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An extreme value analysis of the last century crises across industries in the U.S. economy

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ABSTRACT

The two large scale crises that hit the world economy in the last century, i.e. the *Great Depression* and the *Great Recession*, have similar outbreak and recovery patterns with respect to several macroeconomic variables. In particular, the largest depressions are likely to be accompanied by stock-market crashes. This study investigates the behavior of the U.S. stock market before, during and after deep downturns, focusing particularly on the tails of the return distribution. We develop two automatic procedures to identify multiple change-points in the tail of financial time series as well as in the co-crash and co-boom probabilities of different markets. We then apply our methodology to twelve time series representative of the sectors of the U.S. economy. We find that regime shifts in the lower tail of the distribution tend to co-occur before deep downturns. Our results contribute to a better understanding of the origin and systemic nature of large scale events to make policy interventions more timely and effective.

1. Introduction

"September and October of 2008 was the worst financial crisis in global history, including the Great Depression."
– Ben Bernanke

The long economic downturn that began in late 2007 and is known as the *Great Recession* has raised new concerns regarding the possibility of a depression period (Eggertsson and Mehrotra, 2014). This has produced a widespread debate about the differences and commonalities of these events and those experienced during the *Great Depression* of the 1930s (Bordo and James, 2010; Stiglitz, 2015).

Both crises started in the United States, but had huge effects on the economy worldwide, forcing national governments to extraordinary commitments. The Great Depression lays its roots in the collapse of the stock market. The market exuberance of the mid-twenties prompted people to borrow money and investing in stocks. This created a spurge in the stock prices that culminated in the stock market collapse of the 23rd October 1929. The losses suffered by the investors made them unable to repay their debts causing the default of a large number of banks. The Great Recession is characterized by

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a similar scenario, but the housing market was the playground in this case. People were buying houses with sub-prime mortgages bearing high interest rates but guaranteed by the value of the house itself. The fall of the houses price coupled with the inability of creditors to meet their obligations caused large losses in the banking sector and among institutional investors.

Even though the origins are different, the Great Depression and the Great Recession are similar with respect to the evolution of several macroeconomic variables, such as the decline in GDP, investment and consumption and the rise of the unemployment rate (Bordo and James, 2010). As noticed by Barro and Ursúa (2009), stock market crashes provide important guidance about the prospects for depression. They find, for 25 countries with long-term data, that stock market crashes go along with minor depressions (multi-year decline of consumption or GDP of 10%) 30% of the time and major depressions (declines by more than 25%) 11% of the time. Therefore, structural changes in the dynamics of the stock market can be used as an early-warning signal of macroeconomic contraction. In particular, given the evidence of heavy tails for the stock return distribution (Fama, 1965; Mandelbrot, 1963), structural changes of the tail probabilities are important because they entail changes in the likelihood of observing extreme events. In this paper, we study the tails of the unconditional return distribution.

Change-point detection in the tails has attracted a great deal of attention in the last decade. Early studies of Quintos et al. (2001) report evidence of changes in the tail heaviness for three Asian countries during the Asian financial crises of the mid-nineties. Candelon and Straetmans (2006) extend the test of Quintos et al. (2001) to multiple change-points and apply it to Asian and Western exchange rate data to assess the impact of monetary policies. A different but related approach has been used in Bee et al. (2016) to uncover tail seasonality in several U.S. industries. Straetmans et al. (2008) generalize these frameworks to the bivariate joint distribution and propose to test changes in the co-crash probability (joint lower tail) and co-boom probability (joint upper tail) between two assets. This test can be used to understand changes in the probability of contagion or joint crashes.

We rely on these techniques to investigate whether the tails of the unconditional return distribution of twelve financial time series providing a market proxy of the U.S. economic sectors behaved differently during the Great Recession and the Great Depression. The availability of stock market data for almost a century allows for an integrated analysis of the two crises that would not be otherwise possible with standard long-run economic data. We develop a new algorithm based on the test of Kim and Lee (2009) to detect and estimate multiple change-points in the tails of the time series of the U.S. economic sectors over the last century. This allows us to evaluate which sectors were more prone to extreme events during the two crises and the diffusion pattern of regime shifts in the negative tail of returns across sectors. In the spirit of Straetmans et al. (2008), we then extend our methodological approach to the multivariate framework to shed more light on the contagion pattern of the crisis. We perform a bivariate analysis aimed at identifying multiple change-points in the co-crash and co-boom probabilities across sectors. As a consequence, we can evaluate tail spillovers and contagion, along with the implications for systemic risk.

Both the univariate and bivariate approaches rely on an algorithm for multiple change-point detection. Therefore, it is not necessary to specify in advance the dates of the tail structural breaks. This constitutes an advantage as we let the data speak for themselves without interfering with the statistical properties of the time series. We find several change-points in both the upper and lower tails of the different sectors and changes in the co-crash and co-boom probabilities. All the structural breaks can be justified on strong economical basis as they correspond to the main economic events that characterized the nineteenth century and the first decade of the new millennium. We focus our discussion on the change-points close to the Great Depression and the Great Recession in order to see how the two crises affected the economy and whether the policy responses were effective.

Our main findings can be summarized as follows. First, all the economic sectors are affected by the two crises, both at the univariate level, with an increase of extreme events, and at the multivariate level, with an increase in the probability of co-crash and systemic risk. Second, the change-points tend to anticipate the crucial dates of the two crises, so that the detection of tail change points can be used as an early warning for large-scale financial crises. Change-points in the financial sector occur earlier than in the others in both crises, consistently with the fact that the banking industry was at the core of the crises' origins. Finally, the recovery time, defined as the time elapsed before another change-point occurs, is different in the two cases, and we suggest to relate it to the effectiveness of the policies implemented by the U.S. government.

The remainder of the paper is structured as follows. Section 2 presents the econometric model and the change-point algorithms. Section 3 illustrates the results of the univariate and bivariate empirical analyses. Section 4 discusses a real-time monitoring example. Finally, Section 5 concludes.

2. Methodology

As our analysis covers both the univariate and bivariate case, we first define the econometric model describing the dynamic of the assets considered, i.e. the economic sectors. We then describe the strategy used to identify multiple change-points in the upper and lower tails of a single asset and in the co-crash and co-boom probabilities of two assets.

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