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The determinants of dentists' productivity and the measurement of output

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ABSTRACT

Improving the productivity of the healthcare system, for example by taking advantage of scale economies or encouraging substitution of expensive specialist personnel with less expensive workers, is often seen as an attractive way to meet increasing demand within a constrained budget. Using data on 558 dentists participating in the Longitudinal Study of Dentists' Practice Activity (LSDPA) survey between 1993 and 2003 linked to patient data and average fee schedules, we estimate production functions for private dental services in Australia to quantify the contribution of different capital and labour inputs and identify economies of scale in the production of dental care. Given the challenges in measuring output in the healthcare setting, we discuss three different output measures (raw activity, time-, and price-weighted activity) and test the sensitivity of results to the choice of measure. Our results suggest that expansion of the scale of dental services is unlikely to be constrained by decreasing returns to scale. We note that conclusions about the contribution of individual input factors and the estimated returns to scale are sensitive to the choice of output measure employed.

1. Introduction

Faced with increasing demand for services many countries have considered ways to expand supply of dental services or improve the productivity of the existing system, for example by increasing insurance subsidies or encouraging substitution of expensive dental specialist personnel with less expensive healthcare workers (Duckett, 2006; Gallagher et al., 2010; Health Workforce Australia, 2011; Sibbald et al., 2004). In dental services a small number of empirical studies to date in Europe and the USA have suggested that there are economies of scale in dental production, with a positive effect from the additional use of auxiliary personnel (Sintonen and Linnosmaa, 2000). However, the output of dental practices can be measured in different ways and little is known about the sensitivity of findings to the choice of output measure. For example, while some output measures focus only on activity (e.g. number of patients seen), others incorporate information about the complexity of services. This paper estimates a production function for private dentists comparing results for different measures of output, thereby making more robust predictions possible, for example on any potential for changes in service mix or other policy changes that might affect access to dental services.

The particular policy context here is that seen in many settings – the need to expand adult dental services in response to a perceived gap in the provision of services relative to need (Whittaker and Birch, 2012). Specifically here we use the Australian context, however the same issues are present in most developed countries where the proposed policy response to the lack of provision is often the expansion of public finance or insurance coverage for dental services. The National Health and Hospital Reform Commission (2009) suggested an expansion in public funding, at least for selected services for disadvantaged groups in the population, either through subsidizing the price charged by private dentists (who currently provide 80% of services) or by expanding the public sector that provides services to lower income disadvantaged adults. A number of commentators have suggested that any increase in public insurance or funding for public delivery of services would most likely be ineffective in increasing the level of

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dental service utilization at least in the short to medium term if there is an insufficient supply response, for example if production cannot readily be scaled up. There is a paucity of evidence on the dental production function in Australia that prevents an informed discussion of these concerns.

This paper provides evidence on the way in which the producers of dental services could expand output to meet increased demand with current technology. The aim of the paper is to assess these issues using production functions to a) identify the effect of dental production factors (capital and labour) on different measures of output, and b) to assess whether Australian dentists operate under increasing returns to scale. Our results inform the policy debate about possible ways in which production could be increased to meet any expected changes in demand in the dental sector if insurance coverage was to be expanded. These include increases in scale or changes to the mix of inputs as far as technically feasible with the current production technology.

2. Measuring dentists' output

Measuring the output of healthcare providers is a challenging task and constitutes a central problem in productivity studies (Atkinson, 2005; Castelli et al., 2005). Healthcare is consumed by patients presenting with different medical conditions and underlying severity. Certain patients will require more attention and resources than others because they suffer from more severe conditions or differ with respect to other relevant factors that determine treatment decisions, such as age, gender, or comorbidities. Healthcare providers must adapt treatment processes to the patients' individual needs and provide, at the margin, different services to each patient (Bradford et al., 2001). As a consequence, overall output consists of a mixture of distinct output categories.

The analysis of the dentists' production process requires a means of integrating these different outputs into a common metric. The question then arises which weights should be used. Ideally, one would like to measure the effect of dental care on each patient's outcome, i.e. the change in oral health trajectory induced, or averted, by treatment. The rationale is that patients rarely seek dental treatment because of the care process itself. Instead, they consult a dentist to restore their health or prevent imminent deteriorations. Health improvement describes "*the 'value-added' to health as a result of the contact with the health system*" (Jacobs et al., 2006, p. 23) and would hence constitute an ideal measure of output that combines aspects of quality and quantity of care provided.

Unfortunately, comprehensive measures of oral health are not routinely collected. Hence, the current literature on dental productivity that employs routine data focuses on other weighting systems as summarized in Table 1. These weights are based on activity, time or monetary value (typically based on market prices) (Mitry et al., 1976; Sintonen and Linnosmaa, 2000), each of which is based on different assumptions about outputs.

Activity-based measures are by far the most predominant means of describing output. Seven out of ten surveyed studies use measures such as 'number of patients treated' or 'number of patient contacts' to summarize the activity of dental practitioners. The implicit weights used are equal across output categories. Accordingly, check-up visits are treated as equivalent to complicated tooth extractions.

The advantage of the activity-based approach lies in its simplicity and the quality of data available. Activity numbers can be easily retrieved from routine documentation such as medical records, claim files or practice schedules, or obtained as part of a survey. In the context of an expansion of insurance coverage there may be some relevance in evaluating the change in the number of patients seen since this may be a policy relevant parameter. However, activity is an inherently blunt measure of output and assumes homogeneity across dental practices, with respect to patient need (i.e. oral health) as well as mix and quality of procedures (Sintonen, 1986).

Time-based measures are derived from the idea that more complex patients will, in general, require more attention than their healthy counterparts and therefore receive more time-consuming procedures. By specifying the time requirements of each procedure and using these as weights, one can generate a measure of output which takes account of the particular mix of procedures and, by extension, the underlying case-mix of the dental practice. Bentley et al. (1984) use weights derived from an expert panel to study the costs of dental care delivery in school children, whereas (Mitry et al., 1976) use the average observed time per procedure as weights in a simulation model of dental productivity. While the time-based approach improves over a simplistic activity-based approach, it shares several limitations: First, one cannot take account of variation in quality and might falsely regard time spent in excess of the benchmark as inefficiency when it really reflects better care (Sintonen, 1986). Indeed, this is a limitation shared by all measures discussed here. Second, the approach does not take account of intermediate, non-labour inputs that are used in the production process and are valued by patients. Some procedures might not primarily require time (i.e. labour input) but costly prosthesis or implants. Time-based measures would thus underestimate the output for dentists that supply many such procedures.

Price-based weights provide alternative means of integrating heterogeneous output and are a natural choice in economic studies. Here, the value of a procedure or a treatment continuum is taken to be the monetary valuation as represented by its market price. The advantage of price weights is that they capture some of the variation in product characteristics that are valued by patients. For example, patients may be willing to pay more for a tooth reconstruction than an extraction, and the differential value attached to this may not be proportional to the differential time requirement of the procedure. The downside is that if markets are not operating efficiently, for example due to local monopolies, prices may be distorted and not reflect the true value to the consumer. The latter may be somewhat mitigated by averaging prices across markets.

We might expect a high correlation between time-based and price-based measures of output if the price charged is closely

Table 1
Overview of dental productivity studies and measures of output considered.

Authors	Country	Sample size	Measure of output			Functional form
			Raw activity	Time	Value	
Beazoglou et al. (2009)	US	154	X		X	CD
Conrad et al. (2010)	US	829	X			CD
DeVany et al. (1982)	US	447	X			TC
Gray (1982)	UK	266			X	TC
Jostein Grytten and Dalen (1997)	Norway	1754	X			TL
Grytten and Rongen (2000)	Norway	14/84[a]	X			CD
Mitry et al. (1976)	US	128[b]		X		TC
Scheffler and Kushman (1977)	US	29,000	X			CD, TL
Shuman et al. (1992)	US	31		X	X	L
Sintonen (1986)	Finland	98	X		X	TC

CD = Cobb–Douglas, TL = Translog, TC = Transcendental, L = Linear.
Note: We only included published studies (in English) that estimate a cost or production function. This excludes some earlier work, most notably the unpublished PhD theses by Maurizi (1967), Boulier (1974) and Crakes (1984).
[a] Pooled over time.
[b] Number of computer simulations with different combinations of input factors and case-mix.