THE UNIVERSITY *of York*

CHE
Centre For Health Economics

Competition, Prices, and Quality in the Market for Physician Consultations

CHE Research Paper 89

Competition, prices, and quality in the market for physician consultations

[1]Hugh Gravelle
[2]Anthony Scott
[2]Peter Sivey
[2]Jongsay Yong

[1]Centre for Health Economics, University of York, UK
[2]Melbourne Institute for Economic and Social Research, The University of Melbourne, Australia

July 2013

Background to series

CHE Discussion Papers (DPs) began publication in 1983 as a means of making current research material more widely available to health economists and other potential users. So as to speed up the dissemination process, papers were originally published by CHE and distributed by post to a worldwide readership.

The CHE Research Paper series takes over that function and provides access to current research output via web-based publication, although hard copy will continue to be available (but subject to charge).

Acknowledgements

The research was supported by funding from Australian Research Council Discovery grant DP110102863. MABEL is supported by a National Health and Medical Research Council Health Services Research Grant (454799) and the Commonwealth Department of Health and Ageing. We thank the doctors who gave their valuable time to participate in MABEL, and the other members of the MABEL team. The views expressed are those of the authors and not necessarily those of the funders. We are grateful for comments received from seminars in the Department of Health Policy and Management, Harvard School of Public Health; the Health Econometrics and Data Group, University of York; the Health Economists' Study Group conference, June 2012; the Network of Industrial Economists conference on competition in healthcare markets, December 2012; and the CAER Health Economics Workshop, University of New South Wales, January 2013.

Centre for Health Economics
Alcuin College
University of York
York, UK
www.york.ac.uk/che

Abstract

Prices for consultations with General Practitioners (GPs) in Australia are unregulated, and patients pay the difference between the price set by the GP and a fixed reimbursement from the national tax-funded Medicare insurance scheme. We construct a Vickrey-Salop model of GP price and quality competition and test its predictions using a dataset with individual GP-level data on prices, the proportion of patients who are charged no out-of-pocket fee, average consultation length, and characteristics of the GPs, their practices and their local areas. We measure the competition to which the GP is exposed by the distance to other GPs and allow for the endogeneity of GP location decisions with measures of area characteristics and area fixed-effects. Within areas, GPs with more distant competitors charge higher prices and a smaller proportion of their patients make no out-of-pocket payment. GPs with more distant competitors also have shorter consultations, though the effect is small and statistically insignificant.

JEL: I11, I13, L1

Keywords: Competition, Prices, Quality of care, Primary care, Doctors.

1. Introduction

Market structure may have important effects on healthcare costs, quality and access in many developed countries. The majority of studies in the literature have examined the effect of competition in hospital or insurance markets; there are few studies of the effects of competition in the market for physician services (Gaynor and Town, 2011). In this paper we examine the effects of competition on prices and quality in the market for general practitioners (GP) in Australia. The market provides a useful context in which to test for the effects of market forces in healthcare: prices for consultations are unregulated, patients have a free choice of GP, and new GP-level data on prices and distance measures of competition are available.

In Australia, patients pay a fee for each GP consultation. The fees that GPs charge are not regulated and GPs are free to price discriminate between patients. The national, tax financed, Medicare insurance scheme provides a subsidy for the cost of a consultation (the Medicare rebate). The patient pays the excess of the GP fee over the Medicare rebate and these out of pocket copayments by patients cannot be covered by insurance. GPs can choose to 'bulk bill' a patient, so that the patient pays nothing to the GP who claims the rebate direct from Medicare as full payment.

In this study, we add to the literature in two main ways. First, building on previous theoretical models (Gravelle 1999, Brekke et al 2010), we develop a formal model of GP price and quality discrimination under bulk billing with free entry into GP markets. We use it to generate predictions about the effects of competition, as measured by distance between GPs, as a guide to our empirical analysis.

Second, we use within-area variation in prices, and distance between GP practices, to identify the effects of competition. We use area fixed effects to control for all area-level variables that are unobserved and may influence prices and GP supply in a local area. We use a definition of local areas ('Statistical Local Areas'), with an average population of about 33,000, so that areas are small enough to capture the locational preferences of GPs when choosing where to practice, but large enough to provide some within-area variation in prices and distance between GP practices. Our distance measure of competitive pressure follows a strand in the industrial economics literature which emphasizes distance to nearby competitors as a determinant of prices (Alderighi and Piga, 2012; Thomadsen, 2005). Distance between firms has also been found to be an important determinant of prices in studies of hospital competition (Gaynor and Vogt 2003). Our approach contrasts with previous literature which has used area based measures of competition in healthcare markets, such as the number of physicians per head of area population. These area-level measures may be correlated with unobservable area demand or cost conditions that affect pricing behaviour. In our models we can also control for a rich set of GP-level variables (including gender, experience, country of qualification, whether the GP is a partner or employee in their practice, and the size of their practice).

Our empirical findings are consistent with the predictions from our theoretical model. GPs whose rivals are further away, bulk bill (charge zero copayment to) a smaller proportion of their patients and charge higher prices to those they do not bulk bill. We also find that the effects of competition on bulk billing and prices are stronger in areas of greater socio-economic advantage. Distance to other GP practices tends to reduce quality, though the effects are generally not statistically significant.

Our study is relevant for other health care systems with unregulated prices for physicians. In the US the practice of charging fees above the price reimbursed by the insurer is widespread and is known as balance billing (Glazer and McGuire, 1993; McKnight, 2007). It is also permitted in some provinces in Canada (Sullivant and Baranek, 2002). In France and Germany GPs can choose a contract which permits them to charge fees above the fixed insurance rebate (L'Haridon et al, 2008; Busse and Reisberg, 2004).

1.1 Related Literature

Studies including theoretical models of physician competition and pricing behaviour include Savage and Jones (2004), who model bulk billing by monopolistically competitive GPs but do not examine the effects of an increase in the number of GPs. Glazer and McGuire (1993) use a 2 firm Hotelling model to examine how prices, bulk billing and quality vary with patient location. Brekke et al (2010) have a Vickrey-Salop circular city model with an exogenous number of doctors and all patients facing the same price and quality. There is no patient insurance and so no possibility of bulk billing. They show that the effects of an increase in the number of doctors on price and quality depend on assumptions about patient utility and doctor cost functions. Gravelle (1999) also studies price and quality in a Vickrey-Salop model and allows for entry by doctors, but does not consider bulk billing or for prices and quality to vary across patient types.

Empirical studies of prices and competition in physician markets start with Pauly and Satterthwaite (1981), who use data on 92 US metropolitan areas and, after instrumenting for physician supply with measures of area attractiveness, they find that areas with more physicians per capita have lower prices. More recently, Bradford and Martin (2000) find that higher physician density (physicians per head of population) is associated with less profit sharing amongst physicians in group practices and lower prices. Schneider et al (2008) find that physician market concentration in California, measured by the Herfindahl Hirschman Index (HHI) is associated with higher prices. Gunning and Sickles (2012) adopt the Bresnahan (1989) structural approach to use price and cost data to measure the competitiveness of physician markets and conclude that these markets, including a submarket for GPs are not competitive: physicians have market power.

There have been four area level studies of pricing by Australian GPs. Richardson et al (2006) use 1995 Australian area level data and instrument GP supply with area socio-economic status and the supply of private schools. They report that areas with more GPs per capita have higher prices to patients who are not bulk billed but also have a higher proportion of patients who are bulk billed, so that the average price to all patients is unaffected by GP supply. Savage and Jones (2004) have a panel of data 1989/90 to 2000/01 across the eight Australian states. After controlling for state and year fixed effects, they find that increases in GPs per capita increase the proportion of patients who are bulk billed. McCrae (2009) uses a 1996-2003 panel of data on all 816 Australian Statistical Local Areas, using area characteristics to instrument GP supply, and finds that an increase in area GP supply is associated with higher prices and a greater supply of services by GPs. Johar (2012) has patient-level data and examines the relationship between prices and patient income. She finds that in areas with more general practitioners per capita the effect of patient income on price is reduced, but does not account for the endogeneity of GP density.

2. Institutional setting

General practitioners in Australia are paid by fee-for-service for consultations. They are free to charge what the market will bear. Their patients are subsidised by Medicare, a national tax-financed insurance scheme. Patients can claim back a fixed rebate from Medicare as set out in the Medicare Benefits Schedule (Australian Government, 2008). Copayments by patients (the difference between the rebate and the price charged) cannot be covered by insurance. GPs can choose to 'bulk bill' a patient, so that the patient pays nothing to the GP who claims the rebate direct from Medicare as full payment. Some GPs choose to bulk bill all patients, whilst others bulk bill none or only a proportion of their patients. There are some incentives for bulk billing, in the form of a higher Medicare rebate, for certain groups of patients, mainly children and the elderly.

There is no enrolment of patients or list system. Patients can choose to visit any GP practice each time they consult. GPs are gatekeepers to specialist and hospital services, though patients can access hospital services directly through emergency departments which can substitute for GP services. There are no restrictions on geographical location of practice, apart from doctors arriving from overseas who must first practice for a set period in under-doctored rural areas. GPs in designated geographical areas of workforce shortage are eligible for a range of payments to encourage them to locate to and remain in these areas. These issues do not affect our data which are for GPs in metropolitan areas.

3. A model of bulk billing, price and quality

3.1 Specification

We model GPs' decisions by extending the Vickrey-Salop model of monopolistically competitive firms (Vickrey, 1964; Salop, 1979) to include choice of quality as well as prices. We also allow for the possibility that GPs bulk bill (ie charge a price equal to the Medicare rebate for a proportion of their patients).

Under the Medicare system the GP receives a gross fee per consultation of $p + m$, the patient reclaims the rebate m from Medicare and pays a net price of p.[1] Patients demand at most one consultation per period from their GP and the utility gain from a consultation at GP j is

$$u_j = r - p_j + \alpha q_j - t d_j \tag{1}$$

where p_j is the price the patient pays at GP j, q_j is the quality of the consultation (measured by its length), d_j is the distance to the GP, $\alpha \in [\alpha_0, \alpha_1]$ and t are taste parameters. We assume that r is large enough to ensure that the market is covered: all patients demand a consultation. All patients have the same marginal distance cost t. They differ in their marginal valuation of quality (α).

There are H patients in total, distributed uniformly around the circular market of length L, so that the density of patients at any point in the market is $h = H/L$. The probability distribution and density functions of patient types, $F(\alpha;\theta)$ and $f(\alpha;\theta)$, are independent of location within the market, so that at each point there are $hf(\alpha;\theta)$ patients of type α. The parameter θ shifts the patient type distribution. We assume that $F_\theta < 0$ so that markets with higher θ have a larger mean valuations of quality.

There are G GPs equally spaced around the market so that the distance between GPs is $\ell = L/G$. GPs observe patient types and can charge different prices and provide different quality to each type. The demand for GP j from type α patients depends on the price $p_j(\alpha)$ she charges them and the quality $q_j(\alpha)$ she provides, as well as the prices and qualities of her immediately neighbouring GPs:[2]

$$D_j = \frac{hf(\alpha;\theta)}{2t}\left\{p_{j+1}(\alpha) - p_j(\alpha) + \alpha[q_j(\alpha) - q_{j+1}(\alpha)] + t\ell\right\}$$

$$+\frac{hf(\alpha;\theta)}{2t}\left\{p_{j-1}(\alpha) - p_j(\alpha) + \alpha[q_j(\alpha) - q_{j-1}(\alpha)] + t\ell\right\}$$

$$= D_j(p_i(\alpha), q_j(\alpha); p_{j+1}(\alpha), q_{j+1}(\alpha), p_{j-1}(\alpha), q_{j-1}(\alpha), \alpha, \ell, h, \theta) \tag{2}$$

where the first term is demand from patients between GP j and GP $j + 1$ and the second is demand from patients between GP j and GP $j - 1$. The average variable cost of serving patients who get quality q is $\frac{1}{2}\delta q^2$.

---

[1] Strictly, the amount the patient can reclaim from Medicare is the minimum of the gross price and the Medicare rebate limit m: $min\{p+m, m\}$. Thus the net amount paid by the patient is $p+m - min\{p+m,m\} = p - min\{p,0\} = max\{p,0\}$. This implies that it can never be optimal for the GP to set $p < 0$. Increasing p to 0 would have no effect on demand, since the net amount paid by the patient is unchanged, and so would increase revenue with no change in cost. Hence, the net amount paid by the patient is $max\{p,0\} = p$. Without loss of generality we impose the constraint $p \geq 0$ in the GP's profit maximisation problem below.

[2] See Gravelle (1999), Brekke et al (2010).

GP *j* profit is

$$\pi_j = \int_{\alpha_0}^{\alpha_1} \left[p_j(\alpha) + m - \tfrac{1}{2}\delta q_j(\alpha)^2 \right] D_j(p_j(\alpha), q_i(\alpha); \cdot) f(\alpha;\theta) d\alpha$$

$$= \int_{\alpha_0}^{\alpha_1} \pi\left(p_j(\alpha), q_j(\alpha); \cdot \right) f(\alpha;\theta) d\alpha \qquad (3)$$

Given that the profit function is separable across patient types, the GP chooses $p_j(\alpha)$, and $q_j(\alpha)$ to maximises $\pi(p_j(\alpha),q_j(\alpha);\cdot)$, subject to the constraint that $p_j(\alpha) \geq 0$.[3] First order conditions are

$$\pi_{jp_j(\alpha)} = D_j(p_j(\alpha), q_j(\alpha); \cdot) - \left[p_j(\alpha) + m - \tfrac{1}{2}\delta q_j(\alpha)^2 \right] hf(\alpha;\theta) t^{-1} \leq 0,$$

$$p_j(\alpha) \geq 0, \quad p_j(\alpha)\pi_{ip_j(\alpha)} = 0 \qquad (4)$$

$$\pi_{iq_i(\alpha)} = -\delta q_j(\alpha) D_j(p_j(\alpha), q_j(\alpha); \cdot) + \left[p_j(\alpha) + m - \tfrac{1}{2}\delta q_j(\alpha)^2 \right] \alpha h f(\alpha;\theta) t^{-1} = 0 \qquad (5)$$

With identical GPs, the Nash equilibrium has all GPs choosing the same price and quality for each type of patient. Dropping the GP subscript, at the equilibrium each GP has $D(p(\alpha), q(\alpha); \cdot)$ = $hf(\alpha;\theta)\,\ell$ patients and the price and quality vary by patient type according to

$$p^b(\alpha;\ell,t,m,\delta) = 0, \quad q^b = q^b(\alpha;\ell,t,m,\delta) = \frac{\left[(\delta\ell t)^2 + 2\alpha^2\delta m \right]^{\frac{1}{2}} - \delta\ell t}{\alpha\delta}, \; \alpha \leq \alpha^b \qquad (6)$$

$$p^{nb}(\alpha;\ell,t,m,\delta) = t\ell + \frac{\alpha^2}{2\delta} - m > 0, \quad q^{nb} = q^{nb}(\alpha;\ell,t,m,\delta) = \frac{\alpha}{\delta}, \quad \alpha > \alpha^b \qquad (7)$$

Patients are bulk billed (*p* = 0) if and only if their marginal valuation of quality is less than the threshold level α^b

$$\alpha \leq \alpha^b(\ell,t,m,\delta) \equiv \left[2\delta(m - t\ell) \right]^{\frac{1}{2}} \qquad (8)$$

and the proportion of patients who are bulk billed is

$$F^b = \int_{\alpha_0}^{\alpha^b(\ell,t,m,\delta)} dF(\alpha;\theta) d\alpha = F\left(\alpha^b(\ell,t,m,\delta); \theta \right) \qquad (9)$$

We see from (6) and (7) that, irrespective of whether they are bulk billed or not, patients with higher marginal valuations (α) of quality will receive higher quality because their demand is more responsive to quality.[4] The price charged to patients who copay and are not bulk billed increases with their marginal valuation of quality.

3.2 Model predictions

We do not observe prices and quality for individual patients but we do have data (see section 4.1) on summary measures of GP's decisions:

a) the average price charged to patients who are not bulk billed ($m + \overline{p}^{nb}$);

[3] See footnote 1 which demonstrates that this constraint is without loss of generality

[4] $q_j(\alpha)$ is increasing and continuous in α (since $\mathrm{Lim}_{\alpha \to \alpha^b} q^b(\alpha) = \alpha^b / \delta$), though $\partial q_j(\alpha)/\partial\alpha$ is discontinuous at α^b.

b) the proportion of each GP's patients who are bulk billed $F^b = F(\alpha^b, \theta)$;

c) the average price charged to all patients ($\overline{p} = (F^b \times m) + (1 - F^b)\left(m + \overline{p}^{nb}\right) = m + (1 - F^b)\overline{p}^{nb}$;

d) the average quality of a GP ($\overline{q}$) (as measured by average consultation time for all her patients);

We use the model to derive predictions about how these variables respond to an increase in the distance between GPs ($\ell = L/G$) which we interpret as a decrease in competition in the market. The first four columns in Table 1 summarise the comparative static properties of the model when the number of GPs (and hence ℓ) is fixed.[5] The table shows the ceteris paribus effects of changes in ℓ, m, δ, t, h, θ on the four variables we observe in our data.

Table 1. Comparative static properties

Increase in	Ceteris paribus effect on prices, bulk billing, quality				Effect on distance between GPs (ℓ)
	$\overline{p}^{nb}$	F^b	$\overline{p}$	$\overline{q}$	
ℓ	?	–	+	–	NA
t	?	–	+	–	0
m	–	+	+	+	–
δ	–	+	–	–	+
θ	+	–	+	+	–
h	0	0	0	0	–
K	0	0	0	0	+

$\overline{p}^{nb}$: average net price (excess over Medicare reimbursement m) paid by patients who are not bulk billed; F^b: proportion of patients who are bulk billed (pay nothing out of pocket); $\overline{p} = (1 - F^b)\overline{p}^{nb}$: average over all patients of net price paid (in excess over Medicare fee m); $\overline{q}$: average quality (consultation length); ℓ : distance between GPs; t: patient travel cost; m: Medicare reimbursement; δ : quality cost parameter; θ : shift parameter for distribution of patient marginal valuation of quality (higher θ implies higher average valuation); K: GP fixed costs net of value of local amenities.

It is immediate from (8) that an increase in the distance between GPs (less competition) reduces the proportion of patients who are bulk billed. It is also clear from (7) that the price to non-bulk billed patients with given willingness to pay (given α) will increase. However, the effect of reduced competition on the average price to non-bulk billed patients ($\overline{p}^{nb}$) is ambiguous. Although a reduction in competition increases the price paid by those who were previously not bulk billed, some patients who were previously bulk billed and so had a zero net price, will now pay a low positive price. If reduced competition reduces the bulk billing proportion sufficiently, the average price for those not bulk billed will fall.

The average price paid across all patients is $\overline{p} = m + (1 - F^b)\overline{p}^{nb}$ and this will increase when competition is reduced since the price for every patient is either increased (if the patient is not bulk billed) or is unchanged (if the patient continues to be bulk billed).

[5] The derivations are in the Appendix.

Finally, reduced competition leads GPs to reduce the quality provided to bulk billed patients because quality is the only way to attract these patients. Competition has no effect on the quality they provide to non-bulk billed patients. Thus average quality is reduced if there is less competition.

The parameter θ shifts the distribution function of patient types. Increases in θ do not affect prices or quality for given types of patient but they do reduce the proportion who are bulk billed. Our assumption that an increase in θ gives a first order stochastic dominating distribution of the willingness to pay for quality implies $F^b_\theta = F_\theta\left(\alpha^b(\ell,t,m,\delta);\theta\right) < 0$ so that the proportion of patients who are bulk billed is reduced. First order stochastic dominance implies, since price is either constant or increasing in α and quality is increasing in α (see(6),(7)), that both $\overline{p}$ and $\overline{q}$ increase with θ. We can show that although the effect of θ on $\partial F^b / \partial\ell$ and $\partial\overline{p}^{nb} / \partial\ell$, are ambiguous, increases in θ make $\partial\overline{p} / \partial\ell$ more positive and $\partial\overline{q} / \partial\ell$ more negative. Thus in markets with higher θ a reduction in competition will lead to greater reductions in average quality and greater increases in average price.

3.3 Endogeneity of competition

We test for the effects of reduced competition (increased ℓ) by estimating cross-section regression models of the prices and qualities chosen by GPs in different markets with differing amounts of competition. However, in the absence of restrictions on entry, the number of GPs in a market and hence the distance between GPs (ℓ) is endogenous which raises the possibility that a simple cross-section model will produce biased estimates of the effect of ℓ .

With free entry into different markets, in equilibrium all markets will yield the same profit. Denote GP fixed cost of operating in the market by K (which can be taken to be a financial cost minus the monetary equivalent of any utility from the amenities in the market). Substituting the optimal patient price and quality from (6) and (7) into(3), maximised GP profit is

$$\pi^* = h\ell\int_{\alpha_0}^{\alpha_1}\left[p(\alpha;\ell,t,m,\delta) + m - \tfrac{1}{2}\delta q_i(\alpha;\ell,t,m,\delta)^2\right]dF(\alpha;\theta) = \pi^*(\ell;\delta,t,m,h,\theta) \qquad (10)$$

The equilibrium number of GPs and hence the distance between GPs is determined by the condition that GPs break even:

$$\pi^*(\ell;\delta,t,m,h,\theta) - K = 0 \qquad (11)$$

so that in equilibrium the distance between GPs is

$$\ell = \ell(\delta,t,m,h,K,\theta) \qquad (12)$$

Using the implicit function rule on (11) the effects of δ, t etc on the equilibrium ℓ are $\partial\ell/\partial\delta = -\pi^*_\delta / \pi^*_\ell$ etc and these are reported in the rightmost column of Table 1.

Endogeneity of ℓ will lead to biased estimates if the estimated model omits variables which determine prices or qualities and are correlated with ℓ . For example, the true model for the bulk billing proportion is $F^b = F(\alpha^b(\ell,t,m,\delta);\theta) = F^b(\ell(m,\delta,\theta,h,K),t,m,\delta,\theta)$. If the regression fails to include variables like θ which affect both F^b and ℓ positively, the estimated effect of ℓ will be positively biased. Omission of variables like t which only affect F^b and are not correlated with ℓ will not bias the estimated effect of ℓ , though it will lead to a loss of efficiency. Finally, variables like K which only affect F^b though their effect on ℓ should be omitted from the regression, though they could act as instruments for ℓ . We discuss the estimation of the regression models in more detail in section 4.2 after describing the data.

4. Empirical Methods

4.1 Data

We use data from the first wave of the Medicine in Australia: Balancing Employment and Life (MABEL) survey, a prospective cohort/panel study of workforce participation, labour supply and its determinants among Australian doctors. The sampling frame is the Australian Medical Publishing Company's (AMPCo) Medical Directory, a national database of all Australian doctors, managed by the Australian Medical Association (AMA). Data was collected from June to December 2008. The questionnaire covered topics such as job satisfaction and attitudes to work; characteristics of work setting (public/private hospital, private practice); workload (hours worked, on-call); finances (income, income sources); geographic location; demographics; and family circumstances (partner and children).

The number of GPs responding in the first wave was 3906 (including 226 GP registrars (trainees)), a response rate of 19.36%. The respondents were nationally representative with respect to age, gender, geographic location and hours worked (Joyce *et al.* 2010). We restrict the study sample to GPs located in the major conurbations in Australia. The areas outside these conurbations are very sparsely populated and GPs in them face different financial incentives and regulations to those in our study sample. After excluding rural GPs, GP registrars, and those with incomplete data we had a study sample of 1966 GPs.

Prices

The survey asks two questions about consultation fees. The first is "*Approximately what percentage of patients do you bulk bill/charge no copayment?*" We use the answers to measure the proportion of patients who are bulk billed (F^b). The bulk billed patients make no copayment and the GP is paid the Medicare rebate (m).

The second question is "*What is your current fee for a standard (level B) consultation? (Include Medicare rebate and patient copayment. Please write amount in dollars; write 0 if you bulk bill 100% of your patients)*". We use the answers to measure the average gross price ($\overline{p}^{nb} + m$) charged to patients who are not bulk billed. Different types of consultation (defined in terms of complexity and length) have different Medicare rebates and may have different copayments set by GPs.[6] In 2008 88.4% of all GP consultations were level B consultations and we believe the answer to this survey question is a good measure of a GP's price setting behaviour for non-bulk billed patients.

Quality

The GPs are asked *"How long does an average consultation last? (Please write number of minutes)"*. Since consultation length is positively correlated with measures of the quality of care including preventative care, lower levels of prescribing and some elements of patient satisfaction (Wilson and Childs 2002), we use this variable as a measure of the average quality of consultations ($\overline{q}$).

Competition measure

There is a large literature on measuring competition in healthcare markets (Gaynor and Town, 2011). Studies on markets for hospital care often calculate Herfindahl-Herschmann indices (HHIs) based on market share information. Recent hospital market studies, such as Gaynor et al (2011), have used

[6] The Medicare Benefits Schedule has four categories of consultation (Australian Government, 2008). Level A are simple consultations with limited examination, for example a consultation for a tetanus immunisation. Level B are more complex than Level A and include history taking, advice giving, ordering tests, formulation and implementation of a management plan. Level C are more complex than level B and must last at least 20 minutes. Level D consultations are yet more complex and must last at least 40 minutes. In 2008, level C consultations accounted for 10.5% of consultations and levels A and D together just over 1%.

the approach of Kessler and McClellen (2000) and Gowrisankaran and Town (2003), to avoid the endogeneity problem that market share depends on prices and qualities. These studies calculate the HHI from regression estimates of demand which include distance but not price or quality. Studies in physician markets generally have not been able to take this approach (with the exception of Schneider et al, 2008) because of the absence of data on patients' residential location. Instead, most physician market studies have used physician density (physicians per capita in an area) (Bradford and Martin, 2000; Johar, 2012; Richardson et al, 2006; Savage and Jones, 2004). This has the disadvantage that all physicians in an area are assumed to face the same competitive pressure.

We construct an individual GP level measure of competition: the distance between a GP's practice and her rival practices. This approach follows directly from the model in section 3 where we use distance between GPs (ℓ) as a measure of competition. Several papers in the hospital competition literature have also used competition measures which are purely geographically defined (Propper et al, 2008). Recent industrial organisation literature has emphasised the importance of distance to competitors, rather than market share measures on pricing decisions (Thomadsen 2005, Alderighi and Piga 2012). Drawing on Bresnahan and Reiss (1991), who show that, in geographically isolated markets for professional services (including doctors and dentists) only the first three additional competitors in a market have a large effect on prices, we use the distance to the third nearest GP as our main measure of competition. We also investigate the robustness of the measure by estimating models using the distance to the nearest and 5th nearest GP practice.

We construct the competition measures using data from the Australian Medical Publishing Company (AMPCo) which covers the whole population of Australian GPs, not just those who responded to the MABEL survey. For each MABEL respondent we calculated the road distance from their practice to the nearest, third nearest, and fifth nearest other GP practice in the AMPCo data, whether or not the other practices were MABEL respondents.

GP and GP practice covariates

We use individual GP and GP practice characteristics to control for differences in GP costs or preferences which may influence pricing decisions. We include GP gender and whether they have a spouse or dependent children, as this may affect their marginal valuations of income and leisure. GPs who went to an Australian medical school (as opposed to graduating overseas) may be perceived by their patients to be better trained or to be easier to communicate with. GP experience (measured in ten year bands) may also affect demand as a proxy for quality. We know whether the GP is a partner or associate in a practice, rather than a salaried employee. Partners and associates share in the profits of the practice which may give them an incentive to charge higher prices. Partner or associate status also indicates seniority of the GP within the practice. We also control for the characteristics of the practice itself: practice size (number of GPs) and whether the practice is taxed as a company or not. Practice size may influence pricing decisions either because of the effect of economies of scale on practice costs or incentive effects (Gaynor and Pauly, 1990). GPs working in a company may place a higher weight on profit.

Area characteristics

We also use data on area characteristics to capture other factors which may affect demand and cost conditions for GPs. We attribute them to GPs by their practice's location in postcode areas or Statistical Local Areas (SLAs). The 1966 GPs in the estimation sample are located in 616 postcode areas with an average population of 18,487. We use postcode area level data on the population age distribution, ethnicity, self reported disability, and socio-economic status measured by the Socio-Economic Index for Areas (SEIFA). The SEIFA Index of Relative Socio-Economic Advantage and Disadvantage is constructed by the Australian Bureau of Statistics from 22 variables measuring education, income, occupational structure, employment status, and family structure. Higher values correspond to greater advantage and we expect postcodes with a higher SEIFA score to have greater valuation of quality and thus to have GPs who set higher prices and provide higher quality.

The GPs in the estimation sample are located in 402 Statistical Local Areas (SLAs) with an average population of 33,164. We attribute SLA level data on median house prices and population density to GPs via their practice address. House prices may capture higher premise costs for GPs and richer populations who have a higher willingness to pay for GP services. In some SLAs there are additional incentives for bulk billing and we also include a dummy variable to indicate these SLAs.

Table 2 has descriptive statistics of the sample for all of the variables in the estimating equations.

4.2 Estimation

We estimate models for the proportion of patients who are bulk billed F^b, the average gross price $\overline{p}^{nb}+m$ (which equals m when the GP bulk bills all patients), the average gross price for all patients $m+\left(1-F^b\right)\overline{p}^{nb}$, and the average consultation length $\overline{q}$. We use log transformations $\ln(\overline{p}^{nb}+m)$, $\ln(m+\left(1-F^b\right)\overline{p}^{nb})$ for the price variables and quality $\ln(\overline{q})$ to allow for right skewness of the data.

Linear models

Our baseline model is a linear regression for GP *j* in area r

$$y_{jr}=\beta_0+\beta_1 GPdist_{jr}+\beta_2 GPchars_{jr}+\beta_3 Areachars_r+\varepsilon_{jr} \tag{13}$$

where y_{jr} is one of the four dependent variables. $GPdist_{jr}$ is a GP-practice specific measure of the distance between a GP and nearby practices, corresponding to ℓ in the theory model; $GPchars_{jr}$ is a vector of the characteristics of the GP and her practice; $Areachars_r$ are characteristics of the area in which the GP is located.[7]

The variable of particular interest is $GPdist_{jr}$, which we interpret from our theory model as measuring the degree of competition, a greater distance between GPs indicating less intense competition. Our first approach to identifying its effect is through variation in the outcomes *y* and competition $GPdist$ across GPs *j* and areas r. We have a rich set of GP and practice characteristics but more limited area level information on patient characteristics which may shift demand. The key identification problem with this approach is related to GPs' ability to choose where they practice. If there are unobserved factors which affect their choice of location and are correlated with both y_{jr} and $GPdist_{jr}$, then the error term ε_{jr} will not be conditionally uncorrelated with $GPdist_{jr}$ thereby biasing the OLS estimate of β_1. For example, areas may differ in amenity. High amenity areas may attract more GPs and a population of patients who have a greater willingness to pay for consultations. Although we control for a range of area characteristics, they may not adequately capture all of these correlations. The estimated effect of distance between GPs on prices will then be biased downward.

We attempt to overcome this problem by taking advantage of the fact that we have a measure of competition which is GP specific (distance to rival GPs) and thus varies both between areas (over r) and within areas (over *j* within r). There are an average of 4.7 GPs in the estimation sample in each SLA. We make use of this within area variation in three ways: random area effects, fixed area effects, and Mundlak (1978) models. In the random effects model

[7] In the model for average price to non-bulk billed patients we use the full observation sample by setting the average price to non-bulk billed patients to zero for GPs who bulk bill all their patients.

$$y_{jr} = \beta_0 + \beta_1 GPdist_{jr} + \beta_2 GPchars_{jr} + \beta_3 Areachars_r + \gamma_r + \upsilon_{jr} \quad (14)$$

γ_r is a $N(0,\sigma^2)$ random variable. In the fixed effects specification we include the γ_r as parameters and the $Areachars_r$ are omitted from the model as they are perfectly collinear with the area fixed effects. The Mundlak (1978) specification is

$$y_{jr} = \beta_0 + \beta_1 GPdist_{jr} + \beta_2 GPchars_{jr} + \beta_3 Areachars_r + \lambda_1 \overline{GPdist}_r + \lambda_2 \overline{GPchars}_r + \gamma_r + \upsilon_{jr} \quad (15)$$

where γ_r is a $N(0,\sigma^2)$ random effect and $\overline{GPdist}_r$, $\overline{GPchars}_r$ are the area means (for each *r*) of $GPdist_{jr}$ and $GPchars_{jr}$.

The area random effects specification will yield a consistent estimate of β_1 if the unobserved area effects γ_r are conditionally uncorrelated with $GPdist_{jr}$. The fixed effects estimation is consistent for β_1 if υ_{jr} is uncorrelated with $GPdist_{jr}$ given γ_r and $GPchars_{jr}$. The Mundlak specification is consistent if γ_r and υ_{jr} are uncorrelated with $GPdist_{jr}$ conditional on $GPchars_{jr}, \overline{GPdist}_r$, and $\overline{GPchars}_r$. This is more stringent than the requirement for fixed effects since the included area mean variables must capture the correlation between unobserved area characteristics and the GP varying characteristics (eg distance to other GP practices). The fixed effect estimator ensures all the unobserved area characteristics are picked up by the area effect γ_r.

Using the Mundlak or fixed effects specification means that we need sufficient within area variation in both y_{jr} and $GPdist_{jr}$ areas to successfully identify β_1. The advantage of including area effects in the estimation is that it controls for characteristics of areas that would otherwise be unobserved but which may influence prices, including demand side influences not captured in the observed area level variables, and supply-side influences, such as the availability of other health services that may be substitutes for GP care (eg the number of pharmacies and emergency departments). We will obtain consistent estimates of the effect of *GPdist* on prices and quality provided that GP location decisions within areas are uncorrelated with within-area varying factors affecting pricing and quality decisions.

For the Mundlak and area fixed effects models ((14) and(15)) we use SLAs as the area, since there is more within-area variation than if we used the postcode as the area: there are an average of 4.9 GPs per SLA and 3.1 per postcode.

Tobit model

The linear models do not make full use of the available data. When estimating the model for the average price to non-bulk billed patients $\overline{p}_j^{nb}$ we ignore the information on the proportion of GP *j*'s patients who are bulk billed (F_j^b). From the model in section 3 (see equation (7)), the profit maximising net price p_i to patient i with taste α_i is $p_i = p^{nb}(\alpha_i;\cdot)$ if $\alpha_i \geq \alpha^b$ and $p_i = p^b(\alpha_i;\cdot) = 0$ if $\alpha_i < \alpha^b$, or $p_i = \max\{p^{nb}(\alpha_i;\cdot), 0\}$. Thus, allowing for the variables determining the price to vary across GPs in different markets, the optimal net price to patient i of GP j is $p_{ij} = \max\{p_j^{nb}, 0\}$, and the optimal gross price is $p_{ij} + m = \max\{p_j^{nb} + m, m\}$.

Using the same log transform as in the linear model define

$$y_{ij} = \ln\left[\left(p_{ij} + m\right)/m\right] = \ln\left[\left(\max\{p_{ij}^{nb}, 0\} + m\right)/m\right] = \max\left\{y_{ij}^{*}, 0\right\} \quad (16)$$

where $y_{ij}^{*} = \ln\left[\left(p_{ij}^{nb} + m\right)/m\right]$. If we had data on the gross prices charged to patient *i* of GP *j* we could estimate a Tobit model with log likelihood

$$\ln L_1 = \sum_j \sum_i^{S_j} \left\{ \left(1 - d_{ij}\right)\left[-\ln\sigma + \ln\phi\left(\frac{y_{ij} - x_j\beta}{\sigma}\right)\right] + d_{ij}\ln\left[1 - \Phi\left(\frac{x_j\beta}{\sigma}\right)\right]\right\} \quad (17)$$

where $d_{ij} = 1$ if the patient is bulk billed and $d_{ij} = 0$ otherwise, S_j patients are treated by GP *j* and $y_{ij} = \max\{y_{ij}^{*}, 0\} = \max\{x_j\beta + \varepsilon_{ij}, 0\}$ where ε_{ij} picks up all the unobserved patient i and GP j characteristics affecting the optimal price and is distributed $N(0,\sigma^2)$. Estimation of the model parameters β and σ would yield estimates of the effect of competition on the expected price to non-bulk billed patients, the probability that a patient is bulk billed, and the expected gross price.

Estimation using the log likelihood in (17) requires S_j observations of (y_{ij}, x_j) for each GP_j . However, we observe only the average price for non-bulk billed patients $\overline{p}_j^{nb}$ and the proportion F_j^b who are bulk billed. Assuming that all non-bulk billed patients have the same price we can replace $y_{ij} = \ln((p_{ij} + m)/m)$ in (17) with $y_j = \ln((\overline{p}_j^{nb} + m)/m)$ to get

$$\ln L_2 = \sum_j S_j \left\{ \left(1 - F_j^b\right)\left[-\ln\sigma + \ln\phi\left(\frac{y_j - x_j\beta}{\sigma}\right)\right] + F_j^b\ln\left[1 - \Phi\left(\frac{x_j\beta}{\sigma}\right)\right]\right\} \quad (18)$$

Making the further assumption that all GPs see the same number of patients ($S_j = S$), the values of β and σ which minimise (18) do not depend on S.

We use our data to create two observations for each GP of the form (y_j, x_j) = $\left(\ln\left(\left[\overline{p}_j^{nb} + m\right]/m\right), x_j\right)$ and $(0, x_j)$ with weights $(1 - F_j^b)$ and F_j^b respectively and use the *tobit* command in Stata to estimate β and σ.

The vector of explanatory variable *x* is specified as in the linear model in equation (13). We also estimate a version of the Tobit with the Mundlak area-average terms as in equation (15). Although the Tobit model we estimate is a partial misspecification of the data generation process because we replace individual prices with average prices, it can be viewed as an alternative non-linear specification which makes better use of the available information than the separate linear models for prices and the bulk billing rate.

The estimates of β and σ yield estimates of three quantities of interest for each GP

(i) the bulk billing probability

$$F_j^b = \Pr(y_j = 0 | x_j) = 1 - \Phi\left(x_j\beta/\sigma\right) \quad (19)$$

(ii) the expectation of $y_j = \ln\left(\left[\overline{p}_j^{nb} + m\right]/m\right)$ for non-bulk billed patients

$$E[y_j \mid y_j > 0, x_j] = x_j\beta + \sigma\lambda(x_j\beta/\sigma) \quad (20)$$

where $\lambda(x_j\beta/\sigma)=\phi(x_j\beta/\sigma)/\Phi(x_j\beta/\sigma)$

(iii) the expectation of y_j for all patients $\left(\ln\left(\left[(\overline{p}_j+m\right]/m\right) = \ln\left(\left[\left(1-F_j^b\right)\overline{p}_j^{nb}+m\right]/m\right)\right)$

$$E[y_j|x_j]=\Pr(y_j>0|x_j)E[y_j|y_j>0,x_j]=\Phi(x_j\beta/\sigma)\left[x_j\beta+\sigma\lambda(x_j\beta/\sigma)\right] \quad (21)$$

We report the estimated average marginal effects of our competition measure, distance to competing practices, and other variables on these three different measures of GP price setting.

5. Results

Table 2 presents summary statistics. The GPs in our sample bulk bill (charge zero copayment to) 61% of their patients, with 19.7% of GPs bulk billing all of their patients and 1.6% bulk billing none of them. The average gross price to non bulk billed patients is $50.10 and, since the Medicare rebate for all patients is $32.80, this implies that the average out of pocket payment for these patients is just under $18. The average distance to the third nearest other practice is 1.5km which is more than twice the distance to the nearest practice and two thirds of the distance to the 5th nearest practice.

Nearly half the GPs are female, which is similar to the proportion in other developed countries. Almost 20% are qualified overseas and most probably therefore not born in Australia. Just under a half of GPs are partners or associates and so have a direct financial interest in profits of their practice. Only 14% work as single-handed GPs.

5.1 Models for average price to all patients: $(1-F^b)\,\bar{p}^{nb} + m$

Linear Models

Table 3 presents detailed results for linear regression models where the dependent variable is the log of the gross price averaged over all patients seen by the GP: $\ln((1-F^b)\,\bar{p}^{nb} + m)$. All models in this and subsequent tables have standard errors corrected to allow for clustering at area (SLA) level.[8] The size and significance of the key results are similar across the four model specifications. A Hausman test comparing the area random and fixed effects models fails to reject the null of the random effects model for all four dependent variables (results available from authors).

The first row in Table 3 reports the coefficients and SEs for our preferred measure of competition: the log of the distance to the third-nearest GP-practice. Since the dependent variable is also a log, the coefficients on the distance measure are elasticities. The coefficients are positive and statistically significant for all models: the greater the distance to the 3rd nearest practice, the higher the average price charged by the GP. The size of the effect is consistent across the alternative models, including the Mundlak and fixed effects models, which control for unobserved area-level characteristics.

Tobit models

Table 4 presents average marginal effects from two Tobit models of the average price to all patients in the practice. As in the linear models, the log transformation of the price measure means that the average marginal effects for the competition measure are average elasticities. The pattern of results is similar to the linear models but the estimated marginal effects of the competition measure are a little larger: 0.022 for the Tobit models compared to 0.018 for the equivalent linear models. This may be because the Tobit makes better use of information on the non-trivial proportion (17.7%) of GPs who bulk bill all patients.

[8] The 1966 GPs are located in 1379 practices. We also allowed for clustering at practice level but this made little difference to the results.

Table 2. Summary statistics

Variable	Mean	S.D.	Min	Max
Dependent Variables				
Average price (\$): $m + (1\text{-}F^b)\ \overline{p}^{nb}$	42.063	9.712	32.800	150.000
Patients bulk billed (%): F^b	60.949	31.433	0.000	100.000
Bulk billed zero patients (%)	0.016	0.127	0.000	1.000
Bulk billed all patients (%)	0.197	0.398	0.000	1.000
Price (\$): $\overline{p}^{nb} + m$	50.107	11.607	32.800	150.000
Consult time (mins)	16.679	5.632	5.000	60.000
Competition Variables				
Closest GP Practice (km)	0.696	0.988	0.000	9.434
Third closest GP practice (km)	1.519	1.592	0.003	17.448
Ln(Third closest GP practice (km))	0.002	0.975	-5.954	2.859
Fifth closest GP practice (km)	2.166	1.977	0.067	19.005
GP and Practice Variables				
Female GP	0.472	0.499	0.000	1.000
Spouse	0.867	0.339	0.000	1.000
Children	0.640	0.480	0.000	1.000
Australian Medical School	0.814	0.389	0.000	1.000
Experience 10-19 years	0.208	0.406	0.000	1.000
Experience 20-29 years	0.366	0.482	0.000	1.000
Experience 30-39 years	0.265	0.441	0.000	1.000
Experience 40+ years	0.092	0.289	0.000	1.000
GP registrar	0.035	0.183	0.000	1.000
Partner or associate	0.455	0.498	0.000	1.000
Practice taxed as company	0.276	0.447	0.000	1.000
Practice size: 2-3 GPs	0.169	0.375	0.000	1.000
Practice size: 4-5 GPs	0.200	0.400	0.000	1.000
Practice size: 6-9 GPs	0.326	0.469	0.000	1.000
Practice size: 10+ GPs	0.160	0.366	0.000	1.000
Area Variables				
SEIFA Index of adv/disadv	0.000	1.000	-4.521	2.242
Incentive area	0.228	0.420	0.000	1.000
Median House price (\$0,000)	55.522	29.379	16.550	302.250
Proportion of residents U15	0.177	0.048	0.025	0.293
Proportion 65+	0.134	0.045	0.023	0.309
Proportion disabled	0.039	0.014	0.006	0.091
Proportion NW Europe	0.082	0.040	0.011	0.269
Proportion SE Europe	0.049	0.042	0.005	0.301
Proportion SE Asia	0.042	0.051	0.002	0.422
Proportion Other	0.096	0.082	0.002	0.496
Popn density (pop/km2) ('000)	2.047	1.609	0.019	8.757

Note: Descriptive statistics for estimation sample of 1966 GPs. Area variables are measured at SLA level for the incentive area dummy, population density and median house prices, and at postcode level for all others. For the regression models we standardise the SEIFA variable to have a zero mean and standard deviation of one.

Table 3: Linear models of average price to all patients

	OLS			R.E.			Mundlak			F.E.		
Explanatory Variable	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
ln(3rd closest GP pr)	0.018	0.005	***	0.018	0.005	***	0.018	0.007	***	0.017	0.006	***
Female GP	0.041	0.010	***	0.041	0.010	***	0.041	0.011	***	0.040	0.011	***
Spouse	0.005	0.012		0.009	0.012		0.011	0.013		0.014	0.013	
Children	0.006	0.010		0.005	0.010		0.005	0.010		0.008	0.010	
Australian Medical School	0.074	0.010	***	0.071	0.010	***	0.069	0.012	***	0.070	0.012	***
Experience 10-19 years	0.042	0.019	**	0.042	0.018	**	0.042	0.019	**	0.041	0.019	**
Experience 20-29 years	0.026	0.018		0.028	0.017		0.034	0.018	*	0.032	0.019	*
Experience 30-39 years	0.028	0.019		0.033	0.018	*	0.040	0.019	**	0.040	0.020	**
Experience 40+ years	-0.024	0.020		-0.018	0.019		-0.005	0.021		-0.005	0.021	
Registrar	-0.008	0.021		0.001	0.021		0.013	0.021		0.011	0.021	
Partner or associate	0.038	0.010	***	0.038	0.010	***	0.037	0.011	***	0.037	0.011	***
Company	0.012	0.010		0.008	0.009		0.004	0.010		0.004	0.010	
Practice size: 2-3 GPs	-0.012	0.016		-0.012	0.015		-0.011	0.016		-0.012	0.016	
Practice size: 4-5 GPs	0.019	0.016		0.024	0.016		0.034	0.018	*	0.032	0.018	*
Practice size: 6-9 GPs	0.032	0.014	**	0.030	0.014	**	0.030	0.015	*	0.030	0.016	*
Practice size: 10+ GPs	0.027	0.017		0.023	0.017		0.018	0.018		0.011	0.019	
SEIFA adv/disadv	0.038	0.013	***	0.035	0.013	***	0.035	0.013	***			
Incentive Area	0.042	0.016	***	0.040	0.017	**	0.040	0.016	**			
Median house price	0.001	0.000	***	0.001	0.000	***	0.001	0.000	***			
Percentage U15	-0.554	0.177	***	-0.525	0.186	***	-0.520	0.186	***			
Percentage 65+	0.239	0.202		0.304	0.200		0.311	0.194				
Percentage disabled	-0.799	0.814		-1.026	0.809		-1.021	0.804				
Percentage NW Europe	0.013	0.184		-0.047	0.188		-0.057	0.198				
Percentage SE Europe	-0.548	0.184	***	-0.468	0.189	**	-0.472	0.191	**			
Percentage SE Asia	0.201	0.170		0.104	0.173		0.092	0.173				
Percentage Other	0.067	0.107		0.105	0.107		0.119	0.106				
Pop per km2	-0.001	0.005		-0.002	0.005		-0.003	0.005				
State dummies	Yes			Yes			No			No		
Local area random effects	No			Yes			Yes			No		
Local area averages	No			No			Yes			No		
Local Area FE's	No			No			Yes			Yes		
Obs	1966			1966			1966			1966		
R-squared	0.289			0.287			0.297			0.078		

Notes: Dependent variable is ln (Average Price): $\overline{p} = \ln[m + (1\text{-}F^b)\,\overline{p}^{nb}]$ where m is the Medicare rebate, $\overline{p}^{nb}$ is the average price to patients who are not bulk billed and F^b is the proportion of patients who are bulk billed. Standard errors adjusted for clustering at SLA level. *: p < 0.10, **: p< 0.05; ***: p < 0.01 (two tailed). All regression models include a constant term for which the coefficient estimate is not reported.

Table 4: Tobit models of average price to all patients

	Tobit			Tobit with Mundlak		
Explanatory Variable	Marg eff.	S.E.		Marg eff	S.E.	
ln(3rd closest GP pr)	0.022	0.006	***	0.022	0.007	***
Female GP	0.041	0.009	***	0.042	0.010	***
Spouse	0.013	0.012		0.019	0.012	
Children	0.003	0.010		0.002	0.010	
Australian Medical School	0.091	0.013	***	0.087	0.014	***
Experience 10-19 years	0.038	0.019	**	0.046	0.019	**
Experience 20-29 years	0.024	0.019		0.040	0.019	**
Experience 30-39 years	0.025	0.019		0.043	0.019	**
Experience 40+ years	-0.032	0.022		-0.003	0.022	
Registrar	-0.007	0.023		0.017	0.022	
Partner or associate	0.040	0.010	***	0.037	0.011	***
Company	0.011	0.010		0.005	0.010	
Practice size: 2-3 GPs	-0.003	0.016		0.000	0.017	
Practice size: 4-5 GPs	0.027	0.016	*	0.042	0.018	**
Practice size: 6-9 GPs	0.035	0.014	**	0.034	0.015	**
Practice size: 10+ GPs	0.026	0.017		0.016	0.018	
SEIFA adv/disadv	0.048	0.011	***	0.045	0.011	***
Incentive Area	0.046	0.015	***	0.045	0.015	***
Median house price	0.001	0.000	***	0.001	0.000	***
Percentage U15	-0.560	0.166	***	-0.574	0.169	***
Percentage 65+	0.311	0.192		0.345	0.184	*
Percentage disabled	-1.080	0.732		-1.224	0.724	*
Percentage NW Europe	-0.109	0.177		-0.156	0.181	
Percentage SE Europe	-0.582	0.214	***	-0.566	0.214	***
Percentage SE Asia	0.055	0.184		0.008	0.181	
Percentage Other	0.067	0.113		0.092	0.112	
Pop per km2	0.000	0.004		-0.001	0.004	
State dummies	Yes			Yes		
Local area random effects	No			No		
Local area averages	No			Yes		
Local Area FE's	No			No		
Obs	1966			1966		
Pseudo - R2	0.010			0.104		

Tobit models for dependent variable log average price, ln$[m + (1\text{-}F^b)\,\overline{p}^{nb}/m]$. The observations are weighted by the proportion of patients who are bulk billed, as described in section 4. Average marginal effects are reported. Standard errors adjusted for clustering at SLA level.

5.2 Bulk billing, price to non bulk billed patients, and quality

Table 5 presents the estimates of the marginal effects of the competition measure from linear and Tobit models for the three other aspects of GP decisions: the proportion of patients bulk billed F^b, the log of average price to those not bulk billed $\ln(\overline{p}^{nb} + m)$ and average quality $\overline{q}$.

In all the models greater distance to the third nearest practice is associated with a lower bulk billing rate. The t statistics on the competition measure are all considerably larger in the bulk billing rate models than in the models for the other outcomes of GP decisions, suggesting that the main effect of distance to nearby competitors on the average price $(1-F^b)\,\overline{p}^{nb}$ is through the bulk billing rate F^b. However, the empirical models also suggest that greater distance to rivals is associated with a higher $\overline{p}^{nb}$.

Finally, greater distance to rivals is associated with lower average quality as measured by average consultation time. However, the estimated effects, which are elasticities, are small and have p values greater than 0.10. The modest estimated impact of competition on consultation length may be because the theory model suggests that completion will only affect the quality supplied to non-bulk billed patients.

5.3 Effects of competition and patient socio-economic status

The theory model suggests that the effect of competition on the average price to all patients and on average quality will be greater in areas where there is a greater willingness to pay for quality (higher values of θ). To test this prediction, Table 6 reports the effects of distance to rival GPs and its interaction with the SEIFA advantage/disadvantage index at the postcode level. In the fixed effects and Mundlak models the interaction with the index of local area advantage is statistically significant in the models for average price to all patients and for bulk billing. In all cases, the socio-economic advantage of the area strengthens the effects of distance to local competitors on the price or quality outcome. Thus distance to local competitors has a stronger positive effect on average price to non-bulk billed patients and on average price to all patients in advantaged areas, and a stronger negative effect on bulk billing in more advantaged areas. The interaction term is not significant in the quality model, though the direct effect of distance to other GPs on consultation time is now slightly greater in all the linear models and significant at in the fixed effect specification.[1]

5.4 Effects of covariates

The effects of the covariates are consistent across the linear and non-linear (Tobit) models reported in Tables 3 and 4 and seem plausible. Female GPs set higher prices. This is perhaps because there is greater willingness to pay for a consultation with female GPs who may be perceived to have better interpersonal skills (Roter et al, 1991) or because female patients may prefer to consult female doctors. Reyes (2006) found that US female obstetricians/gynaecologists also charged higher fees than male obstetricians/gynaecologists.

[1] In all models we normalise the SEIFA index to have a mean of zero over the estimation sample. Thus in the linear models the average marginal effect of competition is β_{comp}.

Table 5: Average marginal effects of competition (ln distance to 3rd nearest GP) on alternative outcome variables

	OLS			R.E.			Mundlak			F.E.			Tobit			Tobit with Mundlak		
Dependent Variable	Marg eff	S.E.		Marg eff	S.E.		Marg eff	S.E.		Marg eff	S.E.		Marg eff	S.E.		Marg eff	S.E.	
Log price to non bulk billed patients: $ln(\overline{p}^{nb}+m)$	0.019	0.008	**	0.018	0.008	**	0.019	0.011	*	0.018	0.011	*	0.017	0.004	***	0.017	0.005	***
Bulk billing rate: F^b	-3.009	0.800	***	-2.945	0.762	***	-3.159	0.959	***	-3.090	0.940	***	-3.265	0.832	***	-3.369	0.106	***
Log average price: $ln[m+(1-F^b)*\overline{p}^{nb}]$	0.018	0.005	***	0.018	0.005	***	0.018	0.007	**	0.017	0.006	***	0.022	0.006	***	0.022	0.007	***
Log of consult time: $ln(\overline{q})$	-0.007	0.008		-0.007	0.008		-0.015	0.011		-0.016	0.011		N/A			N/A		

Notes: Table reports coefficients for linear models and average marginal effects for Tobit models of log distance to the 3rd closest other GP practice. Each coefficient and standard error represents a different model estimation. Models also contain covariates in full models reported in Tables 3 and 4. *: p < 0.10, **: p< 0.05; ***: p < 0.01 (two tailed).

Table 6: Average marginal effects of competition on measures of price and quality: Interaction with socio-economic status

Dependent Variable	OLS			R.E.			Mundlak			F.E.		
Explanatory variables	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
Dep Var: log price = *ln(p+m)*												
ln(3rd closest GP pr)	0.017	0.008	**	0.017	0.008	**	0.021	0.011	**	0.022	0.011	**
x SEIFA adv/disadv	-0.004	0.007		-0.002	0.007		0.009	0.009		0.012	0.009	
Dep Var: bulk billing rate = F^b												
ln(3rd closest GP pr)	-3.105	0.886	***	-3.225	0.838	***	-3.713	1.023	***	-3.783	1.011	***
x SEIFA adv/disadv	-0.301	0.800		-0.830	0.745		-1.738	0.872	**	-2.177	0.858	**
Dep Var: log average price = $ln[m+(1-F^B)*\overline{p}^{nb}]$												
ln(3rd closest GP pr)	0.018	0.006	***	0.018	0.006	***	0.021	0.007	***	0.206	0.007	***
x SEIFA adv/disadv	-0.002	0.005		0.001	0.005		0.008	0.006		0.012	0.006	**
Dep var: log consult time = $ln(\overline{q})$												
ln(3rd closest GP pr)	-0.005	0.007		-0.005	0.007		-0.014	0.011		-0.060	0.011	***
x SEIFA adv/disadv	0.008	0.007		0.008	0.007		0.001	0.011		-0.001	0.011	

Notes: Table reports coefficients for linear models of log distance to the 3^{rd} closest other GP practice and the interaction with SEIFA: "socio-economic index for areas", an area advantage/disadvantage index. Each group of two coefficients and standard errors represents a different model estimation. Models also contain covariates in full models reported in Tables 3 and 4. *: p < 0.10, **: p< 0.05; ***: p < 0.01 (two tailed).

GPs who graduated from an Australian medical school also set higher prices, suggesting that consultations with them are regarded as being of higher quality. Partners or associates in practices set higher prices, presumably because they have a share in practice profits. There is no evidence that prices are affected by the GP's experience and there is only a small effect of the size of the practice. GPs in areas with more advantaged patients set higher prices, suggesting that these patients have a higher willingness to pay.

Disabled patients are likely to have a higher demand for consultations (which should drive up the price) but are also likely to have lower incomes which should lower the price. The results suggest that the latter effect is dominant. GPs in areas with older patients set higher prices, reflecting that such patients have higher demands, possibly have higher incomes, and a greater cost of shopping around.

Areas with financial incentives to bulk bill patients (charge zero copayment) have higher prices, this may reflect that these incentives do not fully offset the factors that drive high prices (and low bulk billing rates) in such areas. Prices are higher in areas with higher house prices, either because this reflects a greater willingness to pay of the local population or higher premise costs.

5.5 Robustness checks

Table 7 presents results for average price where we use alternative measures of localised competition as the key explanatory variable. In particular we explore the sensitivity of the results to the number of GP practices in the distance calculation. Using the log of distance to the fifth nearest GP practice gives a larger marginal effect (approximately 50% larger) of distance on the average price. Using the log of distance to the nearest GP practice gives smaller and less consistently statistically significant results. We attribute this to the lack of variation (evidenced by a smaller standard deviation) in this variable compared to the other distance measures.

Table 8 presents the results of linear models and Tobit models for average price with different sets of covariates. The first row of the table contains models with the log distance to 3rd nearest practice as the only covariate. In the OLS and Tobit model with no controls and no area effects, the estimated coefficient is much smaller and insignificant. We can see that for the models with area random effects, area Mundlak correction, and area fixed effects, the coefficient on log distance is similar to the models with a full set of controls. The second set of models is the same as the previous set except that we add the GP and practice covariates but not the area-level covariates. Again, the models that do not account for area effects fail to find a statistically significant coefficient on the distance to nearby competitors, but with area effects, the models are similar to the full specification. In the full specification there is little difference in the key results between the models with and without area effects. The results in Table 8 demonstrate the importance of accounting for area effects. They also demonstrate that in the full specification, the area-level covariates pick up this important variation, explaining why there is little difference between the different model results.

Table 7: Average marginal effect of competition on average price to all patients: alternative measures of competition

Dep Var: log average price = $ln[m+ (1-F^B)* \ \bar{p}^{nb}]$	OLS			R.E.			Mundlak			F.E.			Tobit			Tobit with Mundlak		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Marg eff	S.E.		Marg eff	S.E.	
ln(closest GP pr)	0.007	0.003	**	0.006	0.003	**	0.006	0.003	*	0.005	0.003		0.009	0.003	***	0.007	0.004	**
ln(3rd closest GP pr)	0.018	0.005	***	0.018	0.005	***	0.018	0.007	***	0.017	0.006	***	0.022	0.006	***	0.022	0.007	***
ln(5th closest GP pr)	0.027	0.008	***	0.026	0.007	***	0.031	0.009	***	0.029	0.009	***	0.033	0.008	***	0.038	0.011	***

Notes: dependent variable is log of average price $\ln[m+(1-F^b)\ \bar{p}^{nb}]$. Each coefficient and standard error represents a different model estimation. Models also contain covariates in the models reported in Tables 3 and 4. *: p < 0.10, **: p< 0.05; ***: p < 0.01 (two tailed).

Table 8: Average marginal effect of competition on average price to all patients: alternative sets of covariates

Dep Var: log average price = $ln[m+ (1-F^B)* \ \bar{p}^{nb}]$	OLS			R.E.			Mundlak			F.E.			Tobit			Tobit with Mundlak		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Marg eff	S.E.		Marg eff	S.E.	
ln(3rd closest GP pr) with no other covariates[1]	0.005	0.008		0.013	0.005	***	0.018	0.007	**	0.018	0.007	**	0.008	0.008		0.021	0.007	***
Only GP and practice covariates[2]	0.004	0.007		0.012	0.005	**	0.017	0.006	***	0.017	0.006	***	0.008	0.007		0.020	0.007	***
Full specification[3]	0.018	0.005	***	0.018	0.005	***	0.018	0.007	***	0.017	0.006	***	0.022	0.006	***	0.022	0.007	***

Notes: dependent variable is log of average price $\ln[m+(1-F^b)\ \bar{p}^{nb}]$. Each coefficient and standard error represents a different model estimation. [1] Models include constant, ln distance to 3rd nearest practice. The RE and FE models include random and fixed area effects and the Mundlak models include the area mean of the distance variable. [2]Models are as in previous case but with the addition of the GP and practice covariates but with no area level covariates. [3]Full specification as reported in tables 3 and 4. *: p < 0.10, **: p< 0.05; ***: p < 0.01 (two tailed).

6. Discussion

This paper develops theoretical and empirical models of the relationship between localised competition, measured by distance between GP practices, and price and quality setting in a market for General Practitioner services. Our approach follows a strand in the literature which emphasizes distance to nearby competitors as a determinant of prices in general IO models (Alderighi and Piga, 2012; Thomadsen, 2005) and in hospital markets (Gaynor and Vogt 2003).

Our empirical results generally support the predictions from the theory model set out in Table 1. Our preferred measure of competition, distance to third-nearest GP practice, is significantly negatively associated with the proportion of patients who are bulk billed F^b, positively associated with the average price to patients who are not bulk billed $\overline{p}^{nb}$,and with the average price to all patients $\overline{p}$ = $(1-F^b)\,\overline{p}^{nb}$.

Although all models yield qualitatively similar results, our preferred empirical specification is the Tobit model with the area-Mundlak adjustment. It combines the information on GP decisions on prices and the proportion of patients who are bulk billed and allows for area level unobservables. This model yields an estimated elasticity of 0.022 for the average price to all patients with respect to distance to third nearest GP. A one standard deviation (0.975) increase in the log distance to the third nearest GP practice implies a \$0.90 increase in the average gross price and a 3.3 percentage point fall in the number of patients bulk billed. Shifting a GP from the lowest decile of the distribution of distance to third nearest GP (0.29km) to the top decile (3.0km) is associated with \$2.17 increase in the average price and a 7.9 percentage point reduction in the proportion of patients who are bulk billed (ie face zero copayment).

We also find that in areas with higher socio-economic status, an increase in the distance to rival GP practices is associated with a larger increase in price and a larger reduction in the proportion of patients who are bulk billed. This finding matches the prediction from our theoretical model that the taste for quality in a market (θ), which we proxy with socio-economic status, increases the responsiveness of average price to competition. The finding is also in line with Johar (2012) who finds the relationship between patient income and prices charged is larger in areas with higher GP density.

We interpret the results from the area fixed effects and Mundlak models as evidence of a causal effect of distance to nearby competitors on GP pricing decisions. We think it reasonable to assume that omitted variables correlated with the competition measure and pricing decisions operate mainly at the area (SLA) level. This requires either that factors affecting GP location operate across SLAs and not within them or that factors shifting demand or cost functions and thereby affecting price are fairly homogenous within SLAs and vary mainly across them. The fact that we find similar sized effects in models with and without area effects suggests that our area-level variables capture most area-level factors that are correlated with pricing decisions and our measures of competition. Our results are also broadly in agreement with previous studies of the Australian market using area-level data which find that higher GP density increases the bulk billing rate (Richardson et al 2006, Savage and Jones 2004).

There has been increasing concentration in the market for GP services in Australia. Between 2003 and 2008, although the number of GPs in Australia grew by 4.6% the number of GP practices fell by 6.7% (Moretti et al 2010). Both state and federal government policy has encouraged the formation of larger practices, with current policy funding the establishments of 'GP Superclinics'. Increasing concentration could also be explained by a trend for private companies to own chains of large GP practices. There has also been an increase in concentration in the US (Liebhaber and Grossman, 2007). Our results suggest that the trends to increasing concentration in markets for physician services in the US and Australia may lead to higher prices.

References

Alderighi, M. and Piga, C. 2012. Localized competition, heterogeneous firms, and vertical relations. *The Journal of Industrial Economics* 60 (1):46-74.

Australian Government, Department of Health and Ageing. 2008. *Medicare Benefits Schedule Book*. http://www.health.gov.au/mbsonline.

Brekke, K., Siciliani, L., Straume, O. 2010. Price and quality in spatial competition. *Regional Science and Urban Economics*, 40, 471-480.

Bradford, W., Martin, R. 2000. Partnerships, profit sharing, and quality competition in the medical profession, *Review of Industrial Organization* 17(2): 193-208.

Bresnahan, T. 1989. Empirical studies of industries with market power. In Schmalensee, R. and Willig, R. (eds.) *Handbook of Industrial Organisation.* Vol 3, Amsterdam. North Holland.

Bresnahan, T., Reiss, P. 1991. Entry and competition in concentrated markets. *Journal of Political Economy*, 99, 5, 977-1009.

Busse, R., Reisberg, A. 2004. *Health Care Systems in Transition: Germany*. WHO Regional Office for Europe on behalf of the Europea Health Observatory on Health Systems and Practices, Copenhagen.

Dranove D. and Satterthwaite, M.. 2000. The industrial organization of healthcare markets. in A.J. Culyer and J. Newhouse (Eds.) *The Handbook of Health Economics*. Amsterdam, North Holland.

Gaynor, M., Moreno-Serra R., Propper, C. 2011. Death by Market Power: Reform, Competition and Patient Outcomes in the National Health Service, *CMPO Working Paper*, 10/242

Gaynor, M., Pauly, M. 1990. Compensation and productive efficiency in partnerships: evidence from medical groups practice. *Journal of Political Economy*. 98, 544-573.

Gaynor, M., Town, R. 2011. Competition in health care markets. Ch 9 of M. Pauly, T. Mcguire and P. P. Barros (eds.), *Handbook of Health Economics* vol 2 Elsevier.

Gaynor, M., Vogt, W. 2003. Competition among Hospitals. *RAND Journal of Economics*, 34(4): 764-85.

Glazer, J., McGuire, T. 1993. Should physicians be permitted to 'balance bill' patients? *Journal of Health Economics*,11, 239-258.

Gowrisankaran, G. & Town, R. 2003. Competition, payers, and hospital quality. *Health Services Research*, 38, 1403-1422.

Gravelle, H. 1999. Capitation contracts: access and quality. *Journal of Health Economics*. 18, 317-342.

Gunning, T., Sickles, R. 2012. Competition and market power in physician private practices. *Empirical Economics* 10.1007/s00181-011-0540-6.

Johar, M. 2012. Do doctors charge high income patients more? *Economics Letters* 117:596-599.

Joyce, C., Scott, A., Jeon, S., Humphreys, J., Kalb, G., Witt, J., Leahy, A. 2010 The “Medicine in Australia: Balancing Employment and Life (MABEL)” longitudinal survey - Protocol and baseline data for a prospective cohort study of Australian doctors' workforce participation. *BMC Health Services Research*, 2010 10:50. http://www.biomedcentral.com/1472-6963/10/50

Kessler, D., McClellan, M. 2000. Is hospital competition socially wasteful? *The Quarterly Journal of Economics*. 115, 577-615.

L’Haridon, O., Paraponaris, A., Protopopescu, C., Ventelou, B., 2008. Length of GP consultation within two payment schemes. *GREQAM, Document de Travail*, 2008-50.

Liebhaber, A., Grossman, A.M. 2007. Physicians Moving to Mid-Sized, Single-Specialty Practices. Center for Studying Health Systems Change, Tracking Report No. 18.

McKnight, R. 2007. Medicare balance billing restrictions: impacts on physicians and beneficiaries. *Journal of Health Economics*. 26, 326-341.

McRae, I. 2009. Supply and demand for GP services in Australia. *Australian Centre for Economic Research on Health. Research Report* No. 6. July.

Moretti C, Carne A, and Bywood P. 2010. *Summary Data Report of the 2008-2009 Annual Survey of Divisions of General Practice*. Adelaide: Primary Health Care Research & Information Service, Discipline of General Practice, Flinders University.

Mundlak, Y. 1978. On the pooling of time series and cross-sectional data. *Econometrica*. 46-69-85.

Pauly, M., Satterthwaite, M. 1981. The pricing of primary care physicians services: a test of the role of consumer information. *Bell Journal of Economics*. 12, 488-506.

Propper, C., Burgess, S., Gossage, D. 2008. Competition and quality: evidence from the NHS Internal Market 1991-9. *The Economic Journal*, 118, 138-170.

Reyes, J. 2006. Do female physicians capture their scarcity value? The case of OB/GYNs. *NBER Working Paper* 12528.

Richardson, J., Peacock, S., Mortimer, D. 2006. Does an increase in the doctor supply reduce medical fees? An econometric analysis of medical fees across Australia. *Applied Economics* 38: 253-266.

Roter, D., Lipkin, M. and Korsgaard, A. 1991. Sex differences in patient's and physicians' communication during primary care medical visits. *Medical care*, 29(11), 1083-1093.

Salop, S.C. 1979. Monopolistic competition with outside goods. *Bell Journal of Economics*. 10, 141-156.

Savage E, Jones G. (2004) An analysis of the General Practice Access Scheme on GP incomes, bulk billing and consumer copayments. *Australian Economic Review* 37 (1): 31-40.

Schneider, J., Li, P., Klepser, D., Peterson, A., Brown. T., Scheffler, R. 2008. The effect of physician and health plan market concentration on prices in commercial health insurance markets. *International Journal of Health Care Financing and Economics* 8(1):13-26.

Scott, A., Shiell, A. 1997. Analysing the effect of competition on General Practitioners' behaviour using a multilevel modelling framework. *Health Economics*, 6, 577-588.

Sullivan, T., Baranek, P. 2002. *First do no harm: making sense of Canadian health reform*. Toronto, Ontario: Malcolm Lester and Associates.

Thomadsen, R., 2005. The effect of ownership structure on prices in geographically differentiated industries, *Rand Journal of Economics*, 36, 908–929.

Vickrey, W.S. 1964. *Microstatics*. Harcourt, Brace and World, New York, pp 329-336. Reproduced in Anderson and Braid (1999).

Wilson, A., Childs, S. 2002. The relationship between consultation length, process and outcomes in general practice: a systematic review. *British Journal of General Practice*, 52, 1012-1020.

Appendix. Derivation of comparative static results in Table 1

a) From (8) and (9), reductions in competition reduce the proportion of patients who are bulk billed

$$\partial F^b / \partial \ell = f(\alpha^b, \theta)\partial \alpha^b / \partial \ell < 0 \qquad \text{(A1)}$$

b) The effect of reduced competition on the average price charged to patients who are not bulk billed ($\overline{p}^{nb}$) is

$$\frac{\partial \overline{p}^{nb}}{\partial \ell} = \frac{\partial \mathrm{E}\left[p(\alpha;\ell,t,m,\delta) \middle| \alpha \geq \alpha^b \right]}{\partial \ell} = \frac{\partial}{\partial \ell}\left[\int_{\alpha^b}^{\alpha_1} p(\alpha;\ell,t,m,\delta) f(\alpha,\theta) d\alpha \frac{1}{1-F(\alpha^b,\theta)} \right]$$

$$= \int_{\alpha^b}^{\alpha_1} \frac{\partial p(\alpha;\ell,t,m,\delta)}{\partial \ell} f(\alpha) d\alpha \frac{1}{1-f(\alpha^b,\theta)} - \frac{p(\alpha^b;\ell,t,m,\delta)}{1-F(\alpha^b,\theta)} \frac{\partial \alpha^b}{\partial \ell}$$

$$+ \int_{\alpha^b}^{\alpha_1} p(\alpha;\ell,t,m,\delta) f(\alpha) d\alpha \frac{1}{\left[1-F(\alpha^b,\theta)\right]^2} \frac{\partial F^b}{\partial \alpha^b} \frac{\partial \alpha^b}{\partial \ell}$$

$$= \int_{\alpha^b}^{\alpha_1} \frac{\partial p_i(\alpha;\ell,t,m,\delta)}{\partial \ell} f(\alpha,\theta) d\alpha \frac{1}{1-F(\alpha^b,\theta)}$$

$$+ \int_{\alpha^b}^{\alpha_1} p(\alpha;\ell,t,m,\delta) f(\alpha,\theta) d\alpha \frac{1}{\left[1-F(\alpha^b,\theta)\right]^2} f(\alpha^b,\theta) \frac{\partial \alpha^b}{\partial \ell} \qquad \text{(A2)}$$

The first term in the last line is positive but the second is negative since α^b is decreasing in ℓ (less competition reduces the threshold type at which the GP sets a positive price). Intuitively, reductions in competition increase the price for those already facing a positive price (the first term) but dilutes the average price to paying patients because of those patients who were previously not charged (ie were bulk billed) and who now pay but face a low price (the second term). If there are sufficient of these payers the average price for those not bulk billed will fall.

c) The effect of ℓ on average quality for all patients ($\overline{q}$) is, from (6) and (7),

$$\frac{\partial \overline{q}}{\partial \ell} = \int_{\alpha_0}^{\alpha^b} \left[\left((\delta \ell t)^2 + 2\alpha^2 \delta m \right)^{-\frac{1}{2}} \ell \left(\delta t \right)^2 - \delta t \right] f(\alpha,\theta) d\alpha$$

$$= \int_{\alpha_0}^{\alpha^b} \left((\delta \ell t)^2 + 2\alpha^2 \delta m \right)^{-\frac{1}{2}} \delta t \left[\delta \ell t - \left((\delta \ell t)^2 + 2\alpha^2 \delta m \right)^{\frac{1}{2}} \right] f(\alpha,\theta) d\alpha < 0 \qquad \text{(A3)}$$

where we use the fact that quality for bulk billed patients is positive so that the square bracketed term in the second line is negative from (6).

d) The effect on average price $\overline{p} = \left(1 - F^b\right)\overline{p}^{nb}$ is

$$\frac{\partial \overline{p}}{\partial \ell} = \frac{\partial \mathrm{E}\left[\, p(\alpha;\ell,t,m,\delta) \middle| \alpha \geq \alpha^b \right]\left[1 - F(\alpha^b,\theta)\right]}{\partial \ell}$$

$$= \frac{\partial}{\partial \ell}\left[\int_{\alpha^b}^{\alpha_1} p(\alpha;\ell,t,m,\delta) f(\alpha,\theta) d\alpha \frac{1}{1 - F^b(\alpha^b,\theta)}\right]\left[1 - F^b(\alpha^b,\theta)\right]$$

$$= \frac{\partial}{\partial \ell}\int_{\alpha^b}^{\alpha_1} p(\alpha;\ell,t,m,\delta) f(\alpha,\theta) d\alpha$$

$$= \int_{\alpha^b}^{\alpha_1} tf(\alpha,\theta) d\alpha - p(\alpha^b;\ell,t,m,\delta)\frac{\partial \alpha^b}{\partial \ell} > 0 \qquad \text{(A4)}$$