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An econometric analysis of asymmetric volatility: Theory and application to patents

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Abstract

The purpose in registering patents is to protect the intellectual property of the rightful owners. Deterministic and stochastic trends in registered patents can be used to describe a country's technological capabilities and act as a proxy for innovation. This paper presents an econometric analysis of the symmetric and asymmetric volatility of the patent share, which is based on the number of registered patents for the top 12 foreign patenting countries in the USA. International rankings based on the number of foreign US patents, patent intensity (or patents per capita), patent share, the rate of assigned patents for commercial exploitation, and average rank scores, are given for the top 12 foreign countries. Monthly time series data from the United States Patent and Trademark Office for January 1975 to December 1998 are used to estimate symmetric and asymmetric models of the time-varying volatility of the patent share, namely US patents registered by each of the top 12 foreign countries relative to total US patents. A weak sufficient condition for the consistency and asymptotic normality of the quasi-maximum likelihood estimator (QMLE) of the univariate GJR(1,1) model is established under non-normality of the conditional shocks. The empirical results provide a diagnostic validation of the regularity conditions underlying the GJR(1,1) model, specifically the log-moment condition for consistency and asymptotic normality of the QMLE, and the computationally more straightforward but stronger second and fourth moment conditions. Of the symmetric and asymmetric models estimated, AR(1)–EGARCH(1,1) is found to be suitable for most countries, while AR(1)–GARCH(1,1) and AR(1)–GJR(1,1) also provide useful insights. Non-nested procedures

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are developed to test AR(1)–GARCH(1,1) versus AR(1)–EGARCH(1,1), and AR(1)–GJR(1,1) versus AR(1)–EGARCH(1,1).

JEL classification: C12; C22; C51; O34

Keywords: Patents; Patent shares; Trends; Volatility; GARCH; GJR; EGARCH; Asymmetry; Regularity conditions; Asymptotic theory; International rankings; Non-nested tests

1. Introduction

Deterministic and stochastic trends in patent registrations have frequently been used to describe a country's technological capabilities and intellectual property, and have acted as a proxy for innovation (see, for example, Pavitt, 1988; Patel and Pavitt, 1995; Griliches, 1986; Marinova, 2001). Having the world's largest economic market, the USA has consistently been a destination for registering patents by innovative US and foreign companies, as well as by individuals with intentions to commercialise new technologies. Consequently, patents registered at the US Patent and Trademark Office (PTO) represent an excellent source of information regarding research and development (R&D), technological strengths, intellectual property and market ambitions.

Most of the research on patents registered in the USA has examined snapshot images representing patent activities for a particular time period, based on a single year or on an aggregated annual information base. For example, patent data have been used in econometric models to analyse the factors affecting decisions by companies to patent innovations (Duguet and Kabla, 2000). Auction models have also been used to analyse the processes of patent acquisition and/or patent renewal (Waterson and Ireland, 2000; Crampes and Langinier, 2000). Patent numbers have been used as a measure of R&D output in several production function studies (Goel, 1999). Cross-country correlations using patent data are also very common (see, for example, Pianta, 1998). When time series data have been analysed, simple methods of estimation have been used, and tests of stationarity have typically not been reported (see, for example, Archibugi and Pianta, 1998).

Volatility in patent registrations has only recently been analysed in the literature. Patents are the most widely used indicator of industrial intellectual property. The most common variation analysed empirically is the patent share, namely patents registered at the US PTO by each of the top 12 foreign countries relative to total US patents. Variations in the patent share are of interest because the patent share is a leading indicator of technical innovation. Moreover, knowledge of the stochastic process underlying variations in the patent share provides crucial information regarding the riskiness associated with innovative activity over time. For example, futures contracts and options, and other derivatives, are used widely to design optimal hedging strategies against price risk in commodity markets. Sensible strategies for hedging, and for pricing options and other derivatives, require knowledge of the volatility of the underlying series. As volatility is generally unknown, it must be estimated. These estimated volatilities are fundamental to risk management in financial models that evaluate risk spillovers and describe the risk-return trade-off, such as