Leverage and Asset Prices: An Experiment.

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February, 2013

Abstract

We test the asset pricing implications of leverage in the laboratory. To this purpose, we develop a model of leverage that is amenable to laboratory implementation and we gather experimental data. Leverage increases asset prices in the laboratory. This increase is significant and quantitatively close to what theory predicts. Moreover, also as theory suggests, leverage allows gains from trade to be realized in the laboratory. In contrast, the prediction that the spread between collateralizable and non-collateralizable assets should increase with the likelihood of bad news is not confirmed by the data.

Keywords: Leverage, Asset Pricing, Experimental Economics.

JEL Codes: A10, C90, G12

The recent financial crisis has highlighted the impact that leverage has on financial system stability. The crisis was preceded by a sharp increase of leverage in the financial system, both at the institution and at the asset level. The crisis poster-children, AIG and Lehman, as well as the systemic banking troubles in the US and Europe illustrate the risks that margin calls pose for the financial system's liquidity

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and solvency. Because of this, recent academic work has focused on the effect of leverage in a financial economy.[1]

An important strand of this literature has studied the asset pricing implications of leverage. Two papers develop a formal theory of asset pricing: Fostel and Geanakoplos (2008) in a general equilibrium model with incomplete markets, and Garleanu and Pedersen (2011) in a CAPM model.[2] These papers show that, in a world where agents are heterogeneous and markets incomplete, using an asset as collateral to borrow money increases its price in equilibrium.

Leverage affects asset prices because when assets can be used as collateral, their prices not only reflect future cash flows, but also their efficiency as liquidity providers. Fostel and Geanakoplos (2008) show that the price of any asset can be decomposed into two parts: its payoff value and its collateral value. The payoff value reflects the asset owner's valuation of the future stream of payments, i.e., it is the value attached to the asset due to its investment role. The collateral value reflects the asset owner's valuation of being able to use the asset as collateral to borrow. The asset collateral role is priced in equilibrium and, as a result, creates deviations from the Law of One Price: two assets with identical payoffs are priced differently if they have different collateral values. An example of such deviations, documented by Garleanu and Pedersen (2011), is the so-called "CDS-basis," which became more severe during the recent crisis.

Economic theory also predicts that leverage allows gains from trade to be realized: when leverage is possible the asset is held by those agents who value it the most. Moreover, as a result of bad news, the spread between assets that can be bought on margin and those that cannot increases in equilibrium. Fostel and Geanakoplos (2008) called this phenomenon "Flight to Collateral:" when the crisis hits, assets that can be used as collateral see their prices drop by less than assets that cannot.

The goal of our paper is to test the asset pricing implications of leverage in a controlled laboratory environment. To the best of our knowledge this is the first paper to do so. To this purpose, we build a model of a financial economy with incomplete

[1] See for instance, Acharya and Viswanathan (2011), Adrian and Shin (2010), Brunnermeier and Pedersen (2009), Fostel and Geanakoplos (2008, 2012a, 2012b), Garleanu and Pedersen (2011), Geanakoplos (2010), Gromb and Vayanos (Forthcoming).

[2] Hindi (1994) studies the pricing implication of leverage in a partial-equilibrium setup with exogenous leverage.

markets and heterogeneous agents that is amenable to experimental implementation. We compare two identical economies that only differ because in one a risky asset can be used as collateral, whereas in the other it cannot. When the asset can be used as collateral, its price is higher.

The laboratory results confirm the theory's main predictions. First, and most importantly, when the asset can be used as collateral, its price increases. This increase is significant and quantitatively very close to what theory predicts. That is, subjects in the laboratory are willing to pay more when the asset can be used as collateral despite the fact that the asset's payoffs in all states of the world are the same. Second, as theory suggests, leverage allows gains from trade to be realized in the laboratory. When leverage is possible, agents who value the asset the most end up holding more of it. Finally, in contrast to the prediction of the theory, Flight to Collateral–an increase in the spread between the yields of securities with different borrowing margins following bad news–does not arise in the laboratory.

Our paper belongs to a large literature in experimental finance, starting from Smith (1962), which tests asset pricing models in a controlled laboratory environment. Our contribution to this literature is to focus on the asset pricing implications of leverage. The paper is also related to Haruvy and Noussair (2006), who study the asset pricing implications of a different feature of investors' budget sets, that is, short sales constraints.

Section 1 develops the theoretical model. Section 2 describes the experiment design and the experimental procedures. Section 3 presents the results. Section 4 concludes.

1 Theory

1.1 The Model

We develop a model of leverage and asset prices that is amenable to laboratory implementation. The model retains the main features of the standards models in the theoretical literature (e.g., Fostel and Geanakoplos, 2008): market incompleteness and agent heterogeneity. As in these earlier models, a spread between collateralizable and non-collateralizable asset prices arises in equilibrium, and there is flight to collateral when bad news is more likely. Our model is novel because it contains three features that make it implementable in the laboratory, and which are not present in the previous theoretical literature: there are only two types (as opposed to a continuum) of agents, agents are risk neutral, and there is no consumption at time zero.

Time and Assets

We consider a two-period economy, with time $t = 0, 1$. At time 1, there are two states of the nature, $s = High$ and $s = Low$, which occur with probability q and $1 - q$. In the economy, there is a continuum of risk-neutral agents, of two different types–which we will characterize later—indexed by $i = B, S$.

There are two assets in the economy, cash and a risky asset Y (from now on "the asset") with payoffs in units of cash. In state *Low*, the risky asset pays D_{Low}, which is the same for all agents' types, whereas in state *High* it pays D^i_{High}, which differs across types. Nevertheless, for each type i, it is always true that $D_{Low} < D^i_{High}$, that is, the payoff in the high state of the world is always higher than the payoff in the low state of the world.

Agents

At $t = 0$, agents of type i have an endowment of m^i units of cash and of a^i units of the asset. Agents' payoff in each state $s = High, Low$ is given by a linear payoff function:

$$u^i_s = w + D^i_s y - \varphi. \tag{1}$$

In equation (1), w denotes final cash holdings, y refers to final asset holdings, $D^i_s y$ represents the asset payoffs in state s, and φ is debt repayment.[3] The expected payoff to agent of type i is given by

$$U^i = q u^i_{High} + (1 - q) u^i_{Low}. \tag{2}$$

As we mention above, in this model, agents are heterogeneous. Following Fostel and Geanakoplos (2008), we consider two types of agents: Buyers and Sellers,[4]

[3] We introduce the debt repayment φ in the payoff function to mimic the way payoffs are explained to the subjects in the laboratory. Once could re-write the model having φ in the budget constraint and only final holdings net of repayment in the payoff function.

[4] In Fostel and Geneakoplos (2008), they are referred to as "Optimists" and "Pessimists."

denoted by $i = B, S$. Each type of agent has unit mass. In order to generate gains from trade, Buyers value the asset more in state High than Sellers do, that is $D^B_{High} > D^S_{High}$.[5] The difference in payoffs may be interpreted as Buyers and Sellers owning different technologies that affect the asset's productivity. What is crucial for our results is to have some sort of heterogeneity. In Fostel and Geanakoplos (2008) heterogeneity is modeled as differences in subjective probabilities over the states of the world. In contrast, here, in order to make the experiment easier to implement, heterogeneity is modeled as differences in the asset payoff in the high state of the world.[6]

The purpose of this paper is to study the asset pricing implications of collateralized borrowing in a laboratory financial market. In order to do so, we study two different economies: first, the No-Leverage economy, from now on the NL-economy, where agents cannot borrow; second, the Leverage economy, from now on the L-economy, where agents are allowed to borrow using the asset as collateral.

The NL-economy

In the NL-economy agents cannot borrow, and therefore $\varphi = 0$. Taking as given the asset price p, agents choose asset holdings y, and final cash holdings w in order to maximize the payoff function (2) subject to their budget constraint:

$$w + py \leq m^i + pa^i. \tag{3}$$

An equilibrium in the NL-economy is given by asset price p, cash holdings w, and asset holdings y such that the asset market clears and that agents maximize their payoff function (2) subject to the budget constraint (3).

The L-economy

In the L-economy agents can borrow from a bank using the asset Y as collateral.[7] Agents cannot borrow unless they post the asset as collateral. We assume that the

[5] This is similar to the way gains from trade arise in the double auction literature, see, e.g., Smith (1962), Plott and Sunder (1982), and subsequent papers.

[6] Our model could be re-written as a model with heterogeneous priors and three states of nature, where the assets pays D_{Low}, D^S_{High}, and D^B_{High}. Buyers would give probability q to the state paying D^B_{High} and 0 to the state paying D^S_{High}, whereas Sellers would do the opposite.

[7] Since we are not modeling the credit market, we assume that the interest rate set by the bank is zero. That is, the amount borrowed at time 0, φ, is also the amount to be repaid at time 1.

maximum amount agents can borrow per unit of the asset is D_{Low}, that is, the asset payoff in the low state. In other words, the minimum downpayment to purchase one unit of the asset is $p - D_{Low}$. This condition guarantees that there can never be default in equilibrium, as the loan equals the asset payoff in state Low. This collateral constraint is sometimes referred to as *Value at Risk* equal to zero ($VaR = 0$) and is widely used in the literature.[8]

Agents take the asset price p as given and choose asset holdings y, cash holdings w, and borrowing φ in order to maximize (2) subject to the collateral constraint (4) and budget constraint (5):

$$\varphi \leq D_{Low} y, \tag{4}$$

$$w + py \leq m^i + pa^i + \varphi. \tag{5}$$

An equilibrium in the L-economy is given by the asset price p, cash holdings w, asset holdings y, and borrowing φ at $t = 0$ such that the asset market clears and that agents maximize their payoff function (2) subject to constraints (4) and (5).

Leverage at the security level is measured by the Loan-to-Value ratio, defined as $LTV = \frac{\varphi}{py}$, which measures how much an agent can borrow using one unit of asset as collateral as a proportion of the asset price. The Loan-to-Value ratio can be interpreted as a measure of how effective the asset is as collateral. In the remainder of the section, we will show that the asset role as collateral has profound asset pricing implications.

1.2 Equilibrium Analysis

Parameter Choice: The Bullish Parameterization

In order to study the asset pricing implication of collateralized borrowing, we calculate the equilibrium in both the L and the NL economy. We solve the model for two sets of parameter values, which we label the *Bullish Parameterization* and the *Bearish Parameterization.* We discuss the Bullish Parameterization first and report the parameter values in Table 1.

[8]See for instance, Acharya and Viswanathan (2011), Adrian and Shin (2010), Brunnermeier and Pedersen (2009), Fostel and Geanakoplos (2008), Garleanu and Pedersen (2011), Gromb and Vayanos (Forthcoming).

Table 1: Parameter Values in the Bullish Parameterization

$Parameters$	D_{Low}	D^B_{High}	D^S_{High}	q	m^B	m^S	a^B	a^S
$Values$	100	750	250	0.6	15,000	0	0	100

Under this parametrization, the asset's payoff in state Low is $D_{Low} = 100$; in state High is $D^B_{High} = 750$ for the Buyers and $D^S_{High} = 250$ for the Sellers. The probability of the state of the world being High is $q = 0.6$. Buyers have initial cash endowments $m^B = 15,000$, whereas Sellers have no cash. In contrast, Sellers have initial asset endowments, $a^S = 100$, whereas Buyers have no asset endowment.[9] Note that since Buyers have all the cash endowment and Sellers have all the asset endowment, Buyers are on the demand side and Sellers on the supply side of the asset market.[10] We refer to this combination of parameters as the *Bullish Parameterization* because the High state is more likely than the Low state. We further discuss our parameter choice in Section 1.3 below.

NL-economy

The equilibrium values are presented in the left two columns of Table 2. The equilibrium asset price is 190.

Table 2: The Equilibrium in the Bullish Parameterization

	NL-economy		L-economy	
Price	190		250	
	Spread: 60			
	Buyers	Sellers	Buyers	Sellers
y	78.95	21.05	100	0
φ	0	0	10,000	0
w	0	15,000	0	25,000
u_U	59,212	20,262	65,000	25,000
u_D	7,895	17,105	0	25,000

[9] The reason why we parameterized the model with large cash and asset endowments is to generate differences in behavior across treatments that can be detectable in the laboratory. For instance, with our parameter values, if subjects had only an endowment of 10 units of the asset and 1,500 of cash, Buyers' equilibrium holdings in the L and NL-economies would be 9 and 10 units respectively. As a result, even a small amount of noise would have masked the effect of leverage in the laboratory.

[10] This simplifies the laboratory implementation considerably and is a standard practice in the literature, see for instance Smith (1962).

Individual decisions are described in the lower part of the table. In equilibrium, the Buyers use all their cash to buy all the assets they can afford; this happens because their expected value of the asset $(0.4(100) + 0.6(750) = 490)$ is higher than the price, and the solution to their optimization problem is a corner solution. As a result, they invest their wealth of $15,000$ in buying 78.95 units at the price of 190, and their final cash holdings are zero.

In contrast, the solution to the Sellers' optimization problem is not a corner solution: at a price of 190 they are indifferent between holding cash and holding the asset, as their expected value $(0.4(100) + 0.6(250))$ equals the price. In equilibrium, they end up with 21.05 units of Y and $15,000$ of cash.[11]

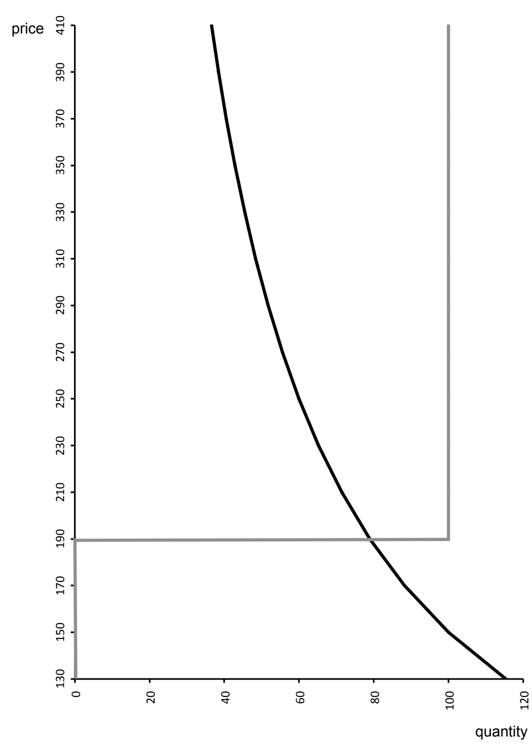

Figure 1: Supply (grey) and Demand (black) in the Bullish NL-economy.

[11]In the experiment, we will assume that the asset is not perfectly divisible, hence we will use as a theoretical benchmark the closest integer approximation.

Figure 1 shows the Sellers' supply and the Buyers' demand. The supply (gray line) is a step function that becomes horizontal at the Sellers' expected value (190). The demand (black line) is a decreasing function of the price, determined by the Buyers' budget constraints.[12] Demand intersects supply in the horizontal segment of the supply schedule. As a result, in equilibrium, Sellers' expected value determines the price, whereas Buyers' budget constraint pins down the quantity traded.

In equilibrium, assets change hands from Sellers (who value the asset less) to Buyers (who value the asset more), thereby realizing gains from trade in the economy. However, due to the Buyers' inability to borrow, gains from trade are not fully exploited. Indeed, in equilibrium, Sellers hold a strictly positive quantity of the asset and share it with Buyers.[13]

Finally, the payoff resulting from the equilibrium allocation are $59,212$ in state High and $7,895$ in state Low for Buyers; $20,262$ in state High and $17,105$ in state Low for Sellers.

L-economy

The equilibrium values are presented in the right two columns of Table 2. The equilibrium asset price is 250. Since Buyers' expected value (490) is greater than the equilibrium price, they buy as many units of the risky asset as they can afford (100 units) on margin. That is, for each unit of the asset that they purchase, they borrow the maximum amount allowed, 100 per unit of the asset, and pay a downpayment of 150 to cover the unit price of 250. Hence, Buyers borrow $10,000$ using the assets as collateral and use their initial wealth to cover the total downpayment, i.e., $100(250-100) = 15,000$. They do not save any of their initial cash endowment and leverage to the maximum extent. As a result, the equilibrium asset loan-to-value is $LTV = \frac{\varphi}{py} = \frac{10{,}000}{250(100)} = 0.4$. By borrowing 100 per asset, Buyers can afford to buy 100 units and, as a result, end up holding all the assets in the economy.

[12] The demand drops to zero when the price reaches the Buyers' expected value (490). In our parametrization, however, this region of the demand curve is irrelevant for the determination of equilibrium price and quantities.

[13] The system of equations solved to find the equilibrium is the following: i) $p = qD^S_{High} + (1-q)D_{Low}$, that is, Sellers are willing to hold the asset; and ii) $py = m^B + pa^B$, that is, Buyers chose zero cash final cash holdings and spend all their endowment on buying the asset. We solve these two equations for p and y. It is easy to see that given the parameters and equilibrium values, this is a genuine equilibrium since the expected return for the Buyers, $\frac{.6(750)+(1-.6)100}{190}$, is greater than 1; that is, Buyers are in a corner solution.

The solution to Sellers' optimization problem is also a corner solution, since their expected value of the asset (190) is now lower than the price. As a result, they sell all their endowment of the risky asset at a price of 250 and receive $100(250) = 25,000$ in cash.

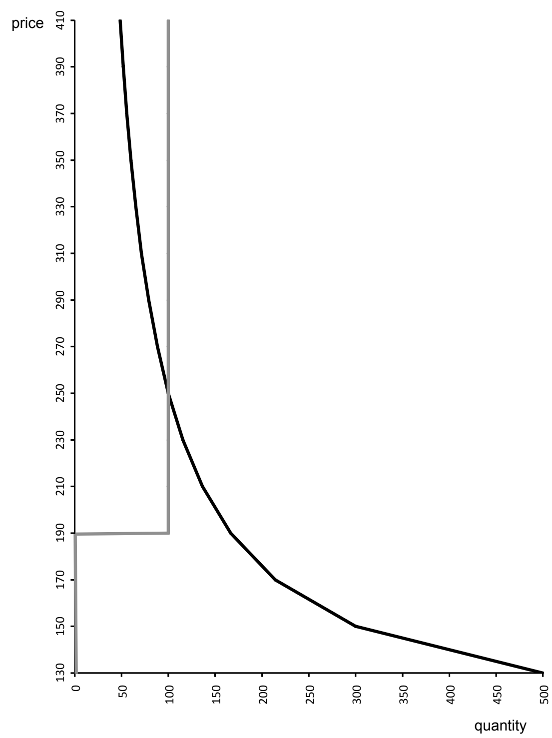

Figure 2: Supply (grey) and Demand (black) in the Bullish L-economy.

In this economy, unlike in the previous one, Buyers determine the equilibrium price through their budget and collateral constraints. This happens because collateralized borrowing reduces the downpayment to be paid at time 0, from p to $p - \varphi$, thereby shifting demand upward with respect the NL-economy. The supply side of the market is not affected by the change in credit conditions since, in this economy, the supply of credit is exogenous and perfectly elastic. As a result, as Figure 2 shows, demand (black line) now intersects supply (gray line) on the vertical segment of the supply curve and, in equilibrium, the price is solely determined by demand.

In contrast to the NL-economy, gains from trade are fully realized in equilibrium: all the assets change hands from the Sellers to the Buyers.[14] The payoffs resulting from the equilibrium allocation are $65,000$ in state High and 0 in state Low for Buyers; $25,000$ in both states for Sellers.

1.3 Leverage and Asset Prices

The Spread in Prices

The main prediction of our model is that the equilibrium price is higher in the L-economy than in the NL-economy. As we saw in Section 1.2, $p_L = 250 > p_{NL} = 190$, and hence the spread in prices is $s = 60$. That is, two assets with identical payoffs (i.e., the risky asset in the L-economy and the risky asset in the NL-economy) have different prices in equilibrium.

The effect of leverage on the equilibrium price can be seen in Figure 3, which combines Figures 1 and 2. The gray line is the supply function which is the same for both economies. The ability to borrow against the asset, however, affects demand: the demand in the L-economy (solid black) is always higher than in the NL-economy (dotted black). This can be seen from equations (3), (4) and (5). In both L and NL economies, Buyers chose zero cash holdings provided that the price is less than 490 (their expected value). From their budget constraint (equation 3), we have that the demand in the NL-economy is given by $p = \frac{m^i}{y}$; whereas from equations (4) and (5) the demand in the L-economy is given by $(p - D_{Low}) = \frac{m^i}{y}$, that is, there is an upward shift in demand. The shift takes place because the downpayment in the L-economy is reduced by the amount borrowed per unit of asset.

Note that the wedge between demands is the only factor generating the spread between prices in the two economies. As a result, demand intersects supply in two different segments of the supply function. In the NL-economy, the intersection occurs where supply is flat, and as a result Buyers and Sellers share the asset, and Sellers' expectation determines its price. In the L-economy, the curves intersect where supply

[14] The equation solved to find the equilibrium is $p100 = m^B + pa^B$. That is, the Buyers chose zero cash final cash holdings and spend all their endowment on buying all the assets in the economy. It is easy to see that given the parameters and equilibrium values, this is a genuine equilibrium since $\frac{.6(250)+(1-.6)100}{250} \leq 1$, that is Pessimists to not wish to hold the asset, and $\frac{.6\times(750-100)}{250-100} \geq 1$, that is, Buyers strictly prefer to hold the asset than cash, so that both agents are in a corner.

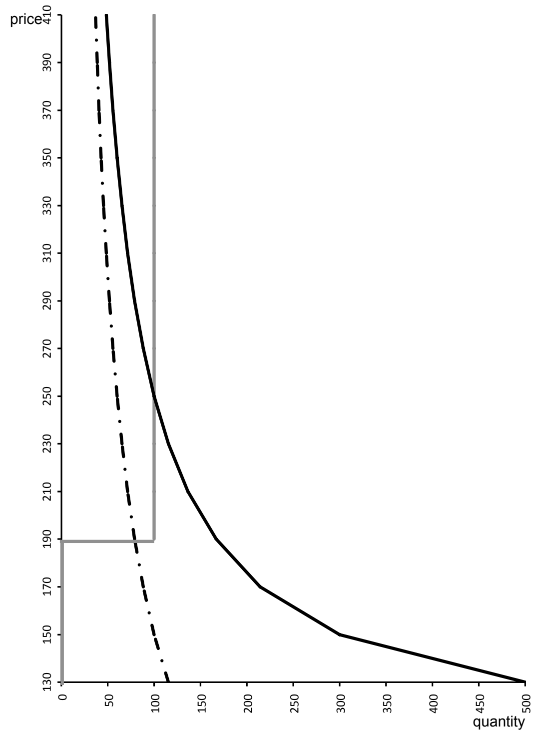

Figure 3: Supply (grey) and Demand (NL-economy: dotted black; L-economy: solid black) in the Bullish Parameterization.

is vertical at 100; as a result, only Buyers hold the assets and their budget and borrowing constraints determine the price.[15]

Notice that the effect of collateralized borrowing is different from the effect of an increase in the cash endowment m^i. The reason is that the loan repayment affects the asset payoffs in the final period. Because of collateralized borrowing in the L economy, the net asset payoff is $D^i_{High} - D_{Low}$ in state High and 0 in state Low. To put it differently, Buyers when buying one unit of asset on margin are effectively buying the Arrow security that pays 1 in state High.

Finally, the equilibrium prices in the NL and in the L-economy are the same if the agents determining the price in the two economies are the same. This can

[15]In the NL-economy, the price needs to be equal to Sellers' expected value for them to be willing to hold (some units of) it; in the L-economy, the price needs to be greater than Sellers' valuation for them to be willing to sell all of it.

happen under two circumstances: i) when Buyers have a large cash endowment m^B so that they can afford to buy all the assets even in the NL-economy, or ii) when the borrowing constraint is very tight (i.e., D_{Low}, the maximum agents can borrow per asset, is small), so that even if the Buyers borrow as much as they can, they are still not able to afford all the assets in the economy. The choice of parameters described in Table 1 ensures that the agents determining the price in the NL and in the L-economy are not the same, so that there is a spread between equilibrium prices.[16]

Collateralized Borrowing: Payoff Value and Collateral Value

Fostel and Geanakoplos (2008) show that in an economy with collateralized borrowing, assets have a dual role: they are not only investment opportunities (i.e., they give a right to a future cash flow), but also allow investors to borrow money (i.e., they provide a technology to transfer wealth across time). That is, their price can be decomposed into two parts: the Payoff Value, which reflects the asset future cash flow, and the Collateral Value, which reflects the premium agents are willing to pay to hold an asset that can be used as a collateral.

Let us first define the Payoff Value. Buyers use all their cash to buy the asset on margin, thereby synthetically creating a new security, the Arrow security that pays 1 in state High. As a result, the payoff of a unit of cash today is given by the payoff of the Arrow security High $(0.6(750 - 100))$ divided by the downpayment $(250 - 100)$. Denote by η_B the payoff to a Buyer of holding one unit of cash at time 0; then, $\eta_B = \frac{0.6(750-100)}{250-100} = 2.6$, which is greater than one. Hence, the appropriate discount factor for the cash flow at time 1 for the Optimist is not 1, but $\frac{1}{\eta_B} = 0.38$. The asset's Payoff Value for a Buyer is therefore given by $PV = \frac{E_B(Y)}{\eta_B} = \frac{490}{2.6} = 188.5$. Another way to interpret the Payoff Value of the asset is as follows: suppose in equilibrium an agent was asked how much he would be willing to pay to buy an extra unit of the same asset without being able to use it as collateral to borrow: the answer would be 188.5.

The second role of the asset is that of a provider of liquidity, which defines the asset's Collateral Value. For each asset, a Buyer can borrow 100 units of cash. As

[16]Note that the set of parameters for which this occurs is an open set with positive measure, that is, small perturbations in the parameter values do not destroy the properties of the equilibria that we describe. For a discussion of the robustness of the pricing effect of leverage, see Fostel and Geanakoplos (2008).

we saw before, Buyers invest cash in the Arrow security High, whose expected return is $(\frac{0.6(750-100)}{(250-100)}-1) = \eta_B - 1 = 1.6$. The resulting expected cash flow from borrowing 100, that is, 100(1.6), is to be discounted as before by $\frac{1}{\eta_B} = 0.38$. Hence, the asset's Collateral Value for a Buyer is given by $CV = \frac{100*(\eta_B-1)}{\eta_B} = \frac{100*1.6}{2.6} = 61.5$.

The price of the asset in the L-economy is given by the sum of the Payoff Value and Collateral Value, that is, $p = PV + CV = 188.5 + 61.5 = 250$, which equals the asset's price in equilibrium (see Table 1). Note that the Payoff Value in the L-economy is lower than that in the NL-economy; In the NL-economy Sellers are not constrained and their marginal payoff of money is one, $\eta_P = 1$. Hence, the Payoff Value coincides with the Sellers' expected value, 190. Nevertheless, because of the presence of the Collateral Value, there is a positive spread between the two economies.

The equilibrium that we describe above is the same as that of an economy where traders simultaneously trade two risky assets, one of which can be used as collateral (whereas the other cannot). As we show in Appendix A, in such an economy, the price of the asset that cannot be used as a collateral is the same as that of the NL-economy, whereas the price of the asset that can be used as collateral is the same as that of the L-economy. This result is a deviation from the Law of One Price, since two assets with the same payoffs in all states of the word have different prices in equilibrium.

1.4 The Bearish Parameterization

In this section, we consider a parametrization identical to the Bullish Parameterization, except that q is lowered to 0.4. We refer to this as the *Bearish Parameterization*, as the probability of state High is now lower than that of state Low. Table 3 shows the equilibrium outcomes when $q = 0.4$ for both the NL and L-economy.

Note that the equilibrium price of the NL-economy drops from 190 in the Bullish Parameterization to 160 in the Bearish one. In contrast, in the L-economy, the equilibrium price remains 250. As a result, the spread between the NL and L-economy increases from 60 in the Bullish Parameterization to 90 in the Bearish one. The increase in spread after bad news is what Fostel and Geanakoplos (2008) interpreted as *Flight to Collateral:* when bad outcomes are more likely, assets that can be used as a collateral become relatively more valuable.

Table 3: The Equilibrium in the Bearish Parameterization

	NL-economy		L-economy	
Price	160		250	
	Spread: 90			
	Buyers	Sellers	Buyers	Sellers
y	93.75	6.25	100	0
φ	0	0	$10,000$	0
w	0	$15,000$	0	$25,000$
u_U	$70,312$	$16,562$	$65,000$	$25,000$
u_D	$9,375$	$15,625$	0	$25,000$

In the Bearish Parameterization, the equilibrium regime is the same as the one described before: that is, in the NL-economy the price is determined by Sellers, whereas in the L-economy it is determined by the Buyers. The supply and demand curves for both the L and NL-economies are shown in Figure 4. In both L and NL-economies, the Buyers' demand function does not shift with respect to the Bullish Parameterization, as Buyers' behavior is determined by their budget and borrowing constraints (which are not affected by the decrease in probability of the high state of the world).[17] In contrast, the Sellers' supply function shifts downward, as their expected value of the asset decreases. Because of this downshift in supply, the price in the NL-economy decreases.

In the L-economy the price is only determined by the Buyers because demand intersects supply in its vertical segment. Since demand does not change as q changes, the price does not change either. Because the decrease in q lowers the price only in the NL-economy, the spread between the L and NL-economies increases when we move from the Bullish to the Bearish Parameterization.

2 The Experiment

2.1 The Experiment Design

The experiment was run at the Interdisciplinary Center for Economic Science, ICES, at George Mason University. We recruited subjects in all disciplines at George Mason

[17]Strictly speaking, this is true only for the region of prices below the Buyers' new expected value (360), which, however, is the relevant region for price determination given the Sellers' supply function.

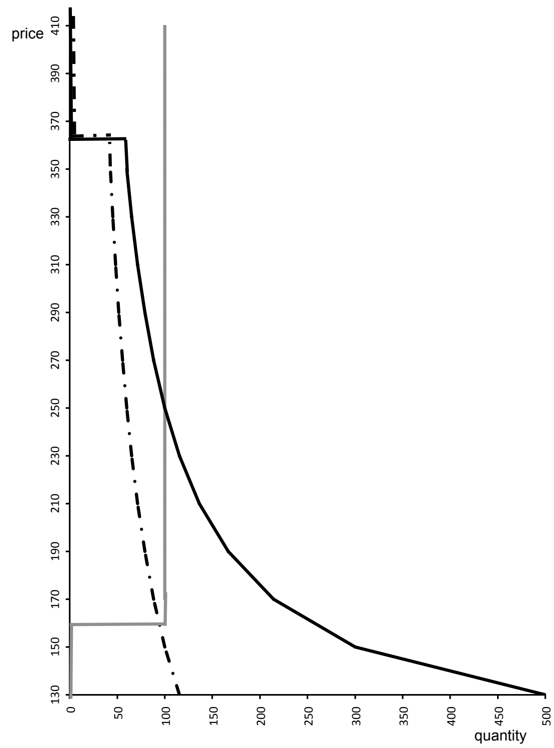

Figure 4: Supply (grey) and Demand (NL: dotted black; L: solid black) in the Bearish Economy.

University using the ICES online recruiting system.[18] Subjects had no previous experience with the experiment. The experiment was programmed and conducted with the software z-Tree[19].

The experiment consisted of five sessions. Twelve students participated in each session for a total of 60 students. Each session consisted of four treatments, corresponding to the four economies described in Section 1:

1. The Bullish Parameterization in the No-Leverage Economy: the *Bull-NL Treatment*.

2. The Bullish Parameterization in the Leverage-Economy: the *Bull-L Treatment*.

[18]When the number of students willing to participate was larger than the number needed, we chose the subjects randomly in order to reduce the chance that the students in the experiment knew each other.

[19]See Fischbacher (2007).

3. The Bearish Parameterization in the No-Leverage Economy: the *Bear-NL Treatment*.

4. The Bearish Parameterization in the Leverage-Economy: the *Bear-L Treatment*.

Note that in each session the same group of students played all four treatments, thus allowing us to study the difference in behavior across treatments with one-sample statistical techniques.

For each of the five sessions, we ran the experiment over two days. In Sessions 1, 2 and 3, we ran *Bull-NL* and *Bear-NL* the first day, and *Bull-L* and *Bear-L* the second day. In Sessions 4 and 5, we ran *Bear-L* and *Bull-L* the first day, and *Bear-NL* and *Bull-NL* the second day. Therefore, in Sessions 4 and 5 we inverted both the sequence of *Bull* vs. *Bear* and of NL vs. L, allowing us to control for order effects in the data.

In each treatment of each session, we ran fifteen rounds of the same economy. The first four rounds of each treatment (both in treatments played on day one and in those played on day two) were used for practice, allowing students to learn, and did not determine students' payments.

2.2 The Procedures

We first describe the procedures for the *Bull-NL* treatment in those sessions (1 to 3) when the NL treatment is played first. Later we will describe the procedures for the other treatments and sessions.

1. At the beginning of the experiment, we gave written instructions to all subjects.[20] We read the instructions aloud in an effort to make the structure of the game common knowledge. Then, we gave the subjects time to ask questions, which were answered in private by the experimenters.

2. All payoffs were denominated in an experimental currency called E\$. The risky asset was referred to as a "widget." In our economy, Buyers hold all the cash (and have to decide how much to buy) and Sellers all the assets (and have to decide how much to sell).

[20] The Instructions and screenshots are presented in Appendix F.

3. At the beginning of the round, each subject was randomly assigned to be either an Buyer or a Seller. In every round, there were six Buyers and six Sellers. Subjects could see their role in the left corner of their computer. Subjects had the same role in any given round of all four treatments they played: that is, if a subject was a Seller in the first round of the *Bull-NL* treatment and a Buyer in the second round, then he was also a Seller in the first round and a Buyer in the second round of the other three treatments. We did so in order to increase the statistical power of our tests (see footnote 27).

4. Next, the demand by Buyers and the supply by Sellers were elicited by presenting them with a list of ten prices and asking them how many units of the asset they wanted to buy (Buyers) or sell (Sellers) at each price. For each of the 10 prices, Buyers were informed of the maximum number of assets that they could afford to buy. The computer mechanically enforced (weakly) upward sloping supply, and downward sloping demand. That is, if an Optimist demanded x^1 at a price p^1, he was only allowed to demand $x^2 \leq x^1$ at a price $p^2 > p^1$.[21]

5. The list of ten prices was taken from a pre-determined matrix and varied from round to round. Note that the matrix was the same (for each round) across sessions and treatments (i.e., we used the same matrix in the same round of each session and each treatment). We let prices vary slightly from round to round in order to avoid habituation.[22]

6. After all the subjects had made their choices, the computer calculated the price at which trading occurred. The price was determined by minimizing the excess supply over the ten prices for which we elicited subjects' choices. Subjects then learned about the price from the computer screen, and the trades were automatically realized. If excess supply was positive (negative) at the equilibrium price, supply (demand) was proportionally reduced for all Buyers (Sellers).

[21]Since the payoff is defined in terms of final cash only, no rational agent would chose an inverted demand or supply function. Moreover, without the above choice restriction in the experiment, mistakes by even a small number of subjects could have created inversions in some segments of aggregate demand or supply. As a result, there could have been multiple prices, far away from each other, for which the distance between aggregate demand and supply is low. Given our price-selection rule, this would have generated large changes in the equilibrium price for small changes in subjects' choices, thus making the equilibrium price less meaningful.

[22]The matrix of prices is shown in Appendix E.

7. After trading occurred, the state of the world was realized. In front of all the subjects, an experimenter extracted a ball from an urn with 6 red balls and 4 green balls. If the ball extracted was red (green), the state of the world was High (Low). The outcome of the extraction was shown to all subjects.

8. After the state of the world was realized, subjects could see in the computer screen their final per-round payoff. In order to avoid zero-payoff, a $E\$10,000$ bonus was paid to each subject at the end of each round in addition to their payoff.

9. After round 1 ended, a new round started. The session continued until all 15 rounds were played. Each round was independent from the previous one: subjects were not allowed to carry over endowments of cash or assets from one round to the next.

After the 15 rounds were played, students were given the instructions for the *Bear-NL* treatment, which was played right after. We followed the same procedure described in points 1 to 9. In the *Bear-NL* treatment, we told subjects that the urn had 4 red balls and 6 green balls (so that the probability of the state High was 40 percent, instead of 60 percent).

The same group of students were gathered the following day to play the two *L*-economy treatments (i.e., the *Bull-L* treatment and the *Bear-L* treatment), following the same procedures outlined in points 1 to 9. In the instructions for the second day, subjects were explained in detail how borrowing worked: the maximum amount of borrowing allowed, its effect on subjects' budget constraint and the impact of loan repayment on their final payoff. During the experiment, the Buyers' screenshots indicated how much they needed to borrow to afford a given number of assets at a given price.[23] Finally, after trading decisions were made, the screenshots indicated how much Buyers had borrowed and had to repay at the trading price determined by the computer.

Buyers were not allowed to borrow and keep a positive cash balance (i.e., if the price was 300, they could borrow only if they wanted to buy more than $15,000/300 =$

[23]For each price, Buyers were told how many assets they could afford if: a) they did not want to borrow, b) if they wanted to borrow the maximum of $E\$100$ per asset, c) if they wanted to borrow only $E\$30$ per asset, and d) if they wanted to borrow only $E\$60$ per asset. In the instructions, Buyers were told that this information was for reference only, and that they were not restricted to borrow the quantities indicated in the screen. Note that the data do not show any discreetness in subjects' borrowing behavior (borrowing exactly 100, 30 or 60 was not very frequent).

50 assets). This allowed us to simplify the choice problem facing the Buyers in that, for each price, they only had to choose the number of assets they wanted to buy. Given the complexity of the experiment, such simplification seemed sensible. Furthermore, not allowing subjects to maintain positive cash balances while borrowing, if anything, reduces the amount borrowed. This works against finding significant differences in the spread between the prices in the L and NL-economies, which is the main result of our paper.

Notice that our procedures were different from that of a standard double auction or of a call auction since we elicited the *whole* demand and supply schedule for each subject and in each round, with a novel methodology reminiscent of the "strategy method."[24] We chose to collect information about the whole demand and supply schedule because, as will be clear in the next section, this is necessary to understand the mechanism generating the price spread between the L and NL-treatments.

After the end of the second treatment of the second day of the experiment, five rounds were extracted out of the last 11 rounds of each treatment (as we mentioned before, the first four rounds were for learning purposes only). Payoffs were summed up and converted into US$ at the rate of $E\$20,000$ per US$.[25] Identical procedures were followed in Sessions 4 and 5, with the exception that the sequence in which the treatments were played was changed.

3 Results

3.1 Prices and Quantities in the NL and L-treatments.

We start by analyzing the equilibrium results, comparing the Leverage and the No-Leverage treatments under both the Bullish and the Bearish parameterizations. Under both parameterizations, the main two predictions of the theory were confirmed

[24]In a strategy method, a subject chooses an action conditional on all possible choices by the other subjects. In the game theory terminology, the subject chooses an action for all the nodes in the game where he may be called upon to act. In contrast, in our method, the subject chooses an action conditional on the market price, which is the result of the choices of all subjects, including himself (the price is in itself an equilibrium outcome and not a node in a game).

[25]Due to a minor programming error in the z-tree code, earnings ("final cash") of Buyers who did not borrow in the L-treatments were under-reported as a proportion of per-round earnings by an average of 0.0013, which corresponds to \$0.002. This minor miscalculation was evidently invisible to subjects, as no subject mentioned this small reduction in experimental earnings.

in the laboratory: leverage increases asset prices and allows traders to fully realize gains from trade.

Tables 4a and 4b show for the Bullish and the Bearish parameterizations, the average equilibrium prices across the five sessions of the experiment and in each session separately.[26]

Table 4a: Average Equilibrium Prices in the Bullish Parameterization

	Average	S1	S2	S3	S4	S5
NL	216	213	210	219	210	228
L	254	241	263	260	241	263
Spread	38	28	54	42	32	35

Table 4b: Average Equilibrium Prices in the Bearish Parameterization

	Average	S1	S2	S3	S4	S5
NL	188	182	187	203	195	175
L	230	228	236	230	230	227
Spread	42	46	49	27	35	52

As theory predicts, the average equilibrium price is higher in the L versus the NL-treatment in each session, with an average spread 40 across sessions. Under both parameterizations, the difference in prices is statistically significant ($p - value = 0.001$),[27] and robust to order effects. Moreover, it is consistent even across rounds of the experiment: for instance, in the Bullish Parameterization, out of 55 rounds (11 for each session), the spread between the L and the NL-treatment is zero in only 14, and is never negative (see Appendix C).

[26] As we mentioned above, subjects were paid only on their earnings in the last 11 rounds. Therefore, in the analysis, we restrict ourselves to the last 11 rounds of data. The results for all 15 rounds are reported in Appendix D, and are in line with those reported here.

[27] We regressed the per-round changes in the equilibrium price between L and NL-economy against a constant (remember that, in each round of the two treatments, the same subjects act as Buyers and Sellers, and face the same price vector). We tested whether the regression constant is significantly different from zero, correcting the standard errors with by-session clustering. Note that we obtain a similar result if we run a non-parametric sign test on per-round price differences (p-value=0.000).

Moreover, as predicted by the theory, as we move from the NL to the L-treatment, the equilibrium level of transactions increases, that is, a larger number of assets is sold by the Sellers to the Buyers. As Tables 5a and 5b indicate, the average quantity traded per subject increases from 56 to 69 assets in the Bullish Parameterization and from 59 to 74 in the Bearish one, a difference that is statistically significant and robust to order effects.[28] Therefore, the relaxation of the collateral constraint between the NL and the L-treatment allows gains from trade to be exploited in the laboratory market to a greater extent: for instance, in the Bullish Parameterization, the sum of Buyers and Sellers payoff increases on average by $(69 - 56)(500)(0.6) = 3,900$.

Table 5a: Per-Subject Average Transactions in the Bullish Parameterization

	Average	S1	S2	S3	S4	S5
NL	56	57	46	63	64	49
L	69	75	59	70	76	66

Table 5b: Per-Subject Average Transactions in the Bearish Parameterization

	Average	S1	S2	S3	S4	S5
NL	59	49	56	62	66	61
L	74	76	61	76	80	74

Importantly, these experimental results are driven by the same forces that drive their theoretical counterparts. In order to understand this, we need to analyze the behavior of the demand and supply for the risky asset.[29] The left panel in Figure 5 shows, for the Bullish Parameterization, the empirical demand and supply in the NL and L treatments. The empirical demand in the L-treatment (dotted black line) *shift rightwards* with respect to that of the NL-treatment (solid black line), as subjects are allowed to leverage. As the theory developed in Section 2 predicts (see Figure 3), this rightward shift in demand generates the spread between the prices in the NL and L-treatments, as well as the increase in the quantities traded. Note also that also in accordance to the theory, the ability to leverage does not have an

[28]The p-value is 0.000.

[29]As we mentioned in Section 2.2, this is why, in the experimental design, we elicited from the subjects the whole demand and supply schedules.

effect on the supply: the empirical supply in the L-treatment overlaps with that in the NL-treatment. Incidentally, this is a good check that subjects understood the experiment since the problem that Sellers face is the same in the two treatments. Similar remarks can be made about the supply and demand behavior in the Bearish Parameterization (see right panel of Figure 5).

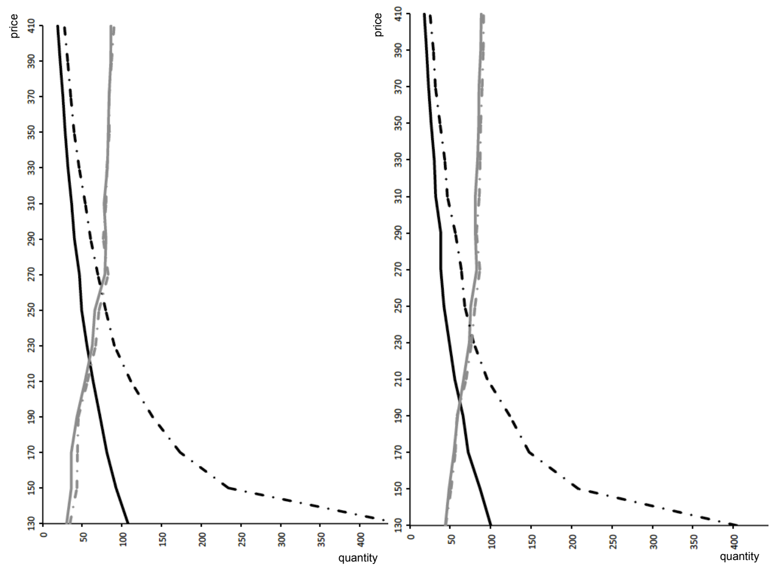

Figure 5: Left Panel: Supply (grey) and Demand (black) in the *Bull-NL* treatment (solid) and in *Bull-L* treatment (dotted). Right Panel: Supply (grey) and Demand (black) in the *Bear-NL* treatment (solid) and in *Bear-L* treatment (dotted).

Note also that subjects' behavior is consistent with collateralized borrowing as opposed to a simple credit line. Figure 6 compares, for the Bullish Parameterization, the empirical demand in the L-treatment (dotted black) with the two different theoretical demand curves.[30] The solid black line is the demand schedule under collateralized borrowing. The grey solid line is the theoretical demand schedule when Buyers are given an uncollateralized credit line; that is, it is the demand in a theoretical model in which agents have access to a credit line from the bank of $E\$10,000$ without the need of posting collateral.[31] By construction, the two theoretical demands intersect at the equilibrium price of 250, since, at this price, the amount

[30]Similar remarks can be made on the behavior of demand under the Bearish Parameterization.
[31]Notice that $E\$10,000$ is the amount agents borrow from the bank in the$L$-equilibrium.

borrowed is $E\$10,000$. As Figure 6 shows, subjects' demand in the laboratory is closer to the collateralized demand than to the credit line demand. In particular, if agents wanted to borrow a fixed amount their demand should be relatively vertical (as the theoretical demand with a credit line is). In contrast, the empirical demand is strongly downward sloping (as it is in the L treatment): as the price goes down subjects demand more not only because they can afford more given the cash they have but also because they can borrow more by using the asset as a collateral. In other words, the behavior of the empirical demand curve shows that in the L-treatment, the asset has a positive collateral value.

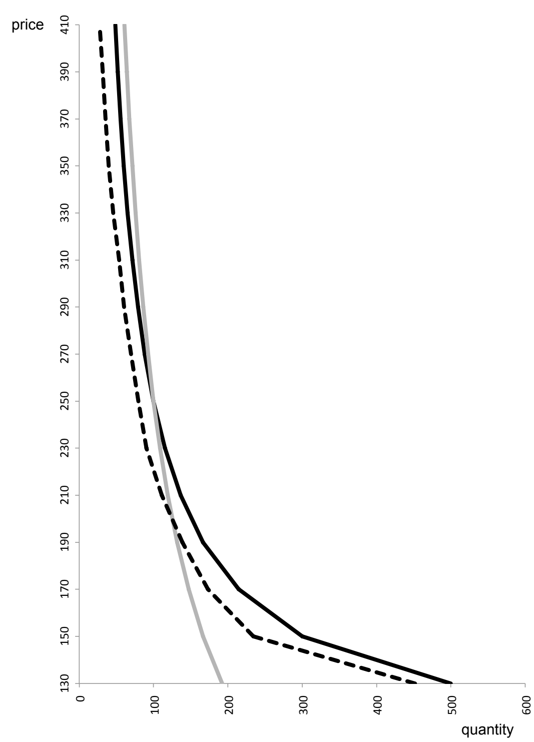

Figure 6: Experimental Demand (dotted black), Theoretical Demand (solid black) and Theoretical Demand with a Credit Line (solid gray) in the *Bull-L* Treatment.

Although the experimental results are in line with the main predictions of the theoretical model and the mechanism that generates them, we find some interesting differences between the behavior predicted by the theory and subjects' behavior in the laboratory.

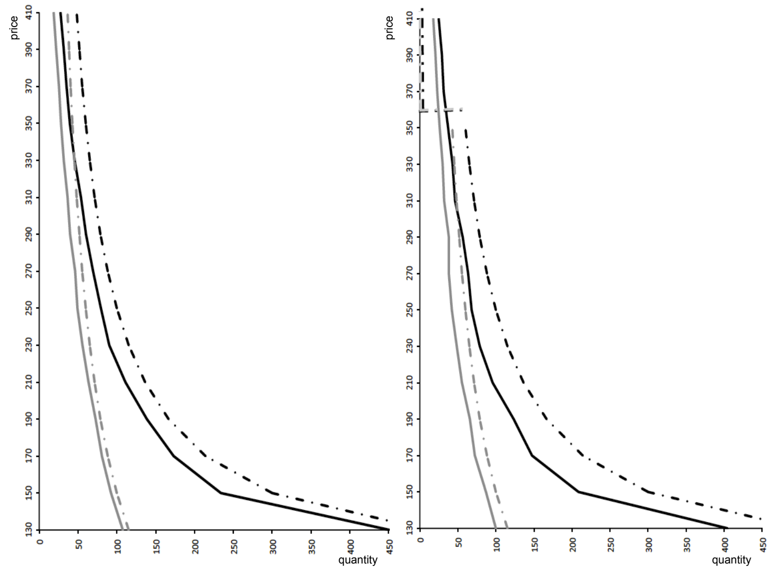

Figure 7: Left Panel: Experimental (solid) and Theoretical Demand (dotted) in the *Bull-NL* treatment (gray) and *Bull-L* treatment (black). Right Panel: Experimental (solid) and Theoretical Demand (dotted) in the *Bear-NL* treatment (gray) and *Bear-L* treatment (black).

The left panel in Figure 7 shows, for the Bullish Parameterization, the experimental demand (solid line) and its theoretical counterparts (dashed lines) in both NL and L economies. In both economies, the empirical demand is to the left of the theoretical one. In particular, in the NL-treatment (gray lines), the Buyers' demand is not determined by the budget constraint as theory predicts. Indeed, as column 1 of Table 6a shows, in the Bullish Parameterization Buyers' average final cash holdings– which theoretically should be zero–are on average around $E\$3,000$ (out of an initial endowment of $E\$15,000$).

Table 6a: Buyers' Final Cash Holdings and Borrowing in the Bullish Parameterization

	Final Cash	Borrowing per Widget	Aggregate Loan to Value Ratio
NL	$3,065$	-	-
L	$1,570$	45	0.23

Table 6b: Buyers' Final Cash Holdings and Borrowing in the Bearish Parameterization

	Final Cash	Borrowing per Widget	Aggregate Loan to Value Ratio
NL	$3,921$	-	-
L	$2,076$	38	0.23

Moreover, as Figure 7 shows, also in the L-treatment the empirical demand is to the left of its theoretical counterpart. That is, subjects do not exhaust all the collateral value of the assets. Indeed, by looking at Table 6a we find that Buyers borrow on average E\$45 per asset, whereas in the theoretical equilibrium they should borrow E\$100.

The deviation in the behavior of aggregate demand in both the L and the NL treatment explains why quantities traded per subject (56 in the NL and 69 in the L Bullish treatment) are lower than what theory predicts (78 and 100 respectively).[32] Similar remarks apply to the Bearish Parameterization (See right panel of Figure *7* and Table *6b*).

The rightward shift in demand that we observe between NL and L-treatment, although in agreement with the theoretical predictions, is somewhat surprising given subjects' behavior in the laboratory. As we mentioned above, in the NL-treatment, the demand curve is not determined by the Buyers' budget constraint, that is, Buyers are not spending all their cash endowment. One would expect that, in such circumstances, allowing subjects to leverage should not affect their behavior; instead, we observe it does. This shift in demand cannot be explained by risk aversion or by

[32]As a result, the increase in the expected payoffs for Sellers and Buyers when leverage is allowed (that is, the realization of gains from trade) is lower than theory predicts.

risk-loving behavior: in Appendix B, we show that, under very general conditions on subjects' payoff functions, if a Buyer chooses not to use all the available cash in the NL-economy, he should chose not to borrow in the L-economy.

Table 7: Buyers' Borrowing Per Widget

Percentage of Subjects	20	25	50	75	95
Borrowing Per Widget Lower than	0.00	4.68	35.71	65.51	97.62

Instead, the aggregate shift in demand is the result of heterogeneity in borrowing choices by subjects. Table 7 shows individual borrowing behavior in the L-treatment. As the table shows, individual behavior is quite heterogeneous. On the one hand, 20 percent of subjects decide not to borrow at all, whereas 25 percent of subjects borrow on average less than $E\$5$. On the other hand, there are subjects who do exploit the collateral capacity of the asset: 50 percent of subjects borrow on average more than 35.71 and 25 percent of subjects borrow on average more than 65.51 per asset.

Heterogeneity can only explain the shift in aggregate demand if the subjects who do borrow are primarily those who are at (or close to) their budget constraints in the NL-treatment. This is indeed what we find in the data. Figure 8 shows, for each subject, the average percentage borrowing per widget in the L-treatment vs. the average final cash holdings in the NL-treatment.[33] There is a clear negative association between the two variables: the closer subjects are to their budget constraint in the NL-treatment, the more they borrow in the L-treatment.

Another interesting deviation from the theory is found in the aggregate supply schedules submitted by subjects, when playing the role of Sellers. According to the model, Sellers should sell 0 assets at a price below their expected value ($E\$190$ in the Bullish Parameterization, and $E\$160$ in the Bearish one), and sell all their holdings, 100, at a price above its expected value. Instead, as the left panel of Figure 10 shows, under both parameterizations, in the experiment Sellers offer positive quantities for prices below their expected value (i.e., the empirical supply is to the right of the theoretical one), and supply less than 100 units for prices above their expected value (i.e., the empirical supply is to the left of the theoretical one). That is, although

[33]The chart is built using data for both parameterizations.

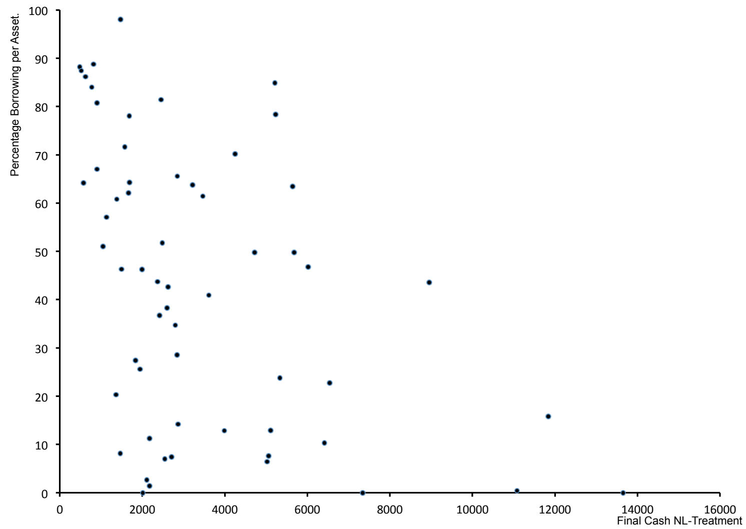

Figure 8: Scatter Plot of the Average Individual Percentage Borrowing Per Asset in the L-treatment over Final Cash Holding in the NL-treatment in both parameterizations.

supply monotonically increases in the price, it is a smoother version of the theoretical one.[34]

The smooth behavior of the empirical supply is a reason why, in the experiment, the price is higher than theory predicts, and the quantity traded is lower. The departure of the empirical supply from the theoretical one has a much stronger effect on the equilibrium price of the NL-treatment than on that of the L-treatment; the reason is that whereas in the L-treatment theoretical demand meets supply where the supply is vertical, in the NL-treatment demand and supply meet in the perfectly elastic section of the theoretical supply curve. As a result, whereas in the L-treatment the average price is very close to its theoretical counterpart (e.g., 254 vs. 250 in the L-Bullish-economy), the equilibrium price in the NL-treatment is much higher than the theoretical one (216 vs. 190 in the $NL-$Bullish treatment).

[34]Note also that for a price higher than 250 (Sellers' value in state High), supply is very close to 100, which reassures us that most of Sellers' decisions reflect a good understanding of the experiment. Incidentally, the small deviations from 100 at a prices above 250 do not represent real arbitrage opportunities for subjects (and may be the result of a small endowment effect), since although we are eliciting the whole supply schedule, trading only occurs at the equilibrium price.

The behavior of the aggregate supply cannot be reconciled with subjects having a uniform attitude toward risk: subjects supply a positive quantity of the asset for a price lower than the asset's expected value (thus suggesting risk aversion), but do not supply all their asset endowments for a price higher than the asset's expected value (thus suggesting a risk-loving behavior).

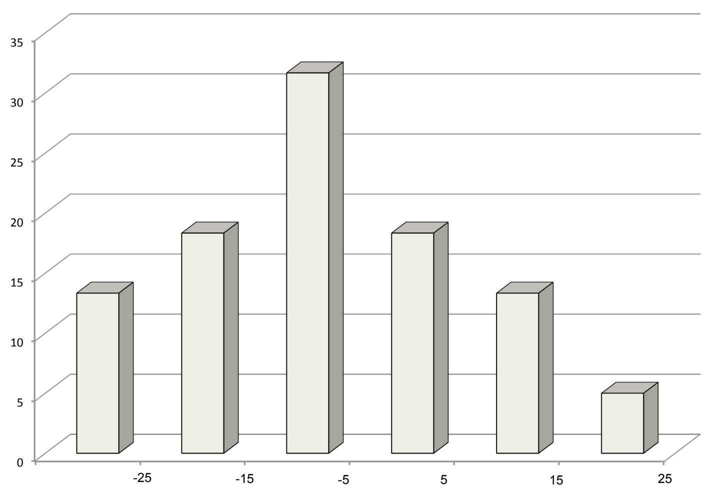

Figure 9: Histogram of Individual Supply Behavior. Horizontal axis: Deviation from Theoretical Supply. Vertical axis: Relative Frequency.

Figure 9 shows the histogram of the Sellers' individual average deviation from the theoretical supply across prices and rounds.[35] As the figure shows, only less than 20 percent of the subjects are supplying more than theory suggests by less than 5 units of the asset. A similar proportion of subjects supply on average five units or more than predicted by theory, with 5 percent supplying an excess of 15 units or more. These subjects exhibit a behavior that is consistent with some form of risk aversion. On the other hand, a full 63 percent of subjects are selling on average at least 5 units less than predicted by the theoretical supply, with 13 percent supplying an excess of 15 units or more.[36] These subjects exhibit a behavior that is consistent

[35]The chart combines data from the Bullish and Bearish parameterizations.

[36]Note that the same subjects, who want to hold more assets than theory predicts, would not be

with risk loving (since they keep a risky asset when they should sell it) or some form of endowment effect. As a result of the heterogeneity of individual behavior by subjects in the laboratory, the empirical aggregate supply function is a smooth version of its theoretical counterpart.

3.2 Comparing the Bullish and the Bearish Parameterizations

In this section, we compare the experimental results across the two parameterizations, the Bullish (where q equals 0.6) and the Bearish (where q equals 0.4).

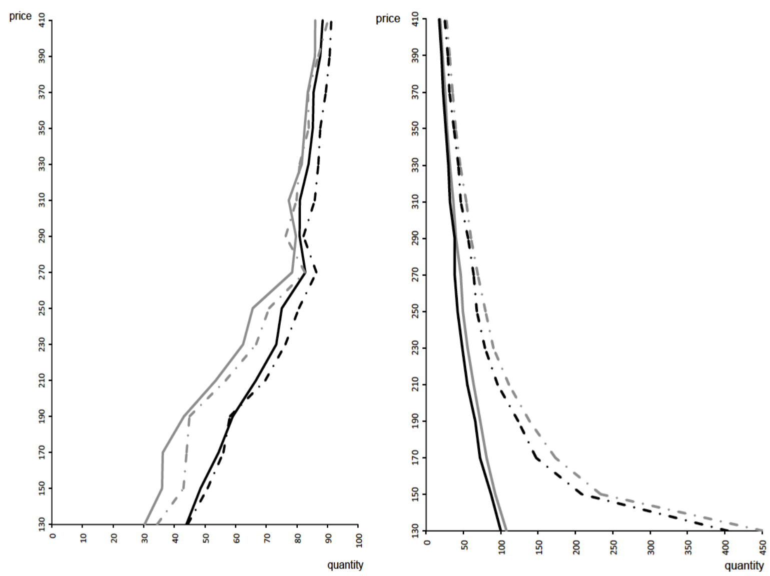

Figure 10: Left Panel: Empirical supply curves in the *Bull* (gray) and *Bear* (black) Parameterization. Right Panel: Empirical demand curves in the *Bull* (gray) and *Bear* (black) Parameterization. Solid lines refer to the NL-treatments; dotted lines to the L-treatments.

The left panel of Figure 10 shows the empirical supply curve (both in L and in NL-treatments) averaged across rounds and across sessions; whereas the right panel

able to do so when acting as a Buyer (because the optimal choice is on the budget and borrowing constraints, in both L and NL-economies). Therefore, these subjects would not generate deviations of the aggregate demand curve with respect to the theoretical one.

shows the empirical demand curve. Two predictions of the theory are confirmed in the laboratory. First, supply shifts rightward as we move from the Bullish to the Bearish Parameterization, reflecting the decrease in the asset's expected value, and therefore, Sellers' willingness to hold it.

Moreover, Buyers' demand does not shift significantly as q changes (i.e., when we move from the Bullish to the Bearish Parameterization): in other words, the movement in demand between L and NL-treatment is unaffected by the parameterization (see the right panel of Figure 10). This is what theory predicts. The reason is that demand is determined by the budget constrain (in NL-treatment), and by Buyers ability to leverage (in the L-treatment), but it is not affected by the asset expected value (i.e., by q).

However, in contrast to what theory predicts, as we go from the Bullish to the Bearish Parameterization, equilibrium prices decrease both in the L and in the NL-treatments. Because of this, the spread generated by collateralized borrowing does not increase with the arrival of bad news (i.e., the decrease in q). Indeed, the spread moves from 38 to 42, a statistically insignificant difference.[37] That is, we do not observe "Flight to Collateral" in the laboratory.

As we mention in the theory section, the spread between the L and NL-economy should increase as we move from the Bullish to the Bearish parametrization because the price in the L-economy does not change with q. This occurs because the theoretical supply function is a step function, which crosses demand in its vertical segment; as the function shifts downward (when q decreases) equilibrium prices and quantitates are unaffected. In the laboratory, however, the empirical aggregate supply curve increases smoothly as the price goes up. As a result, when we move from Bullish to Bearish, the equilibrium price decreases not only in the NL treatment, but also in the L-treatment, with the spread between collateralizable and non-collateralizable assets remaining roughly constant.

In Fostel-Geneakoplos (2008), Flight to Collateral arises under two conditions: i) agents value borrowing, so that demand for the collateralizable asset is higher than that for the uncollateralizable one; ii) the elasticity of demand (supply) around the equilibrium price for the collateralized asset with respect to q is higher (lower)

[37] When regressing the per-round spread on a constant, the p-value is 0.61 (correcting for by-session clustering).

than that of demand (supply) for the uncollateralized asset. The first condition holds in our theoretical model and is confirmed by our experimental results. The second condition holds in our model since the elasticity of demand with respect to q is zero, and that of supply is higher in the NL economy (infinity) than in the L economy (zero). It is not however confirmed by the experimental results: although the empirical demand is inelastic with respect to q, the elasticity of the empirical supply is broadly the same in both treatments, which prevents "Flight to Collateral" from arising. The experimental results suggest that Flight to Collateral is not a robust phenomenon, as it depends on the relative elasticity of the empirical aggregate demand and supply schedules.

4 Conclusion

This is the first paper to study the implication of leverage (collateralized borrowing) on asset prices in a controlled laboratory environment. To this purpose, we develop a model of leverage that is amenable to laboratory implementation, and we gather experimental data. The laboratory experiment allows us to construct two securities with identical payoffs but different borrowing constraints, something which is virtually impossible to find in the field.

We show that, in the laboratory financial market, these two securities have different prices, as theory indeed predicts; in particular, when an asset can be used as a collateral its price is higher. Both the direction and the magnitude of the increase is in line with what theory suggests. The higher price of the collateralized asset stems from a shift in demand, as theory predicts in the presence of collateral value. Moreover, leverage allows gains from trade to be realized in the laboratory; when leverage is possible, agents who value the asset the most end up holding more of it. However, in contrast to the prediction of the theory, Flight to Collateral (that is, an increase during a crisis in the spread between the yields of securities with different borrowing margins) does not arise in the laboratory, due to the different elasticity of the empirical supply with respect to the theoretical one. This calls for further theoretical and experimental research on the behavior of the spread between collateralizable and no collateralizable assets during a crisis.

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