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A Financial Stress Index for a Small Open Economy: The Australian Case*†

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Abstract

We construct a Financial Stress Index (FSI) for a small open economy, which aims to provide clear and timely signals of financial market strains. This can be used in developing appropriate responses to address these adverse events. To do so, we use the principal component framework and apply it to Australian monthly data on interest rates, spreads, exchange rates, house price growth and inflation expectations. Decomposing the index into foreign and domestic components, we find that the foreign factors can explain more than half (57.4%) of our Australian Financial Stress Index (AFSI). To determine the information content of our index, we run a series of Granger causality tests on several economic and financial observables. We also estimate whether including the AFSI can improve the prediction of the different economic and financial outcomes relative to a specification that uses only its own previous data. We find that including the AFSI improves the forecasts for future retail sales growth and bank credit growth. Finally, we show that financial stress can have non-linear effects on bank credit growth. In particular, an increase in financial stress affects credit growth more adversely if AFSI is high. This result further highlights the importance of an accurate and timely measure of financial stress in an economy for researchers and policy makers.

Keywords: financial stress index, financial stability, small open economies
JEL Classifications: F30, G01, G15

*The views expressed in this paper are solely those of the authors and should not be interpreted as reflecting the views of the Board of Governors, its staff or anyone associated with the Federal Reserve System. All remaining errors are our own.

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1 Introduction

Equity and credit markets are a cornerstone of the financial system and are critical for economic growth. Although it was generally recognized that financial frictions could play an important role in economic fluctuations, the 2007-2009 financial crisis made it clear that the adverse effects of financial disruptions on economic activity could be far worse than anticipated. In particular, Ollivaud and Turner (2015) find that among the 19 OECD countries, that experienced a banking crisis over the period 2007-11, the median loss in potential output in 2014 is estimated to be about five and a half per cent, compared with a loss in aggregate potential output across all OECD countries of about three and a half per cent.[1] In order to prevent such loses, it may be useful to have various measures that try to capture disruptions in the normal functioning of financial markets. To identify such *abnormal* episodes researches gather a variety of financial data capturing increased uncertainty that private investors are facing, increased asymmetric information in financial markets and decreased willingness to hold risky and illiquid assets.

This paper aims to develop a clear and timely measure of financial stress for a small open economy that can serve as a warning system for investors and policymakers when monitoring financial markets. A Financial Stress Index (FSI) aims to monitor the current state of financial markets by creating a time series that has the property that increases in the index indicate increased financial stress. Since no single financial market is independent from the activity in other markets within a country and across countries, we consider a variety of financial and macroeconomic measures. In addition, since we are considering a small open economy, we also explicitly consider external factors that directly affect domestic output and prices through trade and price channels as well as indirectly through domestic financial markets. Because of the potential for negative spillovers from financial markets to the real economy, accurately measuring financial stress is important to investors and policymakers alike. Thus, understanding the specific channels by which negative disturbances to financial markets can spill over to the rest of the economy can be helpful in providing clear and timely signals of market strains to develop appropriate responses to address these adverse events.

Financial stress in itself is abstract and has no unique definition. In this paper, we follow the notion advocated by Hakkio et al. (2009). We assume that financial stress is defined as periods with increased uncertainty about the fundamental value of financial assets or the behavior of investors, increased asymmetric information and a decreased willingness to hold risky or illiquid assets.[2] To construct an Australia Financial Stress Index (AFSI), we collect monthly data on interest rates, exchange rates, spreads, house price growth and inflation expectations. We aggregate this data by applying principal component analysis (PCA) to establish a single index (the AFSI) that provides a measure of financial

[1]Laeven and Valencia (2013) estimated the output loss of banking crises in advanced countries to be 32% of trend income and the fiscal costs to be 4% of GDP. Similarly, Cardarelli et al. (2009) finds that recessions that were preceded by financial crises tend to be more severe and Afonso et al. (2018) provide evidence for the adverse impact of financial stress on the economy for several countries.

[2]See Balakrishnan et al. (2011) or Illing and Liu (2006) for alternative definitions and Kliesen and Smith (2010) for an overview.

markets stress in Australia. The underlying assumption is that financial stress moves the various observables series jointly. The data selection for the AFSI closely follows the approaches taken in the existing literature, but also includes data that are important and relevant for small open economies, such as Australia.[3]

Given that we are interested in small open economies, we decompose the AFSI and measure how much of financial stress in Australia are due to financial stress abroad. We do so by regressing the AFSI on financial stress indices for China, Japan and South Korea as Australia's main trading partner, and the United States, which is a global financial center. We find that foreign financial stresses can account for more than half of the AFSI. Moreover, to evaluate the information content of our financial stress measure, we compare it to several stress indices for both Australia and other countries. We also consider and compare the AFSI to broader measures of stress such as economic policy uncertainty indices. When doing so, we find that the AFSI is largely in line with foreign financial stress measures. We also show that there are small differences between AFSI and other indices that capture financial stress and economic uncertainty for Australia.[4]

We also determine whether the AFSI has relevant information content by helping better predict macroeconomic outcomes. To do so, we run a series on Granger causality tests on real GDP per capita growth, retail sales growth, bank credit growth and the unemployment rate. We find that the AFSI can improve forecasts for both retail sales growth and bank credit growth relative to forecasts that only rely on their own past data. Finally, we estimate the effect of a financial stress shock to the economy. To do so, we consider a time-varying VAR that includes central bank balance sheet growth, bank credit growth, retail sales growth and the unemployment rate. Our results show that the effect of an increase in financial stress depends on the level of financial stress. Overall, when financial stress is higher we observe a stronger reaction of a financial stress shock to central bank balance sheet growth and bank credit growth. These latter findings indicate a non-linear relationship between financial stress and economic outcomes. The various analysis carried out in this paper suggest that the AFSI contains relevant macroeconomic information, as in Davig et al. (2010), van Roye (2014), Hatzius et al. (2010) and Groen et al. (2020). Thus, the AFSI might be able to provide clear and timely signals of financial stress in the Australian economy, which may be useful for both policymakers and investors alike.

The remainder of this paper is structured as follows. Section 2 provides a literature review, while section 3 describes the data and the methodology used to construct the AFSI. Section 4 compares the index to several measures of financial stress and uncertainty in Australia and abroad. Section 5 relates the index to economic different outcomes, while section 6 concludes.

[3] Kliesen et al. (2012) provide an overview of the variables included in some selected FSI. They furthermore argue that papers constructing Financial Condition Indices (FCI) tend to include more information on quantities, prices and economic indicators, whereas papers measuring FSI tend to focus solely on prices.

[4] These latter indicators rely on different data or capture economy wide notions of uncertainty.

2 Literature Review

This paper connects with two strands of literature. The first one studies the effect of financial stress and financial crises on the economy, while the second quantifies and measures financial stress.

In order to measure financial stress and disruptions, Financial Stress Indices (FSI) or Financial Condition Indices (FCI) are constructed using a wide array of financial and macroeconomic variables. While early papers provide measures of financial stress as binary variable, meaning either the economy is in a crisis or not, other papers aim to construct indices that indicate the severity of financial stress. These include Illing and Liu (2006) for Canada, Hakkio et al. (2009) (Kansas City Fed FSI or KCFSI), Kliesen and Smith (2010) (St. Louis FSI or STLFSI), Oet et al. (2012) (Cleveland FSI or CFSI), Hatzius et al. (2010) and Groen et al. (2020) for the United States , Cardarelli et al. (2009) (IMF FSI) for selected advanced economies, Park and Mercado Jr (2014) for emerging market economies, Balakrishnan et al. (2011) for 18 emerging economies, van Roye (2014) for Germany and Hanschel et al. (2005) for Switzerland, among others.

In the existing literature on FSI and FCI, the underlying data used to construct these indices vary greatly. Kliesen et al. (2012) provide an overview of the variables included in FSI and FCI. The authors conclude that papers constructing FCI tend to include more information on quantities, prices and economic indicators, whereas papers measuring FSI tend to focus solely on prices. The methodology to construct FSI also varies to some extent across papers, as there are several ways to combine multiple variables into a single index. Cardarelli et al. (2009), Hanschel et al. (2005) and Balakrishnan et al. (2011) use an equal variance weighting average to construct a single index, whereas Hakkio et al. (2009) and Kliesen and Smith (2010) use principal component analysis.[5] Illing and Liu (2006) use factor analysis, credit-aggregate based weighted averages, variance equal weighted averages and transformation of variables using the sample CDF's to construct indices. Lastly, van Roye (2014) uses a dynamic approximate factor model to construct an index for Germany.

In terms of the information content of these indices, Davig et al. (2010) show that financial activity tends to be lower in high financial stress periods. Moreover, the authors also find that a financial stress shock has a larger macroeconomic impact during periods of heightened financial stress. Similarly, van Roye (2014) finds that financial stress has a negative impact on the economy once financial stress increases above a specific threshold. Hatzius et al. (2010) test several existing FSI to see if they can improve forecasts of economic activity. They find that including the FSI together with single measures (such as the stock market index, real M2, the term spread, the federal funds rate or the short-term credit spread) can improve forecasts. Moreover, the authors show that some FSI can outperform the stock market as an indicator of financial stress. Also Groen et al. (2020) find that including financial stress can improve forecasts to industrial production.

This paper is also closely related to Hartigan and Wright (2023), who construct a FCI for Australia

[5] To compare the different methods, Park and Mercado Jr (2014) use both a variance equal weighted average and principal component analysis.

using data on asset prices, interest rates and spreads, credit and money, outstanding debt securities, as well as indicators of leverage, banking sector risk, financial system complexity, financial market risk and survey indicators of businesses and consumers.[6] The authors find that more restrictive financial conditions play an important role in explaining downside risk to growth in both GDP and employment and upside risk to changes in the unemployment rate. In contrast to Hartigan and Wright (2023), we use primarily monthly price data to construct the AFSI. Using higher frequency data allows us to receive a closer insight to short-term developments in financial markets.

3 Developing the Australian Financial Stress Index

Since we are considering a small open economy, domestic output and prices are influenced by two type of factors. The first group characterizes domestic financial markets, while the second reflects the external factors.[7] Conditions abroad directly affect domestic output and prices through international trade. In addition, foreign factors can indirectly impact domestic prices and output through domestic financial markets. Moreover, external conditions may influence monetary policy, ultimately affecting domestic financial conditions, output and prices. External factors also influence the exchange rate and domestic asset prices through cross-border capital flows, affecting the terms of trade, wealth and financing conditions. Depending on the extent of domestic financial frictions, financial markets can then also amplify the direct effects of external shocks through a feedback effect that runs from interactions between the real economy and financial markets. Explicitly considering external factors when constructing a FSI for a small open economy is then key.

Following the approach used in the literature, we construct such a financial stress index using the principal component analysis framework. To do so, we collect a series of variables that capture different aspects of financial disruptions faced by investors in a variety of financial markets.

3.1 Financial Measures

Symptoms of financial stress are informed by both theory and practice. These include: (i) uncertainty about the fundamental value of financial assets or the behavior of investors; (ii) increased asymmetric information; and (iii) decreased willingness to hold risky or illiquid assets. Thus, data used to construct the AFSI needs to capture different financial markets trading patterns and investors' expectations. In particular, we collect information for the banking sector, the equity market, government securities, international trade, and the foreign exchange market. The data contains monthly information on changes in interest rates, yield spreads, volatility of the effective exchange rate, returns and volatility in equity markets, idiosyncratic volatility of bank stock prices, housing markets, inflation expectations and sovereign real debt spreads. We also consider Australia's major trading partners.

[6]The authors use quarterly data in an unbalanced panel from 1976 to 2020 and dynamically demean the series using a 10-year backward-looking estimate of the sample mean.

[7]These external factors include commodity prices, world demand and global financial conditions.

The data considered in this paper spans from January 1990 to August 2020. The corresponding data sources are listed in Table 13, which can be found in Appendix A.

Banking Sector

It is well known that disruptions in the banking sector contribute significantly to periods of financial stress. To capture this important feature, we include various banking sector measures. Following Hakkio et al. (2009), we construct the banking sector β over a 2-year time horizon. This measure is constructed as follows

$$\beta = \frac{cov(r, m)}{var(m)};$$

where r denotes the monthly return on the bank stock index and m denotes the monthly return of the Australian stock market index (ASX200). When $\beta > 1$, the volatility in the banking sector is larger than the volatility in the overall equity market, implying that the banking sector is relatively risky.[8] Using the estimates of β, we then calculate the residual return of the banking sector aggregate stock market index. Lastly, we estimate the residual return volatility using a GARCH(1,1) process.

In addition, Hakkio et al. (2009), among others, emphasize that in periods of financial stress, banks are likely to experience increased uncertainty about the quality of borrowers. As a result, they are less willing to hold risky assets. This increased uncertainty can lead to sharp increases in the inter-bank rate and the rate of bank accepted bills, leading to an increase in the spread of bank refinancing rates and short-term government bond yields. To capture this, we consider the *3-month TED spread* and the *3-month BAB treasury spread.* The 3-month TED spread measures the spread between the Australia 3-month inter-bank rate (BBSW) and the 3-month government bond yield. The 3-month BAB treasury spread measures the difference between the 3-month BAB (bank accepted bills) rate and the 3-month government bond yield. Finally, to capture changes to banks' funding costs that are driven by changes in macroeconomic circumstances, we also consider *changes in the cash rate*, which is the key policy rate of the Reserve Bank of Australia.

Equity Market

As Hakkio et al. (2009), among others, highlight that financial stress periods are accompanied by increased uncertainty about assets' fundamentals. This leads to sharp changes in returns and increases in volatility in equity markets. To capture this phenomena, we consider data on *S&P/ASX 200 return* and *S&P/ASX 200 return volatility*, which capture activity in the Australian equity market. Following Park and Mercado Jr (2014), the return volatility is calculated by estimating a GARCH(1,1) process.

Housing Market

The Global Financial Crisis (GFC) has emphasized how disruptions in the housing can lead to financial stress. Sharp declines in the housing market can lead to increased losses for banks and investors. Thus, it is not too surprising that the housing market is a key factor when designing macro-prudential

[8] We refer to Park and Mercado Jr (2014) for more on this.

policies. In order to capture financial stress arising from the housing market, we include *housing price growth* data. This series combines the growth of the hedonic home value index in eight major Australian capital cities.

Foreign Exchange Market

As a small open economy, it is likely that financial stresses and macroeconomic shocks experienced abroad can spill over to the Australian economy. To account for this possibility, we include data on the *effective exchange rate volatility*. To measure the effective exchange rate volatility, we take first differences of the trade weighted index of the Australian Dollar.[9] We then measure the effective exchange rate volatility with a GARCH(1,1) process.

Inflation Expectations

In addition to changes in behavior and beliefs, agents are likely to adjust their expectations about the future during periods of financial stress as Kliesen et al. (2012), Abdymomunov (2013), Illing and Liu (2006) and others, point out. To capture changes in inflation expectations, we consider data on *break-even inflation rate*. The break-even inflation rate is calculated by subtracting the 10-year inflation indexed bond yield from the 10-year nominal bond yield.

Liquidity and Safety

Lastly, during financial stress periods we observe investors shift their portfolio toward safer and more liquid assets.[10] To capture this phenomena in the Australian context, we consider data on *changes in the 5-year Commonwealth government bond yield* to measure changes medium-term expectations and *changes in the 10-year Commonwealth government bond yield* to measure changes in long-term expectations. In addition, we include data on the *term premium* to capture changes in the current monetary policy stance relative to investor's long-term expectations as in Hakkio et al. (2009). The term premium is calculated by subtracting the 3-month Australia treasury bill yield from the 10-year nominal Commonwealth government bond yield. When monetary policy is tight relative to long-run expectations, short-term yields tend to increase relative to long-term yields, leading to an increase in the spread.

Given that we are analyzing a small open economy, we also consider the actual and perceived safety of Australian public debt relative to other foreign public debt. To measure changes in the yields of Australian safe assets relative to yields of other foreign safe assets, we include data on the *5-year real sovereign debt spread* between Australia and the United States. This is the case as the United States is one of the most important global financial centers. To do so, we compute the real yield of the 5-year government bond yields in Australia and in the United States by subtracting the inflation rate from the nominal yields. The inflation rate measures the monthly year-on-year change in the CPI of both countries. For Australia, the CPI is only available on a quarterly frequency. To

[9]The trade weighted index is a weighted basket of 18 currencies. The weights are determined according to the trade balance of the respective country with Australia.

[10]We refer to Hakkio et al. (2009), among others, for more on this topic.

obtain monthly frequencies, we interpolate the quarterly data based on a cubic interpolation of the values in neighboring grid points. We then compute the spread according to the following equation

$$y_{i,t} = AUD5Y_t - UnitedStates5Y_t;$$

where y_t denotes the real sovereign debt spread in period t, $AUD5Y_t$ denotes the real 5-year government bond yield in period t and $US5Y_t$ denotes the real 5-year government spread for the United States

Having described all the data, Table 1 depicts descriptive statistics for all of the data series.

Variable	**Mean**	**Standard Deviation**
Change in cash target rate	-0.0112	0.0554
Change in 5-year government bond yield	-0.0076	0.0589
Change in 10-year government bond yield	-0.0060	0.0503
Term premium	0.8439	1.0826
Inflation expectation	2.8331	1.3999
United States real sovereign debt spread	1.3585	1.5661
3-month TED spread	0.2063	0.2266
3-month BAB spread	0.2131	0.1921
Banking sector volatility	0.0315	0.0041
S&P / ASX 200 return	0.4373	3.9057
S&P / ASX 200 volatility	3.8175	0.8765
Effective exchange rate volatility	1.5792	0.3102
Housing price growth	0.0039	0.0063

Table 1: Descriptive statistics.

3.2 Methodology

Having identified several financial measures that can capture disruptions in financial markets when negative shocks hit the economy, we can construct the AFSI. Following the approach used in the literature, we consider the principal component methodology. Various authors have considered different components when constructing the financial stress index. In particular, Hakkio et al. (2009) use the first component, while Park and Mercado Jr (2014) consider the first three components. In this paper we consider the first four components. We do so as it allows us to: (i) increase the share of the total variation of the variables explained by the index to 59.9 percent, and (ii) delivers a more realistic stress measure during the Covid-19 pandemic.[11]

To construct the AFSI, we first transform each of the data previously described so they have the same units. In particular, for each series we subtract the sample mean and divide by the standard

[11] Looking at the standardized time series suggests that several of the variables included in our AFSI measure showed a large change in the beginning of the pandemic. The first four components pick up some these changes in the AFSI estimate that would otherwise be subdued when using only the first-two or the first-three components, respectively.

deviation. We then apply the principal component analysis to calculate the coefficients corresponding to these variables. The financial stress index is then constructed by adding the weighted first four components. To do so, we first multiply each component with the standardized time series. We then weigh each component by the eigenvalue of the respective component relative to the sum of the eigenvalues of the first four components and add them to a single index. To compute the adjusted coefficients, we scale the coefficients such that the standard deviation of the index is one. We then weigh the adjusted coefficient of each component for each variable by it's eigenvalue relative to the sum of the eigenvalues of the first four components. Lastly, we add them up to obtain the adjusted coefficient corresponding to the AFSI. The resulting adjusted coefficients are reported in Table 2.

Variable	**Adjusted coefficient**
Change in cash target rate	-0.1735
Change in 5-year government bond yield	-0.0248
Change in 10-year government bond yield	0.0168
Term premium	0.0389
Inflation expectation	0.1278
United States real sovereign debt spread	0.1404
3-month TED spread	0.2578
3-month BAB spread	0.2171
Banking sector volatility	0.1959
S&P / ASX 200 return	-0.0874
S&P / ASX 200 volatility	0.3015
Effective exchange rate volatility	0.2901
Housing price growth	-0.1700
Percent of total variation of variables explained by AFSI	59.9

Table 2: Adjusted coefficients.

Since the coefficients are standardized, they represent the effect of a one standard deviation change of each variable on the AFSI.[12] For example, the coefficients in Table 2 highlight that a one standard deviation change in the exchange rate volatility has approximately 7.25 times the effect on the financial stress index as a one standard deviation change in the term premium. Moreover, a one standard deviation change in the exchange rate volatility has an impact on the index that is roughly twice as large as the one implied by one standard deviation in inflation expectation changes. We also find that one standard deviation change in the exchange rate, equity market, and the banking sector volatility have the highest impact on financial stress. In contrast, changes in medium to long-term government bond yields have a very small and for the 5-year government bond yield even a negative effect.

Next, we report the correlations between each of the first four components and the 13 variables included in the index. These are reported in Table 3.

[12] We refer to Hakkio et al. (2009) for more on this topic.

Variable	**1**	**2**	**3**	**4**
Change in cash target rate	-0.4907	-0.0135	0.2916	-0.5333
Change in 5-year government bond yield	-0.6717	**0.6403**	0.1817	-0.1017
Change in 10-year government bond yield	-0.5974	**0.6740**	0.1417	0.0201
Term premium	-0.2339	0.2614	-0.0891	0.3555
Inflation expectation	-0.1530	-0.2010	**0.7867**	0.2491
United States real sovereign debt spread	-0.1461	-0.1524	**0.7817**	0.2553
3-month TED spread	**0.7072**	0.4626	0.1144	-0.3421
3-month BAB spread	**0.7336**	0.0978	0.2415	-0.3166
Banking sector volatility	0.2998	0.3590	-0.0127	0.2045
S&P / ASX 200 return	-0.1698	-0.0792	-0.1739	0.0758
S&P / ASX 200 volatility	0.4590	0.2571	-0.0311	**0.6844**
Effective exchange rate volatility	0.4555	**0.6130**	0.1792	-0.0430
Housing price growth	-0.4309	0.1926	-0.4928	0.0656

Table 3: Correlation between the first four components and the 13 variables.

As we can see from Table 3, the first component is most heavily correlated with the 3-month TED and the 3-month BAB spread. The second component correlates mostly with exchange rate volatility as well as changes in the 5-year and 10-year government bond yield. The third component is mostly correlated with inflation expectations and the real sovereign debt spread, while the fourth components correlates mostly with equity volatility. Based on these results, we identify the first component as bank funding and the second component as the exchange rate and liquidity components. Furthermore, we identify the third component as the expectations and safety and the fourth component as the equity volatility components.

Having identified the first four components, we can generate a time series for the AFSI. By construction, the average value of the index is zero and is associated with normal financial market conditions. Thus, values below zero imply low financial market stress, whereas values above zero suggest higher financial market stress periods. Moreover, larger values of the AFSI indicate greater financial stress and financial disruptions relative to other periods. Figure 1 depicts the resulting AFSI from December 1989 to August 2020. The gray bars indicate Australian recessionary periods. These correspond to two consecutive quarters of negative growth in real GDP per capita, as suggested by Restrepo-Echavarria and Reinbold (2019).

As we can see, the AFSI successfully captures the surge in financial stress during the GFC of the 2007-2009 period. Since then the level of financial stress in Australian markets has been higher than in the 1990s. The AFSI also captures the negative impact of the Covid-19 outbreak in Australia, starting in March 2020. The financial stress and disruptions experienced by Australian investors due to Covid-19 in April 2020 has been roughly 2.3 times higher than the financial stress resulting from the Greek debt crisis in June 2010.[13]

[13] In Appendix B, we present stress indices where we lag one variable. We present indices for each one of the variables lagged for one period. These indices exhibit a very similar pattern relative to the AFSI presented here. We argue therefore that our index for financial stress would not change materially if we include lags of these variables.

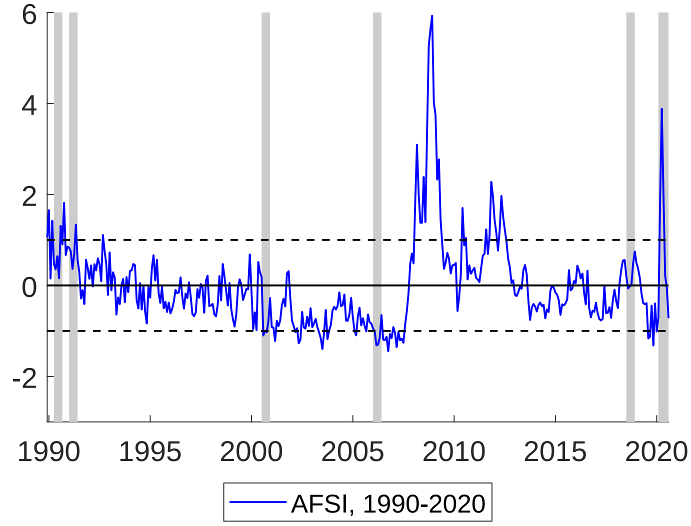

Figure 1: AFSI (own calculation) for the 1990-2020 period.

4 Evaluating the AFSI

We now analyze the properties of AFSI in terms of its external and domestic factors. We also assess the financial stress of the Covid-19 period relative to the global financial crises. Finally, we evaluate the relative performance of our index when compared to other indices.

4.1 Domestic and Foreign Factors

Given that the United States is a major global financial center and that China is the largest Australian trading partner, we consider these two countries when examining the impact of foreign factors in shaping the AFSI. First, we highlight the importance of these countries for Australia by comparing the time series of the AFSI with other financial stress indices for the United States and China. We then further decompose the AFSI.

United States

To determine the importance of disruptions in one of the most important global financial markets, we compare the AFSI with the Kansas City Fed FSI (KCFSI) and the St. Louis Fed FSI (STLFSI).[14] Both US indices apply the principal component analysis and consider just the first component. The

[14]The STLFSI uses data on a series of interest rates, yields spreads and additional indicators such as different measures of volatility, inflation expectations and data on other financial products. Similarly, the KCFSI includes data on yield spreads and volatility measures. Compared to these indices, we do not include data on corporate bond spreads. In Australia, the corporate bond market plays a smaller role in firms' financing than it does in a number of other countries. Since 1990, the share of financial intermediaries in the corporate bond market has increased significantly, making up about 60% of the corporate bond market (Black et al., 2012).

main difference between AFSI and the KCFSI/STLFSI is that we include a measure of exchange rate volatility and international public debt spreads. These are arguably important factors when considering small open economies and not global financial centers like the United States. Moreover, the STLFSI includes more information on corporate bond yields. We do not consider corporate bond yields in our measure of financial stress since the number of corporate bonds in Australia is relatively small. Lastly, the KCFSI does not include the term premium and inflation expectations.

Figure 2 compares the time series for the AFSI with the two United States indices. The red and grey bars indicate recessionary periods in the United States and in Australia, respectively.

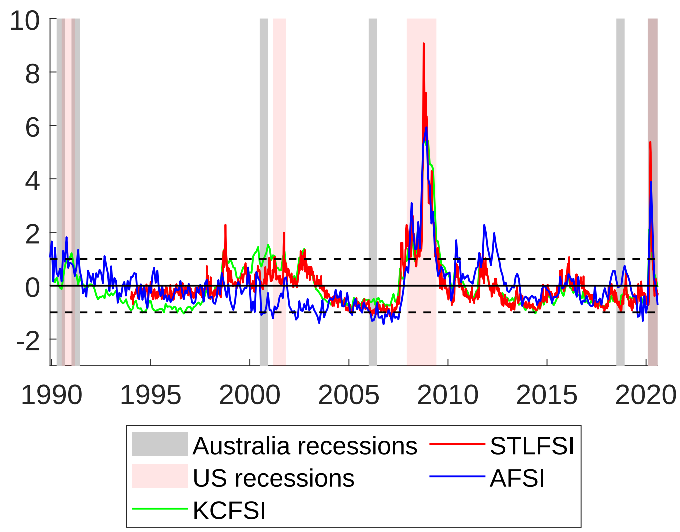

Figure 2: AFSI, KCFSI and STLFSI (Data source: Own calculation, FRED).

Broadly speaking, the three indices co-move from December 1989 until March 2020. The STLFSI shows considerably larger financial stress during the financial crises of 2007-2009, when compared to the KCFSI and the AFSI. In addition, from 1998 to 2003 the AFSI shows less financial disruptions than the United States indices. However, the AFSI delivers larger values of financial stress after the the financial crises of 2007-2009. Lastly, the AFSI financial stress measure during the Covid-19 pandemic is somewhat similar to the KCFSI, whereas the STLFSI is somewhat larger.

China

To capture the potential disruption stemming from the largest Australian trading partner, we now compare the AFSI to a Chinese financial stress developed by the Asia Regional Integration Center of the Asian Development Bank (CHFSI).[15] Figure 3 plots the AFSI and the CHFSI where grey bars

[15] The methodology of the CHFSI is based on the methodology of Park and Mercado Jr (2014). The CHFSI considers the relative volatility of the banking sector relative to equity markets (β, as defined above), changes in equity returns, equity volatility, sovereign debt spreads between the 10-year government bond yield and the 2-year government bond yield and changes in valuation of the domestic currency relative to the United States dollar (Asia Regional Integration Center, 2021).

indicate recessions in Australia.[16]

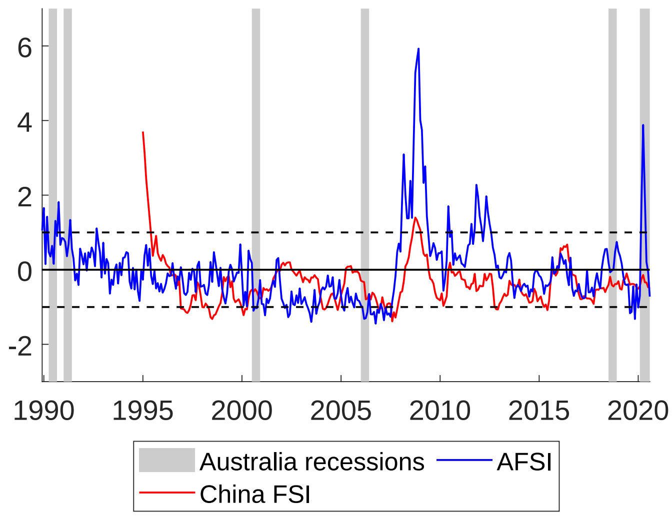

Figure 3: AFSI and CHFSI (Data source: Own calculation, Asian Development Bank).

As we can see from Figure 3, the AFSI seems to be much less correlated with the CHFSI when compared to the United States indices. This suggests that Australian financial markets are globally connected and less influenced by the financial conditions of its major trading partner.

Correlations with Foreign Series

To formally asses the co-movement of the US and Chinese indices with the AFSI, we calculate the corresponding correlations. In particular, Table 4 reports the correlation coefficients for our measure of the AFSI, the measure of AFSI obtained from the Asian Development Bank, the KCFSI, the STLFSI and the CHFSI. We also report correlation coefficients with one lag.[17]

	KCFSI	STLFSI	CHFSI
AFSI	0.6590	0.7419	0.3747
AFSI(-1)	0.6303	0.6400	0.3680

Table 4: Correlation of AFSI, KCFSI, STLFSI and CHFSI (Data source: Own calculation, FRED, Asian Development Bank).

As we can see from Table 4, the AFSI is more correlated with financial stress in the United States relative to financial stress in China. Among the United States stress indices, the AFSI has the highest correlation with the STLFSI.

Domestic and Foreign Decomposition

[16] Using OECD data on nominal GDP, inflation and population from China, we could not identify recession periods defined as two consecutive quarters of negative real GDP per capita growth for the time period from 1995-2022.

[17] Correlations reported on Table 4 are at monthly frequency. Thus, the weekly measures for the STLFSI are converted into monthly averages.

An alternative way to show the importance of foreign factors in a small open economy is to decompose the AFSI into domestic and foreign components. To do so, we follow the approach taken by Moore (2017). In particular, we consider financial stress indices for the United States, China, Japan and South Korea when decomposing the AFSI.[18] First, we focus on the impact of financial stress in the US and China. It is of course plausible that financial stress in Australia can be transmitted from other economies other than the United States and China. Since the United States and China were the major trading partners for the period we are considering, we assume that if financial stress spills over to the Australian economy from abroad, it is most likely that it arises from these economies. The first specification we consider is as follows

$$\text{AFSI}_t = \beta_0 + \beta_1 \text{FSI}_{US,t} + \beta_2 \text{FSI}_{China,t} + \varepsilon_t; \tag{1}$$

where the coefficients β_1 and β_2 measure the contribution of financial stress stemming from the United States and China, respectively. The residual ε_t can be interpreted as the component of financial stress that does not arise from the United States or China. We refer this as the domestic component. To include additional major trading partners for which financial stress may spillover, we consider the following second specification:

$$\text{AFSI}_t = \beta_0 + \beta_1 \text{FSI}_{US,t} + \beta_2 \text{FSI}_{China,t} + \beta_3 \text{FSI}_{Japan,t} + \beta_4 \text{FSI}_{SouthKorea,t} + \varepsilon_t. \tag{2}$$

Our estimates are reported in Table 5. The data covers the period from January 1995 to August 2020. Specifications (i) and (ii) estimate Equation 1, where (i) uses the STLFSI as a measure of financial stress in the US and specification (ii) uses the KCFSI as measure of financial stress in the US. Specification (iii) estimates Equation (2), using the STLFSI for financial stress in the US.[19]

As we can see from Table 5, the results are similar across the different specifications. Financial stress in Australia exhibits high correlation with financial stress in the US and to a somewhat lower extent with financial stress in China. In particular, a one unit increase in the STLFSI leads to a 0.79 unit increase in the AFSI, whereas a one unit increase in the CHFSI leads to a 0.24 unit increase in the AFSI in specification (iii). Financial stress in Japan and South Korea is not significantly correlated with financial stress in Australia, but including them in the regression yields a higher value of the adjusted R^2. Together, financial stress from abroad can explain more than half (57.4%) of the financial stress in Australia.

Figure 4 illustrates the results of the decomposition. The top panel shows the AFSI (blue) and the predicted contribution of financial stress arising from the United States, $\tilde{y_t}^1 = \beta_1 STLFSI_t$ (green). The second panel shows the AFSI (blue) and predicted contribution of financial stress emerging from China, $\tilde{y_t}^2 = \beta_2 CHFSI_t$ (green). The third and fourth panels show the AFSI (blue) and the predicted contribution of financial stress in Japan and South Korea, respectively. That is $\tilde{y_t}^3 = \beta_3 FSI_{Japan,t}$

[18]The financial stress indices for Japan and South Korea were obtained from the Asian Development Bank (Asia Regional Integration Center, 2021) and follows the methodology in Park and Mercado Jr (2014).

[19]Appendix C reports additional regression results.

	(i)	(ii)	(iii)
Intercept	0.0088	0.0466	0.0007
	(0.1016)	(0.1323)	(0.1155)
STLFSI	0.7436***		0.7885***
	(0.0736)		(0.0684)
KCFSI		0.6216***	
		(0.1214)	
CHFSI	0.2196***	0.3638***	0.2441***
	(0.0826)	(0.1128)	(0.0916)
Japan FSI			−0.0645
			(0.0645)
South Korea FSI			0.0281
			(0.0359)
Adjusted R^2	0.568	0.5015	0.5737
RMSE	0.676	0.8181	0.0117
N	308	308	308

Newey-West standard errors in parentheses. *** denotes statistical significance at the1% level.

Table 5: Regression results of the AFSI decomposition.

and $\tilde{y_t}^4 = \beta_4 FSI_{SouthKorea,t}$ in green. Finally, the bottom panel shows the domestic component, which is the residual, $y_t - \tilde{y_t}^1 - \tilde{y_t}^2 - \tilde{y_t}^3 - \tilde{y_t}^4$. Figure 4 highlights the results from Table 5. Financial stress in Australia shows high correlation with US and some correlation with financial stress in China. Financial stress in South Korea and Japan do not seem to contribute to financial stress in Australia markedly.

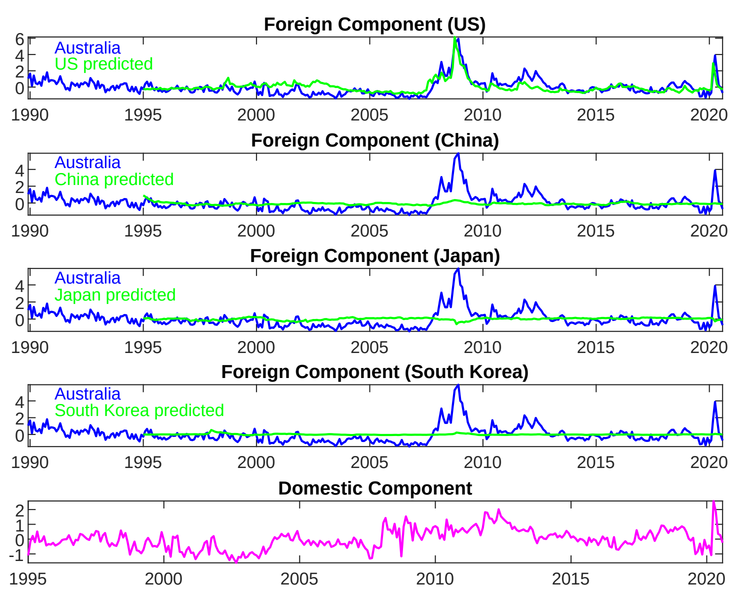

Figure 4: Foreign and domestic decomposition (Data source: Own calculation, FRED, Asian Development Bank).

4.2 The Covid-19 Pandemic

To capture the financial stress during the Covid-19 pandemic, we report the daily new confirmed Covid-19 cases in Australia as well as four measures of financial stress, namely the KCFSI, STLFSI, the FSI for Australia produced by the Asian Development Bank and our measure of the AFSI.[20] These different indices are depicted in Figure 5 together with the number of daily confirmed cases of Covid-19 in Australia.

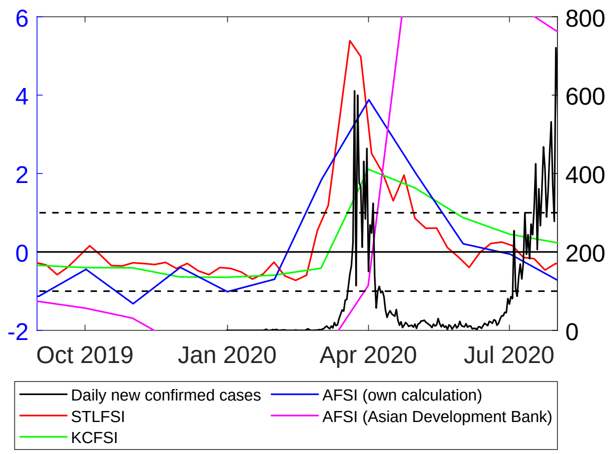

Figure 5: Financial stress indices and daily confirmed cases of Covid-19 (Data source: Own calculation, FRED, Asian Development Bank, Australian Department of Health).

As we can see from Figure 5, with the exception of the FSI produced by the Asian Development Bank, the indices show an increase in financial stress that coincides with the first wave of Covid-19 and a subsequent decrease to average levels of financial stress after that. The FSI obtained from the Asian Development Bank, however shows an sharp increase in financial stress only at the end of the first wave.

4.3 Comparison with Other Indices

Australian Economic Policy Uncertainty Index

We now consider the Australian economic policy uncertainty index (EPU) by Baker et al. (2016) as a broader alternative measure of financial stress. Figure 6 shows the AFSI relative to the EPU index for a period from January 1998 to August 2020.[21] In the following discussion, we also refer to Moore (2017) to identify specific Australian events. In particular, the letters (a) through (f) correspond to the following episodes of large increases of the economic policy uncertainty: (a) Close Australian election fought over goods and services tax introduction and Russian economic crisis; (b) the 9/11

[20] The Covid-19 case data is obtained through the Australian Department of Health.
[21] The data is taken from `www.policyuncertainty.com`

attacks; (c) the invasion of Iraq; (d) the great financial crisis; (e) Greek debt crisis, mining tax and carbon policy uncertainty; (f) United States debt ceiling dispute; (g) the Brexit vote, and (h) the beginning of the Covid-19 pandemic.

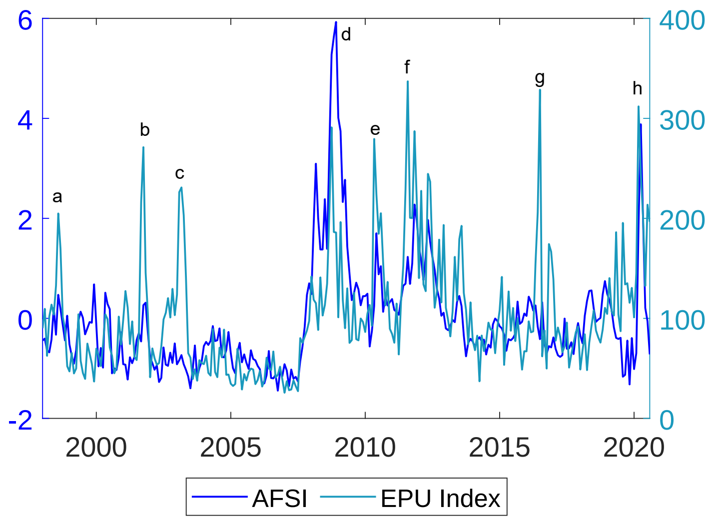

Figure 6: AFSI and economic policy uncertainty index (Data source: Own calculation, `www.policyuncertainty.com`).

As we can see from Figure 6, our estimates of heightened financial stress periods overlap with some periods of large increases in the Australian economic policy uncertainty. These instances are the great financial crisis (d) and the Covid-19 pandemic (h). For other periods of high economic policy uncertainty, such as the close Australian election fought over goods and services taxes (a), the Greek debt crisis and mining and carbon policy uncertainty (e) and the United States debt ceiling dispute (f), the AFSI shows somewhat elevated levels of financial stress . Lastly, some periods of higher economic policy uncertainty such as the Brexit vote (g), the 9/11 attacks (b), the invasion of Iraq (c) do not correspond to periods of higher financial stress as captured by the AFSI.

Asian Development Bank Index

Using Park and Mercado Jr (2014) methodology, the Asia Regional Integration Center of the Asian Development Bank tracks financial stress across several countries. In the case of Australia, the Asian Development Bank uses data on the relative volatility of the banking sector relative to equity markets (β, as defined above), changes in equity returns, equity volatility, sovereign debt spreads between the 10-year government bond yield and the 2-year government bond yield and changes in valuation of the domestic currency relative to the United States dollar (Asia Regional Integration Center, 2021). From now on we refer this index as AFSI-ADB. It is important to highlight that our measure of Australian financial stress index (AFSI) is likely to differ, since we include additional data. Figure 7 depicts the time series of these two financial stress indices.

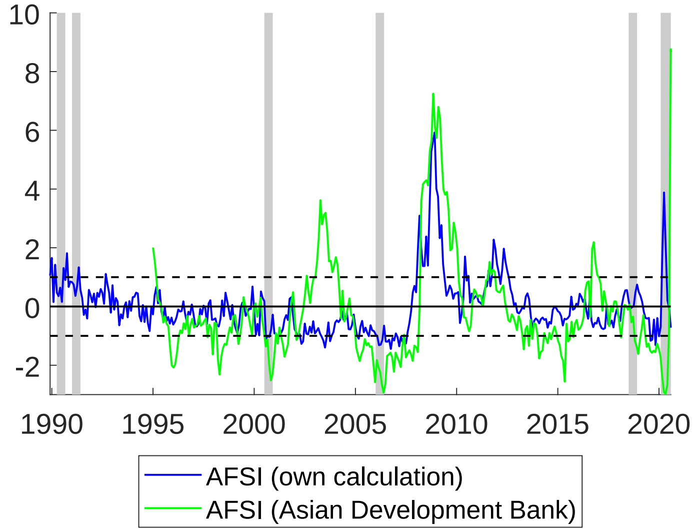

Figure 7: AFSI and AFSI-ADB by Asian Development Bank (Data source: Own calculation, Asian Development Bank).

As we can see from Figure 7 and Table 6, our measure of the Australian financial stress is highly correlated with the measure of financial stress in Australia developed by the Asian Development Bank. It is worth noting, however, that our measure imply lower financial stress during the 1995-1996, 2002-2003 and 2016-2017 periods. Moreover, in contrast to our AFSI, the Asian Development Bank index suggests that the financial stress during the Covid-19 pandemic is larger than the one experienced during the Global Financial Crisis.[22]

	AFSI-ADB
AFSI	0.64921
AFSI(-1)	0.6604

Table 6: Correlation between AFSI-ADB and AFSI and AFSI-ADB and lagged AFSI (Data source: Own calculation, Asian Development Bank).

5 The AFSI and Macroeconomic Outcomes

One of the advantages of measuring financial stress is that can capture disruptions in the normal functioning of financial markets that can lead to adverse real economic outcomes. This can occur in several ways. In times of increased uncertainty, firms and households may delay or reduce hiring,

[22]In Appendix D, we discuss the differences in our estimate of financial stress and the financial stress index from the Asian Development Bank in more detail.

investment, and spending. It is not too surprising then that financial stress, as measured by FSI, can forecast declines in economic activity.[23] We now examine the relationship between AFSI and various measures of economic activity. Finally, we also explore how AFSI shocks may affect and propagate in the economy.

5.1 Granger Causality Tests

Financial stress episodes are frequently connected with economic downturns. This is the case as they destabilize the financial system and hinder its ability to operate smoothly. Being able to asses whether the AFSI can be an early warning system and/or help improve forecasts of key macroeconomic indicators is of paramount importance. Next, we evaluate these possibilities by considering real GDP per capita growth, bank credit growth and the unemployment rate. Before doing so, Table 7 reports the different correlations between the AFSI and these observables.

(1) GDP per capita	(2) Bank credit	(3) UR_t	(4) UR_{t+15}	(5) UR_{t+37}
−0.3845	−0.2967	−0.0455	0.1550	0.1932

Table 7: Correlation between the AFSI, GDP per capita growth, bank credit growth and the unemployment rate (Data source: Own calculation, Australian Bureau of Statistics, Reserve Bank of Australia).

Unsurprisingly, Table 7 highlights that real GDP per capita growth is negatively correlated with our measure of financial stress. This indicates that periods of higher financial stress tend to be accompanied with lower real GDP per capita growth. Column (2) shows that the AFSI is negatively correlated with bank credit growth, indicating that bank credit growth tends to be lower in periods of financial stress. Finally, columns (3) through (5) in Table 7, we report the correlation between the AFSI and the unemployment rate (UR) for various time periods. The contemporaneous correlation with unemployment at t is negative. In contrast, the 15 and 37 months ahead unemployment rate relative to the AFSI at period t, is positive. This correlation increases with the number of unemployment lags.

GDP

We now examine the information content of the AFSI when it comes to aggregate economic performance. Figure 8 plots real GDP per capita growth and our AFSI from January 1990 to June 2020, where the grey bars indicate recessions in Australia.[24]

As we can see from Figure 8, our measures of higher than average financial stress periods in 1990/91, 2008, 2020 coincide with periods of lower real GDP per capita growth. However, we also

[23] We refer to Apostolakis and Papadopoulos (2019) for more on this topic.

[24] Since GDP is only available at a quarterly frequency, we take the mean of the values of the AFSI of each month within a quarter to create a quarterly time series of the AFSI.

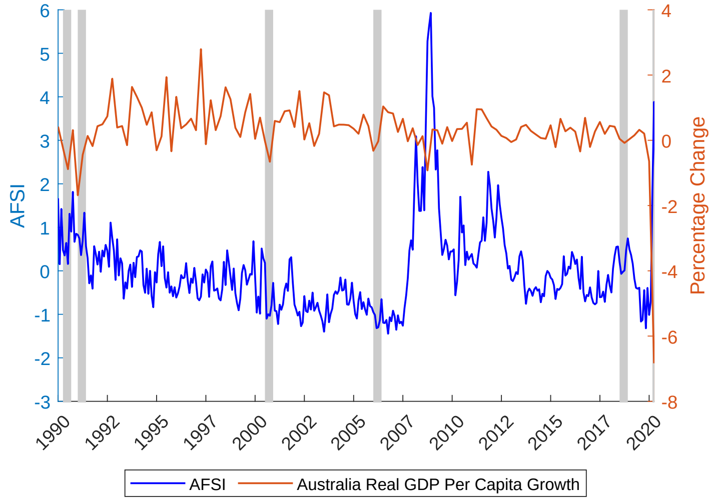

Figure 8: AFSI and real GDP per capita growth (Data source: Own calculation, Australian Bureau of Statistics).

find periods of lower real GDP per capital growth where we do not see a corresponding increase in the financial stress index. Such instances are the recessionary periods in 2000/01, 2006 and 2018/19.

Next, we run a Granger causality tests to determine whether including measures of the AFSI can improve the forecasts of real GDP per capita growth relative to a forecast that only includes its past values. The Null hypothesis is that the AFSI does not Granger-cause real GDP per capita growth. We fit a VAR(4) model to real GDP per capita growth and our financial stress index, where the number of lags was chosen based on the AIC criterion and the maximum number of lags was set to 4. The Granger causality tests are reported in Table 8.

	F-statistic	p-value
Exclude lagged AFSI in real GDP per capita growth equation	1.1214	0.2896
Exclude lagged real GDP per capita growth in AFSI equation	0.4742	0.4911

Table 8: Granger causality test for AFSI and real GDP per capita growth.

Our findings suggest that we cannot reject the null hypothesis that the AFSI does not Granger-cause real GDP per capita growth. Thus, our measure of the AFSI cannot improve forecasts of real GDP per capita growth relative to forecasts based on past realizations of real GDP per capita growth. One possible explanation for this finding is that in the case of Australia, an increase in financial stress does not always coincide with negative real GDP per capita growth, as is evident by Figure 1 in the period of the financial crisis in 2008. In addition, given that GDP data is quarterly monthly temporary financial disruptions may not be fully captured. Appendix E provides some robustness Granger tests for the AFSI, the underlying variables used to construct the AFSI and real GDP per capita growth as well as other credit measures.

Retail sales growth

To have more information on economic activity at a higher frequency, we consider monthly retail sales growth data.[25] To capture the information content of the AFSI, we estimate whether including the AFSI can improve the prediction of retail sales growth relative to using only previous values of retail sales growth. To do so we fit a VAR(4) model and conduct a Granger causality test.[26] The results are reported in Table 9.

	F-statistic	p-value
Exclude lagged AFSI in retail sales growth equation	12.947	0.0115
Exclude lagged retail sales growth in AFSI equation	3.6864	0.4501

Table 9: Granger causality test for AFSI and real GDP per capita growth.

Our results indicate that we can reject the null hypothesis that the AFSI does not Granger causes retail sales growth at the 5% significance level. Thus, we can conclude that the including the AFSI can improve predictions for retail sales growth. This suggests that the AFSI captures relevant information that is key for retail sales.

Loans

Another measure of economic activity that is widely used when assessing the performance of an economy is the volume of bank loans. During periods of financial stress and economic downturns, we expect bank credit growth to be lower relative to normal times. Figure 9 depicts the AFSI and monthly bank credit growth data.[27]

As we can see from Figure 9, the negative correlation is most evident in November 2008 and during the recessions of the 1990s. We, however, also observe periods without a negative correlation. For instance, during the onset of the Covid-19 pandemic, bank credit growth seems to have increased even though this was also a period of higher financial stress. One possible explanation for such anomaly is that the Reserve Bank of Australia implemented several relief programs in order to support bank lending.

Next, we perform the Granger causality test to determine if including financial stress, as measured by the AFSI, can improve forecasts of bank credit growth. We do so by fitting a VAR(4) model to the data, which is reported on Table 10.[28]

As we can see from Table 10, we can reject the null hypothesis that the AFSI does not Granger cause bank credit growth at the 1% significance level. Thus, we conclude that including the AFSI can improve forecasts of bank credit growth. Once again, this finding suggests that the AFSI captures relevant information that is key for the credit growth in an economy. Appendix E provides more Granger causality tests on the AFSI and other measures of credit.

[25] This data is taken from the Reserve Bank of Australia

[26] The number of lags was again selected based on the AIC criterion and the maximum number of lags was set to 4.

[27] The bank data is taken from the Reserve Bank of Australia.

[28] Again, the number of lags was selected with the AIC criterion and the maximum number of lags was set to 4.

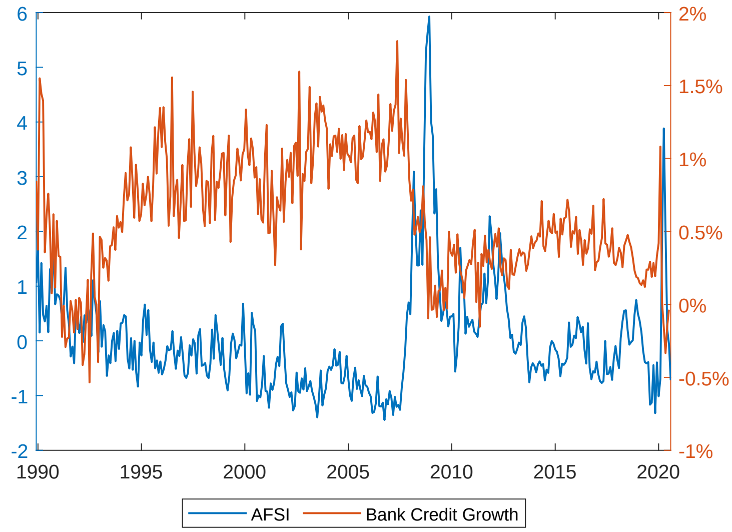

Figure 9: AFSI and bank credit growth (Data source: Own calculation, Reserve Bank of Australia).

	F-statistic	p-value
Exclude lagged AFSI in bank credit growth equation	34.861	0.0000
Exclude lagged bank credit growth in AFSI equation	2.1248	0.7128

Table 10: Granger causality test for AFSI and bank credit growth.

Unemployment

Lastly, we look how our measure of financial stress compares to the unemployment rate.[29] Figure 10 depicts the monthly unemployment rate in Australia together with the AFSI. Since GDP growth and unemployment tend to be negatively correlated and we have shown that our AFSI is negative correlated with GDP per capita growth, we expect a positive correlation.

As we can see from Figure 10, periods of higher unemployment tend to follow periods of financial stress with a lag. Table 11 reports the Granger causality test for our AFSI measure and the unemployment rate. To do so, we fit a VAR(14) model and test the hypothesis that the AFSI does not Granger cause unemployment.[30]

	F-statistic	p-value
Exclude lagged AFSI in unemployment rate equation	28.7975	0.0111
Exclude lagged unemployment rate in AFSI equation	25.823	0.0273

Table 11: Granger causality test for AFSI and unemployment rate.

Our finding suggest that we can reject the null hypothesis that the AFSI does not Granger cause

[29]The unemployment data is taken from the Australian Bureau of Statistics.

[30]The lag was again selected with the AIC criterion. The maximum number of lags was set equal to 40 to account for large lags visible in the data.

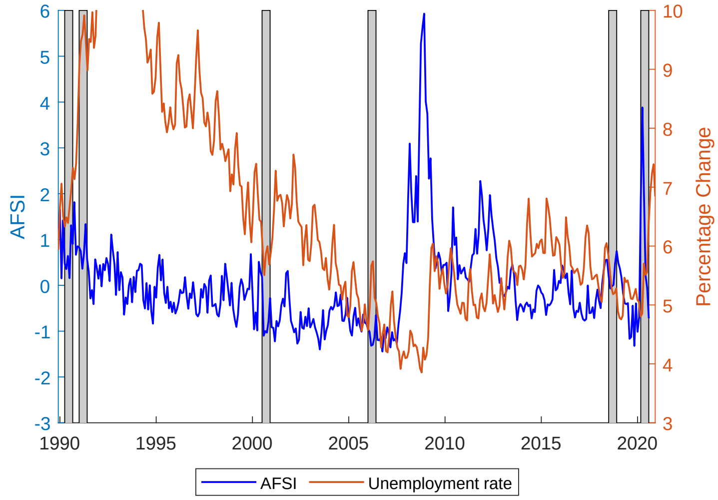

Figure 10: AFSI and unemployment rate (Data source: Own calculation, Australian Bureau of Statistics).

unemployment. Moreover, we also find that we can reject the null hypothesis that unemployment Granger causes financial stress. These results indicate a feedback loop and we therefore cannot argue that using the AFSI to predict unemployment does not provide a better forecast compared to a prediction using only passed values of unemployment.

5.2 Responses to an AFSI shock

In this section we estimate the effect of a financial stress shock, as measured by an increase in AFSI, to the unemployment rate, growth of bank loans, retail sales growth as a proxy for the real GDP per capita growth and the growth of the central bank balance sheet as a measure of monetary policy. In order to do so, we utilize a time-varying parameter (TVP) VAR model with stochastic volatility developed by Primiceri (2005) and Nakajima (2011). The TVP-VAR model has an advantage over the constant parameter VAR models in that it does not need to arbitrarily divide data into sub-samples to identify the change of structure of the model. Instead, the model allows both time variation in the simultaneous relations among variables. This can occur due to variations in the structural dynamic equations relating the various macroeconomic aggregates. It also allows heteroskedasticity in the innovations, which can be driven by changes in the size of exogenous shocks or their impact on macroeconomic variables.

A TVP-VAR model is estimated using monthly data from January 1990 to August 2020. The basic structural model is given by

$$A_t Y_t = F_{1,t} Y_{1,t-1} + \ldots + F_{s,t} Y_{s,t-s} + u_t; \tag{3}$$

where Y_t is a vector that includes the AFSI, growth of central bank balance sheet as a measure of monetary policy, credit growth, change of the unemployment rate and retail sales growth as a proxy for the real GDP per capita growth.[31] $A_t, F_{1,t}, ...F_{s,t}$ represent 5×5 matrices of coefficients that we are going to estimate. Finally, u_t is a 5×1 structural shock where $u_t \sim N(0, \Sigma_t \Sigma_t)$. We specify the simultaneous relations of the structural shocks by recursive identification, assuming that A_t is lower-triangular. More precisely, we have the following structure

$$\Sigma_t = \begin{pmatrix} \sigma_{1,t} & 0 & 0 & 0 & 0 \\ 0 & \sigma_{2,t} & 0 & 0 & 0 \\ 0 & 0 & \sigma_{3,t} & 0 & 0 \\ 0 & 0 & 0 & \sigma_{4,t} & 0 \\ 0 & 0 & 0 & 0 & \sigma_{5,t} \end{pmatrix} \quad \& \quad A_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21,t} & 1 & 0 & 0 & 0 \\ a_{31,t} & a_{32,t} & 1 & 0 & 0 \\ a_{41,t} & a_{42,t} & a_{43,t} & 1 & 0 \\ a_{51,t} & a_{52,t} & a_{53,t} & a_{54,t} & 1 \end{pmatrix}.$$

Note that equation (3) can be rewritten as follows

$$Y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t \quad \text{where} \quad X_t = I_5 \bigotimes (Y_{t-1}, \ldots, Y_{t-s}) \quad \text{and} \quad \varepsilon_t \sim N(0, I_5).$$

Following Primiceri (2005), let $a_t = (a_{21,t}, a_{31,t}, ..., a_{54,t})'$ be a stacked vector of the lower-triangular elements in A_t, and $h_t = (\log \sigma_{1,t}^2, ..., \log \sigma_{5,t}^2)'$. We further assume that the time-varying parameters follow a random walk process as follows

$$\beta_{t+1} = \beta_t + u_{\beta t}, \quad a_{t+1} = a_t + u_{at}, \quad h_{t+1} = h_t + u_{ht};$$

where the disturbances have the following structure

$$\begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N \left(0, \begin{pmatrix} I & O & O & O \\ O & \Sigma_\beta & O & O \\ O & O & \Sigma_a & O \\ O & O & O & \Sigma_h \end{pmatrix} \right).$$

We estimate the model using the Bayesian methods described as in Nakajima (2011) and choose the number of the VAR lags to be one.

Stochastic Volatility of the AFSI

First, we estimate the stochastic volatility of a financial stress shock from the period of January 1990 to August 2020. Figure 11 depicts our estimate and the associated standard deviation over time. The stochastic volatility has two episodes of increased volatility. One is during GFC in 2008 and at the beginning of 2020, right at the beginning the Covid-19 pandemic. The first spike in 2008 was followed by a period of higher than average volatility before dropping to pre-GFC period levels.

[31] We adjust central bank asset growth by retail sales growth in order to measure growth in central bank assets that is in excess of short-term fluctuations in economic activity.

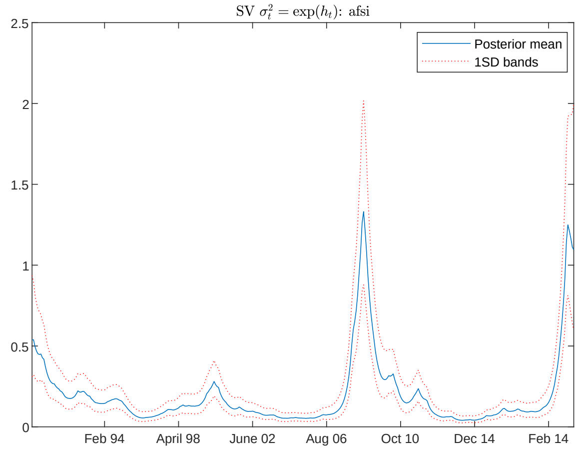

Figure 11: Posterior Estimate for Stochastic Volatility of Financial Stress Shock.

Impulse Responses

Next, we compute impulse response functions and compare the results to a financial stress shock for the periods in November 2005, November 2008 and March 2020.[32] We chose November 2005 to capture an environment before the global financial crises, where the Australian economy did not experience large disturbances. Not surprisingly, our measure of the AFSI exhibits low values of financial stress. To highlight the impact of financial disturbances and higher financial stress, we compare it to November 2008 and March 2020. The results are depicted in Figure 12.

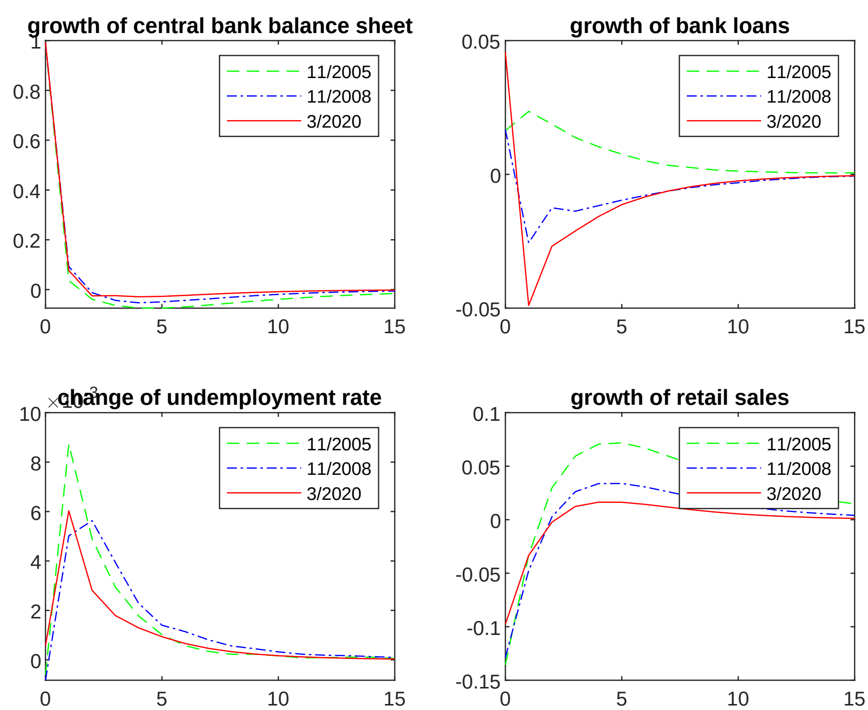

Figure 12: Impulse Responses to a Financial Stress Shock.

[32] Our results are robust to including two or three lags.

The first thing to note is that a financial stress shock has different effects to the growth of the central bank's balance sheet, credit growth, changes in the unemployment rate and retail sales growth. This depends on whether the economy is in a state of low financial stress or in a period of heightened financial stress. An increase in financial stress shock leads to an initial increase in the growth of the central banks balance sheet, followed by a gradual and significant decrease to negative values, and ultimately a return to zero. Similarly, credit growth increases initially as an increase of financial stress and then decreases over time. However, the magnitude of the increase in credit growth is lower during periods of low financial stress, and it eventually converges to zero. In contrast, during periods of high financial stress, credit growth experiences a sharper decrease after the initial increase, eventually leading to negative values, before converging back to zero. Moreover, the increase in the unemployment rate is less pronounced during periods of high financial stress than during periods of low financial stress. Lastly, an increase in financial stress initially results in a decline in retail sales growth, followed by a subsequent recovery over time. Specifically, during a period of low financial stress, retail sales growth surpasses the initial level before declining again.

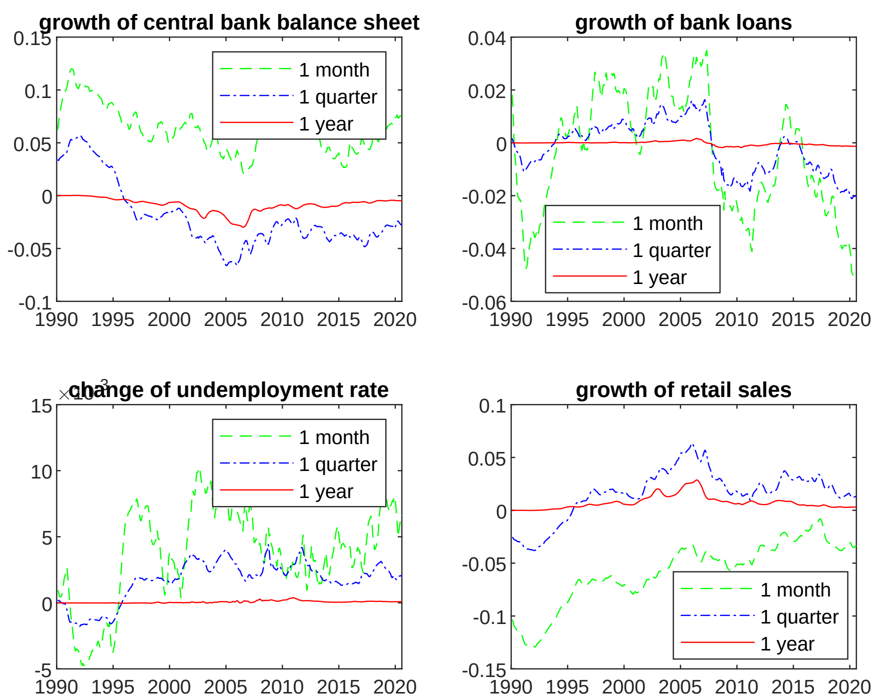

Figure 13: Time-varying Responses to a Financial Stress Shock for the Whole Sample

Next, we examine the iso-interval time-varying impulse responses for the whole sample period. Figure 13 illustrates the effect on central bank balance sheet growth, credit growth, change in the unemployment rate and retail sales growth one month after the shock (green), one quarter after the shock (blue) and one year after the shock (red) varies over time. Generally speaking, the effect of an increase in financial stress is larger in the short-run (one-month/ one quarter) compared to the one-year horizon. These results also highlight the importance of higher frequency data for a financial stress index. The growth of bank loans and unemployment rate are found to be sensitive to the level of financial stress. Specifically, high financial stress periods, such as the global financial crisis in 2008 and the onset of the pandemic in early 2020, are associated with a decrease in the growth of bank loans and a spike in unemployment rate. Conversely, during low financial stress periods, bank loans tend to increase and unemployment rate tends to decrease. The central bank balance sheet growth responds positively to a financial stress shock across all time horizons, while retail sales growth exhibits a consistently negative response. However, the magnitude of these impacts tends to weaken over time, with the effect becoming negligible after a year from the initial shock.

6 Conclusion

Theory and empirical findings have emphasized the strong and negative connection between stress episodes on the financial markets and financial and macroeconomic stability as well as their adverse impact on overall economic activity. Thus, it is important to continuously develop and improve tools for the timely capture of financial market disruptions. Within this spirit, in this paper we develop Australian Financial Stress Index (AFSI) that is based on monthly data on interest rate, spreads, volatility measures, exchange rates, housing price growth and inflation expectations. We find that the first four AFSI principal components are private bank's funding cost (first component), the safe and liquid asset and exchange rate (second component), the inflation expectation and the United States real sovereign debt spread (third component) as well as equity volatility (fourth component). A decomposition of the AFSI into foreign and domestic factors shows that more than half of financial stress in Australia can be attributed to financial stresses arising from external factors. We also show that the AFSI has relevant information content that might be of interest to both investors and policymakers. In particular, we find that the AFSI can improve forecasts for bank credit growth and retail sales growth relative to forecasts that only rely on past data. In our TVP-VAR analysis, we further show that financial stress can have non-linear effects on important macroeconomic aggregates. In particular, an increase in financial stress shock has more adverse effects on bank credit growth if disruption in financial markets, as measured by the AFSI, is high. The various findings regarding the information content of the AFSI further highlights the importance and usefulness of having a measure of financial stress that can be used by policy makers as timely signal of future economic activity.

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Appendix

A Data Series and Sources

Data Series	Data Source
Asian Development Bank FSI Australia	Asia Regional Integration Center, Asian Development Bank, https://aric.adb.org/database/fsi, accessed on September 13 2021.
ASX200 banking index	Global Financial Data: Global Financial Data_AXBAJD
ASX200 composite index	Global Financial Data: Global Financial Data_AXJOD
Australia CPI	Reserve Bank of Australia: Consumer Price Inflation G1 - GCPIAG
Australian GDP	Reserve Bank of Australia: Gross Domestic Product and Income H1 - GGDPCVGDP
Australian 3-month interbank rate (BBSW)	Global Financial Data: Global Financial Data_IBAUnited States 3D
Australian 3-month treasury bill yield	Global Financial Data: Global Financial Data_ITAUnited States 3D
BAB 3-month	Reserve Bank of Australia: Interest Rates and Yields Money Market - Monthly- F1.1FIRMMBAB90
Broad money growth	Reserve Bank of Australia: Monetary Aggregates - D3 - DMABMN
Cash Rate Target	Reserve Bank of Australia: Interest Rates and Yields Money Market - Monthly- F1.1 - FIRMMCRI
Central bank assets	Reserve Bank of Australia: Liabilities and Assets Detailed A1.1 - ARBAATAW
Commonwealth Government 5-year bond yield	Reserve Bank of Australia: Capital Market Yields Government Bonds - Monthly - F2.1 - FCMYGBAG5
Commonwealth Government 10-year bond yield	Reserve Bank of Australia: Capital Market Yields Government Bonds Monthly F2.1 - FCMYGBAG10
Credit	Reserve Bank of Australia: Lending and Credit Aggregates - Table D2
Credit growth	Reserve Bank of Australia: Growth in Selected Financial Aggregates - D1 - DGFACM
Daily confirmed Covid-19 cases in Australia	Our World in Data https://ourworldindata.org/explorers/coronavirus-data-explorer
Economic policy uncertainty index	https://www.policyuncertainty.com/, accessed on September 16 2021.
Effective exchange rate	Reserve Bank of Australia: Exchange Rates - Daily and Monthly - F11 - FXRTWI
Financial Stress Index for China	Asia Regional Integration Center, Asian Development Bank, https://aric.adb.org/database/fsi, accessed on September 13 2021.

Table 12: Data Series and Sources 1/2

Data Series	Data Source
Financial Stress Index for Japan	Asia Regional Integration Center, Asian Development Bank, https://aric.adb.org/database/fsi, accessed on October 20 2022.
Financial Stress Index for South Korea	Asia Regional Integration Center, Asian Development Bank, https://aric.adb.org/database/fsi, accessed on October 20 2022.
Housing price growth	Sirca: Sirca_CoreLogic_Hedonic Home Value_8 Combined Capital Cities[33]
Inflation indexed 10-year bond yield	Global Financial Data: Global Financial Data_IGAUnited States ID
Kansas City Fed Financial Stress idex	FRED, https://fred.stlouisfed.org/series/KCFSI, accessed September 13 2021.
Population in Australia	Australian Bureau of Statistics https://www.abs.gov.au/statistics/people/population
Retail sales growth	Reserve Bank of Australia: Monthly activity indicators H3 - GISSRTCYP
St. Louis Fed Financial Stress Index	FRED, https://fred.stlouisfed.org/series/STLFSI2, accessed September 13 2021.
United States 5-year government bond yield	FRED, Federal Reserve Bank of St. Louis: 5-Year Treasury Constant Maturity Rate [DGS5], https://fred.stlouisfed.org/series/DGS5, accessed September 13, 2021.
United States CPI	OECD (2021), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en, accessed on March 16, 2021.

Table 13: Data Series and Sources 2/2

[33] Sirca data was obtained by Pedro Gomis-Porqueras and Xuan Zhou under the purview of Deakin University licenses. The remaining co-author, Romina Ruprecht, did not have any unauthorized access to this data while working on this paper.

B Robustness tests with lagged variables

To test the robustness of the AFSI, we generate different stress indices, each with one variable lagged by one period. Figure 14 depicts the financial stress indices, each with one variable lagged for one period. Each of these indices exhibit a very similar pattern across time relative to the AFSI.

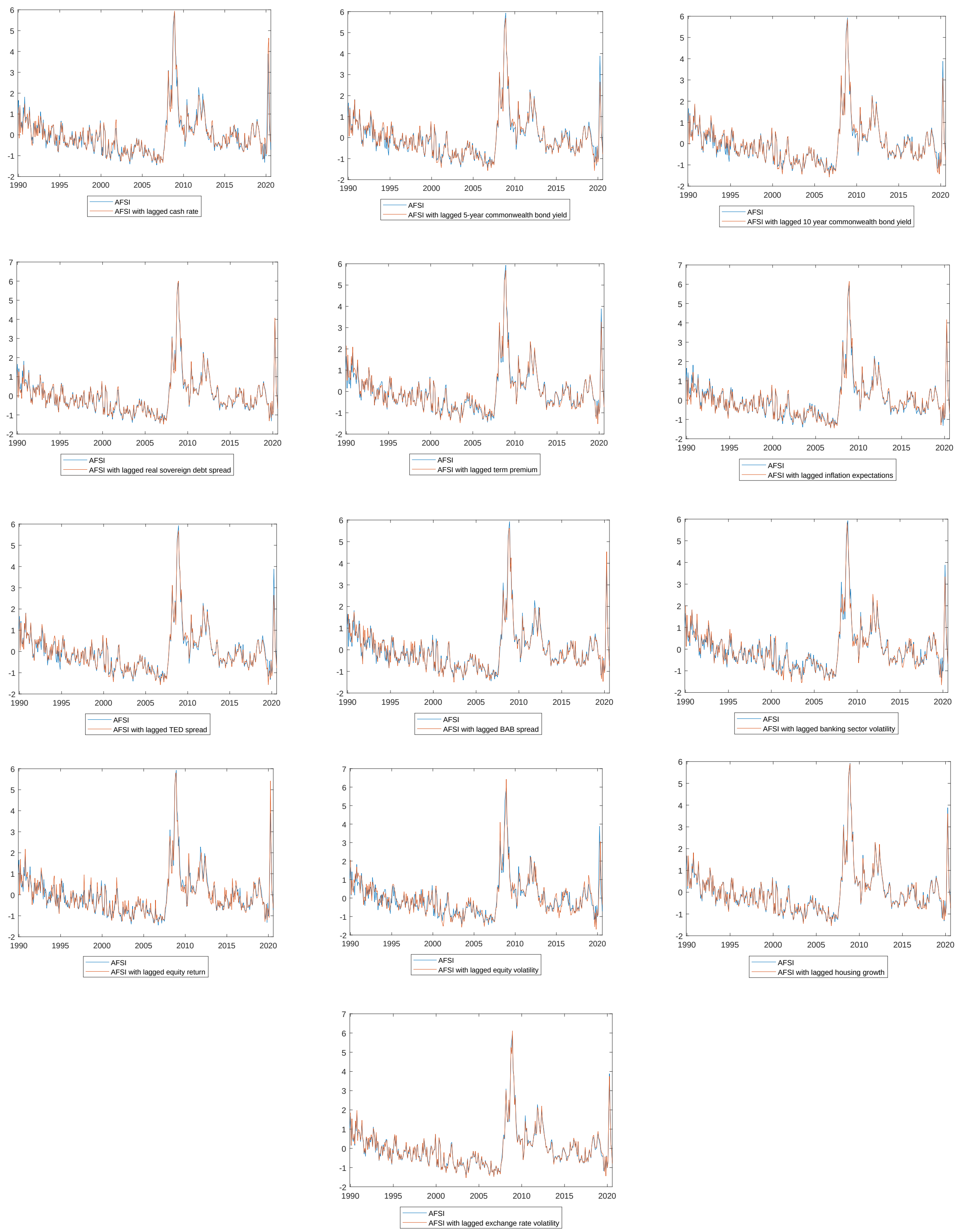

Figure 14: AFSI with lagged variables

C Decomposition robustness tests

Here, we provide some robustness tests for our decomposition results. In addition to financial stress indices from the US and China, we also include indices from Japan and South Korea (as computed by the Asian Development Bank) in our regression. Thus, we estimate the following regression:

$$\text{AFSI}_t = \beta_0 + \beta_1 \text{FSI}_{US,t} + \beta_2 \text{FSI}_{China,t} + \beta_3 \text{FSI}_{Japan,t} + \beta_4 \text{FSI}_{SouthKorea,t} + \varepsilon_t; \quad (4)$$

where the coefficients β_1 and β_2 measure the contribution of financial stress stemming from the United States and China, respectively and the coefficients β_3 and β_4 measure the contribution of financial stress from Japan and South Korea, respectively. The residual ε_t can be interpreted as the component of financial stress that does not arise from the United States, China, Japan and South Korea. We refer this as the domestic component. The data covers a period from January 1995 to August 2020. Our results are reported in Table 14. Regression (i) and (ii) report the results using the stress indices from the US and China, where (i) includes the STLFSI and (ii) includes the KCFSI as in the main text. Regression (iii) includes the stress index for Japan and Regression (iv) includes the stress index for South Korea. Regression (v) includes indices for the US, China, Japan and South Korea. Specifications (i), (ii) and (v) are presented in the main text. We replicate them here for convenience.

As Table 14 shows, adding the financial stress index for Japan or South Korea individually does not materially improve the results relative to specification (i), as both the adjusted R^2 is lower and the RSME is higher in those specifications.

	(i)	(ii)	(iii)	(iv)	(v)
Intercept	0.0088	0.0466	0.0012	0.0089	0.0007
	(0.1016)	(0.1323)	(0.1198)	(0.1118)	(0.1155)
STLFSI	0.7436***		0.7948***	0.7419***	0.7885***
	(0.0736)		(0.0734)	(0.0752)	(0.0684)
KCFSI		0.6216***			
		(0.1214)			
CHFSI	0.2196***	0.3638***	0.228***	0.2204***	0.2441***
	(0.0826)	(0.1128)	(0.0901)	(0.0854)	(0.0916)
Japan FSI			−0.0448		−0.0645
			(0.051)		(0.0645)
South Korea FSI				0.0018	0.0281
				(0.021)	(0.0359)
Adjusted R^2	0.568	0.5015	0.5724	0.5666	0.5737
RMSE	0.1538	0.8181	0.0212	0.1569	0.0117
Number of observations	308	308	308	308	308

Newey-West standard error are in parantheses. *** denotes statistical significance at the 1% level

Table 14: Regression results of the AFSI decomposition.

D Robustness tests with the financial stress for Australia from the Asian Development Bank

In this section, we test how our estimate of financial stress in Australia compares to the financial stress index for Australia from the Asian Development Bank. Table 15 shows the correlations of the Australian financial stress index from the Asian Development Bank (ADB AFSI) with real GDP per capita, bank credit and unemployment including lags of 15 months and 37 months.

(1)	(2)	(3)	(4)	(5)
real GDP per capita	Bank credit	UR_t	UR_{t+15}	UR_{t+37}
0.0882	−0.3054	−0.1019	−0.1184	−0.1727

Table 15: Correlation between the ADB AFSI, GDP per capita growth, bank credit growth and the unemployment rate

Compared to our measure of financial stress in Australia, the ADB FSI exhibits a lower correlation with real GDP per capita growth GDP and bank credit growth, whereas the correlation with contemporaneous unemployment is higher. Moreover, the ADB FSI seems to exhibit a positive correlation with GDP and a negative correlation with unemployment across all lags, whereas our estimate of the AFSI exhibits negative correlation with real GDP per capita growth and a positive correlation with unemployment after 15 months. Intuitively, we would expect that financial stress that affects the economy negatively would be negatively correlated with real GDP per capita growth and positive correlated with unemployment.

Table 16-19 show Granger causality tests for the ADB with real GDP per capita growth, bank credit, unemployment and retail sales growth. Lags were chosen based on the AIC criterion, where the maximum number of lags was set to 4 for real GDP per capita growth, credit growth and retail sales growth and to 40 for the unemployment rate.

	F-statistic	p-value
Exclude lagged ADB FSI in real GDP per capita growth equation	0.7683	0.6810
Exclude lagged real GDP per capita growth in AFSI equation	5.6738	0.0581

Lags: 2.

Table 16: Granger causality test for the ADB FSI and real GDP per capita growth

	F-statistic	p-value
Exclude lagged ADB FSI in bank credit growth equation	19.218	0.0007
Exclude lagged bank credit growth in AFSI equation	7.0386	0.1339

Lags: 4.

Table 17: Granger causality test for the ADB FSI and bank credit growth

Based on these results, we can reject the Null hypothesis that the ADB FSI does not Granger cause credit growth and the unemployment rate. Therefore including the ADB FSI can improve forecasts of credit growth and the unemployment rate relative to forecasts based solely on previous values of credit growth and the unemployment rate, respectively. Compared to our estimate of financial stress in Australia (AFSI), we however cannot reject the Null hypothesis that the ADB FSI Granger causes

	F-statistic	p-value
Exclude lagged ADB FSI in unemployment rate equation	30.221	0.0071
Exclude lagged unemployment rate in AFSI equation	8.8335	0.8416

Lags: 14.

Table 18: Granger causality test for the ADB FSI and the unemployment rate

	F-statistic	p-value
Exclude lagged ADB FSI in retail sales growth equation	21.162	0.0003
Exclude lagged retail sales growth in AFSI equation	15.029	0.0046

Lags: 4.

Table 19: Granger causality test for the ADB FSI and retail sales growth

retail sales growth. Thus, the AFSI has similar results compared to the ADB FSI with respect to credit growth and real GDP per capita growth.

E Granger causality tests for variables used to construct AFSI

We furthermore test how well our estimate of financial stress in Australia does compared to using single variables that are used to construct the AFSI to predict economic outcomes. We first test each of the 13 variables against real GDP per capita growth, using quarterly averages of the monthly values of the 13 variables used to construct the AFSI. The results are reported in Table 20. Lags are selected based on the AIC criterion with the maximum number of lags set to 4. All significant results that we discuss refer to significance at the 5% significance level.

Based on these results, we find that we can reject the Null hypothesis that a given variable does not Granger cause real GDP per capita growth for changes in the cash rate, changes in the 5-yer commonwealth bond yield, housing growth and the S&P / ASX return. To study how the AFSI compares relative to those four variables, we also test if any of these variables can Granger cause a series of financial variables, including credit growth, loans and advances by banks, loans and advances by non-banking financial institutions (NBFI), loans and advances by authorized financial institutions (AFI), narrow credit, personal credit and lending to the government by AFI.[34] Table 21 reports the results of the Granger causality tests for the AFSI and credit measures. Tables 22 - 25 report the Granger causality tests for changes in the cash rate, changes in the 5-year commonwealth bond yield, housing price growth and ASX return; and credit measures.

Table 22 shows that for six of the seven credit measures used in the Granger causality test, we can reject the Null hypothesis that changes in the cash rate does not Granger cause the given credit measure. However, we can also reject the Null hypothesis that the given credit measure does not Granger cause the cash rate. From Table 23, we find that for changes in the 5-year commonwealth bond yield, we can reject the Null hypothesis that changes the 5-year commonwealth bond yield does not Granger cause credit growth and lending to the government by AFI. Next, Table 24 shows the Granger causality test results for housing price growth. We find that we can reject the Null hypothesis that housing price growth does not Granger cause credit growth, loans and advances from banks, loans and advances from AFI and narrow credit. Finally, from Table 25, we find that we can reject the Null hypothesis that the ASX return does not Granger cause credit growth, loans and advances from banks and personal credit. In comparison, from Table 21, we find that we can reject the Null hypothesis that the AFSI does not Granger cause credit growth, loans and advances from NBFI, personal credit and lending to the government by AFI. Thus, in comparison we find that changes in the cash rate and changes in the 5-year commonwealth bond yield can explain less in credit measure relative to our index. Housing price and growth and ASX returns can explain more variables that capture credit measures, the main difference being that both housing price growth and ASX returns seem to Granger cause loans and advances by banks, whereas the AFSI seems to Granger cause loans and advances by NBFI.

[34] Data on different measures of credit are taken from the table Lending and Credit Aggregates (D2) from the Reserve Bank of Australia. Data on credit growth is taken from the table Growth in Selected Financial Aggrages (D1) from the Reserve Bank of Australia. AFI refers to authorized deposit-taking institutions and non-authorized deposit-taking institutions. Banks refer to authorized deposit-taking institutions, which includes banks, credit unions and building societies. NBFI refers non-authorized deposit-taking institutions, which includes money market corporations, finance companies and securitisers as well as issuers and funds managers (See `https://www.rba.gov.au/fin-stability/fin-inst/main-types-of-financial-institutions.html`). Narrow credit includes both loans and advances from AFI plus bill acceptances. Personal credit refers to credit to households that are not mortgages.

Variable	Test	F-statistic	p-value
Changes in cash rate	Exclude lagged cash rate in real GDP per capita growth equation	8.3501	0.0039
	Exclude lagged real GDP per capita growth in cash rate equation	0.6653	0.4147
	Lags: 1		
Changes in 5-year commonwealth bond yield	Exclude lagged 5-year bond yield in real GDP per capita growth equation	8.979	0.0027
	Exclude lagged real GDP per capita growth in 5-year bond yield equation	1.3761	0.2408
	Lags: 1		
Changes in 10-year commonwealth bond yield	Exclude lagged 10-year bond yield in real GDP per capita growth equation	3.3197	0.0685
	Exclude lagged real GDP per capita growth in 10-year bond yield equation	0.4313	0.5113
	Lags: 1		
Real sovereign debt spread	Exclude lagged debt spread in real GDP per capita growth equation	4.0884	0.3942
	Exclude lagged real GDP per capita growth in debt spread equation	15.702	0.0034
	Lags: 4		
Inflation expectation	Exclude lagged inflation exp. in real GDP per capita growth equation	1.6659	0.4348
	Exclude lagged real GDP per capita growth in inflation exp. equation	3.6437	0.1617
	Lags: 2		
Term premium	Exclude lagged term premium in real GDP per capita growth equation	2.1975	0.3333
	Exclude lagged real GDP per capita growth in term premium equation	1.0506	0.5914
	Lags: 2		
TED spread	Exclude lagged TED spread in real GDP per capita growth equation	1.2575	0.5333
	Exclude lagged real GDP per capita growth in TED spread equation	0.4701	0.7906
	Lags: 2		
BAB spread	Exclude lagged BAB spread in real GDP per capita growth equation	2.4306	0.1190
	Exclude lagged real GDP per capita growth in BAB spread equation	1.0463	0.3064
	Lags: 1		
Housing growth	Exclude lagged housing growth in real GDP per capita growth equation	10.969	0.0119
	Exclude lagged real GDP per capita growth in housing growth equation	3.6157	0.3061
	Lags: 3		
S&P / ASX return	Exclude lagged ASX return in real GDP per capita growth equation	7.2761	0.0070
	Exclude lagged real GDP per capita growth in ASX return equation	0.4926	0.4828
	Lags: 1		
S&P / ASX volatility	Exclude lagged ASX volatility in real GDP per capita growth equation	1.4192	0.2335
	Exclude lagged real GDP per capita growth in ASX volatility equation	0.8781	0.3487
	Lags: 1		
Banking volatility	Exclude lagged banking volatility in real GDP per capita growth equation	4.2863	0.1173
	Exclude lagged real GDP per capita growth in banking volatility equation	2.7976	0.2469
	Lags: 2		
Exchange rate volatility	Exclude lagged exchange rate vol. in real GDP per capita growth equation	0.0158	0.9000
	Exclude lagged real GDP per capita growth in exchange rate vol. equation	0.0214	0.8837
	Lags: 1		

Table 20: Granger causality test for variables used to construct the AFSI and real GDP per capita growth

Variable	Test	F-statistic	p-value
Credit growth	Exclude lagged AFSI in credit growth equation	34.861	0.0000
	Exclude lagged credit growth in AFSI equation	2.1248	0.7128
	Lags: 4		
Loans and advances - banks	Exclude lagged AFSI in bank loans equation	26.21	0.0000
	Exclude lagged bank loans in AFSI equation	23.83	0.0001
	Lags: 4		
Loans and advances - NBFI	Exclude lagged AFSI in NBFI loans equation	8.6144	0.0033
	Exclude lagged NBFI loans in AFSI equation	2.6829	0.1014
	Lags: 1		
Loans and advances - AFI	Exclude lagged AFSI in AFI loans equation	18.504	0.0010
	Exclude lagged AFI loans in AFSI equation	14.385	0.0062
	Lags: 4		
Narrow credit	Exclude lagged AFSI in narrow credit equation	18.54	0.0010
	Exclude lagged narrow credit in AFSI equation	12.355	0.0149
	Lags: 4		
Credit, other - personal	Exclude lagged AFSI in personal credit equation	31.321	0.0000
	Exclude lagged personal credit in AFSI equation	1.5569	0.2121
	Lags: 1		
Lending to government by AFI	Exclude lagged AFSI in government lending equation	12.296	0.0005
	Exclude lagged government lending in AFSI equation	0.0663	0.7967
	Lags: 1		

Table 21: Granger causality test for the AFSI and credit measures

Variable	Test	F-statistic	p-value
Credit growth	Exclude lagged cash rate in credit growth equation	27.95	0.0000
	Exclude lagged credit growth in cash rate equation	23.985	0.0001
	Lags: 4		
Loans and advances - banks	Exclude lagged cash rate in bank loans equation	44.838	0.0000
	Exclude lagged bank loans in cash rate equation	20.718	0.0004
	Lags: 4		
Loans and advances - NBFI	Exclude lagged cash rate in NBFI loans equation	3.8383	0.4283
	Exclude lagged NBFI loans in cash rate equation	18.59	0.0009
	Lags: 4		
Loans and advances - AFI	Exclude lagged cash rate in AFI loans equation	39.643	0.0000
	Exclude lagged AFI loans in cash rate equation	12.767	0.0125
	Lags: 4		
Narrow credit	Exclude lagged cash rate in narrow credit equation	36.828	0.0000
	Exclude lagged narrow credit in cash rate equation	12.156	0.0162
	Lags: 4		
Credit, other - personal	Exclude lagged cash rate in personal credit equation	11.805	0.0081
	Exclude lagged personal credit in cash rate equation	8.429	0.0379
	Lags: 3		
Lending to government by AFI	Exclude lagged cash rate in government lending equation	21.457	0.0000
	Exclude lagged government lending in cash rate equation	6.8871	0.0087
	Lags: 1		

Table 22: Granger causality test for changes in the cash rate and credit measures

Variable	Test	F-statistic	p-value
Credit growth	Exclude lagged 5-year bond yield in credit growth equation	11.987	0.0175
	Exclude lagged credit growth in 5-year bond yield equation	8.8068	0.0661
	Lags: 4		
Loans and advances - banks	Exclude lagged 5-year bond yield in bank loans equation	25.813	0.0000
	Exclude lagged bank loans in 5-year bond yield equation	9.8454	0.0431
	Lags: 4		
Loans and advances - NBFI	Exclude lagged 5-year bond yield in NBFI loans equation	4.9932	0.1723
	Exclude lagged NBFI loans in 5-year bond yield equation	49.908	0.0000
	Lags: 3		
Loans and advances - AFI	Exclude lagged 5-year bond yield in AFI loans equation	15.267	0.0042
	Exclude lagged AFI loans in 5-year bond yield equation	28.844	0.0000
	Lags: 4		
Narrow credit	Exclude lagged 5-year bond yield in narrow credit equation	13.441	0.0093
	Exclude lagged narrow credit in 5-year bond yield equation	28.572	0.0000
	Lags: 4		
Credit, other - personal	Exclude lagged 5-year bond yield in personal credit equation	2.2005	0.6989
	Exclude lagged personal credit in 5-year bond yield equation	26.14	0.0000
	Lags: 4		
Lending to government by AFI	Exclude lagged 5-year bond yield in government lending equation	5.0394	0.0248
	Exclude lagged government lending in 5-year bond yield equation	3.4743	0.0623
	Lags: 1		

Table 23: Granger causality test for changes in the 5-year commonwealth bond yield and credit measures

Variable	Test	F-statistic	p-value
Credit growth	Exclude lagged housing price growth in credit growth equation	12.705	0.0128
	Exclude lagged credit growth in housing price growth equation	2.5818	0.6301
	Lags: 4		
Loans and advances - banks	Exclude lagged housing price growth in bank loans equation	23.775	0.0001
	Exclude lagged bank loans in housing price growth equation	5.3437	0.2538
	Lags: 4		
Loans and advances - NBFI	Exclude lagged housing price growth in NBFI loans equation	1.4773	0.6875
	Exclude lagged NBFI loans in housing price growth equation	6.8595	0.0765
	Lags: 3		
Loans and advances - AFI	Exclude lagged housing price growth in AFI loans equation	14.563	0.0022
	Exclude lagged AFI loans in housing price growth equation	1.8113	0.6125
	Lags: 3		
Narrow credit	Exclude lagged housing price growth in narrow credit equation	15.062	0.0046
	Exclude lagged narrow credit in housing price growth equation	3.3367	0.5032
	Lags: 4		
Credit, other - personal	Exclude lagged housing price growth in personal credit equation	11.059	0.0259
	Exclude lagged personal credit in housing price growth equation	11.587	0.0207
	Lags: 4		
Lending to government	Exclude lagged housing price growth in government lending equation	2.0419	0.5638
by AFI	Exclude lagged government lending in housing price growth equation	1.5009	0.6821
	Lags: 3		

Table 24: Granger causality test for housing price growth and credit measures

Variable	Test	F-statistic	p-value
Credit growth	Exclude lagged ASX return in credit growth equation	21.404	0.0003
	Exclude lagged credit growth in ASX return equation	0.7333	0.9472
	Lags: 4		
Loans and advances - banks	Exclude lagged ASX return in bank loans equation	12.991	0.0113
	Exclude lagged bank loans in ASX return equation	8.7163	0.0686
	Lags: 4		
Loans and advances - NBFI	Exclude lagged ASX return in NBFI loans equation	1.1027	0.2937
	Exclude lagged NBFI loans in ASX return equation	3.1189	0.0774
	Lags: 1		
Loans and advances - AFI	Exclude lagged ASX return in AFI loans equation	8.6704	0.0699
	Exclude lagged AFI loans in ASX return equation	7.5614	0.1090
	Lags: 4		
Narrow credit	Exclude lagged ASX return in narrow credit equation	8.5014	0.0748
	Exclude lagged narrow credit in ASX return equation	7.2179	0.1248
	Lags: 4		
Credit, other - personal	Exclude lagged ASX return in personal credit equation	7.2015	0.0273
	Exclude lagged personal credit in ASX return equation	1.7555	0.4157
	Lags: 2		
Lending to government	Exclude lagged ASX return in government lending equation	0.0513	0.8208
by AFI	Exclude lagged government lending in ASX return equation	0.0869	0.7681
	Lags: 1		

Table 25: Granger causality test for ASX return and credit measures