Search-Theoretic Foundations of the Keynesian Multiplier

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Abstract

In a monetary search model, a real, temporary sectoral shock generates a long, economy-wide business cycle. The shock is propagated across sectors and through time by consecutively affecting the purchasing power of different types of agents. This business cycle can have persistence, sectoral comovement, immediate amplification, and a hump-shaped response of output. The paper confirms that essentiality of money in an economy also affects the non-monetary aspects of that economy. Monetary and fiscal policies can help but they usually cannot eliminate the recession. In the presence of price stickiness, policy expectations, and policy lags, policies might actually delay the recovery.

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"What calls for explanation is, in the first place, the duration and wide amplitude of the fluctuations – particularly those in the negative direction, since the upward movement, the approach to full employment, might be explained as a natural consequence of the inherent tendency of the economic system towards equilibrium."

Gottfried Haberler (1963), p. 265

1. Introduction

Recessions are often attributed in popular opinion and by policy-makers to large, identifiable, negative shocks, which hit specific important sectors. For example, the slow recovery from the last U.S. recession was attributed to the attacks of September 11, 2001, which hit the travel sector. Terrorism also hurt tourist destinations like Israel, while natural disasters wrecked the tourism and fishing sectors in Louisiana (Hurricane Katrina) and South Asia (the 2004 tsunami).

It is not obvious how such a temporary sectoral shock gets propagated across sectors and through time, thus affecting the entire economy negatively even after it is gone. This paper discusses one propagation mechanism and demonstrates it in an environment that is based on the monetary search model of Kiyotaki and Wright (1989, 1993). Since that model is supposedly too narrow for analyzing broad macroeconomic issues, I explain the intuition up front. In the model there are n types of agents and goods, and agents specialize in production and consumption: Type i produces good i and consumes good i+1 (mod n). If the production of good i is temporarily impossible the income of type i agents is reduced. They will buy less of their consumption good, good i+1, next period. Their low demand for good i+1 will, in turn, reduce the money holdings of that good's producers – type i+1 agents – so those agents will later buy less of good i+2, and so on. The propagation of the shock continues in a chain reaction from one sector to another even if the shock to good i lasts only one period.

Of course, well-functioning credit markets could help agents in mitigating these effects, but the use of money in an economy proves that at least some of its credit markets are *not* well-functioning. The propagation mechanism is therefore closely related to the essentiality of money.

Governments are widely expected to do something in such cases. After the September 2001 terrorist attacks in the U.S., both Congress and the Federal Reserve acted promptly to try and prevent a deep recession in the entire economy. Their actions were based more than anything on gut feeling and one-sector standard models. It is useful to provide policy-makers with explicit multi-sectoral models.

The propagation of changes in purchasing power is implicit in the static Keynesian multiplier, but here it is dynamic and creates a long, auto-stabilizing business cycle in a sectoral context. This paper complements the literature on sectoral linkages through intermediate goods (Long and Plosser 1983, Scheinkman and Woodford 1994), in which a sectoral shock deprives other sectors of a production input[2]. Here there are no intermediate goods: Sectors are connected by liquidity from the demand side instead of the supply side. Kiyotaki and Moore's (1997a) "credit chains" model also uses intermediate goods, in order to justify limited credit relationships: A default by one debtor causes a liquidity contagion because each agent owes money to its supplier. They derive an immediate contagion similar to the Keynesian multiplier. I show that a liquidity contagion is possible even in an economy in which any type of credit is completely impossible, and I describe a complete business cycle. The business cycle described in

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[2] Sectoral linkages have been explored in other non-monetary models. In Murphy, Shleifer, and Vishni (1989) a shock affects the shocked good's consumers rather than its producers. In Lilien (1982) workers are reallocated across sectors. In Phelan and Trejos (2000) the frictions in such reallocation are combined with complementarity in demand for goods.

Kiyotaki and Moore's (1997b) "credit cycles" model also has contagion but not due to illiquidity: It comes from changes in asset prices of collateral used by both sectors. Wallace (1997) already uses a monetary search model to analyze propagation of a shock, but he does so for a monetary shock whereas here the shock is real.

Money is not new to business cycle analysis, but its role here is fundamentally different from the roles previously given to it. The literature has analyzed the effects of exogenous or endogenous *changes* in money supply. In contrast, money belongs here simply because when it is needed in its most fundamental role – a medium of exchange – it propagates a real, isolated shock into a persistent, economy-wide business cycle.

The paper is organized as follows. Section 2 presents the basic model and the propagation of a one-period shock to one sector. Sections 3 and 4 show robustness to properties of the shock and to consumption preferences, respectively, while generating additional business cycle regularities. Various monetary policies are discussed in Section 5, and fiscal policies are in Section 6. Section 7 discusses complications that arise with policy lags, sticky prices, and policy expectations. Section 8 concludes. An appendix shows robustness to the indivisibilities assumed in the text.

2. The Basic Model

Here I formalize in the simplest possible way the propagation discussed in the Introduction.

2.1. Environment

Time is discrete and lasts forever. There is a continuum of infinitely-lived households, with a unit mass of each type $i = 1, \dots, n$. There are n types of goods. A type i household gets utility $u(q) > 0$ from consuming q units of good i+1 (mod n), and incurs a cost $c(q) > 0$ from producing q units of good i. The discount rate is $r \equiv 1/\beta - 1 > 0$. Goods perish at the end of a period. The only durable object is intrinsically useless money. A household can hold up to two money units ($2). Households are anonymous and trading histories are private information.

Because the key to propagation is a distortion in the distribution of money, it is convenient to have a degenerate distribution in steady state. This can be derived by incorporating Lucas' (1980) two-member household in a directed search model, as suggested in Wallace (2002). The directed search model modified for that purpose is Goldberg (2007). All households of type *i* live in houses in City *i*, which is where good *i* is produced. Each household has two agents – a buyer and a seller. The seller stays home and can sell goods to buyers of other types. The buyer can travel without cost only to the city that produces its consumption good, where it is randomly matched with one seller. The short side of the market is fully matched, and no seller is visited by more than one buyer. At the end of a period, the buyer returns home with the purchased goods and/or money. Excess money must then be disposed of.

Prices and quantities in a match are determined by symmetric Nash bargaining. In all the cases analyzed here the allocations are the same as in strategic bargaining with alternating offers at equal probabilities (as in Trejos and Wright 1995).

There can be an exogenous, negative, unexpected, once-and-for-all shock that completely shuts down one sector for one period[3]. All households know in real time which sector is hit, the shock's duration, and its magnitude. All the above implies that trade requires a type *i* buyer to visit a type *i*+1 seller who is willing to, and can, produce good *i*+1.

[3] Shutting down the entire sector simplifies the analysis and makes it observationally equivalent to a total shock to the demand for that good. It also emphasizes that the model is about large shocks, whose effects cannot be easily prevented even with precautionary savings and insurance.

2.2. Strategies

A household decides whether the buyer should go shopping, and whether the seller should produce. Let $V_t(m)$ be the value function of a household with \$*m* right after period-*t* matches. If *m* > 2 the household must then dispose of \$(*m*-2). If the household's seller meets a buyer, let $\tilde{m}_b$ be the money holdings of that buyer. Similarly, let $\tilde{m}_s$ be the money holdings of the household of a seller that our household's buyer meets (if it meets any). The probability that a seller who wants to sell does sell (a quantity $q_s(m,\tilde{m}_b)$ for a payment $d_s(m,\tilde{m}_b)$) is $s(m,\tilde{m}_b)$. The probability that a buyer who wants to buy does buy (a quantity $q_b(m,\tilde{m}_s)$ for a payment $d_b(m,\tilde{m}_s)$) is $b(m,\tilde{m}_s)$. The collection of strategies of a household is {sell, not sell} $\times$ {buy, not buy}. If a type *i* buyer goes anywhere, it should go only to City *i*+1. Elsewhere it may spend money but not receive anything it can consume or store. From now on I ignore such dominated strategies. Equation (1) considers only pure strategies:

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(1)\quad
\begin{aligned}
& rV_t(m) = \max E_t\{0, \\
& b[u(q_b) + V_{t+1}(m - d_b) - V_{t+1}(m)], \\
& s[-c(q_s) + V_{t+1}(m + d_s) - V_{t+1}(m)], \\
& bs[u(q_b) - c(q_s) + V_{t+1}(m - d_b + d_s) - V_{t+1}(m)] \\
& + b(1-s)[u(q_b) + V_{t+1}(m - d_b) - V_{t+1}(m)] \\
& + (1-b)s[-c(q_s) + V_{t+1}(m + d_s) - V_{t+1}(m)]\}
\end{aligned}
$$

The first row describes an idleness strategy of the entire household. The second row describes only buying. The third row describes only selling. The rest describes the strategy of *trying* to both buy and sell.

2.3. Equilibrium

Definition 1: A symmetric stationary monetary equilibrium is a collection of pure production strategies of sellers, buying strategies of buyers, and a distribution of money, such that: 1. All sellers who produce sell the same strictly positive quantities of goods for money. 2. The distribution of money is consistent with initial endowments and the evolution of money holdings implied by trades. 3. The distribution is degenerate and constant.

To simplify the exposition both goods and money are assumed here to be indivisible. The Appendix shows that this is innocuous. Assume that a household cannot produce or consume more than one unit each period. Let $u \equiv u(1)$ and $c \equiv c(1)$, with the latter being arbitrarily small. Also assume that $\beta^n u > c$.

Proposition 1: If each household is endowed with \$1 then a symmetric stationary monetary equilibrium exists.

Proof: Conjecture that a household always goes shopping, and produces if and only if it has \$0 or \$1. With the initial money endowments every buyer finds a producing seller and every seller meets one buyer holding \$1, so $b = s = 1$. The indivisibility of goods and money implies that on the equilibrium path $d_s = d_b = q_s = q_b = 1$. With c arbitrarily small it can be verified that payments are 1 even if buyers hold \$2. With these conjectured strategies, $rV(0) = \beta u - c$, $rV(1) = u - c$, and $rV(2) = u - \beta c$. It is easy to verify the guess. Since every household starts with \$1, and it both buys and sells for \$1, the distribution of money remains degenerate at \$1 per household. Therefore, the equilibrium can recur next period if there is no shock. *QED*

In this steady state there is full (self-)employment[4]. Output per household is 1 and the price level is 1, so with *n* types aggregate output is *n*. Because the focus below is on negative shocks, an expansion in this economy is synonymous with a recovery from a recession (as in p. 2's Haberler quote).

2.4. A Business Cycle

Suppose that in period -1 the economy is in the monetary steady state, but in period 0 there is a one-period shock to Sector *i*. The dynamic analysis is restricted to the class of equilibria that satisfy long-run neutrality of the shock: Eventually the economy goes back to the same steady state. The resulting business cycle is described in Proposition 2, while Table 1 provides an example for $i = 1$ and $n = 3$.

Proposition 2: Aggregate output immediately falls from *n* to *n*-1, and remains at *n*-1 until it returns to the level *n* in period *n*.

Proof: *Period 0*: Due to discounting, type *i* buyers still go shopping in period 0. The indivisibility of their only unit of money prevents consumption smoothing (this is relaxed later). They therefore end the period with no money. Since type *i*-1 households cannot consume in period 0, if they produce that period they end up with \$2. I conjecture here that they do produce, and I verify it later.

Period 1: In period 1 the production of good *i* can be resumed. Type *i* households begin period 1 without money. In order to consume ever again, they must produce and sell to type *i*-1 households, and they do so. However, the money that type *i* sellers earn in period 1 arrives too late to be used for shopping in period 1. Type *i* buyers therefore cannot buy good *i*+1. Type *i*+1 households, then, do not produce; they still spend all their money on buying from type *i*+2 due to

[4] Obviously there is also an autarkic steady state in which nobody accepts money.

discounting and money's indivisibility, so now type i+1 households are the ones who end up without money. All the other types buy and sell for $1, so their money holdings are unchanged (in the example of Table 1 this only refers to type 3).

Period 2: Type i+1 households have no money, so they cannot buy from type i+2, and the process repeats itself. In any period $j \in \{1, \ldots, n\text{-}1\}$, type i+j-1 households have no money and cannot buy from type i+j households.

Period n-1: The ones who cannot sell now are of type i+n-1, or simply i-1 (recall mod n). These are the same households who accumulated a spare $1 earlier. Now they end the period holding $1, just like all other households. The distribution of money is now exactly as in the steady state, so in period n the economy is back in steady state.

In order to verify the conjecture that type i-1 households do produce in period 0, note that it costs them c in period 0, but the spare $1 they earn then is useful after the propagated shock hits Sector i-1 in period n-1. Without it, type i-1 cannot consume in period n. It is optimal to produce in period 0 if and only if $\beta^n u > c$.   *QED*

2.5. Discussion

This is the basic mechanism that the paper explores: The trigger for the recession can be a supply shock or a demand shock that directly affects only one sector for only one period. But the recession does not last just one period. The shock impoverishes the households making a living in the hit sector, and this brings down all other sectors, one by one, like domino blocks. While in the static Keynesian multiplier all the domino blocks fall simultaneously (thus creating a large multiplier), here each sector falls in a different period. As Haberler (1963, pp. 231-232) notes, this lag must exist in a monetary economy, and it can be thought of as time between paychecks[5].

The recovery is "natural," as Haberler puts it: After the sectors start failing, they also recover, one by one. The sector that was hit first recovers and accumulates money. Next period, this new purchasing power will help in the recovery of the next sector's purchasing power, and so on. There are two processes of a dynamic Keynesian multiplier: One of them propagates the reduction in output, causing contagion across sectors; as soon as the original exogenous shock is gone, the other process revives trade in every sector, in the same order, with a lag. Overall, output is low by $1/n$ of its steady state value for n periods. Note that a sector can be interpreted as a geographical unit. It can represent a city, a county, a state, or a country. Disasters, whether natural or man-made, usually hit particular geographical units rather than particular industries, although there is obviously some correlation (e.g., a fishing industry and a hurricane).

3. Other Shock Realizations

Here I discuss a shock that hits most sectors or lasts more than one period, while assuming $n = 3$. When two sectors are hit at once the recession is shorter (see Table 2). The shock to Sector 2 prevents type 1 from buying so its money holdings are not depleted. Instead, type 2 immediately runs out of money, and in the following period, after failing to buy from the rich type 3, the recovery is almost complete. This case can represent a single shock that affects most sectors directly (e.g., an oil shock). Even in such a case, then, the effects of the shock persist after it is gone. The key point is that although such a shock affects many agents directly, it does not affect

[5] The non-monetary equilibrium may appear just for period 0. If the economy completely shuts down for the duration of the shock, there is no propagation. The economy can return to the monetary steady state in period 1. Because of discounting, the recession of Table 1 has higher welfare than this immediate loss of all output.

everyone in the same way and at the same time. For example, a columnist is little affected by an oil shock at first, but may be fired because of low newspaper purchases by those directly affected by the shock.

Consider now a long shock instead (and let households hold up to \$3). Table 3 shows that the longer shock not only delays the recovery, as could be expected, but also causes an amplified, hump-shaped response of output, as observed in the data (Cogley and Nason 1995). In no period is there a shock to two sectors at once, and the shock is not hump-shaped, and yet the output gap looks after a while as if two sectors are hit at once (i.e., aggregate output is 1 instead of 3).

4. Robustness to Preferences

The consumption preferences assumed so far, taken from Kiyotaki and Wright (1989), are unrealistic in a few ways, some of which may seem relevant for the propagation. Here I allow agents to substitute consumption away from a shocked good, I sever the tie between agents' production specialization and consumption specialization, and I make the consumption specialization milder than the production specialization. These changes are done one at a time.

4.1. Substitution in Consumption

One might suspect that if households could shift consumption from the shocked sector to another sector, then one sector is up while another sector is down so there is no aggregate business cycle. Such an intuitive conjecture is wrong, and actually misses the point of the paper. Assume that type i-1 prefers good i but if that good is unavailable then it tries to consume good $j \neq i, i-1$ instead. Also assume that there can be positive shocks, so that a positively shocked sector can produce two units of a good. Specifically, in period 0 there is the usual negative shock to Sector i, but luckily there is also a positive shock to Sector j.

Table 4 shows an example with $n = 3$, $i = 1$, and $j = 2$. Type i-1 wants to buy good j instead of good i. Good j is normally consumed by type j-1. All type i-1 buyers and type j-1 buyers visit City j. With enough of good j to sell to both types, aggregate output is indeed unchanged in period 0. But a recession is soon to follow *anyway*. Even though aggregate output remains constant for the duration of the shock, the problem is the same as before: The distribution of money has been disturbed. Some households who could not produce in period 0 (type i) cannot consume in period 1, just like before. The fact that other households have more money than usual (type j) is not going to eliminate the ensuing recession, just like it did not prevent the recession in the simpler variants of the model discussed above.

The particular Kiyotaki-Wright linkage between sectors does make the recession shorter. In Table 4, type 3 shifts consumption to good 2 so now type 2 becomes rich (whether types 2 and 3 barter or use money). But in period 1 the weak purchasing power of type 1 brings type 2 back to normal money holdings and the recession is over. Of course, with more types of households and goods, the recession can be longer than one period.

4.2. Uncorrelated Specializations

The Kiyotaki-Wright patterns of specialization are correlated: All households who produce good i also consume good i+1 and vice versa. This is unrealistic: Just because both you and I are economists does not mean that we both like chicken and non-economists do not. Assume then that a fraction $1/(n\text{-}1)$ of type i households consume good i+1, another such fraction consume good i+2, etc. Money is still useful, because a type i buyer who likes good i-1 cannot identify those type i-1 sellers who like good i. Barter can work occasionally, but it is safer to use money.

With $n = 3$, Figure 1 shows that the propagation mechanism is robust to this change. The recovery starts earlier but lasts longer than in Table 1. The drop in output spreads immediately across the entire economy, and yet the recession is long. This pattern of contagion is obviously more realistic than the illustrative chain reaction assumed in the rest of the paper, and should be adopted in any empirical application.

4.3. Consuming Two Types of Goods

Real people consume more types of goods than they produce. Assume then that every period type i households want one unit of good i+1 and one unit of good i+2, can produce two units of good i, are endowed with $2 each, and can hold up to $3 each. In steady state each buyer spends $1 in each relevant city. If a household does not have enough money to buy both goods in some period, or it chooses to buy only one good, it randomizes between them. This allows consumption smoothing.

A shock to Sector i indeed induces type i buyers to smooth consumption. Half of them go shopping only in City i+1 and the other half go shopping only in City i+2, and they save half of their money for the next period. The result is an immediate drop in output of all three sectors: In Sector i due to the exogenous shock, and in Sectors i+1 and i+2 due to the demand shock from Sector i. This causes both an immediate amplification of the shock and sectoral comovement.

As an example, Figure 2 shows aggregate output for n = 5. The larger number of types is needed to maintain essentiality of money with the new consumption preferences. Note the immediate amplification, compared with the basic example in which each household consumes only one good. The reduced specialization in consumption speeds up the propagation across sectors, and thus reduces persistence. However, even with each household consuming a staggering 40% of all the types of goods in the economy, persistence is still substantial. Figure 3 shows the comovement of sectoral outputs for the same example. While in the basic example all cross-sector correlation coefficients are negative (they are equal to -1/(1+n) in Table 1), here they range from -.3 to .95. Their average of .37 is close to the data (Long and Plosser 1987).

The message here is that realistic changes in consumption preferences do not eliminate the propagation mechanism. In fact, some of them improve the model's ability to replicate other business cycle features. Similarly, it does not matter if only some of the producers of a certain good are affected by a shock. While the remaining, functioning producers will become richer at the expense of consumers, this will not change the main results: Whoever gets hurt will reduce consumption of other goods, thus propagating the shock.

5. Monetary Policies

In the basic example of $n = 3$ and $i = 1$, the socially optimal solution to the shock's propagation is for type 3 households to give their money to type 1 households in period 0, even though they do not get goods in return. Without credit markets, they have no incentive to do so. Without private insurance or savings, only the government can help the economy. *Monetary policy* is defined here as any policy that adds new money and does not explicitly tax anyone. Such a policy can be helpful in that it gives money to the "weakest link" – the households who become impoverished by the shock. In doing this, it helps maintaining stable demand for the other goods. The exact way in which the money is added turns out to be very important. I assume for now that prices are flexible, the policy is unexpected, and inflation has no costs (but see Section 7).

5.1. A Proportional Transfer

Suppose that, right after the shock, at the end of period 0, the government unexpectedly increases all households' money holdings proportionaly by 100%. In the long run, prices must be \$2 to maintain the neutrality of money. I focus for now on equilibria with immediate price adjustment. Equilibria where prices are sticky for a while are discussed in Section 7.

Lemma 1: There is an equilibrium in which all sellers increase the price level to 2 in period 1 and keep it at that level.

Proof: Suppose that everyone expects prices to rise to 2 immediately. Given that sellers expect all prices to be even forever, none of them would agree to be paid $1, since this would be as useless as being paid $0. *QED*

Table 5 shows that nothing changes in real terms. Money is neutral even in the short-run, and the recession is just as long and as bad as before.

5.2. A Lump-sum Transfer

Suppose that, right after the shock, the government gives $1 to each household. This can still result in an equilibrium with an immediate price adjustment as above, under the following assumption: If all households of some type hold odd quantities of money but the price level is even, they all pool money within their type and redistribute it so as to maximize their type's consumption. For example, in period 1, when the price is 2, type 1 households pool their $1 and redistribute it in a lottery, such that half get nothing and half get $2 each. On average, then, this type can purchase .5 units. As shown in Table 6, this policy is helpful because it immediately restores some of type 1's purchasing power (half of it), thus reducing the magnitude of the propagation of the shock[6].

A $2 lump-sum transfer is even better, as shown in Table 7: With a new money supply of 9 units, the new price level is 3, and type 1 can buy 2/3 units in period 1 rather than 1/2. As seen in the previous tables, the economy is back at full employment if and only if the previous period ends with a degenerate money distribution. Given that the sectoral shock distorts the distribution, a lump-sum transfer can realign it immediately only if it is infinitely large. With arbitrarily small

[6] Alternatively, with an assumption of divisible goods, all such households will buy .5 unit each.

inflation costs this is clearly not optimal. However, this exercise hints that recovery may be better achieved if the policy is directed towards the hit sector. This possibility is explored next.

5.3. A Directed Transfer

Suppose that the government gives new money to those hit directly by the shock, such that, as before, the money supply increases by 100%. The results are in Table 8. The aggregate results happen to be identical to those of a 100% lump-sum transfer (Table 6), but in general this is not the case.

A monetary transfer directed only at type 1 may actually be a better approximation to real-world open market operations than the policies discussed above. This is because, when one sector is hit and its workers and owners lose wages and dividends, they are more likely than others to immediately sell their bond holdings for cash. The injection of new money, traded for bonds immediately after the shock, is then more likely to happen with agents in the hit sector. Although there is no official or designed policy of giving new money to the hit sector only, this is effectively what could happen, as demonstrated in a very different model by Alvarez, Atkeson, and Kehoe (2002).

To find the optimal size of the transfer, the policy-maker needs to take into account that resurrecting type 1's purchasing power with too much money decreases the purchasing power of others (through the increase in prices). In particular, type 1's purchasing power should not be made more than it can consume (1 unit), as described in Lemma 2 and Table 9.

Lemma 2: A better directed transfer would be 1.5, if there were no indivisibility issues[7].

[7] Indivisibility is not an issue if steady state money holdings are even, say because of a previous monetary expansion. If everyone already has $2, Lemma 2 means that the transfer and the new price level are both 1.5 times this, or $3.

Proof: A transfer of $$T$ to type 1 increases the long run price level to $P = MV/Y = (3+T)*1/3$, where M is aggregate money, V is velocity, and Y is aggregate output. Given the immediate price adjustment, the transfer immediately increases type 1's purchasing power to $T/P = 3T/(3+T)$. This exactly restores type 1's purchasing power to 1 if and only if $T = 1.5$. Then $P = 1.5$. *QED*

The closer the policy brings the distribution of money holdings back to a degenerate one the quicker is the return to steady state. Since the steady state has full employment, the quicker is the return the better. Therefore, the optimal monetary policy, shown in Table 10, would give $2 to type 1 and $1 to type 2, thus immediately realigning the money distribution and restoring the steady state. This is not because of some egalitarian considerations per se, but because the degenerate distribution happens to be the distribution of money in steady state. It is not clear how to implement such a policy in reality.

By the way, a degenerate distribution in steady state is reasonable in some sense. Type i households represent everyone who makes a living in sector i, from the most junior employees to the CEO and shareholders. Taken as a group, it is not clear whether any sector in the economy is significantly richer than another. In fact, free entry should rule out such a possibility.

6. Fiscal Policy

Fiscal policy is defined here as a policy that does not add new money, but taxes and then redistributes existing money. The redistribution can be a gift, or a wage for the production of some public works, whose utility is not modeled. Such a policy is another way of providing badly needed money to the "weakest link," only that this time it comes from other taxpayers rather than the central bank. I ignore the possibility that this money is already at the Treasury or borrowed by it.

Suppose that at the end of every period the government randomly takes $1 from a fraction $X < 1$ of those households who have more than they need for current consumption, and gives all of that money to households in shocked sectors. In steady state there are neither rich households nor shocked households, but after a shock to Sector 1 all type 3 households are eligible for such taxation. Since the probability to be taxed is less than 1, and the production cost is arbitrarily small, type 3 households produce in period 0 even if they expect such probabilistic taxation. The recovery for the case $X = .5$ is described in Table 11, where it is assumed that in period 2, when only half of type 3 sellers can sell, those who were taxed get the privilege of selling their goods.

This policy is successful. Applied to reality, it is like fiscal aid that troubled sectors sometime receive. Notable examples include "too big to fail" policies regarding banks, and aid to the U.S. airline industry after September 2001. Since sectors in the model can be interpreted as geographical areas, the model somewhat justifies federal assistance to disaster areas by FEMA and/or through a presidential declaration of *disaster areas*, which make them eligible for fiscal benefits. Of course, in reality, moral hazard makes such policies problematic.

This policy is also observationally equivalent here to unemployment insurance because only those who do not work in period 0 get the aid in real time. It is also observationally equivalent here to food stamps, because only those who end period 0 with no money at all, and are about to go hungry in period 1, receive aid. Of course, it is easy to conceive of a general version of this model, where these fiscal programs will not be observationally equivalent to ad-hoc fiscal aid.

7. Policy Problems

Things become more complicated when one introduces the Keynesian feature of sticky prices, and the Friedmanian features of expectations about policy and policy lags.

7.1. Sticky Prices

Suppose that prices are exogenously sticky for one period. They have to be $1 in period 1 and can adjust only in period 2. As before, indivisibility is overcome with pooling, a lottery, and a redistribution. If another redistribution is needed at some point, I assume that the former losers then become the winners.

Table 12 shows that under price stickiness, a proportional transfer is not neutral. Surprisingly, it is not harmless either, as we might expect from a proportional transfer. It prolongs the recovery and is worse than no intervention (Table 1) both in aggregate terms and for types 1 and 3. Sticky prices are usually thought of as good for a monetary expansion because then the extra money increases purchasing power. The problem here is that a proportional transfer does not give money to those who need it the most, i.e., type 1 households. The other types already have enough money regardless of the price level. The new money, translated into increased purchasing power of the rich households because of stickiness, only messes up the auto-stabilizing money distribution.

Table 13 repeats the experiment of a small lump-sum transfer. It is better than in the case of flexible prices (Table 6) and so better than non-intervention (Table 1). Sticky prices are therefore good here. It is easy to show that the same holds for the other monetary experiments in Tables 7-9. Once the hit agents get $1 somehow, then as long as the price level is 1 they can buy as they did before the shock. The economy gets a temporary break from the effect of the shock so long as the stickiness lasts. Once it is over, we get the full cycle as before. Due to discounting, and because agents here are not averse to the increased volatility, this is good. Stickiness does not matter for the optimal monetary policy of Table 10.

7.2. Expected Policy

Further complications can arise if the policy is expected. Suppose that prices are sticky and a policy of a proportional monetary transfer is expected. This policy could harm the economy in a different way. Since it rewards households for high money holdings, type 1 households may choose not to buy during period 0. That way they keep their $1 and get another dollar at the end of the period. With $2 they can buy every period until the return to steady state. Thus they give up u in period 0 but gain $\beta u + \beta^2 .5u$ (compare with Table 12). If $\beta + .5\beta^2 > 1$ then it is optimal not to buy in period 0. This means that type 2 will not sell and thus it faces the exact same choice as type 1. If both types choose not to buy then the economy is effectively shut down during period 0 (see Table 14). In period 1 the economy is back at full employment with sticky prices and in period 2 there is still full employment but prices adjust. The loss of three units of output is similar to Table 1, only that most of the loss in Table 1 is discounted while here it is not. Therefore this policy is harmful.

It is easy to show that if the policy is expected but prices are flexible no one gives up consumption in period 0: Then the analogous condition is $\beta > 1$, which never holds. It is therefore the combination of policy expectations and price stickiness that causes this problem.

7.3. Policy Lags

Ad-hoc fiscal aid requires legislation, and this could take time. The conventional wisdom is that such a policy lag can be harmful: A tax cut might stimulate the economy after it had already recovered, thereby causing an excessive expansion and a crisis later on. Here I show a different problem caused by a policy lag when a specific sector gets aid. As before, the shock is only in period 0. Legislation is written in period 1, and the aid (financed as before by progressive taxation) is given to Sector 1 at the end of period 1. As seen in Table 15, the policy lag delays the return to full employment compared with non-intervention.

The reason is that, when help arrives, Sector 1 had already recovered, and now the trouble is with Sector 2. Without government intervention (Table 1), the crisis is about to be over, because in the following period – period 2 – Sector 2 will transfer the shock to Sector 3, which is cushioned against the shock because it had previously saved money. With a policy lag, however, the propagated shock that is about to hit (the taxed) Sector 3 is not as diminished as in Table 11, but still bears its full magnitude. One solution is to prepare an assistance package in advance, as is done in the context of geographical areas (disaster area legislation).

The problem of policy lag happens because a particular sector is marked for help, and when the help arrives it is actually needed by another sector. The problem does not exist in programs that look at those who are *currently* unemployed or without money – namely, unemployment insurance and welfare payments.

8. Conclusion

It is widely believed that a business cycle is often caused by a negative, observable shock, which is amplified and propagated through time, to be followed by a natural recovery (Haberler 1963, Mankiw 1989). This paper shows one way of deriving such a business cycle. The key to the propagation of a negative shock is that it makes some agents poorer than before. Their low purchasing power reduces their demand. In a monetary economy with solid micro-foundations this negative consumption spillover is spread over time, thus causing persistence, because agents spend money with a lag. The paper may be viewed as a micro-foundation for a dynamic, auto-stabilizing version of the Keynesian multiplier, in a sectoral context.

This long business cycle is caused by the existence of money and its essentiality as a medium of exchange. Money is essential here because of an absence of double coincidence of wants, anonymity, and private trading histories. Without these features there is no propagation of the type shown here. For example, if there are only two sectors, then there is always a double coincidence of wants, so households barter. A shock does eliminate trade for the duration of the shock, but barter fully resumes as soon as the shock is over[8].

Indeed, it was recently predicted that the frictions that make money essential should affect not just the monetary aspects of a model but "every aspect of a model" (Wallace 2001, p. 851). These conditions create here a phenomenon that we normally think of as a non-monetary one: A real shock that has significant real effects, with no change in the money supply, and, as shown in the Appendix, with only negligible changes in prices. This paper therefore gives a concrete example that supports Wallace's proposition.

The essentiality of money has no role in current business cycle research, but some of its conditions actually have been invoked in the non-monetary literature cited above[9]. Perhaps any society that has found it essential to use money as a medium of exchange has had this propagation mechanism inherent in its economic system[10]. However, not every model in which money is essential generates the same pattern of propagation[11].

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[8] In such a model, Cooper and Haltiwanger (1990) show that persistence can be generated by inventories.

[9] Murphy, Shleifer, and Vishni (1989), Cooper and Haltiwanger (1990), Scheinnkman and Woodford (1994).

[10] Mitchell (1927), pp. 75-82, claims that modern business cycles began when autarky gave way to money incomes generated from specialization in the production of a few goods, with these incomes then used to buy other goods.

[11] For example, in a standard two-period overlapping generations model a total shock to the only good eliminates the transfer of money to the next generation in an irreversible way. The monetary equilibrium ceases to exist forever.

While this long business cycle is fairly intuitive and plausible, it cannot be generated by otherwise identical non-monetary models, or even by monetary models that lack monetary micro-foundations. Consider a Walrasian model with the same preferences and production technology, but no money, credit or future markets. The response to the shock is a one-period shutdown of all trade, and complete recovery immediately thereafter, as in the two-commodity barter case mentioned above. Now consider an Arrow-Debreu economy with a cash-in-advance constraint. A sectoral shock does not propagate because agents' purchasing power is completely insured. All agents can agree that in case of a sectoral shock the agents with spare money (the would-be buyers) give that spare money to the would-be sellers, even though no purchase is made. Even without complete markets, cash-in-advance models usually assume at least perfect credit markets. Then agents can borrow money after being hit, thus maintaining their purchasing power and eliminating propagation. Wallace (2001) discusses the internal inconsistency of such models: If anyone could borrow at any time, money would not be essential in the first place.

As Table 1 shows, the *only* problem in the economy at the end of period 0 is that the money is misallocated. Where the markets fail, fiscal or monetary policy can transfer the excess purchasing power from type 3 to type 1. With imperfect credit markets the government is indeed, in principle, justified in intervening either through fiscal policy or monetary policy. The only need is to reallocate purchasing power, and when the markets are not good enough with doing that, the government should step in. Keynes (1936) realized that after the credit markets collapsed in many countries. Ironcially, his intuition is proven correct here, by using a model which is very different from the IS-LM model. It is commonly argued that the neoclassical growth model is too far from real-world policy analysis. Some even say that looking for micro-foundations has proven counter-productive. Actually, the only problem was that the search for micro-foundations *did not go far enough*. Instead of replacing just the IS equation with utility and profit maximization, the monetary search model also replaces the LM equation. In doing this, at least some of Keynes's intuition is easily restored.

Recall that policies are helpless in the seemingly similar supply-side propagation of Long and Plosser (1983). It turns out that the same frictions that make money essential not only create a long business cycle but also make policies essential: Better allocations are possible with policies than without policies.

The analysis here shows some caveats. Real-life complications such as price stickiness, fiscal policy lags, and expectations about policy, can all cause policies to be harmful. Further analysis is required to see whether policies are indeed appropriate in reality, based on these caveats. The nature of price stickiness should be better understood, as it can either help or harm, depending on the nature of monetary policy. Monetary economists need to examine which of their idealized policies resemble most open market operations.

Perhaps the best way for the government to help the economy is to facilitate financial markets. After all, it is only because those markets do not work well that the propagation exists at all. This may require more regulation to prevent collapses of the financial system as in the 1930s. It may require better contract enforcement and less bankruptcy protection. It may even require the government to subsidize developments in communications technology: The speed at which credit histories can be checked is key in replacing currency with credit. The more we use credit rather than currency, the less likely it is that a sectoral schock will turn into a long, economy-wide recession in the first place.

Table 1: The Simplest Business Cycle

Period	Sector 1			Sector 2			Sector 3			*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $	
-1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0	1	1	1	1	0	2	2
1	1	0	1	0	1	0	1	1	2	2
2	1	1	1	1	0	1	0	1	1	2
3	1	1	1	1	1	1	1	1	1	3

Notation: "Sell" and "Buy" denote quantities of goods sold or bought by a household during that period, while "End $" refers to the stock of money held by a household at the end of that period. Y is aggregate output. **0** is the exogenous shock.

Table 2: An Almost-Aggregate Shock

Period	Sector 1			Sector 2			Sector 3			*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $	
-1	1	1	1	1	1	1	1	1	1	3
0	**0**	0	1	**0**	1	0	1	0	2	1
1	1	1	1	1	0	1	0	1	1	2
2	1	1	1	1	1	1	1	1	1	3

Table 3: A Long Shock

Period	Sector 1			Sector 2			Sector 3			*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $	
-1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0	1	1	1	1	0	2	2
1	**0**	0	0	0	1	0	1	0	3	1
2	1	0	1	0	0	0	0	1	2	1
3	1	1	1	1	0	1	0	1	1	2
4	1	1	1	1	1	1	1	1	1	3

Table 4: Substitution in Consumption

Period	Sector 1			Sector 2			Sector 3			*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $	
-1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0	**2**	1	2	1	1	1	3
1	1	0	1	0	1	1	1	1	1	2
2	1	1	1	1	1	1	1	1	1	3

Table 5: A Proportional Transfer

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 0	1	1	1; 2	1	0	2; 4	1	2
1	1	0	2	0	1	0	1	1	4	2	2
2	1	1	2	1	0	2	0	1	2	2	2
3	1	1	2	1	1	2	1	1	2	2	3

Notation: In "End $" column, "*j*; *k*" means that at the end of trade the household had $*j* and after policy intervention it has $*k*. *P* is the aggregate price level.

Table 6: A Small Lump-sum Transfer

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 1	1	1	1; 2	1	0	2; 3	1	2
1	1	.5	2	.5	1	1	1	1	3	2	2.5
2	1	1	2	1	.5	2	.5	1	2	2	2.5
3	1	1	2	1	1	2	1	1	2	2	3

Table 7: A Large Lump-sum Transfer

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 2	1	1	1; 3	1	0	2; 4	1	2
1	1	.67	3	.67	1	2	1	1	4	3	2.67
2	1	1	3	1	.67	3	.67	1	3	3	2.67
3	1	1	2	1	1	2	1	1	2	3	3

Table 8: A Directed Transfer

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 3	1	1	1	1	0	2	1	2
1	1	1	3	1	.5	2	.5	1	1	2	2.5
2	.5	1	2	1	1	2	1	.5	2	2	2.5
3	1	1	2	1	1	2	1	1	2	2	3

Table 9: A Better Directed Transfer

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 1.5	1	1	1	1	0	2	1	2
1	1	1	1.5	1	.67	1.5	.67	1	1.5	1.5	2.67
2	1	1	1.5	1	1	1.5	1	1	1.5	1.5	3

Table 10: Optimal Monetary Policy

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 2	1	1	1; 2	1	0	2	1	2
1	1	1	2	1	1	2	1	1	2	2	3

Table 11: Fiscal Policy

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; .5	1	1	1	1	0	2; 1.5	1	2
1	1	.5	1	.5	1	.5	1	1	1.5	1	2.5
2	1	1	1	1	.5	1	.5	1	1	1	2.5
3	1	1	1	1	1	1	1	1	1	1	3

Table 12: A Proportional Transfer with Stickiness

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 0	1	1	1; 2	1	0	2; 4	1	2
1	1	0	1	0	1	1	1	1	4	1	2
2	1	.5	2	.5	.5	1	.5	1	3	2	2
3	1	1	2	1	.5	2	.5	1	2	2	2.5
4	1	1	2	1	1	2	1	1	2	2	3

Table 13: A Small Lump-sum Transfer with Stickiness

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0; 1	1	1	1; 2	1	0	2; 3	1	2
1	1	1	1	1	1	2	1	1	3	1	3
2	1	.5	2	.5	1	1	1	1	3	2	2.5
3	1	1	2	1	.5	2	.5	1	2	2	2.5
4	1	1	2	1	1	2	1	1	2	2	3

Table 14: An Expected Proportional Transfer with Stickiness

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	0	1; 2	0	0	1; 2	0	0	1; 2	1	2
1	1	1	2	1	1	2	1	1	2	1	3
2	1	1	2	1	1	2	1	1	2	2	3

Table 15: Fiscal Policy with a Lag

Period	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1	0	1	1	1	1	0	2	1	2
1	1	0	1; 1.5	0	1	0	1	1	2; 1.5	1	2
2	1	1	1.5	1	0	1	0	1	.5	1	2
3	.5	1	1	1	1	1	1	.5	1	1	2.5
4	1	1	1	1	1	1	1	1	1	1	3

Figure 1: Changes in Aggregate Output when Specializations are Uncorrelated

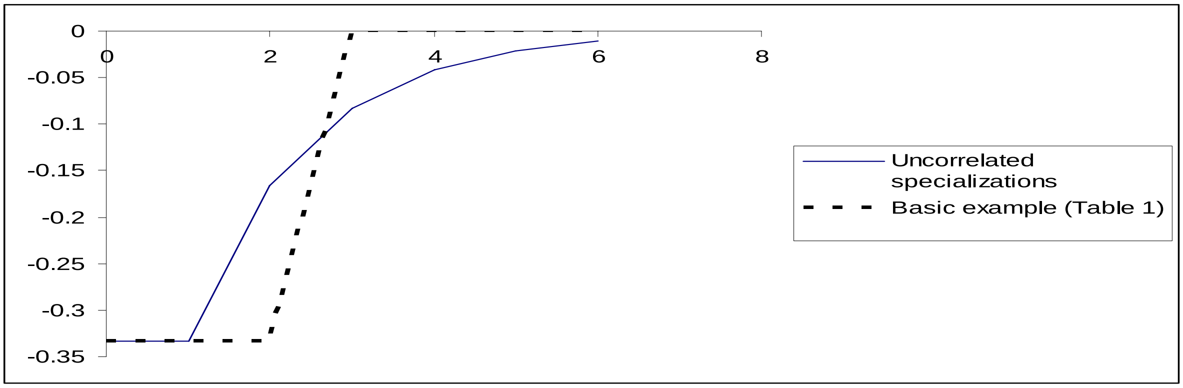


Figure 2: Changes in Aggregate Output when Consuming Two Different Goods

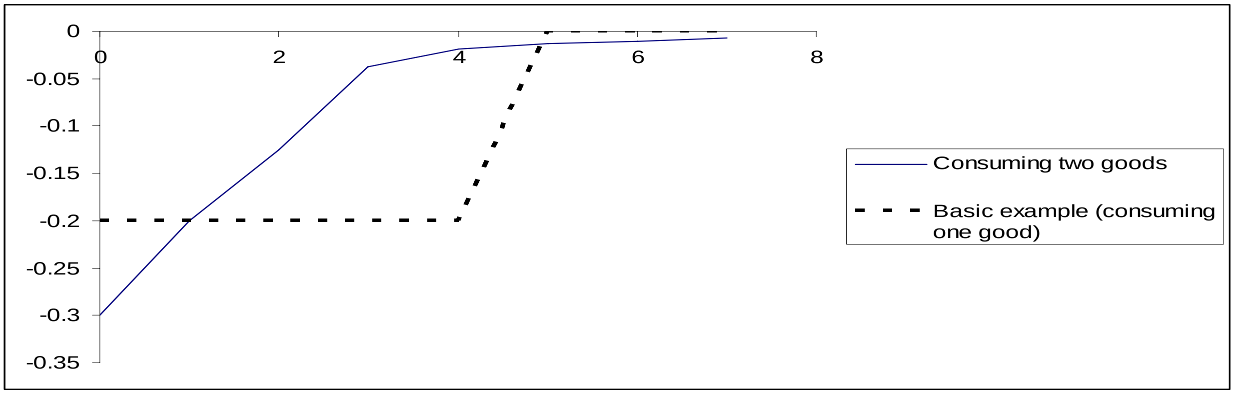
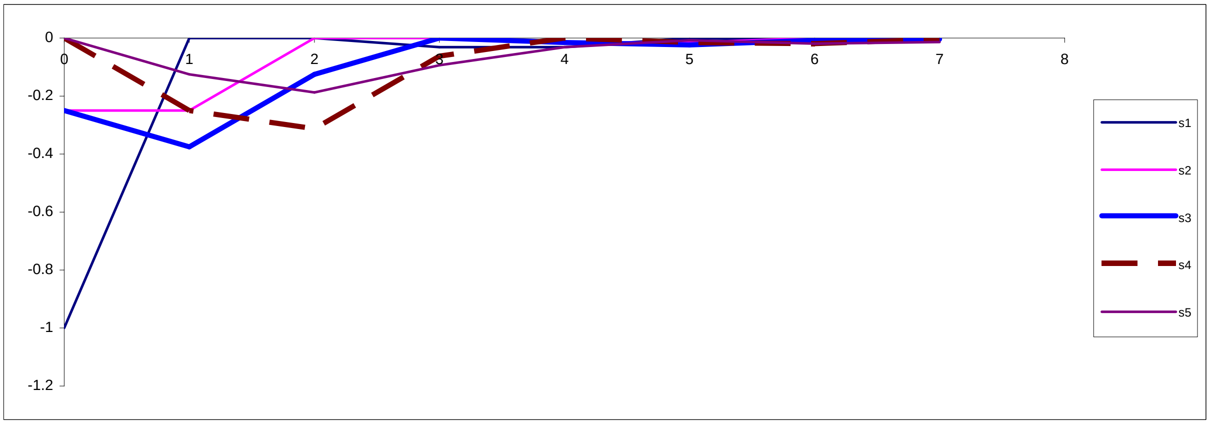


Figure 3: Changes in Sectoral Outputs when Consuming Two Different Goods



Notation: s1 is sales (and production) of good 1.

Appendix

In principle, indivisibility of both money and goods prevents prices from going down in response to the slack demand, and it does not allow buyers to smooth money spending. It is necessary to show that these potential concerns may not matter in practice, and that allowing price changes and smoothing will not eliminate the propagation. Otherwise, one might suspect that these types of exogenous rigidity drive the results. It is convenient to make only goods divisible at first, and then make money divisible too.

A.1. Indivisible Money, Divisible Goods

Assume that goods are perfectly divisible and that the functions $u(q)$ and $c(q)$ have the usual properties as in Trejos and Wright (1995). Proposition 1 still holds iff $\beta u(q) > c(q)$. Now in a symmetric stationary monetary equilibrium $q_s = q_b = q$ maximizes

$$[u(q) + V(1)][-c(q) + V(1)], \tag{A1}$$

where $rV(1) = u(q) - c(q)$. To trace the evolution of allocations during the transition, a numerical example is needed. Let $u(q) = \sqrt{q}$, $c(q) = .49703q$, $i = 1$, $n = 3$, and $r = .002$. Then (A1) is maximized exactly at $q = 1$, as in Table 1. Given the assumed evolution of money holdings, I go back from the steady state which resumes in period 3 to period 0 to calculate output in each match by a recursive computation of the continuation values that appear in the bargaining problem[12]. As Table A1 shows, this exact calculation of prices gives a negligible average gain of .3% in accuracy of the quantities traded for \$1, compared with the indivisible

[12] This procedure, which takes advantage of the return to the steady state in finite time, assures that the equivalence between Nash bargaining and strategic bargaining remains valid. As shown by Coles and Wright (1998), in the general dynamic case Nash bargaining amounts to assuming that agents are myopic.

example (Table 1). The low discount rate makes the upcoming stationary value function much larger than any variation in periodic consumption or production during the transition. Thus, the Nash argument is maximized at almost the exact same level of output.

Table A1: Indivisible Money, Divisible Goods

t	Sector 1			Sector 2			Sector 3			*P*	*Y*
	Sell	Buy	End $	Sell	Buy	End $	Sell	Buy	End $		
-1	1	1	1	1	1	1	1	1	1	1	3
0	**0**	1.004	0	1.004	1.008	1	1.008	0	2	.994	2.012
1	.996	0	1	0	1.012	0	1.012	.996	2	.996	2.008
2	1	1	1	1	0	1	0	1	1	1	2
3	1	1	1	1	1	1	1	1	1	1	3

A.2. Divisible Money and Goods: The Non-Smoothing Equilibrium Exists

To verify that the equilibrium of Table A1 is robust to divisibility of money, it is sufficient to make each money unit divisible into two subunits. It is easy to show as an extension of Proposition 1 that in the steady state in which all trades involve payments of $1, a subunit of money ($.5) is valueless. The divisibility of money enables a type 2 buyer to think of deviating from the strategies of Table A1: It could save $.5 in period 1 in order to use it in period 2. The type 3 seller it meets in period 2 plans to rest that period, reduce money holdings from $2 to $1 by shopping, and resume stationary strategies in period 3. If it agrees to trade with the deviating type 2 buyer in period 2 it will accumulate a spare $.5 right before everyone else is back at the stationary money holdings of $1. But after the return to steady state having a spare $.5 is useless, as mentioned above. So the type 3 seller will not do it.

Given type 3's behavior, type 2 will not deviate. Now suppose that a type 1 buyer wants to smooth consumption by saving $.5 in period 0 in order to use it in period 1. In period 1 it meets a type 2 seller who expects to rest. That seller could now earn $.5 but it will be useless. As just shown, it cannot spend it in period 2, because then type 3 refuses to sell. Therefore, no buyer of either type 1 or 2 can smooth, given that others do not smooth. Therefore, the equilibrium of Table A1 still exists.

A.3. Divisible Money and Goods: A Smoothing Equilibrium does not Exist

A different question is whether there is also an equilibrium in which *everyone* smoothes consumption perfectly, such that the shock does not propagate at all. This requires, first, that nobody ever runs out of money. Second, that prices drop enough to keep the stationary quantities produced even in matches where less than \$1 is paid. Third, that it is incentive compatible for all households. Table A2 shows a plan of money spending in which nobody ever runs out of money and nobody ends up with a useless \$.5 in steady state (note the different column headings).

Table A2: The Evolution of the Money Distribution with Smoothing

Period	Sector 1			Sector 2			Sector 3		
	Earn	Spend	End	Earn	Spend	End	Earn	Spend	End
-1	1	1	1	1	1	1	1	1	1
0	**0**	.5	.5	.5	1	.5	1	0	2
1	1	.5	1	.5	.5	.5	.5	1	1.5
2	1	1	1	1	.5	1	.5	1	1
3	1	1	1	1	1	1	1	1	1

Suppose that households do trade according to this plan. In a period-2 match between a type 2 buyer and a type 3 seller the quantity is determined by $[u(q_2)+V(1)][-c(q_2)+V(1)]$. Comparing to (A1) implies q_2 = 1. Indeed the price falls exactly from 1 to .5 due to the lower nominal spending. Going back in time, it can be verified that indeed the stationary quantity of one unit is traded in all the other matches. The problem is that type 3 does not find it optimal to play along. Given that any quantity of money buys one unit of a good, and given that it expects to earn $.5 in period 1 and $.5 in period 2, it is optimal to rest in period 0. There is no point in accumulating spare money early if just enough money will keep coming in forever (recall the logic of the conjecture in Proposition 2). Therefore, this equilibrium does not exist. Updating this guess of strategies, if type 3 indeed rests in period 0, and recall that type 1 is forced to rest in period 0, then type 2 will also rest. Given that it cannot spend this period, it will otherwise end up accumulating spare money which it will never need. What we have then is a total shutdown of the economy for one period, and an immediate return to steady state in period 1. But this equilibrium is not new: It is just the non-monetary equilibrium discussed in footnote 5.

In conclusion, with divisibility of both goods and money, the business cycle of Table 1 remains intact, and the set of equilibria does not increase.

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