon y$. As no monitoring occurs in equilibrium, this allocation is efficient.

Note that any other proposed equilibrium will necessarily give the type A agents a lower expected payoff. Any other proposed equilibrium would be broken by having one of the type A agents defect from proposed play and act as a bank in the manner described above (in this way, attracting all business away from its competitors). Other type A agents will use the bank for loans because their expected payoff is higher compared to the proposed equilibrium. At date 1, type B agents will accept the banknotes in trade because they anticipate that the type C agent will accept the notes at date 2. At date 2, the type C agents will, in fact, accept the notes for their output and in date 3, the banknotes will flow back to island A.

6.4 Discussion

In the limited information–limited communication environment, the unique equilibrium outcome has an institution arising that both issues liabilities that circulate as the economy's monetary instrument and provides loans to borrowers for which it may end up having to monitor. The equilibrium allocation is efficient in the sense that no resources are devoted to monitoring or auditing activities. Driven by the profit motive, the bank designs an efficient monetary instrument: One that entails the least amount of redemption activity. If the Friedman proposal is imposed on our economy, then there are two possible equilibria. One equilibrium does not entail any costly auditing while the other one does. In both of these equilibria, it is the type A agents' liability that circulates as the monetary instrument. Since the type A agents are indifferent between the two equilibria, they have no incentive to design the most efficient form of money. Even though the example that emerges in our simple model economy may seem contrived, we believe that the general principle will apply in even richer contexts: Only by combining the business of money creation with the business of intermediation can one guarantee the emergence of a well-designed and efficient payment instrument.

It is important to note that our concept of efficiency has centered on the notion of minimizing the costly redemption activity. In contrast, if one was to evaluate the performance of the economy by an alternative social welfare measure, for example, a function that weights equally the expected utility payoff of each agent, then one could be led to argue that the Friedman proposal should be adopted. That is, under our money and banking scenario, social welfare would is then given by $(1-\lambda)[2+\epsilon(1-\epsilon)]y$, while the "bad" equilibrium under the Friedman proposal generates social welfare equal to $3(1-\lambda)y - \lambda\mu$. One can easily verify that this latter number is greater than the former.[11] In other words, while the money and banking scenario minimizes expected redemption activity, not everyone consumes the good that they value most highly (the type A agents end up consuming some of their own good). On the other hand, the Friedman proposal ensures that everyone consumes the good they value most, but at the cost of inefficient redemption activity in the event of a poorly designed monetary instrument.

For a government interested in redistribution, there are three possibilities. One is to simply go ahead with the Friedman proposal and "hope for the best." The second possibility is to go ahead with the Friedman proposal and get in the business of telling money-issuers how to design their payment instrument. In the context of our simple model, this would be an easy thing to do. However, as a practical matter (i.e., in more complicated environments), one would have to wonder whether the government would possess the requisite wisdom to legislate over such matters.[12] The third possibility would be to disregard the Friedman proposal and then redistribute wealth directly through a well-designed fiscal policy.[13] This latter option appears to be the path taken by most governments.

We conclude our discussion with some scattered comments on the likely robustness of our results. The model contains a number of simplifying assumptions. In particular, we assume that agents are risk neutral, that there is no aggregate uncertainty, and

[11] If the social welfare in the bad equilibrium exceeds that in the money and banking equilibrium, then it must be the case that $(1-\lambda)y - \lambda\mu > (1-\lambda)\epsilon(1-\epsilon)$. This inequality is, in fact, valid since we have assumed that $(1-\lambda)y - \lambda\mu > (1-\lambda)\epsilon$, see footnote 4.

[12] In fact, Friedman's (1960) proposal entailed the extreme view of having the government possess monopoly rights in the business of money creation. His conclusions, however, were based on the notion of maintaining financial market stability (and not redistribution), a topic that is beyond the scope of our paper.

[13] If an audit can reveal not only the amount of goods that an agent has but also the amount of money that he is holding, then the government will be able to tax individuals, and redistribute the proceeds. Note that if the goverment does not completely tax away type A agents' "first-mover advantage," then the unique equilibrium to game will be characterized by money and banking.

that the time-horizon is finite. Below, we argue that none of these abstractions are crucial.

Suppose first that agents are risk-averse. Then the money and banking outcome described above will not deliver an efficient outcome because the consumption profiles for type B and C agents are risky. But if we allow an audit to reveal not only the amount of goods that an agent produced but also the amount of money that he is holding, then it will be possible for a money and banking structure to implement an efficient outcome. When agents are risk-averse, at date 0 an "insurance intermediary" will arise on islands B and C. The insurance intermediary will write contracts with all agents on the island. The nature of the contracts involve successful agents—those agents that produced and traded their goods for money in the spot market—paying a net premium to the insurance intermediary and unsuccessful agents receiving a net indemnity. The contracts can be designed so that after the premiums and indemnities are paid all agents will be able to purchase and consume the same amount of goods in the spot market in the subsequent period. If a successful agent attempts to conceal that he is successful by not paying his net premium, then the insurance intermediary will have insufficient funds to honor his indemnity obligations; consequently, an audit will have to be performed on those agents who did not pay a premium until the hidden money is discovered. As a result, successful agents will not have an incentive to hide their money.

Our basic model also assumes that there is no aggregate risk. In spirit, this assumption is similar to one adopted in the financial intermediation literature, (Diamond (1984) and Williamson (1986)). The no-aggregate-risk assumption implies that the bank—in our model—or the financial intermediary—in Diamond (1984) or Williamson (1986)—will never have to be monitored or audited by its creditors.[14] But what if the financial institution can not perfectly diversify away all of its risks? This would imply that creditors might have to monitor or audit the financial intermediary since a "successful" financial intermediary can always claim that it received a bad aggregate outcome and is unable to fulfil its contractual obligations. Since the financial intermediary monitors the borrowers and the creditors may have to monitor the intermediary, it might very well be the case that direct lending dominates financial intermediation in the standard literature, or the trading of incentive compatible Arrow-Debreu securities at date 0 dominates a "money and banking" in our model. Does the introduction of aggregate risk necessarily imply that the financial intermediaries or "money and banking" are no longer optimal institutional arrangements?

Krasa and Villamil (1992a, 1992b) have addressed these questions in the context of the financial intermediary literature. Krasa and Villamil (1992a) assume that there is only a finite number of entrepreneurs with investment projects that require

[14] The way in which no aggregate risk is generated differs between the models; our model we assume correlated outcomes and the financial intermediation literature appeals to a law of large numbers.

funding, where project returns are independently and identically distributed. The finiteness assumption implies that the financial intermediary's aggregate return will be risky. These authors demonstrate that a financial intermediation arrangement can continue to dominate direct lending even when the financial intermediary's aggregate return is risky. The optimal arrangement has the financial intermediary monitoring the borrower if the borrower does not repay a prespecified amount and has creditors monitoring the financial intermediary if it does not pay back a prespecified amount. As in Diamond (1984) and Williamson (1986), under such an arrangement the financial intermediary will at times have to monitor borrowers. The total amount of resources that the financial intermediary collects from borrowers will at times exceed the total amount that it promises to pay the lenders. In this scenario, lenders will not have to monitor the financial intermediary because it has sufficient resources to pay off all of its obligations. However, at times the total amount of resources that the financial intermediary collects from borrowers will fall short of its total obligations; in this scenario, lenders will have to monitor the financial intermediary. Krasa and Villamil (1992a) demonstrate under fairly general conditions that the former scenario is more likely to occur than the latter scenario; hence, financial intermediation will dominate direct lending. We can apply this same reasoning to our environment to arrive at the conclusion that the introduction of aggregate risk need not undermine the efficiency of a money and banking institutional structure.[15]

Finally, it has been brought to our attention that by extending our model to allow for an infinite horizon, the emergence of a fiat money instrument would bypass the need for intermediation and implement an efficient allocation. The basic idea here is that because fiat money is never redeemed, it will simply continue to circulate indefinitely with successful agents willingly bringing their goods to market. We show below that this conclusion does not survive closer scrutiny.

Consider extending our simple model to include an infinite number of periods $j = 0, 1, ..., \infty$. We suppose that within each period, there are still four 'dates' (or stages) $t = 0, 1, 2, 3$, as described earlier. Individual preferences for a type A agent are now given by $E \sum_{j=0}^{\infty} \delta^j [c_1(j) + \epsilon c_3(j) - \mu e_A(j)]$, where $c_t(j)$ denotes the consumption of output at date t in period j, and $0 \leq \delta < 1$ is the discount factor applied to consumption across time *periods* (not dates). The preferences of other agents are analogously defined. Our simple model corresponds to the case in which $\delta = 0$.

Suppose that type A agents are endowed with fiat money in period $j = 0$ and suppose that fiat money is expected to circulate. Then in period 0, the type A agent acquires goods from type B agents, who then purchase goods from the type C agents. The type C agents now wish to purchase output from the type A agents.

[15] Formally demonstrating that the money and banking structure survives aggregate risk is beyond the scope of this paper and is left for future research. The important point that we want to make here is that it is not at all obvious that any of our results will be impaired when aggregate risk is introduced into the analysis.

The type A agents will accept fiat money as payment only if it is their interest to do so. Assuming that they accept the fiat money (and continue to do so indefinitely), results in an expected utility payoff equal to:

$$V_A^F = 0 + \delta \sum_{j=1}^{\infty} \delta^j (1-\lambda) y.$$

But now let us ask whether there exists a profitable deviation for the type A agents at date 3 (at the end of period $j = 0$). Suppose that at this stage, a competitive bank emerges that issues its own money with the intent of lending it out to the A agents in the next period at date 0 (in the manner described in the simple version of our model). Then it is in the interest of type A agents to refuse fiat money as payment in period $j = 0$, since they can rationally expect to use bank money for all future periods $j \geq 1$. The expected utility payoff of such a deviation is given by:

$$V_A^{MB} = \epsilon y + \delta \sum_{j=1}^{\infty} \delta^j (1-\lambda)[y + \epsilon(1-\epsilon)y].$$

The first term in the expression above is the utility benefit that the type A person enjoys by consuming his own good (by declining to dispose of it in exchange for fiat). In all subsequent periods, the type A agent can expect a flow utility payoff equal to $(1-\lambda)y$ associated with consuming the good he values highly *plus* a flow utility payoff equal to $\epsilon(1-\epsilon)y$ associated with consuming $(1-\epsilon)y$ units of his own good. Clearly, as $V_A^{MB} > V_A^F$, it would never be rational for type A agents to accept fiat as payment; hence, fiat money will not be valued in this environment.

7 Conclusion

We have constructed a model that is characterized by a communications friction, an information friction and an intertemporal lack of double coincidence of wants. In this environment a security will be issued by the agents who desire to consume early and produce late, i.e., the type A agents, and this security will look like "money" in that over time it circulates between various agent types in the economy. When agents are prohibited from being money issuers and intermediaries—the Friedman proposal—then type A agents will never be responsible for potentially monitoring the securities that they have issued. These agents will not have a strict incentive to design to most efficient circulating security and, as a result, the equilibrium outcome may be characterized by inefficient monitoring. If, however, there is no prohibition against money issuing intermediaries, then the unique equilibrium has intermediation and money issue being undertaken by one (type A) agent. This outcome is efficient in the sense that costly monitoring will never occur in equilibrium. Here, the agent that issues the security has a strict incentive to design an efficient security since it is he that would bear the cost of any monitoring. Hence, money and banking go hand–in–hand because it provides the money–issuing agent with an incentive to design an efficient circulating security.

Appendix 1: Commitment and Renegotiation

Consider the following contract,

> The bearer of this security is entitled to output y to be delivered at date t by agent i in the event of project success. In the event of an announced failure, the bearer of this security *must* perform an audit designed to verify the project outcome. Title to any output that is discovered as a result of the audit shall be transferred to the bearer of this security.

A number of people have remarked to us that this contractual structure assumes commitment on the part of contracting parties; and that it would not survive if one were to (reasonably) suppose that individuals could renegotiate contractual terms if it was in their mutual self-interest to do so. In particular, note that if the producing agent reports zero output, then the security holder would have an incentive to "tear up" the contract since auditing is costly and, in equilibrium, his audit cannot be expected to find any output. Likewise, tearing up the contract at this stage would not harm the producer and so he would not block such a move. Anticipating this, contracting parties would not make monitoring mandatory, since such a stipulation would not survive renegotiation. In this appendix, we will show that such a conclusion is unwarranted, at least, without a precise specification of the renegotiation game that is assumed to be in place.

Consider first Figure 1, which displays the game that is played between a producer and a security-holder when renegotiation is not possible. First, Nature determines whether the producer is successful, S, or unsuccessful, U. The successful producer can report either y or 0; assume (without loss) that the unsuccessful producer agent can only report 0. The contract stipulates that if the producer reports zero output, then the security holder must audit the producer. The first payoff of the order pair at the terminal nodes represent those of the producer and the second payoff is that of the security holder. The proposed equilibrium of the game has the successful the producer truthfully reporting his success and the unsuccessful producer truthfully reporting his failure. In the latter event, the security holder undertakes a costly audit and (as expected) finds nothing. The successful producer has no incentive to defect from proposed play because if he plays 0, the security holder will audit him, leaving the producer with a zero payoff, which is not greater than the equilibrium payoff. As for the security holder, when the producing agent reports zero output, he is contractually bound to audit the producing agent. The issue of renegotiation naturally arises when the producing agent plays 0. According to the equilibrium strategies, the security holder will put zero weight on being on left node in his information set when zero output is reported and will put a weight equal to one on being at the right node. One would think, so the story goes, that agents can be made better off if they simply "tear up" the contract after the producing agent plays 0. In order to assess the validity of this conjecture, one has to formally model the notion of renegotiation in the extensive form game.

Imagine now that the contract described above is subject to renegotiation. Figure 2 describes a particular contract renegotiation game.[16] As in the commitment game above, Nature first determines whether or not the producing agent is successful. If the producing agent plays 0, then the contract is subject to renegotiation, R. Suppose that the nature of the renegotiation process is such that the producing agent suggests that they "tear up" the contract and "walk away." The holder of the security can then either accept this renegotiation offer, a, or reject it, r. If the security holder plays r, then the initial contract is back in force and the agents implement the contract as it was originally written. The payoffs at the terminal nodes reflect the structure of the renegotiation process. In particular, if the renegotiation offer is accepted, then the security holder always receives zero and the producer receives y if he is successful and zero if not. Note that there cannot exist an equilibrium where the successful producer plays y, the unsuccessful producer plays 0 followed by R, and the contract holder accepts the renegotiation offer, i.e., plays a. To see this suppose such an equilibrium exists. Suppose further that the successful producer deviates from proposed equilibrium play and chooses 0 followed by R. According to the equilibrium strategies, the security holder will believe with probability one that he is at the right node in his information set, implying that his best response is to play a. As a result, the successful producing agent will be made strictly better off by the defection since he will receive y instead of 0, his proposed equilibrium payoff. Hence, there cannot exist an equilibrium where the successful producer plays y and the unsuccessful producer successfully renegotiates the original contract.

The only set of equilibrium strategies to the game described in Figure 2 is as follows: Both successful and unsuccessful producing agents play 0 and offer renegotiation R; the contract holder rejects the renegotiation, i.e., play r, where upon the successful producer displays his output and the unsuccessful producer is audited by the security holders. At this point all we can say is that *for the particular renegotiation game that we chose here*, the equilibrium outcome is the same as in a game where agents are committed to implement the contract. But what about other renegotiation games? It has been shown (see Nosal (1988)) that for a particular class of games, the set of equilibrium allocations where parties are allowed to renegotiate the original contract, and the renegotiation game is taken from a very "unrestricted set" of possible renegotiation games, is identical to the set of equilibrium allocations to the same class of games where it is assumed that the original contract cannot be renegotiated. Furthermore, it is shown the original contract can be implemented *without renegotiation* in the game that allows renegotiation. Hence, for this class of games it would be quite wrong to assert that the proposed contract would not survive

[16] Below, we will discuss other possible renegotiation schemes.

in the presence of a renegotiation opportunity. The “game” that the security holder and producing agent play in our model belongs to the class of games studied in Nosal (1988).

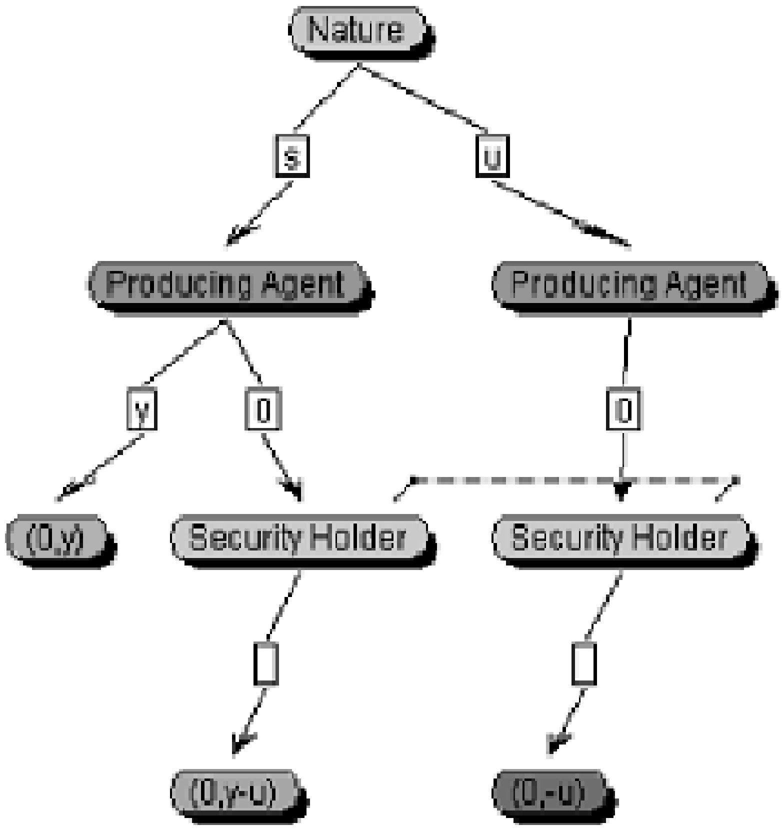

Figure 1: No Renegotiation

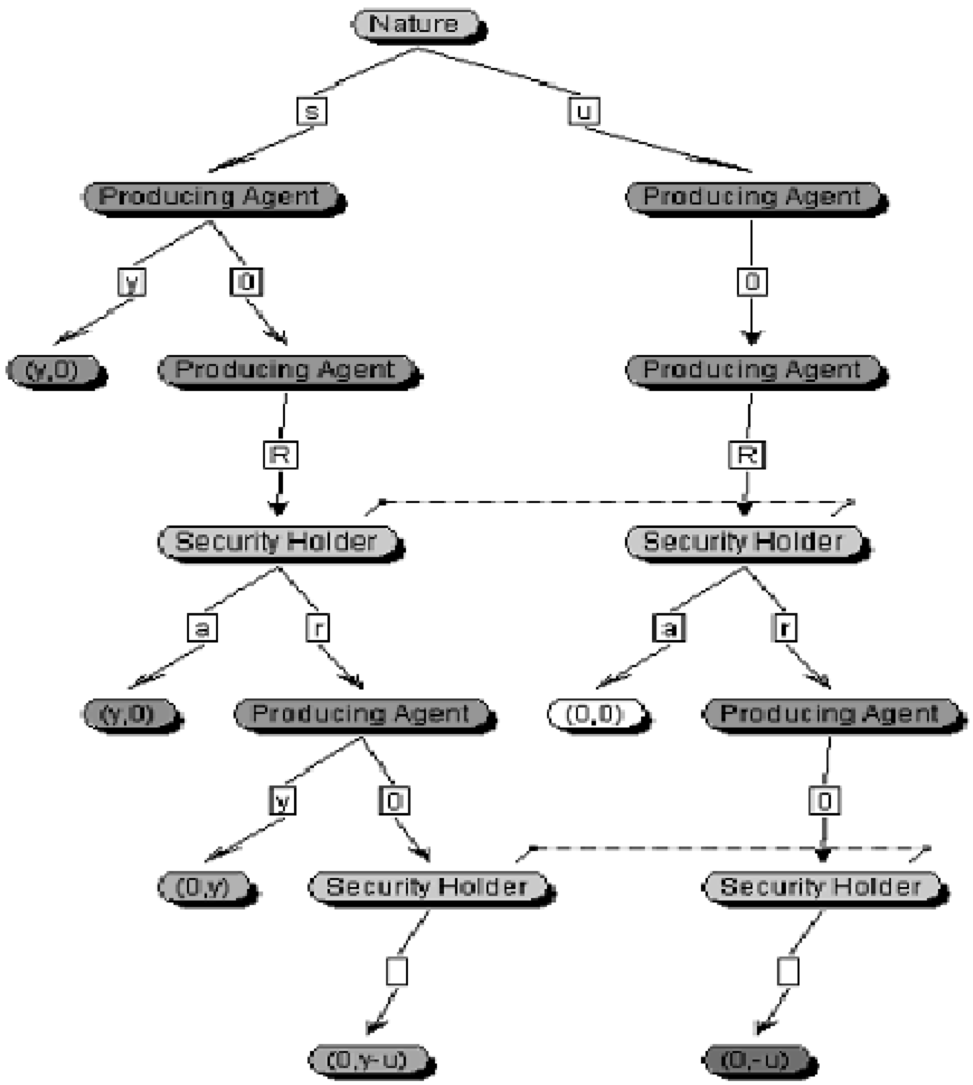

Figure 2: Renegotiation

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