A financial market stress indicator for Austria

Christian Glocker* Serguei Kaniovski†

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Abstract

This paper develops a financial market stress indicator based on monthly data reflecting the functioning and stability of Austria's financial system. We aggregate individual time series in a composite indicator using principle component analysis and identify episodes of heightened financial stress since 2000. We highlight the quantitative importance of macro-financial linkages by modeling the co-movement of the indicator and industrial production. The estimates from two nonlinear models reveal the presence of threshold effects in the transmission of financial market stress to economic activity in Austria.

Key Words: financial market stress indicator, macrofinancial linkages, threshold effects
JEL Classification: E44, G01, G10, G20

1 Introduction

Turbulence in global financial markets following the US subprime mortgage crisis of 2008 had significant negative effects on Austria's financial system. The ensuing uncertainty in financial markets diminished the supply of loans and increased the risk aversion of households and firms, exacerbating the economic downturn. Debt crises in Eastern and South-Eastern European countries further strained the balance sheets of Austrian banks.

Stabilization policies enacted by the Austrian authorities set out to ease financial stress and restore a smooth functioning of financial intermediation. These policies introduced a permanent change in the regulatory environment, as well as temporary measures to be abandoned once tensions in financial markets abate. Both researchers and practitioners agree that monitoring

*Austrian Institute of Economic Research
Arsenal, Object 20, 1030 Vienna, Austria
Tel: +43 1 7982601 303
Email: Christian.Glocker@wifo.ac.at
†Austrian Institute of Economic Research
Arsenal, Object 20, 1030 Vienna, Austria
Tel: +43 1 7982601 231
Email: Serguei.Kaniovski@wifo.ac.at

financial stress and a timely diagnosis of financial crises are essential for an effective policy response. The need to measure financial stress led to the development of composite warning indicators of systemic stress, with the aim of monitoring changes in the overall financial conditions. This is necessary because individual indicators may give ambiguous signals if financial conditions do not change simultaneously or uniformly. There is thus a need for a comprehensive measure of financial stress, which can be used both to monitor the financial sector and provide timely warning.

This paper develops a financial market stress indicator (FMSI) for Austria. Section 2 summarizes the symptoms of financial stress. Section 3 discusses key features of the Austrian financial system. Section 4 motivates the choice of the variables used in the FMSI. We demonstrate the indicator's ability to identify known episodes of heightened financial stress since 2000. Section 5 evaluates the importance of macrofinancial linkages – transmission mechanisms from the financial sector to the real economy – using a bivariate threshold VAR model and supplements the results using a Markov-switching model. A preliminary test shows that the financial market stress indicator indeed leads the fluctuations in industrial production. Estimates of the two models reveal the presence of threshold effects in the transmission of financial stress to industrial production. Moreover, increases in financial stress have little effect on production in times of low financial stress, this effect becomes significant once the economy is in a distressed state. Concluding remarks are provided in the final section of the paper.

2 What is financial stress and how to measure it?

By allocating capital and diversifying sector-specific risks, the financial system provides fundamental services to the economy. Disruptions of the financial system may incur high economic costs. The sensitivity of the financial system and the economy to financial shocks strongly depends on the prevailing financial and economic conditions. Brunnermeier, Crocket, Goodhart, Persaud and Shin (2009) argue that financial crises are more often caused by market dynamics rather than external shocks, and that financial turmoil often results from a combination of a fragile financial system and an exogenous shock.

The literature identifies several symptoms of heightened financial stress. Their relative importance may differ from one episode to another, yet every episode seems to involve at least one of them. Key symptoms of financial stress are:[1]

1. increased disagreement among investors that blurs the relationship between asset prices and their fundamentals, making prices more volatile;

2. increased uncertainty about fundamentals that leads to higher asset price volatility, as investors tend to overreact to new information;

[1] See, Brunnermeier et al. (2009), Fostel and Geneakoplos (2008), Caballero and Krishnamurthy (2008), Mishkin (1991), Gorton (2008), Caballero and Kurlat (2008).

3. increased informational asymmetry that raises borrowing costs and exerts downward pressure on asset prices in secondary markets;

4. decreased willingness to hold risky assets, known as 'flight to liquidity';

5. decreased willingness to hold illiquid assets, known as 'flight to quality'.

Forss, Holmfeldt, Rydén and Strömqvist (2011) have characterized financial stress by "a disruption that impairs the financial markets' ability to act as an efficient intermediary between lender and borrower or buyer and seller". Considered in this way, financial stress can be interpreted as a disruption to the functioning of financial intermediation. This definition is conveniently broad, as financial crises can differ in their origins, transmission channels and market segments affected (Brunnermeier et al. 2009). These different aspects of financial stress are interrelated and may have a tendency to reinforce each other. For instance, Brunnermeier (2009), Brunnermeier and Pedersen (2009) and Krishnamurthy (2010) emphasize that, in the case of fire sales and liquidity spirals, a kind of vicious circle in which deteriorating market and funding liquidity exacerbate each other can emerge.

Most of the aforementioned features of financial stress can be captured more or less readily using standard individual financial market indicators. For instance, the various stress features bring about observable symptoms of financial stress, such as higher asset price volatility, large asset valuation losses, and higher default or liquidity risk premia. It is far less clear, however, to what extent these individual indicators can provide guidance in assessing the overall system of broad financial stress. Hence, the majority of studies in this context aggregate individual indicators in an overall composite indicator. These indicators are generally calculated using financial variables such as stock and bond market developments and risk spreads summarized in a single indicator. Most of the recent literature focuses on the principal components approach. Hakkio and Keeton (2009) of the Federal Reserve Bank of Kansas City and Kliesen and Smith (2010) of the Federal Reserve Bank of St. Louis, for instance, use principal components analysis to construct a monthly financial market stress indicator for the US economy. The financial conditions index of Brave and Butters (2011a) and Brave and Butters (2011b) uses more data and a more general statistical methodology than the former two. A further statistical methodology commonly used in developing financial market stress indicators is based on the weighted averages of individual indicators – a method first used by Illing and Liu (2006). Holl, Kremer and Lo Duca (2012) aggregate the individual transformed variables by making use of basic portfolio theory. The portfolio-theoretic aggregation takes into account time-varying cross-correlations between subindices, with the individual transformed variables put into three subindices. As a result, their composite financial market stress indicator puts relatively more weight on situations in which stress prevails in several market segments at the same time.

3 Key features of the Austrian financial system

This section provides a brief overview of the current state of the financial system in Austria and its main risk exposures. The discussion here is necessarily selective. It is, however, important to understanding the potential choice of variables relevant to a financial market stress indicator.

The Importance of Banking. The Austrian financial system is dominated by banking. At over 300 percent of GDP, total assets of banks comprise more than 3/4 of total financial sector assets (IMF 2011a). The ratio of domestic loans relative to GDP is comparable to that of other European countries (IMF 2011a, OeNB 2010, OeNB 2011). Despite a decline in the number of banks, Austria has one of the highest bank and branch densities in Europe – similar to the densely-branched banking sectors of Germany and Italy (IMF 2011a). Today, the majority of Austrian banks are universal banks, yet significant differences between banking groups exist, and the banking sector remains fragmented due to historical business and ownership patterns.

From the point of view of the monopolistic competition model, we expect the competition to increase with branch density, thereby diminishing the profitability of banks and improving their efficiency. Empirical studies of the Austrian banking sector prior to the global financial crisis largely confirm this hypothesis. In a study of concentration and profitability in the Austrian banking sector, Hahn (2006a) confirms the perception that: 'Austrian banks, in spite of their local quasi-monopoly, are far below international standards in terms of performance' (p. 677). Hahn (2006b) shows the disparities in managerial efficiency among Austrian banks prior to the global financial crisis, with banks operating in urban areas being more efficient than rural banks. While we cannot say whether the global financial crisis has increased the efficiency of Austrian banks, the balance sheet data shows that earnings after the crisis have been disappointing. A recent financial stability report sees 'more sustainable earnings and a stronger capital base as key challenges for Austrian banks' (p.9, OeNB 2013), while underscoring the remaining risks associated with high cross-border exposure of large banks.

The above factors point to the fragility of the banking sector, yet the solvency of the Austrian non-financial sector fosters the stability of the banking system. Household indebtedness relative to income is comparatively low, while corporate leverage levels have continuously fallen in recent years (IMF 2011b, IMF 2012). Real estate prices have grown more moderately than in many European countries. However, the Austrian financial system is strongly influenced by two key risk factors that emerge from two related sources.

Cross-Border Exposure. Following the fall of the 'iron curtain', Austrian banks entered the Central, Eastern and South-Eastern European (CESEE) markets, where they now play a major role. Practically all major Austrian banking groups operate in several CESEE countries, with some subsidiaries playing a systemically important role in the host countries' financial systems. Austrian banks' exposures to CESEE countries are higher (relative to the nominal GDP) than those of other European countries. In the first half of 2011, the total assets of Austrian banks in this region were equal to over 74 percent of the GDP, or roughly a fifth of

total assets held by banks (OeNB 2011, OeNB 2012). The holdings in the CESEE countries generated a significant share of Austrian banks' profits. In the first half of 2011, total assets in CESEE accounted for about 23 percent of Austrian banks' unconsolidated assets and almost 54 percent of total profits (OeNB 2011, OeNB 2012). Returns on assets have thus been markedly higher in the CESEE countries than in the domestic market.

The financial crisis brought the boom in the CESEE to a halt, confronting Austrian banks with both a liquidity squeeze and deteriorating quality of their credit portfolios. The shares of nonperforming loans remain high in CESEE subsidiaries, albeit with notable regional differences. The increase in general risk aversion may exacerbate these strains, and while the countries are diverse, contagion through trade and investment linkages cannot be ruled out completely. However, despite considerable collective exposure, the individual risks of Austrian banks remain diversified because they operate in several countries (IMF 2011a).

High Share of Foreign Currency Loans. The high share of foreign currency denominated loans granted to domestic customers is a phenomenon unique to Western Europe. Although the volume of foreign currency loans has recently decreased, its share in total loans has remained nearly constant. In the third quarter of 2011, nearly 30 percent of all loans in Austria were denominated in foreign currency (OeNB 2012).

In addition to domestic foreign currency denominated loans, Austrian banks hold a large portfolio of similar loans in CESEE countries. At the end of 2010, nearly 50 percent of loans (IMF 2011b) by Austrian bank subsidiaries were in foreign currency. This share is higher than the average of other competitors in the region. With a volume of EUR 15.8 billion, Swiss franc loans (OeNB 2011) account for around one-fifth of all foreign currency loans granted by the CESEE subsidiaries of Austrian banks to households and non-financial businesses abroad. Empirical evidence does not point to higher aggregate nonperforming loan ratios for foreign currency loans. Nevertheless, the exchange rate risk is high, and it has recently materialized as the Swiss franc has appreciated against the euro, while most CESEE currencies have depreciated against the euro. The negative effects of these exchange rate movements have been modest. Nonetheless, the large stock of foreign currency loans is problematic. It limits the scope for a policy response during a crisis by making currency depreciation more costly and domestic demand less resilient to external shocks.

4 The financial market stress indicator (FMSI)

In the following section, we first motivate the selected variables and discuss the computation of the indicator, before examining the behavior of the indicator during past episodes of financial stress.

4.1 Variable selection

The selection of the variables for the financial market stress indicator is based on several criteria. First, each variable has to represent one or more of the features of financial stress. Second, each variable has to reflect characteristics that embody the largest amount of information and are the quickest to reflect changes in financial conditions. Third, each variable has to be available on at least a monthly basis, so that a monthly indicator can be constructed. The following variables capture at least one of the symptoms of financial stress. They may inherit some common characteristics related to the overall state of the financial system. Yet each variable can also change for reasons not necessarily linked to the general level of stress. These idiosyncratic movements may cause the variables to move in opposite directions, complicating an assessment of the current state of the financial system.

The methodology used to combine the variables is based on the idea that financial stress is the principal factor behind the common movement of these variables. This factor is identified by the method of *principal component analysis*, a method that reveals joint variation in the data in response to unobserved latent variables. The observed variables are modeled as linear combinations of the potential factors, plus an error component.

Money Market Spread. Stress in the money market is captured by the difference of the 3-month Euribor and Eurepo interest rates. The Euribor is an average rate at which European banks lend unsecured funds, whereas the Eurepo is a benchmark rate for secured money market operations. The Euribor rate can exceed the Eurepo rate of the same maturity because lending banks fear the loan may not be repaid (default risk), or because banks worry they will experience an unexpected need for funds before the loan is due (liquidity risk). If lending banks face difficulties in assessing the solvency of borrowing banks, a problem of adverse selection can arise, further increasing the money market spread. The Euribor/Eurepo spread can thus capture three aspects of stress: flight to quality, flight to liquidity, and asymmetry of information between buyers and sellers. Although this money-market spread extends beyond the Austrian financial system, we use it as a proxy, because a national counterpart is not available.

Realized Stock Price Volatility. This captures the overall volatility of the Austrian stock price index (ATX). It is common to use the implied volatility index of stock prices, which measures the expected volatility of stock prices based on the market price of options. Since a measure of the implied volatility for the ATX is not available, we instead use the realized volatility. As a measure of the overall volatility of stock prices, it captures the uncertainty about fundamental values of assets as well as the uncertainty about the behavior of financial investors.

Idiosyncratic Volatility of Bank Stock Prices. The idiosyncratic volatility of bank stocks reflects the component of bank stock returns that cannot be explained by movements in the overall stock market. It shows symptoms of financial stress similar to those of realized stock price volatility, but for the banking industry rather than the corporate sector as a whole.

The measure is computed as the difference between the volatility of bank stock prices and the volatility of the ATX.

Cross-Section Dispersion of Bank Stock Returns. When investors become less certain about the solvency of banks, the asymmetry of information between investors and banks increases. One measure of uncertainty about relative quality is the cross-section dispersion in unexpected bank stock returns – or the portion of each bank's stock return that cannot be explained by movements in the overall stock market.

National Excess Stock Price Volatility. In measuring financial stress, we need to account for the level of a country's financial stress relative to a comparably larger entity. The overall Austrian stock price volatility will be compared to the Eurostoxx 50 index, so as to reflect the degree of excess risk in the Austrian corporate sector.

Bond Securities Spread. The degree of uncertainty in the bond securities market is measured using two bond return spreads: bank versus government bond spreads and bank versus corporate bond spreads. These variables measure the extent to which financial sector securities are perceived as riskier than corporate and government bonds. The difference in the yields is due to the fact that in times of financial stress bank-issued bonds are likely to become less liquid than those of non-financial institutions. Increases in the spread of at least one of the former two interest differentials thus provide a measure of the flight to liquidity.

Country Risk Premium. The overall country risk premium can be measured by the realized bond spread volatility between 10-year German and Austrian government bonds. The country risk premium as such is an important quantity, as it reflects the perceived uncertainty about a country's solvency. High public bond spreads quickly spill over to the private sector, where they raise refinancing costs. The overall country risk can be captured by the government bond spread volatility. During economic expansions, the spread between countries' bond returns is likely to be small because investors estimate the risk of sovereign defaults to be similar (and low). However, if investors become concerned about the state of the economy or the solvency of a country, they may assign a higher default probability to that country. In such circumstances, bond returns will rise to compensate investors for higher risk. Such an increase in the spread may not be a symptom of financial market stress if investors' changed their beliefs about default risk. In some cases, however, the increased pessimism of investors may be an overreaction to a prolonged period of excessive optimism. In other cases, investors may demand a higher yield on bonds, not because of an increase in the perceived risk of a specific country's government bonds, but because of a decreased willingness to bear such risk. Either way, the increase in the country spread may reflect a flight to quality. When investors also start to worry about some government bonds being riskier than others, a problem of adverse selection may arise, causing the spreads to diverge further. The spread may thus also reflect increases in information asymmetries.

Correlation between Returns on Stocks and Government Bonds. During periods of low financial stress, returns on stocks and government bonds are either unrelated or they

move together in response to changes in the risk-free rate. In times of financial stress, however, investors may view stocks as riskier than government bonds. This would lead them to shift from stocks to bonds, causing the returns on the two assets to move in opposite directions. The stock-bond correlation provides an additional measure of the flight to quality.

Spread between Lending Rates and Bank Bond Returns. Under normal circumstances, the spread between bank lending rates and bank bond returns is positive. However, during episodes of unfavorable financial conditions, particularly when banks face severe funding constraints, investors may require higher yields on bank bonds. If banks face stiff competition in lending rates, higher yields on bank securities can lead to negative spreads. The negative interest rate margin induces additional risk to financial intermediaries as bank profits decrease. As a result, a vicious circle can emerge, in which ever higher bank bond yields trigger worsening interest rate margins, thereby further deteriorating bank profitability and causing further increases in the bond yields of banks. The spread thus provides a measure of the flight to liquidity.

Lending Rate Yield Curves. The spread between long and short term lending rates should be positive and nearly constant in times of low financial stress. In times of high financial stress, as well as in periods of economic downturns, this spread will rise. Financial intermediaries may be reluctant to provide long term funding as they question the borrower's ability to repay the loan. This can be amplified by a decreased willingness to supply new loans. During such episodes, long term lending rates will rise relative to short term lending rates. This measure not only reflects the current state of the financial market, but also contains an essential forward-looking element: it reflects the overall degree of uncertainty in the credit market and hence also in banks' assets.

Deposit Rate Yield Curves. Typically, the spread between long and short term deposit rates is positive and nearly constant. Episodes of economic expansion in conjunction with a low level of financial stress offer banks easy and cheap access to deposits. This provides incentives to rely on short term rather than long term deposits, as short term liabilities are generally cheaper. This can change quickly during periods of high financial stress. If households and firms question the solvency of financial intermediaries, banks might suffer from severe funding liquidity stress. To safeguard the funding side, banks might shift their deposit policies away from short term to long term deposits by offering higher interest rates on long term debt. As a result, the spread between long and short term deposit rates widens. During such periods, investors may perceive some banks as riskier than others, giving rise to the problem of adverse selection and thus exerting additional upward pressure on the long term deposit rate. The deposit rate yield curve therefore captures increases in information asymmetries, as well as flight to liquidity.

Excess Reserve Liquidity. Uncertainty about the solvency of financial intermediaries may cause excess liquidity holdings in central banks' deposit facility. Banks hold some of their assets with the central bank rather than lending it. The preference for excess liquidity can be measured

by commercial banks' reserve holdings in excess of the minimum reserve requirement. Increases in excess reserve holdings reflect a prudential stance of banks towards uncertain future developments. A high stock of excess reserve holdings reflects a stronger preference for precautionary savings in response to the increased uncertainty.

Exchange Rate Volatility. Significant cross-border exposure of Austrian banks in combination with a high share of foreign currency loans must draw our attention to the volatility of foreign exchange markets. We include the realized volatility of the euro exchange rate with respect to the currencies of financially closely linked CESEE countries: the Czech Republic (14.1%), Romania (7.7%), Hungary (6.9%), Croatia (6.9%) and Poland (3.1%). The percentage figures indicate the country share in Austrian banks' total consolidated foreign claims as of September 2011 (OeNB 2012). Additionally, the volatility of the Euro/CHF exchange rate and the overall exchange rate volatility measured by the variability of the nominal effective exchange rate are included.

4.2 Combining the variables in a composite indicator

Each of the above variables captures one or several of the features of financial stress. Hence, they should inherit some common characteristics once conditions in financial markets change. However, apart from common features, each variable can also change for reasons that are not necessarily linked to the general level of financial stress. These idiosyncratic movements may cause variables to move in opposite directions and hence complicate an assessment of the current state of financial conditions. What remains to be done is to discuss the extent to which these idiosyncratic characteristics can be extracted from the variables' common component to generate an indicator that captures the variables' common features only.

The methodology used to combine the variables is based on the idea that financial stress is the principal common factor behind them. This factor is identified by the method of principal component analysis. This statistical method searches for joint variations in response to unobserved latent variables. The observed variables are modeled as linear combinations of the potential factors, plus an error component. The computations proceed in three steps. First, each of the variables is normalized by subtracting the mean and dividing by the standard deviation. The second step is to compute the factor loadings of each variable for the overall measure. These coefficients are chosen such that the extracted factor maximizes the explained total variation. Finally, the factor loadings are normalized such that the variance of the factor is unity. The estimation exercise is based on data ranging from January 2000 to December 2012. Details on the data can be found in Table A.1 in an appendix at the end of the paper.

Table 1 lists the loading-coefficients obtained by this statistical method. Since the variables have been standardized, their loadings have a natural interpretation. The coefficient on each variable represents the effect on the financial market stress indicator of a one-standard deviation change in the corresponding variable. The magnitude of the coefficients may seem small as they

range from 0.92 for the idiosyncratic volatility of bank stock prices down to a low of 0.07 for the stock-bond correlation. Nevertheless the differences in the size of the loadings are of a reasonable economic magnitude. They indicate, for instance, that a one-standard deviation change in the idiosyncratic volatility of bank stock prices has nearly ten times as great an effect on the financial market stress indicator as a one-standard deviation change in the correlation between returns on stocks and government bonds. The total variation explained by the indicator is estimated at 0.46, indicating that approximately half of the variation in the variables is due to a common factor, the rest being idiosyncratic.

Table 1: Loading Coefficients

	Variable	Loading
1	Idiosyncratic Volatility of Bank Stock Prices	0.92
2	Realized Stock Price Volatility	0.90
3	Money Market Spread	0.30
4	Cross-Section Dispersion of Bank Stock Returns	0.89
	Bond Securities Spread	
5	between yields on bank and government bonds	0.77
6	between yields on bank and corporate bonds	0.79
7	Country Risk Premium	0.87
8	Negative correlation between Returns on Stocks and Government Bonds	0.07
9	Spread between Lending Rates and Bank Bond yields	0.56
	Lending Rate Yield Curves	
10	for mortgage loans	0.26
11	for consumption loans	0.13
12	for corporates loans	0.22
	Deposit Rate Yield Curves	
13	for households	0.16
14	for corporates	0.26
15	Excess Reserve Liquidity	0.23
	Foreign Exchange Market	
16	Nominal Effective Exchange Rate	0.31
17	EUR/CHF (Switzerland)	0.48
18	EUR/HUF (Hungary)	0.73
19	EUR/CZK (Czech Republic)	0.68
20	EUR/PLN (Poland)	0.50
21	EUR/HRK (Croatia)	0.68
22	EUR/RON (Romania)	0.71
	Fraction of total variation explained	0.46

Each loading-coefficient represents the effect of a one-standard-deviation change in the corresponding variable on the FMSI. The variables are transformed so that an increase in the variable implies an increase in the financial stress indicator.

4.3 Can the FMSI detect past episodes of financial stress?

Figure A.1 plots the FMSI. Financial stress was moderate in Austria until the end of 2007. The years from 2000 to 2007 were characterized by three peaks in the indicator, of which the first coincided with the terrorist attacks of September 2011 (`9/11`). Bond spreads and the excess

stock market volatility of financial intermediaries were the main factors behind high financial stress following the terrorist attacks. Financial stress subsided quickly once investors realized that the economic impact of the attacks had been overestimated.

The next peak in the financial market stress indicator appeared as early as one year later in June 2002 (`Lombard Club`). This peak coincided with the announcement of the European Commission's plan to fine Austrian banks involved in a banking cartel called the "Lombard Club". In the words of the European Commission, "the institutionalized set-up of this cartel and its comprehensiveness, both in terms of the banking services covered and geographical scope, makes it one of the most shocking cartels ever discovered" (EC 2002). Although the fine was small relative to banks' assets, the decision raised the level of financial stress to a point exceeding that of the aftermath of the terrorist attacks. The reason lay in the profound influence the Lombard Club had on the Austrian banking industry. The club had existed since the 1950s and been legal until the 1980s. It played a key role within the Austrian banking sector, as its members fixed interest rates for loans and savings for households and commercial customers, in addition to fixing the fees consumers had to pay for certain services. Its influence also extended to money transfers and export financing. The club's closure induced an extreme level of financial stress because of the resulting uncertainty of future price developments in financial markets.

The four years following the peak in June 2002 are characterized by a negligibly low level of financial stress until the subsequent peak in March 2006 (`HAAG, Bawag`). Similarly to the peak of June 2002, the March 2006 peak was directly related to domestic incidents - in particular, the announcement of losses through speculative financial transactions by two Austrian banks. BAWAG P.S.K. announced that it had suffered around one billion euros in losses and Hypo-Alpe-Adria-Bank (HAAG) admitted to 330 million euros in losses. These announcements and the preceding "BAWAG-Affairs"triggered turmoil in Austrian politics and the Austrian financial sector. The turbulences resulted in an unusually high excess stock market volatility of bank equity prices as well as a high degree of cross-sectional dispersion of bank stock returns. The financial stress, however, quickly calmed down once the government announced an assumption of liability of 900 million euros to guarantee the stability of the troubled banks.

In contrast to these three peaks, the greatest increases in the stress indicator occurred during the most recent financial crisis. A detailed discussion of the crisis from an Austrian perspective is beyond the scope of this paper, however it is useful to observe how the financial market stress indicator changed as the crisis progressed. First signal of rising financial turmoil appeared in August 2007. Investors had already expressed concerns about the quality of US subprime mortgages. These concerns increased when several rating agencies downgraded a number of structured mortgage products and the French bank BNP Paribas suspended redemptions for several of its investments into collateralized debt obligations (CDOs). The next series of upturns in the indicator until its intermediate peak in February 2008 (`ABS writedowns`) are a consequence of a series of announcements of major writedowns of mortgage products by US banks, Swiss banks

(UBS and Credit Suisse) and German banks (the German "Landesbanken"). These global incidents spilled over to the Austrian economy and materialized in the form of an increased excess stock market volatility of financial intermediaries, a higher level of cross-sectional dispersion of bank stock returns and increases in the spread between bank and government bond yields.

In the following months, the FMSI initially subsided, only to rebound in the fall of 2008. The level of financial stress took a sharp turn for the worse and the indicator recorded its largest increase ever in the month of September, when AIG was rescued, Lehman Brothers filed for bankruptcy and two further large US banks were absorbed by other banks after intervention by the authorities (`Lehman`). The historically highest peak in the indicator followed in October and November 2008 as the previous month's events took their toll and the re-financing conditions of Austrian banks dramatically deteriorated. These restrictive conditions in the financial sector show up in the form of a negative spread between lending rates and bank bond yields, downward sloping term structures, the increased excess stock market volatility of financial intermediaries, a higher level of cross-section dispersion of bank stock returns and increases in the spread between bank and government bond yields. National authorities took a series of steps to calm down national financial turmoil. The government announced unlimited deposit guarantees for households and corporations and introduced a bank package with a volume of 100 billion euros. The intention behind this package was to (1) re-animate the inter-bank market, (2) stabilize individual financial institutions and (3) re-establish confidence in the national financial system. In addition to these financial market stability measures, two expansionary fiscal policy packages were announced in order to provide stimulus to the struggling economy. These announcements brought about an intermediate attenuation of the level of financial stress at the end of 2008 and the beginning of 2009 (`Bank Package`). However, the financial stress quickly resumed. The comeback of severe financial stress in the first few months of 2009 was not due to deteriorating conditions in the domestic financial market, but because of a higher country risk premium. In particular, the peak in March/April 2009 corresponded to large increases in the yields of Austrian government bonds relative to their German counterparts. The high degree of Austrian bank credit exposure in CESEE countries, coupled with a strong economic downturn in these countries, caused investors to question the soundness of sovereign finances and the sustainability of public debt. The situation deteriorated continuously as the IMF and well-known economists, for instance Paul Krugman, voiced concerns about the mounting risks in the Austrian financial system due to its great CESEE exposure. The introduction of the bank package only shifted risk from banking to public finances, and the package did not alleviate financial stress. Due to the bank package, these risks were finally carried by the government and Austria was considered to be in danger of a sovereign default. However, these concerns did not materialize. On the contrary, financial stress declined significantly in the following months as a result of a public press conference held jointly by the director of the IMF and the Austrian finance minister in May 2009 (`IMF`). At this conference, the IMF director apologized for a 'human, but unacceptable calculation

error', which had led to an overestimation of Austrian banks' CESEE exposure. Following this announcement, financial stress dropped to historically low levels in the first quarter of 2010. These more favorable conditions on the financial markets were supported by an improved national and global economic outlook.

In March 2010 (`Greece Crisis`) the debt crisis in Greece escalated, with the Greek government asking the IMF and the European community for support. Further downgrades of Greece by rating agencies followed. The negative spill-over effects to the Austrian financial system were only moderate and the level of stress quickly attenuated, however, financial market stress increased again in the fall of 2011 (`Euro Crisis`). The peak in October corresponded with the announcement of two large Austrian banks' losses of around 900 million euros each for the current year. The losses primarily originated from these banks' CESEE business, resulting from the economic slowdown of these economies. Further upward pressure on financial stress stemmed from the European debt crisis as the sovereign ratings of Spain and Italy were downgraded.

The above overview of the behavior of the financial market stress indicator for the Austrian economy confirms that peaks have almost always coincided with known periods of financial stress. Another key issue is whether there have been any episodes of financial stress not captured by the indicator. For the indicator to serve as a good measure of financial stress, it should not only have few false positives, but also few false negatives. A thorough review of other authors' lists of national and international financial crises reveals only three episodes that are not captured by the financial market stress indicator, yet might have had an impact: the Argentinean debt crisis of late 2001, the Brazilian confidence crisis in 2002 and the accounting scandals of US companies in the fall of 2002. Despite the severity of the first two episodes, the financial market stress indicator for Austria does not offer any signals. Heightened financial stress also resulted from the US accounting scandals of late 2002. Stress during this period can be attributed to mounting investors' concerns about the accuracy of corporations' financial statements, notably those of Enron and WorldCom. The Austrian financial market stress indicator is, however, completely unaffected by these incidents. These crises were mainly of foreign origin, having few adverse spill-over effects on the Austrian financial system or the financial markets of the CESEE countries. Hence, it should not come as a surprise that these crises had less of an effect on financial stress in Austria than in countries whose financial systems are more closely linked to international capital markets.

5 Macrofinancial linkages

An increase in financial stress can weigh down economic activity through several transmission channels. Before estimating the adverse effects of financial stress on output, we briefly recall two main theories of transmission channels between the financial sector and the production sector of the economy.

The *real option theory* assigns a key role to investors' expectations and the value of postponing a decision.[2] By postponing investment, the firm retains the possibility of receiving more accurate information on its profitability. Moderate levels of uncertainty typically imply small probabilities of extreme events, including an outcome sufficiently bad for the investment to turn unprofitable. The firm clearly has less to gain by postponing investment in a low risk environment, as new information is unlikely to lead to a reassessment of future profitability. In a period of increased uncertainty, the firm might find it optimal to wait for uncertainty to resolve. The real option theory explains the extent to which waiting in response to heightened uncertainty is optimal – that is, the value of waiting. The degree of risk aversion is a central element here, as it determines the sensitivity of an individual's reaction to uncertainty and hence his patience. High levels of uncertainty can reduce investment today and lower output levels in the future. The real option theory thus posits that higher uncertainty leads to a slowdown of output growth and even a decrease in output.

Although it is intuitive, the real option theory has received relatively little attention of late. A more popular explanation for macrofinancial linkages is offered by the *theory on the financial accelerator* as developed by Bernanke, Gertler and Gilchrist (1999). In this setting, firms that need to borrow externally have to pay a premium that depends on their financial position. For example, firms with high debt levels relative to their net worth must pay a higher interest rate on the funds they borrow to undertake an investment than firms with a lower leverage. Within this environment, the financial accelerator arises from a feedback mechanism. When the economy is booming, firms realize higher profits and hence increase their net worth relative to their outstanding debt. This implies high solvency. As a consequence, they appear to be less risky, so banks charge them a lower external finance premium. The lower costs for external finance then induce firms to take on more external debt in order to increase their new investments, further promoting the economic boom. In this scenario, the declining external finance premium augments the economic upswing. This mechanism works in good times when the economy is steadily growing, but also in reverse, generating an adverse feedback loop by means of credit-asset price spirals during a downturn. In particular, economic repressions cause profits to decline. This triggers firms' net worth to decline relative to their stock of debt and hence weakens their balance sheets. In response, banks charge a higher external finance premium, decreasing the incentive for firms to invest. The essential mechanism behind the financial accelerator model is the counter-cyclical external finance premium. It is low during economic upswings, which promotes additional investment, and it increases during economic repressions, which depresses investment due to higher costs for external finance. Within the financial accelerator model, financial stress can make it more expensive for firms and households to raise funds by issuing new equity or borrowing from external sources. Such increases in the cost of external finance may cause businesses and households to cut back on their spending, depressing economic activity

[2]See, Driver and Imai (2003), Bloom (2009), Bernanke (1983), Dixit and Pindyck (1994), Hakkio and Keeton (2009).

still further.

Both theories state that increased financial stress triggers downward pressure on real economic activity. The key distinction, however, is that the real option theory postulates a direct link between uncertainty and real activity: increased financial stress causes economic agents to postpone their investment and consumption decisions, leading to a decline in real activity. In contrast, the financial accelerator theory postulates a link to asset-credit spirals which transmit financial shocks to real activity via interacting banks and entrepreneurs. The following section evaluates the relevance of these macrofinancial linkages. It does not, however, discuss the relative importance of these two theories in explaining the empirical results.

5.1 The quantitative importance of macrofinancial linkages

To assess the quantitative importance of macrofinancial linkages by modeling the co-movement of the financial market stress indicator (FMSI) and real economic activity, we estimate bivariate time series models using a linearly detrended index of industrial production (IP) as a proxy for economic activity. Reducing the analysis to a simple bivariate model may be subject to criticism though it is a natural specification in line with the real option theory discussed above. If, however, the specification of the model is to be based on the financial accelerator theory, then a bivariate setup would not suffice. Since a profound macrofinancial analysis is beyond the scope of the paper, the model's specification is kept simple. Figure A.2 adds the index of industrial production to the stress indicator. To facilitate comparison, we remove a linear trend from the logarithm of the index of industrial production and standardize the detrended series. There seems to be no apparent relationship between the two time series until the outbreak of the financial crisis in the second half of 2008. During this episode a negative correlation structure is apparent, financial stress spikes and the recession deepens.

Figure A.2 suggests a negative relationship between the financial market stress indicator and industrial production, but it is difficult to tell which one helps to predict the future values of the other. Usual methods of establishing this search for significant correlations between the lead and lag values in a pair of variables. The results of a Granger-causality test in Table 2 suggest that the FMSI can predict IP, but IP is a poor predictor of the FMSI. This finding is consistent with the hypothesis that financial stress precipitates a slowdown in economic activity through some combination of increased uncertainty, increased cost of finance, and tighter credit standards, however, it should be noted that the test does not suggest any causal interpretation.

Table 2: Granger Causality Test

Equation	Variable	F(12,117)-statistic	p-Value
FMSI	IP	1.20	0.29
IP	FMSI	3.71	0.00

Contrary to an apparent opposite co-movement of the two variables during the financial crisis and its aftermath, the two variables show no systematic co-movement outside this episode. Figure A.2 suggests that periods of elevated financial stress can sometimes cause an economic slump, while in other times real economic activity is unaffected. An empirical model of the joint dynamics of the financial market stress indicator and industrial production should ideally capture this non-systematic pattern. Such qualitative and quantitative changes in joint dynamics can be captured using a regime-switching model.

The regime-switching models estimated below have two regimes: a LOW STRESS regime and a HIGH STRESS regime. For most of the time, the economy finds itself in a LOW STRESS regime characterized by low levels of financial stress and high economic activity. In times of a major crisis, such as the global financial and economic crisis of 2008, the economy enters the HIGH STRESS regime characterized by high financial stress and low economic activity.[3] A regime-switching model provides a rich framework within which to study how financial stress affects economic activity. In particular, this model captures different channels through which financial stress and economic activity interact. Moreover, it allows the dynamic interaction between financial stress and economic activity to vary between the two regimes.[4]

We first estimate a bivariate threshold vector autoregressive model with one lag. We then use this model to quantify the consequences of increased financial stress to real economic activity and to explore a potentially non-linear relationship between the two. In a threshold VAR model, the coefficient matrix can take two distinct values, depending on the level of the financial market stress indicator. The threshold value and the rest of the model's parameters are estimated simultaneously using the methodology suggested by Ming and Zivot (1999). The estimation results are summarized in the top portion of Table 3. The estimated threshold value equals 1.62 and is plotted in Figure A.2. We interpret times in which the indicator lies below this value as episodes of subdued financial stress. The point estimates in Table 3 suggest that the coefficients vary strongly between the states. In particular, the dependency of industrial production on the financial market stress indicator changes between the regimes.

To explore this link in more detail, we employ impulse response function analysis in order to gain further insight into the macroeconomic importance of financial stress and its impact on economic activity. For this, Figure 1 reports impulse response functions of the financial market stress indicator and industrial production in response to a structural shock to the financial market stress indicator. The shock's identification is implemented by means of a recursive structure of the variables in the threshold VAR model and rests on the assumption that financial

[3]The specification of two regimes is suggested by inspecting the data. An alternative specification could allow two regimes for financial stress and two for economic activity. However, specifying four regimes corresponding to the four possible combinations would be unnecessarily complicated. Specifying two regimes is more parsimonious and captures the basic properties of the data, primarily indicating that the episodic shifts in financial stress and economic activity roughly coincide.

[4]The financial accelerator model from the previous section suggests that certain financial shocks have a larger impact on economic activity when uncertainty is high. Thus, the financial accelerator model suggests that financial shocks should have a larger impact on output in a distressed regime than in a normal one.

stress does not trigger real effects contemporaneously. The shaded area represents the 95 percent confidence interval.

The top panels show the impact of the shock on the financial market stress indicator for the two regimes. The effects appear to be very similar in magnitude and persistence. The lower left panel displays the effects on industrial production in times of low financial stress. As expected, this effect is negative but indistinguishable from 0 at the 5 percent confidence level. This confirms the earlier observation of no apparent relation between the two variables in Figure A.2. In normal times, fluctuations in the level of financial stress have negligibly small real effects. This pattern changes dramatically once the level of financial stress exceeds the threshold value, as was the case in the second half of 2008. The effect of the same shock in a high stress regime is depicted in the bottom right panel of Figure 1. The effect is negative and considerably more pronounced than under normal circumstances.

Table 3: Threshold and Markov-switching Estimates of VAR(1)

	Threshold VAR(1)			
	LOW STRESS (FMSI<1.62)		HIGH STRESS (FMSI≥1.62)	
	$FMSI_{t-1}$	IP_{t-1}	$FMSI_{t-1}$	IP_{t-1}
FMSI	0.879 *	0.009	0.967 *	0.043
IP	-0.092	0.958 *	-0.874 *	0.758 *
Obs.	142		11	
$\lvert\lambda_{max}\rvert$	0.94		0.88 $(0.86 \pm 0.16i)$	
	Markov-switching VAR(1)			
	LOW STRESS		HIGH STRESS	
	$FMSI_{t-1}$	IP_{t-1}	$FMSI_{t-1}$	IP_{t-1}
FMSI	0.857 *	-0.001	0.946 *	0.038
IP	0.002	0.968 *	-0.598 *	0.947 *
$\lvert\lambda_{max}\rvert$	0.96		0.96 $(0.95 \pm 0.15i)$	

*significant at the 5 percent level. $|\lambda_{max}|$ is the magnitude of largest eigenvalue, which can be a real number (LOW STRESS), or an imaginary number (HIGH STRESS). If the eigenvalues all have a magnitude less than unity, the linear systems of the VARs in the two states (regimes) would be stable, as is the case above.

The impulse response functions of the TVAR model show that crossing the threshold value of 1.62 leads to a profound change in the effect of financial stress on industrial production. Nevertheless, we ideally prefer a model that allows a gradual measurement of risk. To this end, we estimate a Markov-switching VAR model (MS-VAR) with two regimes.

Estimating this related but different statistical model allows us to check the results obtained using the TVAR. Similarly to the TVAR, a two state Markov-switching model again assumes

the existence of a LOW STRESS regime and a HIGH STRESS regime, where the levels of financial stress corresponding to the regimes and the relationship between financial stress and industrial production are different in each regime. The advantage of the Markov-switching model is that the probabilities of being in the HIGH STRESS regime can be estimated. At the bottom of Figure A.4 we compare the probabilities of being in the high stress regime (vertical bars) to regime spells obtained using the TVAR model (bullets). Although we have used two different models to obtain the probabilities and the spells, the results seem coherent, although the probabilities obtained by the Markov-switching VAR model indicate a number of shorter episodes of heightened financial stress that have not been captured by the TVAR.[5]

The lower part of Table 3 shows the estimates of the MS-VAR. The estimates of the MS-VAR are very close to those of the TVAR. In particular, most of the coefficients significant at the 5 percent level have comparable magnitudes and the same signs. In particular, the significance of the parameters of both reduced-form models and the pattern of the eigenvalues – either real or complex – are the same in both models. These results once again highlight the importance of a regime switch in the data once the financial stress becomes significant, as well as the necessity of using a non-linear model in this context.

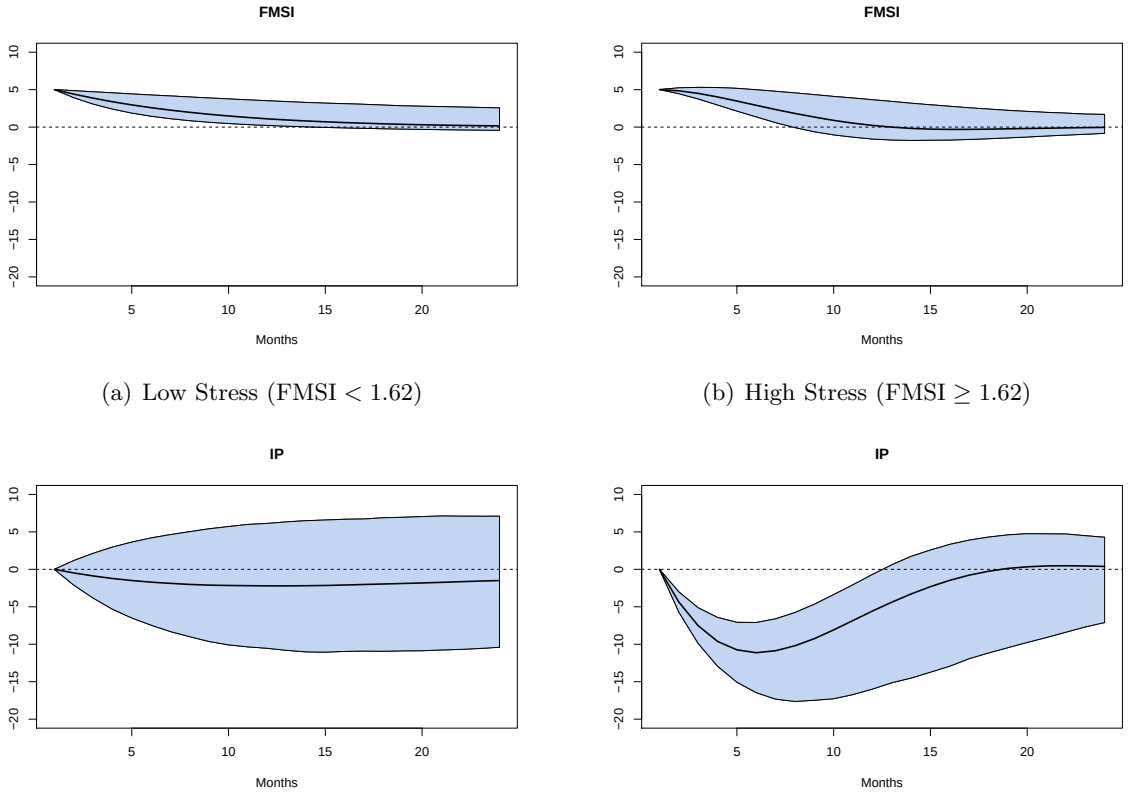
While financial market stress may affect real economic activity within a certain regime, financial turbulence and economic activity may also have an impact on the probability of shifts. In the MS-VAR model, the probability of switching regimes is endogenous – it varies with levels of financial stress and industrial production. The key empirical result of estimating a switching model with this modification is that rising financial stress does indeed play an important role in tipping the economy into the distressed regime. The probability of switching regimes can be written as follows:

$$p_t = \frac{\exp\left(\beta_0 + \beta_1 \cdot FMSI_{t-1} + \beta_2 \cdot IP_{t-1}\right)}{1 + \exp\left(\beta_0 + \beta_1 \cdot FMSI_{t-1} + \beta_2 \cdot IP_{t-1}\right)}.$$

The probability p_t of the economy switching into the HIGH STRESS regime increases with the value of the financial market stress indicator. We find that the estimate of β_1 is positive and statistically significant, whereas the estimate of β_2 is statistically indistinguishable from 0 (Table 3). The latter implies that when the economy is trapped in the HIGH STRESS regime, changes in the level of economic activity contribute little to moving the economy back to the normal regime. This result corroborates the Granger causality test reported in Table 2.

Figure 2 shows the transition probability between the normal and the HIGH STRESS regime. When the financial market stress indicator is below -2, the probability of moving to the HIGH STRESS regime is close to 0, or, equivalently, the probability of remaining in the LOW STRESS is close to 1. The abscissa in Figure A.1 shows the level of financial market stress as measured by the FMSI. As financial stress rises, the probability of the economy entering a recession also

[5]This may indicate the existence of several threshold values, so we reestimate the threshold VAR using two endogenous threshold values. The estimated threshold values are 0.88 and 1.62. The lower threshold lies close to the higher threshold obtained in the one threshold model. Moreover, the VAR obtained for the interval (0.88,1.62] is unstable, so that no meaningful dynamic analysis of the transmission mechanism is feasible.



(a) Low Stress (FMSI < 1.62)

(b) High Stress (FMSI ≥ 1.62)

(c) Low Stress (FMSI < 1.62)

(d) High Stress (FMSI ≥ 1.62)

Figure 1: Response to 1 standard-deviation shock in FMSI.

begins to rise. In particular, once the financial market stress indicator exceeds the value of 0.69, the probability of moving into recession becomes greater than one half. Note that the threshold value estimated using the threshold VAR model implies a rather high probability of being in the distressed regime. Put differently, exceeding the threshold value from below strongly implies imminent financial distress.

6 Summary and conclusions

We develop a monthly composite indicator of systemic financial market stress for Austria. The methodology used to construct the indicator is well-established in the literature. It is based on a principal component analysis of twenty-two financial time series. We motivate the choice of the financial time series and provide an overview of the key characteristics of the Austrian financial system. The indicator can identify past episodes of heightened financial uncertainty.

In the second part of the paper, we explore how the state of the financial system influences real economic activity in Austria, as measured by the index of industrial production. The estimated bivariate threshold VAR models assumes a nonlinear relationship between the levels

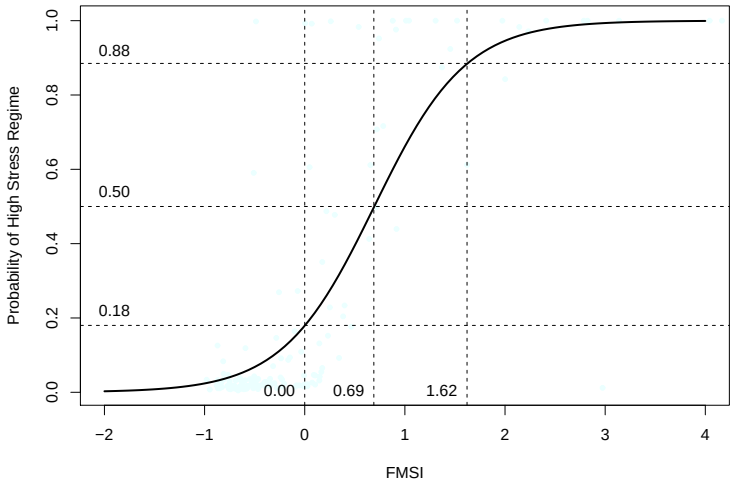


Figure 2: Probability of transition to the HIGH STRESS regime (logit regression)

of financial market stress and real output. This relationship differs depending on the state of the financial system. The adverse effect of financial market stress on real activity is markedly stronger in times of high financial stress and the threshold value indicates the level of stress that should raise concerns of an imminent recession. The results of the threshold VAR are validated using a Markov-switching VAR model, which also yields the probability of being in a high stress regime.

Further work in this area comprises at least two extensions. First, the results in this paper imply that the transmission channel of financial shocks is likely to have changed with the onset of the financial crisis. This raises questions about the underlying structural changes in the economy: is it an increased sensitivity of the financial sector towards firms and households or are they related to changes in the debt structure of financial intermediaries? Questions of this kind should be at the core of any further analysis in this area. Second, this analysis has only roughly discussed the Austrian financial system from an international perspective. The increasing dependency of the Austrian financial system on international capital markets strongly coincides with the upswing of global liquidity at the beginning of the last decade. Changes in the funding structure of Austrian banks, as well as their dependency on cycles in global liquidity, are interesting questions for future research.

We conclude by emphasizing that the results of this paper encourage the implementation of a sound macroprudential policy. Rising financial market stress poses a risk and may direct the economy into a distressed state, or regime. Consequently, policymakers should monitor financial conditions closely, even when the economy appears to be functioning normally. The indicator developed in this paper offers a useful empirical tool in this context.

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OeNB: 2013, Financial stability report 26.

A Appendix

Table A.1: Data Sources

	Description	Source	Frequency
	Austrian Bond Yields (Secondary market)		
1	Central government	OeNB	D/M
2	Domestic non-banks	OeNB	D/M
3	Domestic banks	OeNB	D/M
	10 - year Government Bond Yields		
4	for Austria	OeNB	D
5	for Germany	OeNB	D
	Exchange Rates		
6	euro/CHF (Switzerland)	OeNB	D
7	euro/HUF (Hungary)	OeNB	D
8	euro/CZK (Czech Republic)	OeNB	D
9	euro/PLN (Poland)	OeNB	D
10	euro/HRK (Croatia)	OeNB	D
11	euro/RON (Romania)	OeNB	D
12	Nominal Effective Rate (NEER)	OeNB	M
	Deposit Rates - New Business		
13	of households, maturity up to 1 year	OeNB	M
14	of households, maturity over 2 years	OeNB	M
15	of non-financial corporations, maturity up to 1 year	OeNB	M
16	of non-financial corporations, maturity over 2 years	OeNB	M
	Lending Rates - New Business		
17	to households for consumption, initial rate fixation up to 1 year	OeNB	M
18	to households for consumption, initial rate fixation over 5 years	OeNB	M
19	to households for house purchases, initial rate fixation up to 1 year	OeNB	M
20	to households for house purchases, initial rate fixation over 5 years	OeNB	M
21	to non-financial corporations, up to and including EUR 1 million up to 1 year	OeNB	M
22	to non-financial corporations, up to and including EUR 1 million over 5 years	OeNB	M
23	to non-financial corporations, over EUR 1 million up to 1 year	OeNB	M
24	to non-financial corporations, over EUR 1 million over 5 years	OeNB	M
	Money Market Rates		
25	Euribor	OeNB	M
26	Eurepo	OeNB	M
	Stock Prices		
27	Austrian Trade Index (ATX)	OeNB	D
28	commercial banks' stock prices	MB	D
29	Excess Reserves	OeNB	M

The data are monthly (M) or daily (D) over the period 2000M1:2012M12. The series were taken from the Austrian National Bank (OeNB) and from the Macrobond (MB) database. Interest rates are defined as the annualized agreed rates in percent per annum. The annualized agreed rate covers all intra-year payments on deposits and credits, but no other charges that may apply. Average minimum reserve balances over the maintenance period in excess of the required reserves, computed on the basis of those credit institutions that have fulfilled the reserve requirements.

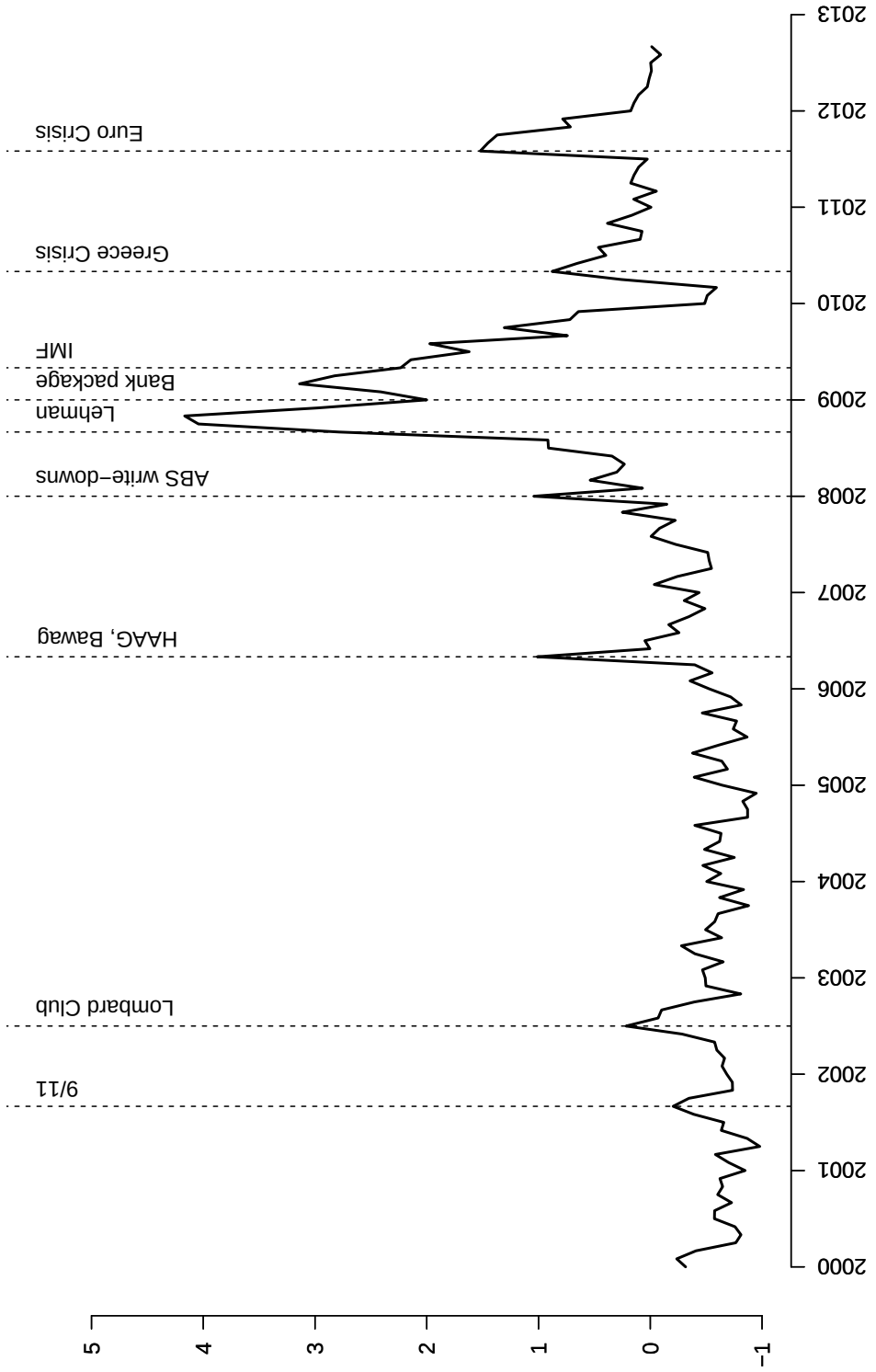

Figure A.1: The financial market stress indicator (FMSI).

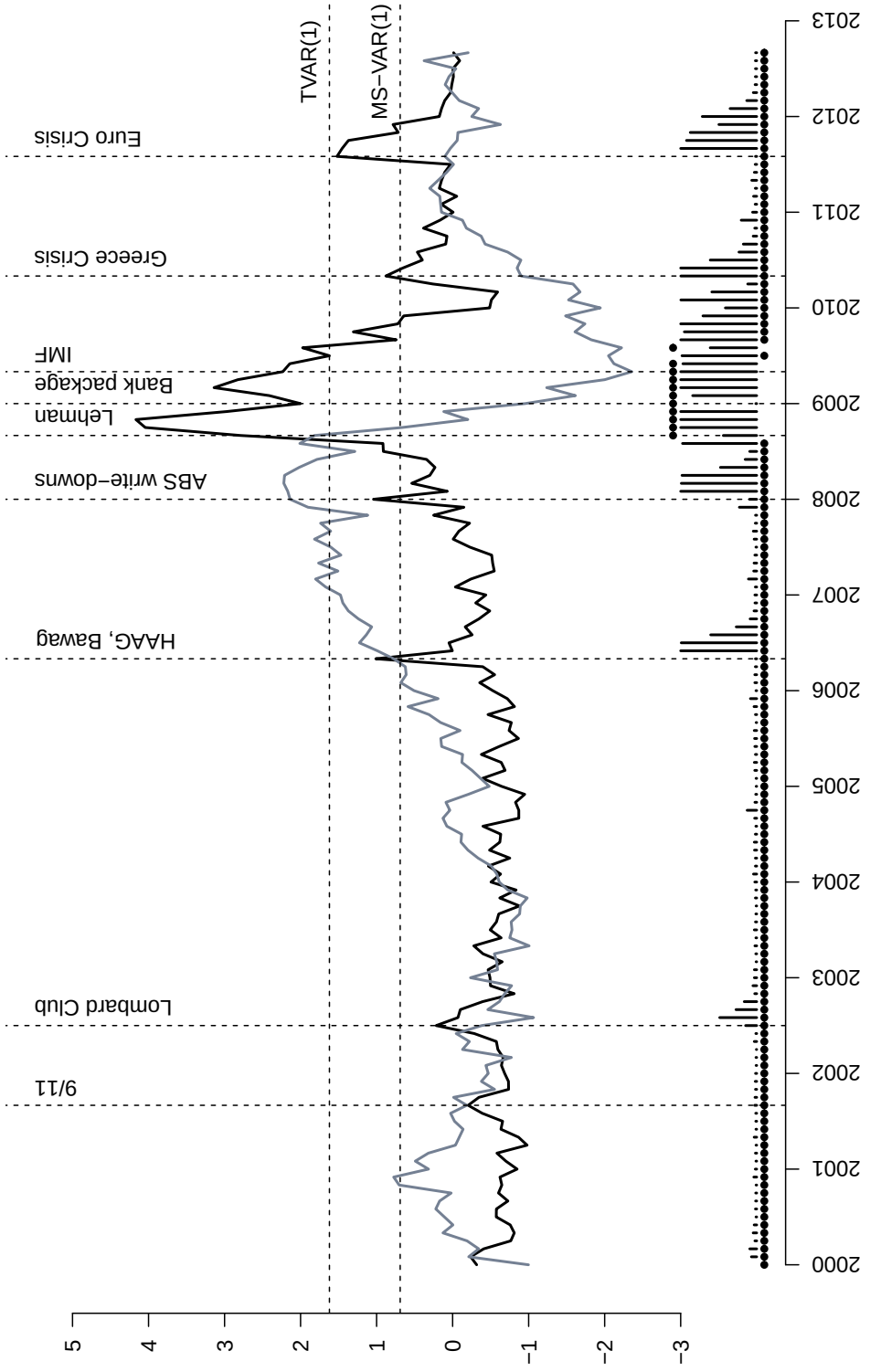

Figure A.2: Low stress vs. high stress regimes.