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Does linkage fuel the fire? The transmission of financial stress across the markets<sup>☆</sup>Frankie Chau<sup>\*</sup>, Rataporn Deesomsak

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## ABSTRACT

This paper develops an indicator of financial stress transmission, called Financial Stress Spillover Index (FSSI), to monitor the condition of financial system and to identify periods of excessive spillover that may lead to financial instability. Specifically, using the “spillover index” approach of Diebold and Yilmaz (2012), we modify and extend the financial stress indices proposed by Oet et al. (2011) to track both *total* and *directional* stress spillovers across the U.S. equity, debt, banking, and foreign exchange markets. Unlike other previous studies, the important linkages among these four major financial sectors in an interconnected world are directly taken into account by considering the average and time-varying connectedness of each individual market. The evidence suggests that there are important stress episodes and fluctuations across markets; the total cross-market stress spillovers were rather limited until the onsets of financial crises. As the crises intensified, so too did the financial stress spillovers; with significant stress carrying over from debt and equity markets to the others. In addition, our results indicate that FSSI has a significant predictive power for the economic activity and provides useful information for dating financial crises.

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## 1. Introduction

The global financial crisis has contributed to the meltdowns of financial markets and the continued economic downturns around the world, and has increased the attention of academics and policymakers on financial stability (Holló, Kremer, & Duca, 2012; Oet, Eiben, Bianco, Gramlich, & Ong, 2011). The Chairman of the Federal Reserve Board of Governors, for instance, recently emphasized that “*The crisis has forcefully reminded us that the responsibility of central banks to protect financial stability is at least as important as the responsibility to use monetary policy effectively in the pursuit of macroeconomic objectives.*”<sup>1</sup> This has in turn motivated many central banks and financial authorities throughout the world to develop a range of indicators to help them monitor and assess the current state of instability or “stress” in the financial system, and take an appropriate regulatory action as necessary. Such a real-time monitoring and early detection system is very important and is considered as the necessary first step in the development of

an “early warning system”, giving policymakers time to prevent or mitigate a potential financial crisis, and to counteract its effects on the economy.<sup>2</sup>

Previous attempts in the development of stress indicators have focused primarily on a range of methodological issues relating to (i) the selection and transformation of relevant variables, (ii) frequency of data, (iii) aggregation methods, and (iv) assessment criteria for the proposed indices (Ishikawa et al., 2012; Louzis & Vouldis, 2011). Most of these studies utilize the market-based or balance sheet data to construct indicators for several different financial sectors and then aggregate them into a composite index of systemic stress to provide critical insights into the “aggregate” level of strains and imbalance in the whole financial system.<sup>3</sup> According to Louzis and Vouldis (2011), there are as many as 13 financial stress indices of varying frequency currently available for tracking the level of stresses in the financial systems around the globe.<sup>4</sup> One of the first and most influential composite indices of financial stress was introduced by Illing and Liu (2006). They constructed a daily financial stress

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<sup>1</sup> “The Effects of the Great Recession on Central Bank Doctrine and Practice.”, Ben S. Bernanke (2011), The Federal Reserve Bank of Boston, 56th Economic Conference.

<sup>2</sup> Oet et al. (2013) present an example of such “early warning systems” designed for the identification of systemic banking risk in the U.S. financial system., which they refer to as “SAFE” (Systemic Assessment of Financial Environment).

<sup>3</sup> Although there is no consensus on the precise definition of financial stress, it is usually interpreted as “*the risk that financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially*” (Holló et al., 2012, p. 8).

<sup>4</sup> See Louzis and Vouldis (2011) and Ishikawa et al. (2012) for more detailed reviews on the constructions and the desirable features of different financial stress measures that are currently available in the literature.

index for Canadian financial system by exploring several different ways of combining raw variables into a composite index (e.g., variance-equal weighting and principal component methods); and selected the indicator that performs best in capturing crisis events identified by an internal survey within the Bank of Canada. Another composite index of financial stress that has attracted widespread attention is the one developed by Hakkio and Keeton (2009). Following the approach of Illing and Liu (2006), they used principal component analysis of 11 variables to create a monthly index for the U.S. economy in order to capture the essential features of a financial crisis. Using the variance-equal weighting of 12 standardized financial variables, Caldarelli, Elekdag, and Lall (2011) at the International Monetary Fund (IMF) compute a monthly financial stress index for seventeen advanced economies. Building on a probit regression of 16 financial market indicators, Grimaldi (2010) from the European Central Bank (ECB) presents a similar weekly financial stress index for the euro area. In a study directly related to this paper, economists at the Federal Reserve Bank of Cleveland (Oet et al., 2011) integrate 11 market-based variables from four most important segments of the financial system (equity, debt, banking, and foreign exchange markets). A separate financial stress index is calculated for each of these four sectors before aggregating the individual sub-indices into a composite index (the Cleveland Financial Stress Index, CFSI) by applying the time-varying credit weighting method.

Evidently, since the global financial and economic crisis, the development of financial stress measures has been an expanding area for both academic and regulatory research. However, despite the widespread attention given to the development of financial stress index, the majority of studies have focused exclusively on constructing an “aggregate” index in assessing the overall level of stress in the global financial system. With an exception of Oet et al. (2011), there has been little research on designing a financial stress indicator for each of the four important sectors in a well-functioning financial system (equity, debt, banking, and foreign exchange markets), and in particular we can identify only a limited number of studies on the potential interaction and transmissions of financial stresses across these major sectors.<sup>5</sup> This is somewhat surprising given the growing concern that “*financial stress is more systemic and thus more dangerous for the economy as a whole if financial instability spreads more widely across the whole financial system*” (Holló et al., 2012, p. 1).<sup>6</sup>

In order to address some of these issues, this paper builds on the work of Oet et al. (2011) and Diebold and Yilmaz (2012) and proposes an indicator of financial stress transmission, which we call “Financial Stress Spillover Index (FSSI)”, to assess the condition of financial system and to identify periods of excessive spillover that may lead to financial instability. Specifically, using the “spillover index” approach of Diebold and Yilmaz (2012), we modify and extend the financial stress indices proposed by Oet et al. (2011) to track both the *total* and *directional* stress spillovers across the U.S. equity, debt, banking, and foreign exchange markets. In contrast to other studies (including Oet et al., 2011), the important linkages among the major financial sectors in an interconnected world are directly taken into account in this paper by considering the average and time-varying interconnectedness of each individual market’s stress indicators.

Taken together, this paper adds to the existing literature in a number of ways. First, unlike other previous studies, we develop an index of

<sup>5</sup> Louzis and Vouldis (2011) and Holló et al. (2012) are other studies in the extant literature that have attempted to incorporate the possible interaction of financial stresses between different market segments by aggregating individual stress indicators from the perspective of standard portfolio theory. However, they only considered the cross-correlations between individual stress indicators and, thus, did not directly address the nature and direction of stress transmissions or spillovers. More importantly, the “origin” of financial stress is not clearly identified.

<sup>6</sup> A study by the economists at the International Monetary Fund (IMF, 2009) “How linkage fuel the fire: the transmission of financial stress from advanced to emerging economies” finds that financial crises in advanced economies have passed through strongly and quickly to emerging economies.

financial stress that incorporates the interconnectedness and spillover of stress across major market segments to provide an early warning system for emergent financial crisis. Second, this paper presents the first attempt to identify the “origin” of systemic stress by estimating “directional” FSSI and to detect the so-called systemically important financial markets. Third, given the evolutionary nature of financial stress, the conditional version of our FSSI tracks the time-varying movements of both total and directional stress spillovers. Finally, the FSSI introduced in this paper provides policymakers and regulators with useful information for dating financial crisis and predicting economic activity.

The findings of this paper are important in understanding the level and transmission mechanism of financial stress across the major market segments and are of significant relevance to the market regulators in formulating effective policies to tackle financial stress transmission, particularly during the turbulence periods. However, we also question how the ‘scapegoating’ of one particular financial sector might serve to distract attention both from the failings of other sectors and from the central problems inherent in the operations and interconnectedness of the financial system as a whole.

The remainder of the paper is organised as follows. Section 2 describes the data and methodology, and examines both conditional and unconditional transmissions of financial stress across markets. Section 3 evaluates the practical applications of our FSSI in dating the past episodes of financial stress and in predicting future economic activity. The channels through which the transmission of financial stress can affect economic activity are also examined in this section. Finally, Section 4 concludes the paper.

## 2. Construction of Financial Stress Spillover Index (FSSI)

Motivated by the extant financial stress literature, and using the financial stress indices of Oet et al. (2011) and the spillover index methodology proposed by Diebold and Yilmaz (2012), this section constructs an indicator named Financial Stress Spillover Index (FSSI) to track the comovement and transmission of financial stress across four major U.S. financial sectors: equity, debt, banking and foreign exchange markets. The remainder of this section proceeds as follows. We begin by describing the data and methodology in Section 2.1, and in Section 2.2, we calculate the level of both *total* and *directional* spillovers over our sample period.

### 2.1. Data and methodology

#### 2.1.1. Cleveland financial stress indices

As a direct response to analytical demand generated by the global financial crisis, many alternative indices have been recently developed by central bankers and financial economists to measure the current level of strains and stress in the whole financial system. For example, the Federal Reserve Bank of Cleveland has developed such a tool in Oet et al. (2011), called “Cleveland Financial Stress Index (CFSI)”. Unlike many other financial stress indices that are available in the literature, the CFSI incorporates information from a number of financial markets to derive a measure of financial system stress on a continuous basis. Specifically, the CFSI is constructed using daily data from 11 components reflecting the conditions in four major financial sectors in the U.S.: equity, debt, banking, and foreign exchange markets. Yet, as many other widely used measures, CFSI again focuses on the “size” aspect of stress and does not sufficiently address the “interconnectedness” nature of financial stress i.e., stress generated in any of financial sectors can quickly be carried over to others, affecting the financial system as a whole.<sup>7</sup>

<sup>7</sup> We thank the anonymous reviewer for the suggestion that a significant amount of foreign exchange, equity and debt market transactions are actually done by banks on behalf of clients and on their own accounts. Thus, these markets could be highly connected with the banking industry. A further examination of why such interconnectedness and spillover might exist is worthy of a study, but is beyond the scope of this paper.

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