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Truncation bias corrections in patent data: Implications for recent research on innovation ☆

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ABSTRACT

We review the effectiveness of various adjustment methods in correcting the truncation-bias in patents data and the implications for existing studies. The NBER patents-database was recently updated, extending the sample from 2006 to 2010. The updated sample is largely free of truncation-bias over the period covered by the NBER-2006 sample, allowing us to evaluate the bias-adjustment methods. We find that existing adjustments perform poorly towards the end of NBER-2006 sample. We re-examine multiple studies from the recent literature on innovation and show that findings based on the last few years of NBER-2006 data are not supported in the updated patents-database.

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1. Introduction

It is well recognized that innovation is vital for economic growth (e.g., Solow, 1957). Consequently, there is considerable interest among policy-makers and academics alike in questions regarding the types of legal and other institutional arrangements that encourage or facilitate the innovative activity of firms. In recent years, the economics literature on intellectual property and technological progress has been aided by the wide availability of data from the NBER *Patents Data Project* (Hall et al., 2001). The NBER patents database provides information on US patents granted from 1975 to 2006 along with technological class, assignee, and citations; we denote this as the "NBER-2006" data.[1] The database was updated recently by Li et al. (2014) and extended up to 2010 ("Harvard-2010," henceforth).

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[1] The first version, discussed in Hall et al. (2001) included data up to December 1999.

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The finance and innovation literature has tended to focus on publicly-listed corporations, corresponding to the greater availability of these firms' data and the importance of their innovative activities. This literature includes papers that examine the effect on firms' innovation due to legal and regulatory changes in corporate governance (Atanassov, 2013), access to financing (Amore et al., 2013; Chava et al., 2013), and stock market liquidity (Fang et al., 2014). Others have examined the impact of unions (Bradley et al., 2016) , managerial overconfidence (Hirshleifer et al., 2012), and other factors on firms' innovation. Publicly-traded corporations play a substantial role in the innovation process: they spend substantial resources on R&D and contribute many of the technological advances (Brown et al., 2009).

Our objective in the paper is to investigate an inherent limitation of the patents data – on account of truncation bias – and its implications for the growing literature that makes use of these data. The existence of the truncation bias is well recognized and has been discussed at some length in Hall et al. (2001). Information about the patent application is publicly released by the US Patent Office (USPTO) only after the grant date.[2] Further, there is a relatively long (median 3 years) and uncertain delay between when a firm applies for a patent and when the patent is granted (if successful). Hence, a truncation bias exists in the patent data because it can take several years to know just how many patents were applied for during any particular period. The relevance of the patent application date, as opposed to the grant date, is that the application date is expected to be closer in time to the firm's innovative activity. With regard to patent citations, the truncation bias is even stronger: this is because citations accumulate over many years after a patent has been granted.

To address the truncation bias, studies tend to follow two different approaches to make adjustments to the currently-available information on patent citations. The first method prescribed by Hall et al. (2001) relies on historical patterns to forecast future realizations of patent citations. These assumptions matter the most for the years toward the end of the sample period for two reasons: First, these are the years most affected by the time-lag between the patent application and grant dates. Second, these years are also most affected by the lack of passage of sufficient time for citations to build. However, there are several reasons why the prescribed adjustments may not necessarily work well. First, as Hall et al. (2001) point out, there is a substantial cross-sectional variation in the time taken for patent review. A further complication is that the time taken to grant patents has tended to change over time. These changes can be correlated with firm and industry attributes, as described below, which makes adjustments based on historical delay less reliable. For instance, factors such as changes in technological nature of patents and the expertise available at the patent office could affect the lag between patent application and grant dates. The second method, also discussed in Hall et al. (2001), adjusts the number of patents and citations for the fixed effects of each technology class and year. This method differs from the first method in that it also takes into account the variation in truncation bias across different technologies. However, a potential drawback is that the fixed effects also absorb any meaningful variation in innovation across sectors.

In this paper, we use the recent update of the NBER patents data to test the adequacy of adjustments made to correct for truncation bias. Using the Harvard-2010 data allows us to obtain relatively bias-free information on patent applications over the span of the *prior* NBER-2006 data set. We can, therefore, examine whether the bias-correction methods work well in practice. Also important is the fact that several recent and prominent papers in the literature on innovation are based on the NBER-2006 data. By using the (relatively bias-free) data from Harvard-2010 over the period ending in 2006, we can re-examine findings that may be more affected by the truncation bias.

Overall, our results indicate that bias-adjustments based on historical patterns do not work well for the NBER-2006 data in the post-2000 period. We use the distribution of patent application-grant time-lag from 1995 to 2000 to derive adjustment factors for patent applications after 2000. However, the adjusted number of patent applications from NBER-2006 are found to be far lower than the actual application numbers from Harvard-2010 over the same period. For 2005, for instance, the adjusted number from NBER-2006 (3.3 patents per firm) is 64% lower than the actual figure from Harvard-2010 (9.1 patents per firm). The fixed-effect adjustment also cannot sufficiently correct the patent truncation bias near the end of the sample. However, it performs better in reducing the truncation bias in the number of citations.

An examination of the historical application-grant time-lag shows that the increasing trend in patent processing time in recent years may explain the failure of the adjustment method. In the 1991–1994 period, the percentage of patents granted within 3 years after filing an application is about 94%, and within 4 years is about 97%. By comparison, in the 2003–2006 period, the percentage of patents granted within 3 (4) years after filing an application is 61.73% (83.48%). Hence, when dating patents according to application year, it may be necessary to exclude the final three to four years of patent data in order to ensure that the data is relatively free of truncation bias.

Dropping the last four or more years of patent data may not always be feasible if, for instance, the interest is in studying an event that occurs toward the end of the sample period covered by the patent data set. In this case, as long as the time-series changes in lags are not correlated with firm/industry attributes, the use of year dummies in regressions may be sufficient to control for the truncation bias. However, our analysis indicates that after controlling for year-specific effects, we are left with a truncation bias that is strongly correlated with certain firm attributes. We find that excluding the last four years of data can correct most of this spurious correlation for the patent data. For patent citations, the correlation between the data bias and

[2] Historically, the USPTO has not revealed information on patent applications that are under review or rejected. After the enactment of American Inventors Protection Act of 1999, patented information is made public 18 months after the application date, even if the patent has not yet been granted. However, the NBER database only covers patents that have been granted as of 2006 even though USPTO publishes patent applications 18 months after the application date. If one adds the pending patent applications published by USPTO to the NBER sample, it would help address the truncation bias issue.

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