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Abhandlungen

Excess Liquidity Creation of Banks and Financial Market Peaks

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Abstract

Mutually reinforcing dynamics between the market liquidity of financial assets and the funding liquidity risks of financial intermediaries were one of the reasons why asset prices declined so significantly with the onset of the financial crisis in 2007. Based on this observation, I show how an excessive rate of funding liquidity risk-taking by financial intermediaries can be used as a timing measure for an upcoming peak of equity market prices in Germany for the time period 1973 to 2010. Funding liquidity risk-taking is thereby defined as the degree of liquidity creation by banks. The working hypothesis is that if banks create liquidity at an excessive rate, then the German equity market will reach a significant peak *at or shortly after* the peak in the liquidity creation activity of the banking system. The proposed early warning indicator predicted all peaks on the equity market in Germany for the time period 1973 to 2010 with an average lead time of 2.9 months. Hence, the rate of liquidity creation seems to provide very useful information about the future state of financial markets. The early warning indicator can be applied in real-time.

Exzessive Liquiditätsschöpfung der Banken und Finanzmarkthöchststände

Zusammenfassung

Sich selbst verstärkende Effekte zwischen der Liquidität auf Finanzmärkten und den Refinanzierungsrisiken von Finanzintermediären waren einer der Gründe warum Wertpapierpreise mit dem Einsetzen der Finanzkrise im Jahr 2007 so

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stark eingebrochen sind. Auf Basis dieser Beobachtung zeigt dieser Beitrag wie ein exzessiver Aufbau von Refinanzierungsrisiken des deutschen Bankensystems als ein Maß für das Timing von signifikanten Höchstständen von Aktienkursen in Deutschland für den Zeitraum 1973 bis 2010 genützt werden kann. Die Refinanzierungsrisiken resultieren dabei aus der Liquiditätsschöpfung des Bankensektors. Die Arbeitshypothese dieses Artikels ist, dass der Zeitpunkt zu dem die Liquiditätsschöpfung des Bankensystems exzessiv wird und einen Höchststand erreicht, sich kurze Zeit *später* ein Höchststand auf dem Aktienmarkt einstellt. Es zeigt sich, dass der in diesem Beitrag entwickelte Frühwarnindikator alle signifikanten Höchststände des DAX 30 für einen Zeitraum von 1973 bis 2010 ca. 2,9 Monate im Voraus identifizieren konnte. Daraus folgt, dass die Rate mit der Banken Liquidität schöpfen, besonders wenn sich diese in einem exzessiven Bereich befindet, nützliche Informationen über zukünftige Finanzmarktentwicklungen liefern kann. Der in diesem Beitrag entwickelte Frühwarnindikator kann in Echtzeit angewendet werden.

Keywords: Early warning indicator for distress on financial markets, Asset prices, Liquidity creation of financial intermediaries, Funding liquidity risks

JEL Classification: G01, G17, E44, E51

I. Introduction

The financial crisis that started in August 2007 showed how the unfolding of funding liquidity risks of financial intermediaries can spill over to asset markets (see *Nyborg/Östberg*, 2014). *Adrian/Shin* (2010) and *Brunnermeier/Pedersen* (2009) argue that one of the mechanisms behind the strong decline of asset prices was a mutually reinforcing liquidity spiral between the market liquidity of financial assets and the funding liquidity of financial intermediaries.[1] However, the empirical literature dealing with financial markets is remarkably muted on the relationship between asset prices on the one hand and the (liquidity) risks of financial intermediaries on the other hand, despite the fact that the aforementioned literature would predict that such a relationship should exist.

One of the few exceptions to this is the empirical work done by *Adrian/Etula/Muir* (2015).[2] They show that when funding conditions deteriorate, financial intermediaries have to decrease their leverage. Using the

[1] Even before the seminal contribution of *Brunnermeier/Pedersen* (2009), the work done by *Gromb/Vayanos* (2002) already showed how a negative shock to the arbitrage capital of market makers can impair market liquidity.

[2] *Adrian/Shin* (2008) were one of the first to point out that contractions and expansions in the size of the balance sheet of banks can be used to predict the risk appetite in financial markets.

leverage of financial intermediaries as a risk factor, the authors then show that a single-factor model accounts for 77 % of the variation in the cross-sectional returns of U.S. stocks and bonds across various asset pricing models for the time period 1968 to 2009. Thus, a simple financial metric from the aggregated balance sheet of financial intermediaries (here: broker-dealers) seems to be an important component of asset returns (see also *Adrian/Mönch/Shin* (2014)). However, both studies rely only on a plain leverage factor and do not explicitly account for the degree of funding liquidity risks taken by financial intermediaries which is actually at the center of the discussion of *Brunnermeier/Pedersen* (2009).

In this paper, I will use the funding liquidity risks of financial intermediaries instead of their leverage ratio and thus explicitly account for a funding liquidity risk dimension in explaining asset prices. The goal of my work is however not to explain returns as done by *Adrian/Etula/Muir* (2015) or *Adrian/Mönch/Shin* (2014) by using an aggregated risk metric from the balance sheet of financial intermediaries. Instead, this article attempts to set up an early warning indicator to predict a short interval for the occurrence of a significant asset market peak by identifying a preceding peak in the liquidity creation rate of the banking system.[3] My paper thereby draws on a theoretical argument put forward by *Allen/Gale* (2000, 2002, 2003). They show that financial (market) fragility can occur at the point in time, when a positive credit expansion is insufficient to facilitate further asset price increases.[4] Based on this argument, section 2 of this paper develops an early warning indicator that triggers a signal for financial market fragility at the point in time when the liquidity risk-taking of banks becomes excessive and thus unsustainable. Once liquidity risk-taking of banks is considered to be in an excessive state, the trigger event for a liquidity spiral in the spirit of *Brunnermeier/Pedersen* (2009) is set and asset prices should form a significant peak.[5] Hence, the key contribution of this paper is to show that the rate

[3] Other studies on early warning indicators for (financial) distress often have a prediction horizon of up to twelve months (see e.g. *Lowe/Borio* (2002)) and often only take a probabilistic perspective. This paper aims at a prediction horizon of around one quarter, meaning that once a distress signal is triggered, it should take around one quarter until asset prices peak.

[4] Although the economic reasoning behind the financial fragility signal is close to the theoretical proposition of *Allen/Gale* (2000, 2002, 2003) with respect to credit growth, the rate of liquidity creation however not only accounts for credit growth but in addition to that also for money growth.

[5] Obviously, there are various other channels that can explain how a reduced rate of liquidity creation may lead to lower asset prices. For example, lower asset

of liquidity risk-taking by banks is a well-suited measure for an early warning indicator in the context of predicting a significant peak of financial markets in Germany.

Funding liquidity risk and liquidity creation of financial intermediaries are thereby treated as one and the same concept and refer to the activity of banks to fund long-term assets such as loans by issuing short-term liabilities such as short-term deposits (see *Diamond/Dybvig* (1983)). For each unit of liquidity that financial intermediaries create, they get exposed to an additional unit of funding liquidity risk. For the remainder of this paper, the term liquidity creation instead of funding liquidity risk-taking will be used. Using the liquidity creation activity of financial intermediaries has two advantages (when compared to other aggregated metrics from the banking sector's balance sheet such as a leverage ratio): First, since Germany has a bank-dominated financial system, the amount and rate at which liquidity is created by the banking system plays an important role for real economic developments. Moreover, as shown by *Fungacova/Turk-Ariss/Weill* (2015), an excessive level of liquidity creation increases the failure probability of banks and hence, a very high rate of liquidity creation should accordingly be reflected in the valuation of financial assets. Second, since the amount of liquidity creation can be interpreted as the exposure of financial intermediaries to funding liquidity risks in the sense of *Brunnermeier/Pedersen* (2009), the degree of liquidity creation should have a direct impact on market liquidity and ultimately, on asset prices.

The only other study that is closely related to my work is *Berger/Bouwman* (2010). They observe that the liquidity creation of U.S. financial intermediaries was significantly above its own trend before the onset of the 2007 financial crisis which hints to the possibility that an excessive rate of liquidity creation may lead to vulnerabilities in the financial system. Despite the finding of *Berger/Bouwman* (2010), liquidity creation has so far not been used in the context for predicting severe distress on financial markets. This is even more surprising, given that *Helbling/Terrones*

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prices may also be driven by expectations of economic agents about lower economic growth (see *Bernanke/Gertler* (1995)). Another channel how asset prices (particularly those of the financial sector) may negatively be impacted is by the failure of some banks that have created an excessive amount of liquidity (see *Fungacova/Turk-Ariss/Weill* (2015)). It is however not the goal of this paper to identify what channel dominates in the transmission of a lower liquidity creation rate but to merely show that a peak in the liquidity creation rate has a very high correlation to – and even precedes – equity market peaks.

(2003), who analyze boom and bust cycles in equity markets can show that historically, credit and money growth are the two key variables which consistently increased before an equity market peak. Since the liquidity creation activity of financial intermediaries can be regarded as a unified measure of money and credit developments, the rate of liquidity creation seems to be a worthwhile measure to investigate when constructing an early warning indicator for distress on financial markets. This paper proxies financial market developments by the key equity market index DAX 30 and draws on the monthly balance sheet data of the German banking system to construct the liquidity creation indicator, following the well-established three-step methodology of *Berger/Bouwman* (2009).[6]

The main finding of this paper is as follows: An early warning indicator with the liquidity creation rate as its key input predicted *all* peaks in the German equity market index over the past 37 years, including the subprime credit crisis of 2007, the New Economy Bubble of 2000, and the 1987 stock market crash. A peak is thereby defined as a minimum decline of 15 % for the equity market index DAX 30. The average lead time of the indicator is 2.9 months, implying that once the indicator triggered the signal for the first time, it takes less than one quarter until the equity market formes a peak. Moreover, nearly all predicted peaks in the equity market were – on average about 7 months later – associated with significant declines in industrial production. Thus, a peak of the rate of liquidity creation has not only a – quite immediate – impact on asset prices as predicted by *Brunnermeier/Pedersen* (2009) but it has also near-term effects for the real economy as for example predicted by *Adrian/Estrella/Shin* (2010).

II. The Signal for an Upcoming Equity Market Peak

In order to set up a real-time early warning indicator, it is not sufficient to just consider the rate of the liquidity creation activity of financial intermediaries. In fact, the marginal profitability of liquidity creation at a given point in time needs to be considered too. Banks that create liquidity benefit from the difference between the interest rates on long-term assets and short-term liabilities which is the term spread. Earning this net interest margin is however not riskless for banks: for each unit of created liquidity, the bank incurs one unit of funding liquidity risk. As long as the term spread is rising, banks should be willing to

[6] Note that *Deep/Schaefer* (2004) were the first to introduce an empirical indicator to measure the liquidity creation of financial institutions.

sustain or increase their funding liquidity risk, even if they already create an above-average rate of liquidity for the financial system and the real economy.

A signal for upcoming distress on the financial market is therefore given by the joint consideration of liquidity creation and the marginal profitability of it: The first condition for a distress signal is that financial intermediaries create an excessive – that is an above-average – rate of liquidity. This argument goes back to the empirical observation made by *Berger/Bouwman* (2010) who show that the liquidity creation of financial intermediaries was significantly above its trend before the onset of the 2007 financial crisis. However, there is also a theoretical argument for this: *Allen/Gale* (2000, 2002, 2003) show in a theoretical setting how financial fragility can occur at the point in time, when a positive credit expansion is insufficient to facilitate further asset price increases. In this paper, the point in time when financial fragility occurs is given when the rate of liquidity creation of financial intermediaries is above its own long-term trend and can thus be considered as excessive which is unlikely to be sustainable. This is, however, not a sufficient condition. As *Allen/Gale* (2002) point out, the uncertainty (and therefore the expectations) of economic agents about the future path of credit expansion is important for whether asset prices will deteriorate significantly. In this paper, the expectation about the future path of liquidity creation is given by the recent development of the term spread which is the second condition for an upcoming distress signal: If the term spread tightened in the recent past, the incentive for financial intermediaries to create liquidity for the financial and economic system is successively reduced since it becomes less profitable for banks to engage in liquidity creation. Thus, banks decrease their funding liquidity risk-taking due to the reduced net interest margin (see *Adrian/Estrella/Shin* (2010) and *Borio/Zhu* (2008)).

Ultimately, a financial fragility signal occurs at the point in time when the liquidity creation rate of banks is significantly above its long-term trend and when the term spread has already tightened which signals that a further increase of the liquidity creation rate is unlikely. When the momentum of liquidity creation starts to decrease and ultimately peaks, the demand for risky assets will start to fall. Hence, the peak phase of asset prices should coincide with the peak phase of liquidity creation, given that the term spread has already tightened. The proposed early warning indicator is constructed in such a way that the peak in the liquidity creation rate of banks triggers an immediate signal for an asset market peak. It is important to note that it is not the contraction of term spread that triggers the distress signal but it is mainly the peak phase of the liquidity creation indicator. Indeed, the average duration of a distress signal is only 3.2 months and is nearly entirely driven by the behavior of the liquidity creation indicator.

III. Calculation of the Liquidity Creation Indicator (LCI)

The key variable of interest in this paper is the liquidity creation measure. To calculate it, the aggregated monthly balance sheet data for the entire German banking system is used. Since Germany has a bank dominated financial system, a liquidity creation indicator based on the aggregated bank balance sheet should give a good gauge on the general liquidity conditions in the German economic and financial system.

The bank balance sheet data is obtained from the Deutsche Bundesbank and is the only source for constructing the liquidity creation indicator. The data set not only accounts for banks headquartered in Germany but also for foreign banks that are registered in Germany. In total, there are 447 monthly observations for the time period from January 1973 to January 2010. To construct the liquidity creation indicator (LCI), the three step methodology proposed by *Berger/Bouwman* (2009) is applied as outlined below.

First, all assets and liabilities of the bank balance sheet are classified as liquid, semi-liquid, and illiquid. Liquid assets are those that provide economic agents with immediate and long-term liquidity (e.g. longer-term loans), whereas liquid liabilities are those that provide economic agents liquidity with immediacy (e.g. overnight deposits). Illiquid assets or liabilities are those positions on the balance sheet of banks that provide no liquidity to the economic or financial system (e.g. reserves held by banks on the asset side or equity issued by banks on the liability side).

In the second step, weights (here given by γ, see Table 1) are attached to each of these three classes, where positive (negative) weights are given to those asset or liability positions that provide (destroy) liquidity for economic agents. Note that some balance sheet positions neither create nor destroy liquidity for the economic and financial system and drop out of the calculation for the liquidity creation measure (thus, receiving a weight of zero). Hence, a weight of *0.5*, *0*, and *–0.5* is given to illiquid, semi-liquid, and liquid assets on the bank balance sheet and a weight of *0.5*, *0*, and *–0.5* is given to liquid, semi-liquid, and illiquid liabilities. The results of the weighting procedure for all assets and liabilities are depicted in Table 1. As it can be seen, long-term loans on the asset side of the balance sheet (loans longer than 5 years) do create liquidity when they are issued to economic agents (and are thus illiquid from the perspective of the bank) and hence receive a weight of *0.5*. Short-term deposits on the liability side also preserve liquidity to economic agents and thus also receive a weight of *0.5*.

In the final step, all asset and liability positions of the bank balance sheet are summed up, where double counting is prevented by attaching weights of one-half to each balance sheet position. Hence, if a bank uses one Euro of short-term deposits (providing liquidity to the economic agents holding those deposits) to finance one Euro of long-term loans (providing liquidity to the holder of those loans), then the banking sector has created one Euro of liquidity (0.5 × 1 Euro-Deposit + 0.5 × 1 Euro-Loan = 1 Euro-Liquidity). The liquidity creation indicator (LCI) is given by summing over all asset and liability positions of the bank balance sheet

$$LCI = \sum^{i} \gamma_i * \text{Asset}_i + \sum^{j} \gamma_j * \text{Liability}_j, \tag{1}$$

where i and j refer to the ith and jth asset and liability position on the banking sector's balance sheet respectively (as depicted in Table 1).

IV. Defining and Extracting Financial Market Peaks

As mentioned in the introduction, financial market developments are proxied by developments of the equity market. The key equity market index for Germany is the DAX 30 which consists of the thirty largest German companies according to the market capitalization and revenues. This index is used to define financial market distress cases. The data has been obtained from Datastream and lists the end-of-month closing prices for the DAX 30 from January 1973 to January 2010.

A decline in the DAX 30 of at least 15 % from its peak-to-trough is defined as a financial market distress case.[7] Technically, peaks are identified endogenously using a minimum reversal percentage of 15 %: To iden-

[7] Defining 10 % as the threshold value would lead to a huge number of distress cases which are unlikely to be all real financial distress cases, whereas a threshold value of 20 % would miss out on some important macroeconomic events. Hence,

Table 1

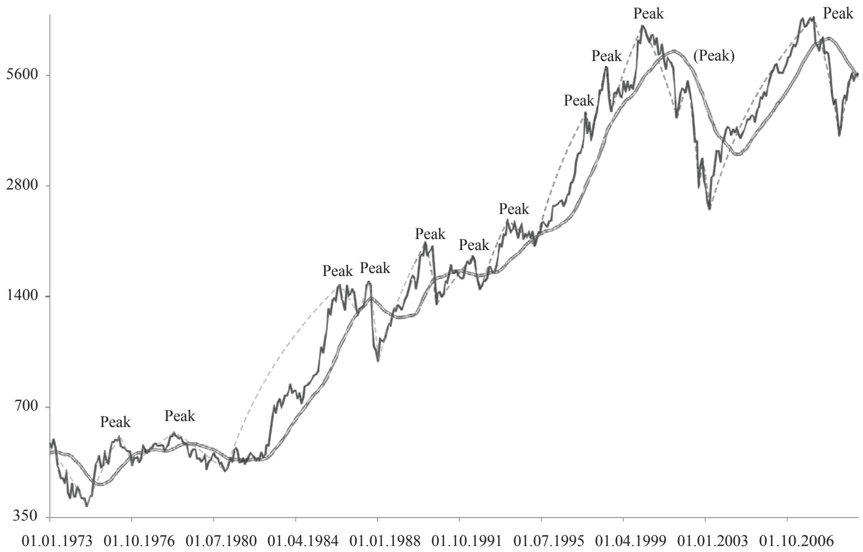
Weights for the Liquidity Creation Indicator (LCI)
(Based on the Aggregated Balance Sheet Positions
of the German Banking System)

Assets$_i$		**Liability$_j$**	
Name	*Weight* (γ)	*Name*	*Weight* (γ)
Cash and reserves	–0.5	Short-term deposits	0.5
Loans up to 1 year	–0.5	Deposits up to 1 year	0.5
Loans 1 to 5 years	0	Deposits 1 to 5 years	0
Loans longer than 5 years	0.5	Deposits longer than 5 years	–0.5
Local Bill of Exchange (BoE)	–0.5	Thrift deposits (non-banks)	
BoE and money market papers	–0.5	TD up to 3 months	0.5
Securities (non-banks)		TD longer 3 months	–0.5
Securities (private sector)	0.5	Savings certificates	0
Securities (public sector)	–0.5	Bonds (issued), banks only	0.5
Equalization claim	0.5	Loans from trustee business	–0.5
Investments	0.5	Equity	–0.5
Other assets	0.5	Other liabilities	–0.5
Interbank loans	0	Interbank deposits	0

tify a peak, the DAX 30 has to decline by at least 15 % from its peak, without closing above the price of the peak date during the decline phase. The period from the highest closing price level since the beginning of the decline until the lowest closing price level is then identified as a declining period if the decline percentage of at least 15 % is reached. Subsequently, the date at which the high price was identified is defined as the peak date. The goal of the early warning indicator is to predict these peaks in advance.

The market is defined to be in the declining state as long as it does not rise by at least 15 % from the lowest closing price and if it is below its long-term average which is defined as the two-year moving average of the variable. This methodology will ensure that peaks and troughs alternate and that only peaks after a significant upward movement of the DAX 30 are identified. Although this is a backward looking algorithm, for the purpose of dating peaks, it is deemed sufficient. The results of the dating procedure are graphically depicted in Figure 1.

15 % seems to be a good proxy for financial market distress (see Figure 1 for the extraction result).



The peak identification is based on a 15 % reversal percentage (log-scale; monthly frequency from January 1973 to January 2010). The dotted line is the resulting time-series of the peak-to-trough algorithm. The double-line is the 24 months moving average of the DAX. The goal of the proposed early warning indicator is to predict each DAX peak labeled "Peak".

Figure 1: Peaks of the German Equity Market Index DAX 30

V. Construction of the Early Warning Indicator

To operationalize the early warning indicator, the well-established approach of *Kaminsky/Reinhart* (1999) is used, where each explanatory variable is transformed into a binary indicator. Thereby, a threshold value is attached to each predictor variable: As long as the value of a variable remains below its threshold value, the binary indicator takes the value of zero. Once the threshold is breached, the binary indicator takes the value of one until the time at which the value of the variable moves again below its threshold value.

In this paper, three binary indicator variables are created and subsequently combined multiplicatively into a binary early warning indicator. The threshold value is determined in the same way for all variables: It is simply given by the *two year moving average* of the variable itself. Hence, this paper refrains from using the Hodrick-Prescott filter procedure to detrend the explanatory variables. The approach of defining the threshold value with a moving average is also preferred to specifying fixed values or conducting a grid-search for the "optimal" in-sample threshold value since the liquidity creation rate time series went through multiple regimes with local heights and lows. Therefore, a dynamic (and adaptive) procedure for the threshold values seems to be the most appropriate approach.

1. Construction of the Binary Liquidity Creation Indicator (LCI)

The liquidity creation time series is used as the main trigger variable for financial distress. Since the liquidity creation indicator based on equation 1 is a non-stationary time series and since the interest is on the *rate of liquidity creation* – as empirically suggested by *Helbling/Terrones* (2003) and argued by *Allen/Gale* (2002) – the first differences have to be taken. In order to extract the peaks of a differenced time series, the cycle has to be extracted. To do this on a real-time basis, the three-month first difference is taken and then smoothed by a six months moving average. Using the three months difference is necessary to account for the fact that an excessive rate builds up over a couple of months.[8] I tried various other lags for the difference and found that three months is the minimum lag, although longer lag values – if they remain below 9 months – also work well. The resulting time series is the cyclical liquidity creation rate indicator, $\left(LCI_t^{cycle}\right)$,

$$(2) \qquad LCI_t^{cycle} = \frac{\sum_{t-6}^{t}\left(\frac{LIQ_t}{LIQ_{t-3}} - 1\right)}{6}$$

A signal for distress is triggered if LCI_t^{cycle} moves above its threshold value (in this paper its 24 months moving average). The binary liquidity creation indicator, $D(LCI_t^{cycle})$, is therefore given by

$$(3) \qquad D(LCI_t^{cycle}) = \begin{cases} 1 \text{ if } LCI_t^{cycle} > MA_{24}\left(LCI_t^{cycle}\right) \\ 0 \text{ if } LCI_t^{cycle} < MA_{24}\left(LCI_t^{cycle}\right) \end{cases},$$

[8] *Lowe/Borio* (2002), applying the methodology as *Kaminsky/Reinhard* (1999), use a cumulative process for the growth rates instead of simple growth rates for the variables which ought to explain financial distress. They were one of the first to recognize that vulnerabilities usually do not emerge suddenly but build up over an extended period of time.

where *D(·)* is the binary indicator taking the value 1 and 0. Therefore, the liquidity creation rate is considered to be in an excessive state at time t if $D(LCI_t^{cycle}) = 1$. The signal is valid (i.e. the binary indicator remains 1) until LCI_t^{cycle} falls below its threshold value.

2. *Construction of the Binary Term Spread Indicator (TS)*

As mentioned in section 2, if the banking system creates liquidity at an excessive rate, this must not necessarily mean that the financial market will suffer distress. In fact, if the term spread – the measure of the marginal profitability of liquidity creation – is positive and rising, banks should still have the incentive to create liquidity. However, if the term spread tightens – which reduces the marginal profitability of liquidity creation – and the liquidity creation rate is in an excessive state, financial intermediaries may have to *actively* cut back their liquidity creation which then spills over to the liquidity on financial markets and thus to asset prices. In a similar manner, *Adrian/Etula/Muir* (2015) and *Adrian/Mönch/Shin* (2014) argue that if funding conditions deteriorate, banks have to cut back their leverage ratio, impairing market liquidity and asset prices. In my paper, I take a similar line of reasoning: If the net interest margin (term spread) deteriorates, banks have to cut back their liquidity provision, impairing market liquidity and asset prices. The term spread is simply defined as

$$\begin{aligned} \mathrm{TS_t} &= \text{Five year German government bond}_t \\ &\quad - \text{Three months money market rate}_t \end{aligned} \tag{4}$$

Note that both interest rates are nominal rates and that the three months money market rate was the Frankfurt Interbank Offered Rate (FIBOR) before the introduction of the Euro and the Euribor after the introduction of the Euro. The binary distress indicator for the term spread at time t, $D(TS_t)$, is given by

$$D(TS_t) = \begin{cases} 1 \text{ if } TS_t < TS_{t-6} \\ 1 \text{ if } TS_t \leq 0 \\ 0 \text{ if } TS_t > TS_{t-6} \end{cases} \tag{5}$$

Hence, $D(TS_t)$ signals distress if either the "slope" of the term spread is negative on a six months basis or if its level is zero or below. The latter case is included to account for the fact that liquidity creation becomes unprofitable if the term spread is zero. Even if the term spread would be rising in this region, financial intermediaries have no incentive to take on funding liquidity risks and hence, any peak signalled in the binary liquidity creation indicator will trigger a distress signal. Six months has been identified as the minimum look-back period for the term spread, although longer-term lags may also be used. It should be noted that the term spread is constructed using nominal interest rates. One could have the notion that the relevant term spread should be based on real interest rates. However, to keep the construction of the early warning indicator simple, only the nominal rates are considered in this paper.

3. Construction of the Binary Equity Market Indicator (EMI)

A regularity condition is set to ensure that a distress signal is only triggered if the equity market is above its long-term trend. Since the goal of this paper is to predict a significant equity market peak, this regularity condition will ensure that equity prices are still considered strong by market participants at the time when a distress signal is triggered. Again, a simple 24 months moving average is used as a threshold value to determine the market state. The 24 months moving average and the DAX 30 are both depicted in Figure 1. The binary equity market indicator, $D(EMI_t)$, is given by

$$D(EMI_t) = \begin{cases} 1 \text{ if } DAX_t > MA_{24}(DAX) \\ 0 \text{ if } DAX_t < MA_{24}(DAX) \end{cases} \tag{6}$$

4. Construction of the Financial Fragility Indicator

If the liquidity creation rate enters into an excessive state (i.e. $D(LCI_{t-1}^{cycle}) = 0$ and $D(LCI_t^{cycle}) = 1$) and the term spread has been declining for at least six months (i.e. $D(TS_t) = 1$) or if the term spread is negative, a liquidity spiral in the spirit of *Brunnermeier/Pedersen* (2009) should start and a significant peak in equity prices should materialize, provided the equity market is still in an upward trending phase (i.e. $D(EMI_t) = 1$). Thus, the binary distress indicator is constructed by combining the binary *LCI*, the binary *TS* and the binary *EMI* indicator multiplicatively. A distress signal is triggered if all three binary indicators are equal to 1. Constructing the early warning indicator multiplicatively has the advantage that there is no need to weight the binary indicator variables and that the indicator can explicitly account for the set of conditions outlined above. Hence, the early warning indicator, y_t^{crisis}, is given by combining the equations (3), (5), and (6) which yields

$$y_t^{crisis} = D\left(LCI_t^{cycle}\right) * D\left(TS_t\right) * D\left(EMI_t\right) \tag{7}$$

where $D\left(y_t^{crisis}\right)$ will have the following cases

$$D\left(y_t^{crisis}\right) = \begin{cases} \text{Upcoming equity market peak} & \text{if } y_t^{crisis} = 1 \\ \text{No crisis} & \text{if } y_t^{crisis} = 0 \end{cases} \tag{8}$$

Figure 2 graphically summarizes the construction process for the early warning indicator. As it can be seen, there were two instances where the equity market was above its 24 months moving average (Subgraph a), the term spread has been declining for at least six months (Subgraph b), and the cyclical liquidity creation indicator was above its 24 months threshold level (Subgraph c). All three indicator variables were therefore equal to one and the early warning indicator send a signal of a pending peak in the equity market (the binary crisis indicator is equal to one in Subgraph d). The construction of the early warning indicator makes a real-time use possible.

VI. Application of the Early Warning Indicator

Table 2 summarizes the empirical performance of the early warning indicator. In total, there were eleven instances where the DAX 30 declined by at least 15 % (see Figure 1). All eleven cases were predicted correctly. The distress indicator triggered a total of 20 signals, leaving nine potentially false signals. Two instances, where the equity market index declined by only 11 % and 12 % respectively are considered as borderline cases which are counted as correct predictions: In the first case (1984-01), a severe German recession occurred three months after the financial distress signal: Industrial production declined by 10 % within one month, the most severe decline ever observed over the 37-year sample period. The industrial production rebounded sharply after one month and this may have prevented a stronger decline of equity prices. In the second case (2000-10), the equity market rebounded from its initial decline that started in February 2000. Since the major decline in the equity market occurred after October 2000, the signal 2000-10 is counted as a borderline case, although the absolute peak actually occurred in 2000-02. For both cases it should be noted that only the month-end closing prices are used for calculating the performance of the DAX 30. The seven remaining sig-

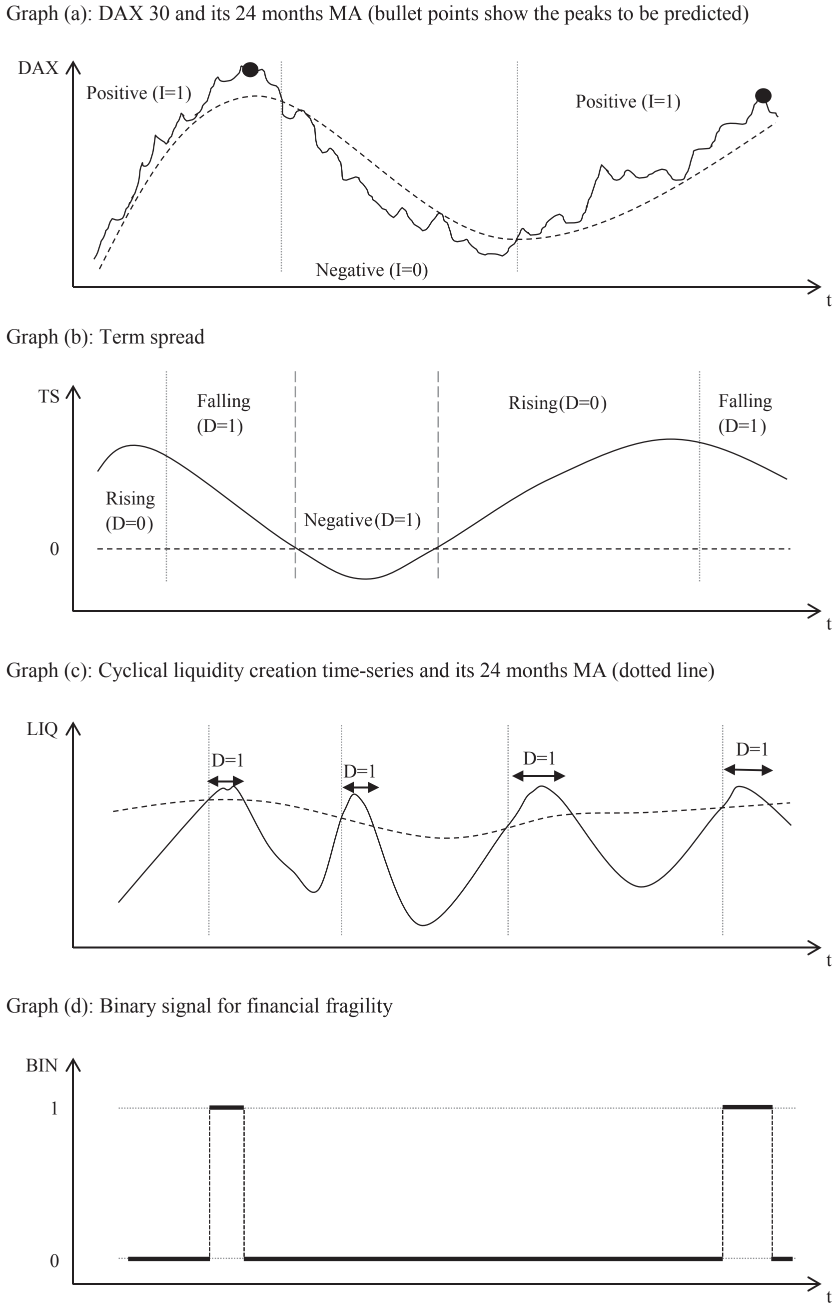


Figure 2: Peaks

nals were not associated with a significant decline of equity market prices. Thus, these signals should be interpreted as false positive signals.

The duration of the distress signal (i.e. $D\left(y_t^{crisis}\right) = 1$) is driven nearly entirely by the duration of the peak phase of the liquidity creation activity of the banking system. This duration was on average 3.2 months (see column DUR[1]) and is given by the time for which the cyclical liquidity creation rate was above its 24 months moving average. On average, the equity market reached its peak 2.9 months after the distress signal was initially triggered (see column *4-2*) and thus just shortly after the peak of the cyclical liquidity creation rate indicator. In fact, in over 80 % of all cases, the peak in the equity market realized within the time frame where the distress signal was valid.

Thus, the empirical results speak to a very strong correlation between the peak of the liquidity creation rate and the peak of the equity market. The average decline resulted in a loss of 31 % of the DAX 30 and had an average duration of around one year. In 80 % of all cases where an equity market peak formed, an economic recession occurred. On average, the economic activity (in this paper measured by the monthly total aggregate of the industrial production of Germany) started to decline nine months after the financial distress signal was triggered (see column *11-2*) and five months after the peak in the DAX 30. This indicates that a peak in the liquidity creation activity of the banking system may indeed have real economic effects, for instance via a lower supply of credit, as suggested by *Adrian/Estrella/Shin* (2010) and as hypothesized for the credit growth component in *Allen/Gale* (2000, 2003).

Finally, note that although the indicator captured all significant equity market peaks, there still remain seven false positive signals. However, it should be noted that the derivation of the early warning indicator relied on some rather ad-hoc assumptions concerning the lag structure for the input parameters (e.g. a 24 months moving average for the threshold values). The performance figures with respect to the Type II errors may further be improved if a grid search that minimizes the noise-to-signal ratio is conducted. Moreover note that (i) the DAX 30 was used as a proxy for the general state of financial markets, (ii) the consideration of other asset markets was outside the scope of this paper, and (iii) the term spread was constructed using nominal rates only. Using a broader range of asset classes, the high and low values for a given month for the DAX 30, or using the real interest rates instead of the nominal interest rates may further decrease the number of false positive signals.

Table 2: **The Signals of the Early Warning Indicator**

	Financial distress							Economic distress					
	No.	Signal Data	DUR[1]	DAX Peak	*(4-2)*	Loss (%)	DUR[2]	Macroeconomic Event	ECO Crisis	ECO Peak	*(11-2)*	Loss (%)	DUR[3]
Correct	1	1975-10	1	1976-03	4	17 %	8	—	No	—	—	—	—
	2	1977-11	3	1978-09	9	22 %	29	Second Oil Price crisis	Yes	1979-12	24	13 %	36
	5	1986-03	3	1986-04	0	15 %	4	—	Yes	1986-07	3	5 %	7
	6	1986-12	1	1987-08	7	39 %	6	Stock Market Crash	No	—	—	—	—
	8	1989-12	2	1990-03	2	32 %	6	German Reunification	Yes	1990-12	11	8 %	9
	9	1992-01	5	1992-05	3	19 %	5	ERM Crisis	Yes	1992-02	0	16 %	17
	11	1993-11	2	1993-12	0	15 %	16	ERM Crisis	Yes	1994-12	12	4 %	11
	13	1996-12	6	1997-07	6	16 %	4	—	No	—	—	—	—
	14	1998-01	4	1998-06	4	24 %	4	Russian Default	Yes	1998-07	5	4 %	5
	17	2000-10	2	2000-10	0	66 %	29	New Economy Bubble	Yes	2001-02	3	6 %	10
	20	2007-08	6	2007-12	3	52 %	14	Subprime Mortage Crisis	Yes	2008-02	5	25 %	14
	3	1984-01	1	1984-01	0	12 %	7	German Recession	Yes	1984-05	3	10 %	1
	16	2000-02	2	2000-02	—	11 %	8	New Economy Bubble	Yes	—	—	—	—
False	4	1984-12	5	—									
	7	1988-12	5	—									
	10	1993-02	5	—									
	12	1995-11	1	—									
	15	1998-11	3	—									
	18	2004-06	2	—									
	19	2005-06	6	—									

Financial distress: No. refers to the signal generation of the fragility indicator in chronological order; *Signal Date* is the year and month in which the signal was generated for the first time and *DUR*[1] refers to the signal duration (i. e. how long the binary distress indicator was equal to 1); *DAX Peak* is the observed date of the peak in the equity market index DAX 30; *(4-2)* calculates the time length between the Signal date and the DAX Peak date; *Loss(%)* refers to the percentage decline in the DAX from the DAX Peak date to the lowest closing value of the subsequent decline, rounded to the nearest integer; *DUR*[2] refers to the duration of the DAX decline, including the months where the low and high closing values were established.

Economic (ECO) distress: ECO Peak refers to the date at which the Industrial Production peaked; *(11-2)* calculates the time length between the Signal date and the Economic Peak date; *Loss(%)* refers to the percentage loss of the Industrial Production from the ECO Peak date to the lowest value of the subsequent decline, rounded to the nearest integer; *DUR*[3] refers to the duration of the economic decline, including the months where the low and high values for the industrial production were established.

VII. Conclusions

This paper is the first to show that peaks in the liquidity creation rate of the German banking system consistently precede peaks on the German equity market. The key result is that a simple binary early warning indicator, comprised of three inputs, predicted *all* major equity market downturns for Germany over the past 37 years with an average lead time of 2.9 months. This finding lends support to *Berger/Bouwman* (2010), who argue that "… the (subprime) lending crisis was preceded by a dramatic build-up of positive abnormal liquidity creation, …" [p. 30]. The duration of the distress signal is nearly entirely driven by the time period for which the liquidity creation remained above its longer-term threshold value.

Contrary to previous papers with a focus on early warning indicators for distress on financial markets, this work is novel in two respects: First, it uses a unified measure for money and credit growth, namely the liquidity creation indicator for the bank-dominated financial system of Germany. Moreover, most empirical papers analyzing the interaction between financial intermediaries and prices on financial markets merely linked the leverage ratio of banks to asset prices. However, a leverage factor does neither allow for an inference on the amount of liquidity (money and credit) the banking system has created for the financial and economic system, nor does it account for the funding liquidity riskiness that the banking sector has incurred. The liquidity creation indicator used in this paper, captures both, money and credit developments. Changes in this measure should have an immediate impact on the financial and economic system and could be a superior measure when compared to a plain leverage ratio. Second, this paper proposes an indicator that explicitly tries to predict the occurrence of an asset market peak and therefore goes beyond explaining asset market returns by risk metrics extracted from the balance sheet of banks as done by *Adrian/Etula/Muir* (2015) and *Adrian/Mönch/Shin* (2014). Particularly the second contribution should not only be interesting to asset or risk managers but also to financial stability experts.

Overall, this work demonstrates that the liquidity conditions that financial intermediaries create for the economic and financial system play a crucial role for the financial and economic stability. This finding is likely to hold for other bank-dominated financial and economic systems as well.

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