This research brief, based on a paper by Weerachart Kilenthong and Robert M. Townsend, explores an externality and its market based solution in an economy with default and collateral requirement. Using a competitive general equilibrium with directly-collateralized and asset-backed securities, Kilenthong and Townsend analyze the interaction between the endogenous valuation of collateral and corresponding default decisions. This interaction generates a price externality which is evident in the literature.

The key point of this work is to propose a market based solution by creating markets that allow agents to contract on the state contingent price under which they will unwind their contract commitments. These appropriately designed markets in rights to trade deliver the correct prices and an efficient outcome. This work provides an alternative solution to an inefficiency problem in the financial markets, an alternative to a literature which largely focuses on some form of government intervention, e.g., portfolio restrictions, restrictions on savings, interest rate manipulation, fiscal policy, or taxes and subsidies.

BACKGROUND LITERATURE
The presence of a pecuniary externality is quite clear from a growing literature, (e.g., Allen and Gale, 2004; Caballero and Krishnamurthy, 2001, 2004; Farhi et al., 2009; Geanakoplos, 2003; Geanakoplos and Polemarchakis, 1986; Golosov and Tsyvinski, 2007; Greenwald and Stiglitz, 1986; Jacklin, 1987; and Lorenzoni, 2008). Much of this literature is linked to modeling the recent U.S. financial crisis and emphasizes fire sales which result from excess credit that has to be unwound, falls in asset prices, and a further tightening of financial constraints. This relates to the larger financial accelerator literature (e.g., Aghion et al., 1999; Bernanke and Gertler, 1989; Bernanke et al., 1996; Cooley et al., 2004; Kiyotaki and Moore, 1997; Krishnamurthy, 2003; Lamont, 1995; Rampini, 2004; and Ranciere et al., 2008). These papers use endogenous borrowing constraints as amplification mechanisms. Hart and Zingales (2011) emphasize that externalities can result in too much saving, providing a model where the limited ability to borrow against future human capital raises the demand for liquid assets which, in turn, raises the price of goods purchased. The study in focus here is closely related. Indeed, in the class of models used in which collateral is required to back promises, the over-savings phenomenon is a general result.

Kilenthong and Townsend provide a solution to all of these pecuniary externality problems using market-based, segregated exchanges in securities. These internalize the externality by creating otherwise missing markets. The contrast with the literature is evident. This method does not require portfolio restrictions, restrictions on savings, interest rate manipulation, fiscal policy, or taxes and subsidies levied by the government. It does not have to quantify any particular policy
response. Rather, appropriately designed markets in rights to trade will deliver the correct prices and deliver an efficient outcome. Lump sum taxes and subsidies can be used to compensate potential losers from the creation of their new markets and achieve any desired optimal allocation.

CHARACTERISTICS OF CONTRACTS
A contract or security consists of two items: a state-contingent promise, or promise which makes an “if-then” contingency based on uncertain future conditions or events, and the collateral backing that promise. Kilenthong and Townsend take it as given that default is possible or, equivalently, that collateral is required to make borrowers (or issuers of securities) repay their loans.

If borrower chooses to default on a particular loan or state-contingent promise, he would lose the value of collateral backing that particular loan or security. A rational borrower will base his default decision security by security on the value of the collateral backing each liability, compared to the original promise to pay. Of course, the value of the collateral good at the time of repayment decisions – the execution period – and in the market for asset backed securities in the contract period is an equilibrium phenomenon. Yet, this market clearing price of collateral determines whether borrowers default or not and hence the overall amount of debt and saving. In particular, the model employed is a general equilibrium model with endogenously determined collateral and so aggregate collateral – and therefore saving – is a result of the actions in the contracting period of all agents as a group. This implies that the market fundamental, the price in the spot market, the price used to unwind collateral, is endogenously determined by the actions in the contracting period of all agents as a group (aggregate savings).

Contracts that promise to pay and which do not default have to be backed by a sufficient, minimum level of collateral. The amount again depends on the promise and the value of collateral. Likewise, asset-backed securities which are issued as a promise to pay have to be backed in collateral by an equivalent value of asset-backed securities acquired, the promises of others. Further, for every set of securities which actually default and an exchange of collateral takes place, there is another set which would be equivalent, with the same overall payoff and no default. Adding up all such promises, over state-contingent security promises directly backed by collateral and state-contingent securities backed by the promises of others, generates a state-contingent collateral constraint on trades which is in play in the ex-ante contract market.

Contracts which do default naturally also require collateral that is to be handed over when the borrower does not repay. That is, partially collateralized securities are still intimately associated with the exact amount of collateral which serves as backing. But rescaling these latter contracts delivers collateral constraints which are equivalent. Kilenthong and Townsend label such constraints collateral constraints, for brevity. The externality problem is in general a missing-market problem, as Arrow (1969) made clear some time ago. In this study, the markets for contracts over the “market fundamentals”, those aspects of the environment which determine the market-clearing price, the valuation of collateral, are missing.

METHOD
There are several key ingredients in Kilenthong and Townsend’s approach to creating these missing markets. First, they define a new object called a type’s “deviation from the market fundamental”, and in equilibrium, by definition, the sum of individual deviations must be zero. Second, they give this deviation a common price per unit deviation, determined by a market. Third, they allow agents to contract ex-ante on the market fundamental determining the state-contingent spotmarket-clearing price. That is, Kilenthong and Townsend create security exchanges at which the value of collateral used for clearing ex post is pre-determined, for the entire range of values for collateral, including out-of-equilibrium values.

The particular security exchanges which emerge in equilibrium are determined by the forces of demand and supply. In any active exchange the clearing price of collateral, allowing retrade within the exchange, is one that is sustained in equilibrium given the types and numbers of agents attracted to that particular exchange. Kilenthong and Townsend then prove that the competitive equilibria with endogenous collateral constraints in this extended commodity space are equivalent with Pareto optima. These results could be viewed as normative, indicative of the need for a systematic but market-
determined way for traders to unwind commitments. (Actual implementation – and what this might look like – is discussed later in this brief.)

Kilenthong and Townsend internalize the externality by making household types pay or be paid for their influence on the spot market prices determining the value of collateral, when their pre-trade endowment ratio is different from the ratio determining the market fundamental. Household types who have a pre-trade endowment ratio smaller than a particular market fundamental will be entering into a market in which price is low for the good in which they are abundantly endowed and thus must be paid for accepting the restriction to trade on that market (and no other). Those with a larger pre-trade endowment will be entering into a market in which the price is high for the good in which they are abundantly endowed and will pay for demanding rights to trade on that market.

In another interpretation, ex-post spot trades are replaced by ex-ante trade in asset-backed securities. In this interpretation, a household has to pay or be paid for the rights to trade in a particular security exchange ex-ante, but these exchanges still determine the price at which asset backed securities are unwound.

The collateralization structure in this model incorporates both “tranching” and “pyramiding” (see also Geanakoplos, 1997). With “tranching”, a specific piece of collateral can be used to back up several contracts as long as their promises to pay are in different states, i.e., there are no conflicting claims. With “pyramiding”, agents are allowed to use financial assets, the contracts for promises to receive goods of others, as collateral for their own promises.

This structure is different from a contract-specific collateralization structure in which the collateral of a contract cannot be used as collateral for any other contract. On the other hand, Kilenthong and Townsend’s structure is similar to that of Chien and Lustig (2010), where several state-contingent contracts can be backed by the same collateral. However, the main results of the former structure are valid under any contract-specific collateralization structure; that is, the externality exists, and more importantly, Kilenthong and Townsend’s solution to the externality problem still works.

Of course, agents are allowed to retrade in spot markets and that is what delivers the spot-market-clearing prices. This is the easiest interpretation of what is going on in the model. However, with pyramiding, agents are indifferent between ex-ante contracting versus ex-post retrading in spot markets. This is because anything which can be done in the spot market – trading one good for another – can be done in the ex-ante contract market, with promises to receive one good backing promises to surrender the other. Hence agents do not need to retrade in spot markets -- but they may well do so.

MARKET IMPLEMENTATION

Kilenthong and Townsend’s solution to the externality problem is intuitive: create a market that allows agents to contract on the state-contingent price under which they will unwind their contract commitments, over and above contracting on intertemporal or state-contingent security exchanges.

Of course, that unwind price is still endogenous, and the contracted price must equal the market clearing price at which supply equals demand, taking into account exogenous endowments, saving, contract positions and who is in the market. When agents contract on the unwind price at which collateral is valued for clearing, they essentially are counting on having the requisite number and types of traders around to support that contracted price. As is usual in a Walrasian equilibrium, and in rational expectations, this presumption is validated, there is a decentralization, and agents need only pay attention to prices, making their own decision independently. No agent cares specifically about the identity or name of other traders. They do care but only implicitly about the composition of traders in the sense they are counting on a promised fundamental, the contracted price. So the new market mechanism does require knowledge of which side of a market a trader will be on, contingent on the state of the world, and hence what commitments they have made previously, in a certain well-defined sense.

Practically, the markets for the right to trade can be implemented using markets for certificates, each of which specifies the security exchange a trader wants to be in, at a price paid, or is willing to be in, at a price received, and the amount of the deviation
from the fundamental that the trader will be holding. These are like market participation rights with market access fees. For Kilenthong and Townsend, though, rather than a fixed fee independent of volume as in contemporary markets, the volume here is implicit in the pretrade position of the trader and the market fundamental. These markets for rights to trade will be opened in the contracting period, and traders can buy any certificate they want and can afford, or be compensated if this puts them in a disadvantageous position. When there is more than one active exchange for a given state contingent contracted price, then queueing with randomized execution of trade is allowed. That is, traders will buy an actually fair lottery over certificates at the beginning of the contracting period, and a platform/utility exchange will draw the outcome of the lottery and assign the certificate accordingly (to get the fractions of traders right) at the end of the contracting period.

In the execution period, markets are segregated or restricted in the sense that a trader with a certificate can trade in the specified security exchange only so long as its deviation from the fundamental on its certificate is the same as the true one or at least the one agreed to in the contracting period. If a household or trader comes to a wrong security exchange or holds an inconsistent deviation from the fundamental, its right to trade will be forfeited. This mechanism requires a technology that can verify ex-post, in the execution period, a household’s collateral/saving and its endowment profiles. This point is explained in the example which follows.

Contemporary Example of Implementation

In order to visualize more clearly the mechanics of Kilenthong and Townsend’s proposed market structure, they offer this example in a contemporary setting.

Imagine that there are two commodities. One is money (good 1), namely deposits or accounts at the Federal Reserve used to secure payments, as in Fedwire. The second is a treasury obligation (good 2, the collateral good). All promises to pay money in the future – whether a simple loan or a state-contingent promise as in an insurance indemnity – require collateral, or the treasuries. In practice, both treasuries and money can clear and settle obligations ex post, but the rate of exchange between the two uses the same

ex post market price or collateral valuation. Even though money and treasuries cannot be consumed directly, as can the commodities of this model, each participant (financial institutions, e.g., banks, insurance companies, hedge funds) derives an indirect utility from holding them in their portfolio at the end of today, this period, and also from holding them given a certain state of the world tomorrow, next period (due to reasons not modeled here). But the utility is less from treasuries when they are used as collateral backing promises to pay. It is as if they were subtracted from end of period portfolio holdings, that is, not used for consumption starting now. In the initial date these financial players borrow and lend in the securities markets and buy and sell insurance obligations, again with loans and insurance contracts dominated in money. The market fundamental in future spot markets under a given state of the world is determined by the relative ratio of money to treasuries at that date and state, equivalently the interest rate at that time. (Obviously, the example requires a more generous interpretation of the model, which actually ends at the second period.)

Some market participants buy for cash a vector of market exchange certificates, designating the future state contingent spot price of treasuries for each state forward. Other participants are paid to hold each item in a vector of market exchange certificates. There can of course be active trade in the sense that traders can be long or short on treasuries, even conditioned on a given state of the world.

The arrangement envisioned in this example essentially offers a guarantee of the spot price of treasuries which will be used to settle obligations, so they are not subject to market fluctuations beyond the usual state-of-the-world contingencies. But the market in the certificates in effect restricts the set of traders with whom there is unwinding of positions tomorrow in such a way that the contracted, insured price is the market clearing spot price. Broker-dealers will clear all the markets for securities and markets of certificates. Of course, these institutional arrangements will require a registration system, to keep track of which exchange market traders are allowed to use (and the securities which are held). It is important to ensure that agents cannot participate across markets where they do not have the right to buy and sell and unwind trades, to forestall the obvious arbitrage when multiple exchanges emerge in equilibrium.
Registration and exclusivity might seem at first blush to be demanding requirements, but Kilenthong and Townsend argue that these have become standard in the operation of U.S. financial markets. In contemporary financial markets, traders do not take physical possession of securities. The U.S. has moved from a system in which securities and money (checks) were used to complete trades bilaterally, with one or the other being raced around downtown New York in courier black bags via bicycle, subject to a deadline, to a system in which securities are registered and fixed in place and do not physically change hands. A primary institution is the Depository Trust and Clearing Corporation (DTCC). Essentially, all issuance and ownership is now electronic, and older securities are in a vault.

Ownership changes by trading on financial markets. There is a Trade Reporting Facility. One of the most obvious exchanges is New York Stock Exchange. An order to buy comes with the name of the trader, typically an identification number, and desired trades (limit order). Of course much of this information is not revealed to the public, but the exchanges know – and regulators can know in principal – and records are kept. In contrast, over-the-counter trades might seem to be bilateral or among dealers and unobserved, but at least the trade in some derivatives (credit default insurance) is now regulated under Dodd Frank legislation and collateral is recorded in a central clearing party (CCP). Further, the responsibility to finalize trade, to transfer securities and money now lies after Trade-plus-2 days with that CCP utility. Evidently, many new registration and clearing platforms are being created. These private entities are a bit like the intermediaries in Kilenthong and Townsend’s model, i.e., trades are netted and cleared through them. The authors’ more general point is that these kinds of reforms have been implemented and in that sense implementation as suggested here would not seem to require more technology. Exclusivity is also not uncommon. For example, some of the new dark pools do not want to deal with hedge funds or high frequency (computer) traders, so they just prohibit them from entering the platform.

Asset-backed securities are allowed in this implementation example and do not cause a problem, though neither are they essential in that various combinations of securities and markets are equivalent. Asset-backed security trades mimic spot market trade and become an essential part of implementation if and only if spot market exchange is, for some reason, more limited. As a result, all arguments and institution-stated terms of spot markets can be restated using the language of asset-backed securities. In particular, the externality problem can be solved by creating segregated security exchanges where agents can trade ex-ante collateralized and asset-backed securities indexed for clearing at a posted price, that is, by the market fundamental. Methodologically, however, Kilenthong and Townsend do not both allow spot trade ex-post and then restrict spot trade with segregated markets. That is, even without spot markets, there is an externality problem in the valuation of asset-backed securities which are used to underwrite promises, and this requires some kind of market clearing valuation.

Extensions to other Models of Implementation
The methods described here can be extended to other forms of implementation in which spot market exchange is desirable or cannot be limited a priori.

First, the model can be extended to incorporate the contract specific collateralization without pyramid-ing and trancheing as in Geanakoplos (2003), among others. In this case, spot trades will be necessary and cannot be substituted by ex-ante contracting.

Second, this model can also be extended to general preferences and dynamic environments. This extended version will be used to study equilibrium cascades. This is, again, closely related to Geanakoplos (2003).

Third, this model can be used to study retraining or anonymous trading in spot markets in incomplete market settings as in Greenwald and Stiglitz (1986); retrade under moral hazard environments with un-observed actions as in Acemoglu and Simsek (2008) and Kilenthong and Townsend (2011); and retrade in a Diamond and Dybvig (1983) preference shocks bank runs environment as in Jacklin (1987). Kilenthong and Townsend (2014) create the requisite notation and embed all these environments, including the collateral environment of this paper into a common general framework.
FOOTNOTES

1 This study by Kilenthong and Townsend is related to the literature on decentralization with autarky as the penalty for reneging, e.g., Alvarez and Jermann (2000); Kehoe and Levine (1993); Koehlerlakota (1996). Similar to the model employed here, they allow ex-ante complete contracts and focus on the decentralization of constrained optimal allocations. On the other hand, the punishment mechanism is different, as Kilenthong and Townsend defaulting agents will only lose their collateral.

2 This externality problem is multilateral. That is, without further restrictions, every agent will experience, as a common price ratio, the same market fundamental, regardless of the fact that other agents are also experience the same thing. In this sense the externality is a non-depletable externality. Indeed, this might suggest that one way to internalize the externality is with personalized prices, using a Lindahl (1958) equilibrium concept. Yet, to the contrary, Kilenthong and Townsend apply a market-based solution concept with a common price per unit deviation. The connection is that the total paid, or received, does depend on type-specific pretrade endowment ratios and in that sense is personalized.

3 A price island is a language one can use to conceptualize the consistent execution of the contingencies on fundamentals. A price island specifies the spot price, the value of collateral ex post, and the set of agents that end up there through their ex ante purchases or sales have to support that price. This is like a club constraint in other literature, e.g., Prescott and Townsend (2006). See also consumption right in Bisin and Gottardi (2006). Agents can carry in goods or securities in such a way that their pretrade ratio of endowments or portfolio in a spot market deviates from the market fundamental, but the sum of the deviations must, by the definition of consistency, be zero so that the spot price that indexed ex ante contracts is the one which prevails in equilibrium.

4 Note that the need for securities with default in Geanakoplos (2003) is not a result of the contract-specific collateralization structure. As shown in Kilenthong (2011), if all promises are feasible, there will be no need for securities with default even when the collateralization structure is contract-specific. In fact, collateralized securities with default are needed in Geanakoplos (2003) because he rules out state-contingent promises ex ante, i.e., only debt-like collateralized securities are allowed.

5 Of course, the collateral constraints are slightly different under different structures. That difference could lead to different quantitative but not qualitative conclusions and the existence and welfare theorems.

6 This study abstracts away from broker dealers who absorb trades on their own account, to make a market so to speak. They have jumped to the standard Walrasian limit with a large (continuum) number of trades of each type, in which markets clear at an anticipated equilibrium price. However, the broker-dealers in this paper would be the outcome of completion among those trying to set up exchanges and attract customers, as in Townsend (1983).

7 Trades are executed in some dark pool equity markets in this manner, as the range of possible prices is fixed by national level quotes for max and min price and not by market clearing within the equity market itself. Rather through a bid, a buyer can make it more likely his proposed trade will receive priority in the queue when demand side is heavy.
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