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Assessing Causality and Delay within a Frequency Band

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Abstract

The frequency-specific Granger causality test is extended to a more general null hypothesis that allows causality testing at unknown frequencies within a pre-specified range of frequencies. This setup corresponds better to empirical situations encountered in applied research and it is easily implemented in vector autoregressive models. Furthermore tools are provided to estimate and determine the sampling uncertainty of the phase shift/delay at some pre-specified frequency or frequency band. In an empirical application dealing with the dynamics of CO_2 emissions and US temperatures it is found that emissions cause temperature changes only at very low frequencies with more than 30 years of oscillation. In a business cycle application the causality and leading properties of new orders for German industrial production are analyzed at the interesting frequencies.

Keywords: Granger causality, frequency domain, filter gain

1. Introduction

The notion of empirical causality as predictive ability has a long history in science and was formalized by Granger (1969). It became very popular among practitioners due to the simplicity of its implementation in linear dynamic models, where a test for non-Granger-causality is equivalent to a joint exclusion test of lagged terms of the candidate variable. A generalization of this concept was later introduced by Geweke (1982), who noted that causal effects can vary between different cycles of time series, where each cyclical component corresponds to a certain frequency of oscillation. Breitung and Candelon (2006, henceforth BC) pointed out that in the framework of a vector autoregression (VAR) the null hypothesis of no causality at some pre-specified frequency is equivalent to two linear restrictions that can be tested with a standard Wald test.

A drawback of the BC test is that the test is formulated in terms of a single frequency that has to be specified a priori. In practice, however, many test statistics are

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