Market Liquidity and Its Impacts During Recession

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We developed a method to quantify liquidity in market. We first developed a framework to quantify market mobility following a concept that connects free volume and mobility which is prevalent in studies of glassy physical systems. We analyzed daily trading volume stocks during the United States 2008 recession period. By taking volume stocks and free volume in physical systems equivalently, we found that high market mobility during recession worsened the economy. This implies that market mobility is a quantity that should be controlled and monitored in addition to other standard macro economic indexs such as inflation rate. Our findings suggest that the quantitive easing during recession might worsen the economy when it is not regulated properly.

INTRODUCTION

The most recent US recession, began in 2007 and ended in 2009, caused devastating conditions. Stock market prices, as measured by Dow Jones Industrial Index, fell by 25% from their 2007 October peak in less than a year, shown in Fig. 1. The unemployment rate was doubled to 10% by late 2009 and many other macro economic data showed poor performances during the recession. It has been always a question whether we could have seen and prevented the coming of the 2009 recession. Or more importantly since recession might have been unavoidable, the foremost question was whether we should have done monetary intervention and how should we have done it. In this paper we tried to answer the later question and specifically we tried to understand the market liquidity during recession.

Recession is usually indicated by decline in prices. There is a saying that volume drives the price as price will not change unless trade is taken place [1–3]. Thus, it is natural to associate traded volume stocks with market liquidity. Indeed, there are many definitions of market liquidity but most are qualitative and it is not clear whether they can be useful for monitoring the health of economy.

In this paper, we will start by describing mobility in physical glassy system which has been well studied [4–6]. Specifically, we studied mobility in polymer melt using classical molecular dynamics simulations. Using this framework, we will introduce an index which quantifies mobility in market. We then further define liquidity index which comprises of market mobility and price changes.

DATA AND METHODS

To simulate polymer melt we used equilibrium molecular dynamics (MD) simulations of a common coarse-grained bead spring model. Non-bonded atoms interact with each other via Lennard-Jones (LJ) potential and bonded atoms are connected via a harmonic spring po-
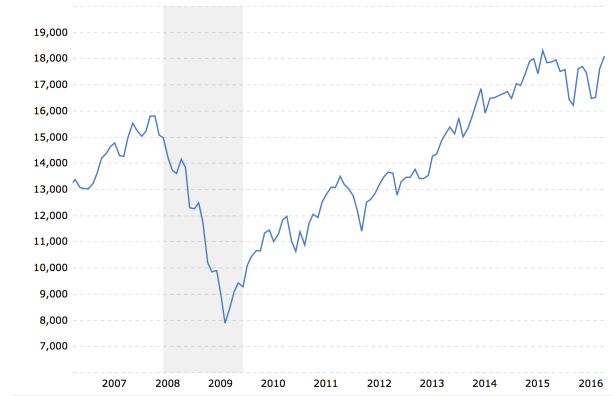

FIG. 1. Dow Jones industrial index. Recession period is indicated by the shaded region. The price dropped by 25% from its 2007 October peak in less than a year. Figure is taken from http://www.macrotrends.net/1319/dow-jones-100-year-historical-chart

tential. The complete details of simulations can be found in Ref. [5].

We analyzed daily trading volume of more than 5000 companies with a total volume of 500 millions (per day) from July 2007 to December 2008. The data are obtained from Bats Global Market stock exchange.

RESULTS

Mobility in Molecular System

Glassy system has been an great interest in scientific community as it has unique properties that are different from standard state of matter such as solid, liquid, and gas. In a simple word, glassy system is a immobile liquid. Structurally a glass is like a liquid: amorphous and lacked long range order. However, dynamically glass is like a solid i.e particles do not move. Many ideas have been proposed to explain this significant slowing mechanism and the most prevalent one is the free-volume idea [4]. The basic idea of free-volume idea is in a dense environment
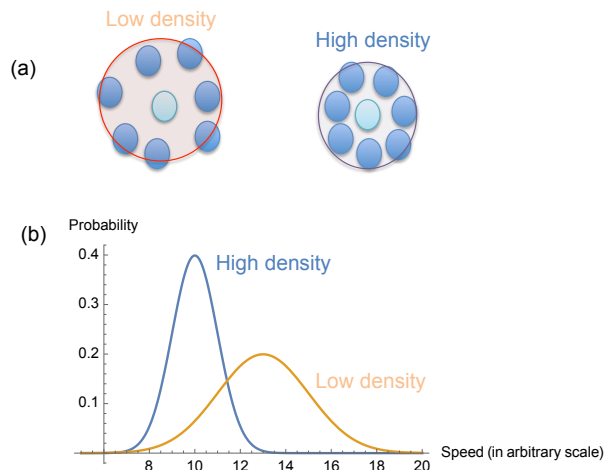
FIG. 2. Illustration of (a) caging effects in molecular system and (b) their speed distributions.
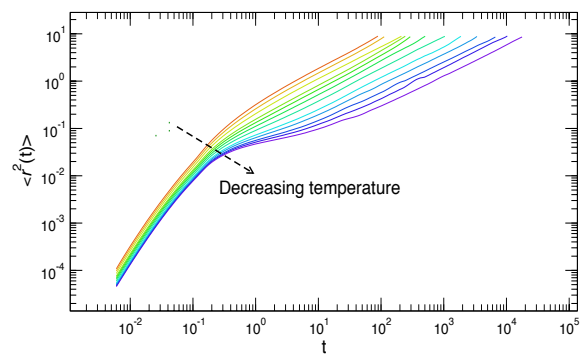

FIG. 3. Mean squared displacement as a function of time for different temperatures. Time unit is in picosecond. It can be seen that the cage size decreases with decreasing temperature.

particles are surrounded by their neighbors and they can only move when their neighbors are moving. This typical slowing down mechanism caused by neighboring is called caging effects [6]. In particular, the particles not only move slower but also need to move cooperatively. So for instance, if the distribution of a dynamical quantity (e.g speed) is gaussian, then in a dense state the gaussian distribution will have smaller a mean and smaller standard deviation (illustrated in Fig. 2.)

Molecular dynamics (MD) simulations have shown great success in explaining dynamics of glassy system such as polymer melt. We performed MD simulations of polymer melt to show the occurrence of caging effects in molecular systems [5]. Specifically, we calculate mean squared displacement of atoms as function of time for various temperature, shown in Fig. 3. The lower temperatures correspond to the less dense states. At short time, atom moves ballistically $|r| \propto |v|t$ until it hits its neighbors. The typical time of this ballistic regime t_{cage} is on the order of picosecond (10^{-12} s). In Fig. 3 we see that at low temperature there is a substantial region where $\langle r^2 \rangle$ does not change for $t > 1$ ps, and so the cage size is normally defined as $u = \sqrt{\langle r^2(t_{\text{cage}}) \rangle}$. Clearly, the cage size decreases with decreasing temperature (increasing in density). Studies of this caging effects in protein systems also show that not only the mean of cage size is decreasing but also the width of distribution [7], qualitatively similar to illustration in Fig. 2. This also suggests an increase in cooperativity in a denser state. With the free-volume idea, we then classify a system is mobile when its free-volume (cage size) is large.

Mobility in Markets

Having established the concepts of mobility in physical system, we now turn to discuss mobility in market. As we have discussed earlier, prices can change only when a transaction is taken place. So it is natural to investigate the dependence of stocks volume on changes in price. In markets, we classify mobile companies as companies having stocks traded frequently in a given day and immobile companies as companies with stocks traded not frequently. This is equivalent to mobile and immobile particles in glassy system.

We create histograms of number traded stocks from July 2007 to December 2008. From Fig. 4, we can see that the two representative data are log-normal distributed, which is given by

$$\mathcal{P}(\ln x; \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{(\ln x - \mu)^2}{2\sigma^2} \right] \qquad (1)$$

where x is number of traded stocks, μ is the mean value of logarithm of x. We found that all data are log-normal distributed. In glassy system, the mean value of cage size and the width of distribution decreases with increasing density [5–7]. Following this approach, we define two mobility indexes. The first one is the mean μ and the second one is ratio between standard deviation of x and the expectation value of x. In mathematic language the second one is called arithmetic coefficient of variation which is given by

$$\gamma = \sqrt{e^{\sigma^2} - 1} \qquad (2)$$

Using these two as defintion for mobility it is clear that in Fig. 4, markets appeared to be more mobile in October 2008. We then did the same analysis for each day from July 2007 to December 2008. The results are shown in Fig. 5.

We can see that, in fact, both μ and γ increase during July 2007 to December 2008 period, but smaller increase
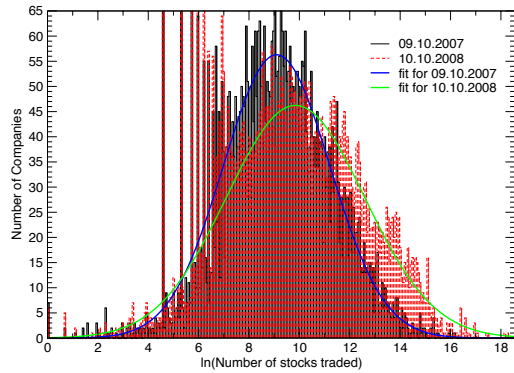
FIG. 4. Histogram of traded stocks volume of September 10 2007 and October 10 2008. The data can be well described by log-normal distribution. The October 2008 distribution has a higher mean and larger standard deviation. Note that we excluded some data near $\ln x \sim 5$ which are large peaks. These peaks appear to be constant (correspond to stocks volume of 200) and can be excluded from analysis without changing the qualitative final results.

in μ. This suggests markets are mobile during recession. The results are consistent with the expectation that a large change in price should be accommodated by large volume since price can only change when volume is not zero. So we now arrive to the most important question: does mobility imply liquidity in markets?

In economic defintion, market is said to be liquid when its assets can be purchased and sold quickly without causing drastic change in price. And so mobility itself is inadequate to quantify liquidity in market. We will introduce a simple model to quantify liquidity based on mobility. First, liquidity is high when transactions are high while changes in price is low. To the most simple estimation, we can write

$$\text{liquidity} \propto \frac{\text{mobility}}{\Delta p}, \qquad (3)$$

where Δp is the change in price. Liquidity is large and postive when Δp is postive and small. A high positive liquidity indicates healthy growing economy while negative liquidity indicates recession. It is well known that keeping inflation rate low is good for the economy. We used inflation rate as a measure of Δp. Note that there is a lag response in inflation rate while stocks price respond to market immediately. Assuming the lag is roughly a year, then we need to use 2008 inflation rate for 2007 mobility and 2009 inflation rate for 2008 mobility. We used year average inflation rate. The year average inflation rates are 3.8% and -0.4% for 2008 and 2009, respectively. We plot liquidity, based on Eq. 3 in Fig. 6. We see that liquidity is low in 2007 and negatively high in 2008 which is
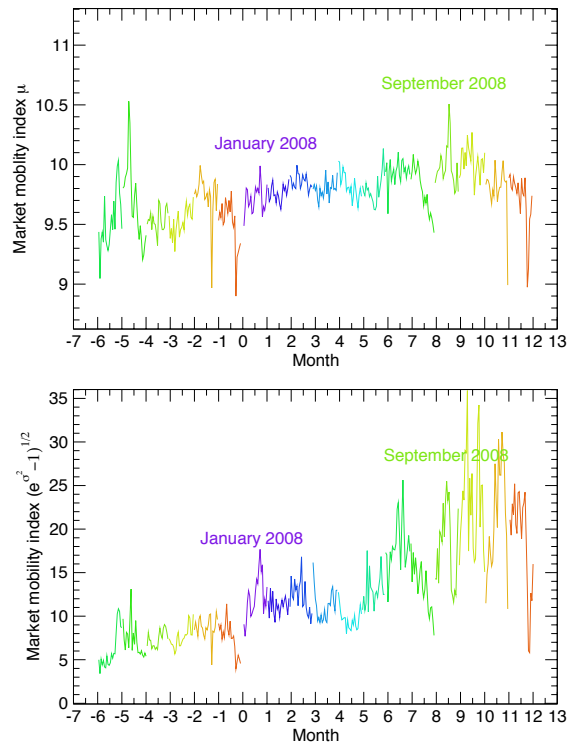

FIG. 5. Time series of market mobility during the 2008 recession. Both indexes increase during recession indicating increase in market mobility.
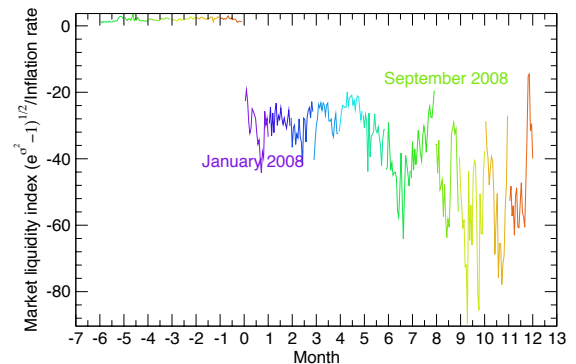

FIG. 6. Time series of market liquidity during the 2008 recession. Liquidity is highly negative in 2008.

consisten with the period of recession. This is an indication that high mobility in markets is not always good for the economy especially during the recession when prices are going down which resulting negative liquidity. Moreover, high market mobility will decrease the price further as volume drives price [1–3].

CONCLUSION

We have developed a framework to quantify market liquidity following concepts of mobility in physical systems. We found that the volume stocks are log-normal distributed and their intrinsic parameters can be used to quantify market mobility. Further we found that markets were mobile during 2008 recession. We then develop liquidity index by taking the ratio between mobility index and inflation rate.

Our results suggest that high mobility is not always good for the economy especially when the price change is negative. During recession, the Fed decided to do quantitative easing (QE). In principle, increasing money supply should increase the price. However, during economic instabilities, prices could drop drastically in a short period of time. And large transactions would worsen the condition as they drive the price down even faster. Clearly that keeping postive low inflation rate might not be enough to keep the economy healthy. We believe that policy makers should start to monitor liquidity index as we have shown that liquidity is related to market mobility which is related to number of stocks being traded. It is possible that controlling market mobility would be an effective way to alleviate recession while controlling inflation rates and adding money supply fail. Policy makers should keep liquidity low below some values similar to keeping infla-tion rates below 2%.

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