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

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Abstract

General Practitioners (GPs) in Australia are free to set prices for consultations. Under the national tax funded Medicare insurance scheme patients pay the difference between the price set by the GP and a fixed reimbursement. GPs can 'bulk bill' the patient when the patient makes no out of pocket payment. We construct a Vickrey-Salop model of GP third degree price and quality discrimination with bulk billing. We test its predictions using a dataset with individual GP-level data on prices, the proportion of patients who are bulk billed, average consultation length, and characteristics of the GPs, their practices and patients. A key variable is the distance between a GP practice and its nearby competitors which allows us to use area fixed effects to account for endogeneity of GP location decisions. We find that within areas, GPs with more distant competitors charge higher average prices, mainly by reducing the proportion of patients who are bulk billed.

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1 Introduction

The market for healthcare is idiosyncratic in many ways. Features of this market include concerns for equity, supplier induced demand, barriers to entry on the supply side and high levels of government subsidy and regulation in most countries. Despite these idiosyncrasies, traditional aspects of industrial organisation such as market structure and the degree of competition can have effects on health care costs, quality of care and access to health care.

Some features of the Australian market for GP services make it a particularly interesting context to test for the effects of market forces. Prices for consultations are unregulated, and innovative GP-level data is available, making this a good market in which to examine the effects of competition on prices and quality. Our study has lessons for policy in other health care systems with unregulated prices for physicians. These include France where some GPs can charge fees above the government rebate (The Commonwealth Fund 2011), and the US, where the practice of charging fees above the price reimbursed by the insurer is known as balance billing (Glazer and McGuire, 1993).

Patients in Australia pay a fee for each GP consultation. The fees that GPs charge are not regulated and they are also 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 co-payments by patients cannot be covered by insurance. Simple intuition and theoretical models (eg Cournot competition) would suggest that the number of local competitors GPs face (GP density) may affect their incentives to charge fees above the medicare rebate. The aim of this paper is to model and estimate the effect of GP density on prices and quality in the market for GP consultations.

The majority of studies in the health economics literature examine the effect of competition in hospital or insurance markets, with few studies on the effects of competition in the market for physician services (Gaynor and Town, 2011). The literature on the influence of competition on prices charged and a range of other physician behaviours has been reviewed by Dranove and Satterthwaite (2000) and more recently by Gaynor and Town (2011). Studies on competition and prices for physicians have often been conducted in the context of supplier-induced demand and have suffered from identification problems due to the use of area-level measures of competition. Small area measures can be correlated with unobservable characteristics of areas that are also associated with the location choice of physicians. Of the more recent studies, Schneider et al (2008) find that physician market concentration in California, measured by the Herfindahl Hirschman Index (HHI) is associated with higher prices. Bradford and Martin (2000) find that higher physician density is associated with less profit sharing amongst physicians in group practices and lower prices. Johar (2012) uses detailed patient-level data to look at the relationship between prices and patient income in Australia. She also finds an interaction with GP density in this relationship, GP density reduces the relationship between rich patients and higher prices.

Studies have also measured the degree of competition using structural models. One strand uses estimates of physician cost functions and observed prices to estimate the degree of competition in the market (Gunning and Sickles, 2012; Bresnahan, 1989). Schaumans and Verboven (2008) have adapted Bresnahan and Reiss' (1991) entry model to find the effect of geographic entry restrictions on the number of pharmacies physicians in Belgium.

We add to this literature in several ways. First, we develop a formal model of GP third degree 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 a guide to our empirical analysis. This builds on previous theoretical models. Glazer and McGuire (1993) use a 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 (2000) 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.

The second way we add to the literature is the method we use for identification. Previous literature has relied on area level GP density measures and so is potentially vulnerable to endogeneity bias if unobserved factors that influence entry and exit into areas are also correlated with prices and qualities. We use a GP-level measure of GP density (distance to nearby other GP practices) that allows us to use area fixed effects to control for all area-level variables that are unobserved and may influence prices, including the characteristics of areas that influence exit and entry into those areas. Identification therefore relies on within-area variation in distance to other GPs. Our use of distance to measure competitive pressure follows a strand in the 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).

Third, most previous studies of the Australian market have relied on administrative data that does not include detailed information on the influence of doctor or practice characteristics (McRae 2009, Richardson et al 2006, Savage and Jones 2004). This is exacerbated by using small area data which takes averages of GP and practice characteristics across areas and therefore masks heterogeneity. Use of administrative data ignores the effects of sources of heterogeneity that influence pricing decisions, in addition to the effect of competitive pressure. For example, depending on the structure of a partnership, each GP in a practice may: i) have full discretion to charge their own prices; ii) have discretion of whether to bulk-bill some patients but not others; iii) may have to charge the price agreed by the owners of the practice, or iv) may opt to bulk-bill all patients. These are decisions influenced by practice characteristics and by patient characteristics, both of which may be correlated with the degree and nature of competition. If these factors are not accounted for then the estimate of the effect of GP density on prices may be biased.

Our theoretical model of the market for GP services generates testable hypotheses about the relationship between price and quality variables, and a measure of competitive pressure: the distance between GP practices. We find results consistent with the predictions from our theoretical model. GPs whose rivals are further away charge higher average prices. This result is robust to alternative estimation strategies, including area fixed-effects estimations. Although distance to rivals tends to reduce quality the effects are not always statistically significant. The main reason for higher average prices for GPs with less competition is that they bulk bill a smaller proportion of their patients. We also find that these effects of competition are stronger in areas of greater socio-economic advantage.

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). Co-payments 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 GP practices choose to bulk-bill all patients, whilst GPs in other practice 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 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.

There has been increasing concentration in the market for GP services. 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. Our study is partly motivated by predicting the outcomes of these trends in terms of prices and quality.

3 A model of bulk billing, price and quality

3.1 Specification

We model GPs' decisions and the market equilibrium by extending the Vickrey-Salop model of monopolistically competitive firms (Vickrey, 1964; Salop, 1979) to include choice of quality as well as prices and for the possibility that GPs bulk bill a proportion of their patients.

The total price per consultation received by a GP is $p + m$ where m is the price paid to the GP by Medicare. Patients pay p per consultation. Patients demand at most one consultation per period from their GP and the utility gain from a consultation at GP i is

$$u_i = r - p_i + \alpha q_i - td_i \tag{1}$$

where p_i is the price the patient pays at GP i, q_i is the quality of the consultation (measured say by its length), d_i 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 disutility of expenditure and the same marginal disutility of distance 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. θ shifts the patient type distribution. We assume that markets with higher θ have higher mean marginal valuations $\bar{\alpha}(\theta)$ of quality.

G GPs are 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 i from type α patients depends on the price $p_i(\alpha)$ she charges them and the quality $q_i(\alpha)$ she provides, as well as the prices and qualities of her immediately neighbouring GPs:[1]

$$\begin{aligned} D_i &= \frac{hf(\alpha;\theta)}{2t}\{p_{i+1}(\alpha) - p_i(\alpha) + \alpha[q_i(\alpha) - q_{i+1}(\alpha)] + t\ell\} \\ &\qquad + \frac{hf(\alpha;\theta)}{2t}\{p_{i-1}(\alpha) - p_i(\alpha) + \alpha[q_i(\alpha) - q_{i-1}(\alpha)] + t\ell\} \\ &= D(p_i(\alpha), q_i(\alpha); p_{i+1}(\alpha), q_{i+1}(\alpha), p_{i-1}(\alpha), q_{i-1}(\alpha), \ell, h, \theta, \alpha) \end{aligned} \tag{2}$$

where the first term is demand from patients between GP i and GP $i + 1$ and the second is demand from patients between GP i and GP $i - 1$.

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

Although GPs can observe willingness to pay for quality α for each patient we assume that there are costs to them of exercising fine degrees of price and quality discrimination and that they discriminate only between two groups of patients (third degree price discrimination). The GP sets a threshold patient marginal valuation of quality $\hat{\alpha}_i$ and GP bulk bills ($p_i(\alpha) = 0$) all patients with $\alpha \leq \hat{\alpha}_i$, and gives the same price ($p_i(\alpha) = p_i > 0$)[2] to all patients with $\alpha > \hat{\alpha}_i$. All patients who are bulk billed get quality $q_i(\alpha) = q_{0i}$ and those who are not bulk billed get quality $q_i(\alpha) = q_{1i}$.

Demand from bulk billed patients of GP i is

$$\int_{\alpha_0}^{\hat{\alpha}_i} D(0, q_{0i}; p_{i+1}(\alpha), q_{i+1}(\alpha), p_{i-1}(\alpha), q_{i-1}(\alpha), \ell, h, \theta, \alpha) d\alpha$$

$$= \int_{\alpha_0}^{\hat{\alpha}_i} D_0\left(q_{0i}; \cdot, \alpha\right) d\alpha = D_0\left(q_{0i}, \hat{\alpha}_i; \cdot\right) \tag{3}$$

so that the marginal effect of quality on demand from bulk billed patients is

$$D_{0q_{0i}}\left(q_{0i}, \hat{\alpha}_i; \cdot\right) = \frac{h}{t} \int_{\alpha_0}^{\hat{\alpha}_i} \alpha f(\alpha; \theta) d\alpha > 0 \tag{4}$$

Demand from non-bulk billed patients is

$$\int_{\hat{\alpha}_i}^{\alpha_1} D(p_i, q_{1i}; p_{i+1}(\alpha), q_{i+1}(\alpha), p_{i-1}(\alpha), q_{i-1}(\alpha), \ell, h, \theta, \alpha) d\alpha$$

$$= \int_{\hat{\alpha}_i}^{\alpha_1} D_1\left(p_i, q_{1i}; \cdot, \alpha\right) d\alpha = D_1\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) \tag{5}$$

and

$$D_{1q_{1i}}\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) = \frac{h}{t} \int_{\hat{\alpha}_i}^{\alpha_1} \alpha f(\alpha; \theta) d\alpha > 0 \tag{6}$$

$$D_{1p_i}\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) = -\frac{h}{t} \int_{\hat{\alpha}_i}^{\alpha_1} f(\alpha; \theta) d\alpha = -\frac{h}{t}\left[1 - F\left(\hat{\alpha}; \theta\right)\right] < 0 \tag{7}$$

The average variable cost of serving patients who get quality q is $\frac{1}{2}\delta q^2$ and so GP i profit is

$$\pi_i\left(q_{0i}, p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) = D_0\left(q_{0i}, \hat{\alpha}_i; \cdot\right)\left[m - \tfrac{1}{2}\delta q_{0i}{}^2\right] + D_1\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right)\left[p_i + m - \tfrac{1}{2}\delta q_{1i}{}^2\right] \tag{8}$$

The GP chooses q_{0i}, p_i, q_{1i}, and $\hat{\alpha}_i$ to maximise π_i. First order conditions are

$$\pi_{iq_{0i}} = -\delta q_{0i} D_0(q_{0i}, \hat{\alpha}_i; \cdot) + \left[m - \tfrac{1}{2}\delta q_{0i}^2\right] D_{0q_i}\left(q_{0i}, \hat{\alpha}_i; \cdot\right) = 0 \tag{9}$$

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[2] It can never be optimal to set $p < 0$ (ie pay the patient in order to get the Medicare rebate m) since increasing p to zero, with quality constant, has no effect on demand (since patients pay nothing in both cases) and therefore no effect on costs, and increases revenue.

$$\pi_{ip_i} = D_1\left(p_i, q_{1i}, \hat{\alpha}; \cdot\right) + \left[p_i + m - \tfrac{1}{2}\delta q_{1i}^2\right] D_{1p_i}\left(p_i, q_{1i}, \hat{\alpha}; \cdot\right) = 0 \tag{10}$$

$$\pi_{iq_{1i}} = -\delta q_{1i} D_1\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) + \left[p_i + m - \tfrac{1}{2}\delta q_{1i}{}^2\right] D_{1q_{1i}}\left(p_i, q_{1i}, \hat{\alpha}_i; \cdot\right) = 0 \tag{11}$$

$$\pi_{i\hat{\alpha}_i} = \left[\left(m - \tfrac{1}{2}\delta q_{0i}^2\right) - \left(p_i + m - \tfrac{1}{2}\delta q_{1i}^2\right)\right] f\left(\hat{\alpha}_i; \theta\right) + \lambda_0 - \lambda_1 = 0 \tag{12}$$

where λ_0, λ_1 are Lagrange multipliers on the constraints on the threshold ($\hat{\alpha}_i - \alpha_0 \geq 0$, $\alpha_1 - \hat{\alpha}_i \geq 0$).

With identical GPs there is a symmetric Nash equilibrium in which GPs make the same choice of threshold, qualities, and price to non-bulk billed patients. We can now drop the GP specific subscript. At the equilibrium, demand for each GP for bulk billed and non-bulk billed patients is

$$D_0\left(q_1, \hat{\alpha}; \cdot\right) = h\ell \int_{\hat{\alpha}_0}^{\hat{\alpha}} f(\alpha;\theta) d\alpha = h\ell F\left(\hat{\alpha};\theta\right) \tag{13}$$

$$D_1\left(p, q_1, \hat{\alpha}; \cdot\right) = h\ell \int_{\hat{\alpha}}^{\alpha_1} f(\alpha;\theta) d\alpha = h\ell \left[1 - F\left(\hat{\alpha};\theta\right)\right] \tag{14}$$

Using (6),(7),(13) and (14) in the first order conditions, and assuming that some, but not all patients, are bulk billed ($\hat{\alpha} \in (\alpha_0, \alpha_1)$ so that $F(\hat{\alpha};\theta) \in (0,1)$), we can show that the equilibrium $q_0, p, q_1, \hat{\alpha}$ satisfy the following conditions

$$q_0 = \left[\frac{2}{\delta}\left(m - \ell t\right)\right]^{\frac{1}{2}} \tag{15}$$

$$p = t\ell - m + \frac{\left(\bar{\alpha}_1\left(\hat{\alpha};\theta\right)\right)^2}{2\delta} \tag{16}$$

$$q_1 = \frac{\bar{\alpha}_1\left(\hat{\alpha};\theta\right)}{\delta} \tag{17}$$

$$\bar{\alpha}_0\left(\hat{\alpha};\theta\right) = \delta\left[2\left(m - \ell t\right)\delta^{-1}\right]^{\frac{1}{2}} \tag{18}$$

where

$$\bar{\alpha}_0\left(\hat{\alpha};\theta\right) \equiv \mathrm{E}\left[\alpha \middle| \alpha \leq \hat{\alpha}\right] = \int_{\alpha_0}^{\hat{\alpha}} \alpha f\left(\alpha;\theta\right) d\alpha \left[\int_{\alpha_0}^{\hat{\alpha}} f\left(\alpha;\theta\right) d\alpha\right]^{-1} \tag{19}$$

$$\bar{\alpha}_1\left(\hat{\alpha};\theta\right) \equiv \mathrm{E}\left[\alpha \middle| \alpha > \hat{\alpha}\right] = \int_{\hat{\alpha}}^{\alpha_1} \alpha f\left(\alpha;\theta\right) d\alpha \left[\int_{\hat{\alpha}}^{\alpha_1} f\left(\alpha;\theta\right) d\alpha\right]^{-1} \tag{20}$$

are the conditional expectations of the marginal valuation of quality by for bulk billed and non-bulk billed patients. For the proof of these results, please see Appendix A.

3.2 Model predictions

We do not observe prices and quality for individual patients but we do have data from each GP in our sample (see section 4.1) which enables us to measure

a) the proportion of each GP's patients who are bulk billed: $F^b = F(\hat{\alpha};\theta)$;

b) the price charged to patients who are not bulk billed: p;

c) the average price charged to all patients: $\overline{p} = (F^b \times 0) + (1 - F^b)p = (1 - F^b)p$;

d) the average quality of GP's consultation (as measured by average consultation time for all her patients): $\overline{q} = F^b q_0 + (1-F^b)q_1$;

We use the model to derive predictions about how these variables respond to an increase in $\ell = L/G$ which we interpret as a decrease in competition in the market.

a) We use (18) and (19) to derive the effect of an increase in distance between GPs on the proportion bulk billed $F(\hat{\alpha};\theta)$. The expectation of the value of quality α for those who are not bulk billed ($\overline{\alpha}_0(\hat{\alpha};\theta)$) is monotonically increasing in the threshold $\hat{\alpha}$ for $\hat{\alpha} \in (\alpha_0,\alpha_1)$. Thus, using condition (18) for the last equality,

$$\operatorname{sgn}\frac{\partial F(\hat{\alpha};\theta)}{\partial \ell} = \operatorname{sgn}\frac{\partial \hat{\alpha}}{\partial \ell} = \operatorname{sgn}\frac{\partial \overline{\alpha}_0}{\partial \hat{\alpha}}\frac{\partial \hat{\alpha}}{\partial \ell} = \operatorname{sgn}\frac{\partial \overline{\alpha}_0}{\partial \ell} = \operatorname{sgn}\left\{-t\left[2(m-\ell t)\delta^{-1}\right]^{-\frac{1}{2}}\right\} < 0 \quad (21)$$

and an increase in the distance between GPs reduces the proportion of patients bulk billed.

b) The effect of ℓ on the price to non-bulk billed patients is

$$\frac{\partial p}{\partial \ell} = t + \frac{1}{\delta}\overline{\alpha}_1(\hat{\alpha})\frac{\partial \overline{\alpha}_1(\hat{\alpha};\theta)}{\partial \ell} = t + \frac{1}{\delta}\overline{\alpha}_1(\hat{\alpha})\frac{\partial \overline{\alpha}_1(\hat{\alpha};\theta)}{\partial \hat{\alpha}}\frac{\partial \hat{\alpha}}{\partial \ell} \quad (22)$$

Since both $\overline{\alpha}_0(\hat{\alpha})$ and $\overline{\alpha}_1(\hat{\alpha})$ are monotonically increasing in $\hat{\alpha}$ for $\hat{\alpha} \in (\alpha_0,\alpha_1)$ we can sign the second term in (22) using (18):

$$\operatorname{sgn}\frac{\partial \overline{\alpha}_1}{\partial \ell} = \operatorname{sgn}\frac{\partial \overline{\alpha}_1}{\partial \hat{\alpha}}\frac{\partial \hat{\alpha}}{\partial \ell} = \operatorname{sgn}\frac{\partial \overline{\alpha}_0}{\partial \hat{\alpha}}\frac{\partial \hat{\alpha}}{\partial \ell} = \operatorname{sgn}\frac{\partial \overline{\alpha}_0}{\partial \ell} < 0 \quad (23)$$

Thus the effect of an increase in the distance between GPs on the price charged to non-bulk billed patients is ambiguous. For the intuition we can use the expression (10) for the marginal profit from an increase in price. An increase in ℓ increases the number of non-bulk billed patients that the GP has, since from (14) $dD_1/d\ell = h(1-F) - h\ell f\partial\hat{\alpha}/\partial\ell > 0$ and increases thus the gain from a price increase if no patients move to another GP. But, from

(7), the increase in ℓ increases the average responsiveness of patients to the price because the reduction in $\hat{\alpha}$ that the average patient now values the GP less highly and is therefore more likely to move to another GP.

c). Distance between GPs also has an ambiguous effect the average price charged to all patients $\overline{p} = (1-F)p$. From (16)

$$\frac{\partial \overline{p}}{\partial \ell} = \left[\frac{\overline{\alpha}_1(\hat{\alpha})}{\delta} \frac{\partial \overline{\alpha}_1}{\partial \hat{\alpha}} \frac{\partial \hat{\alpha}}{\partial \ell} + t \right] \left[\left(1 - F(\hat{\alpha};\theta)\right) \right] - \left[(\ell t - m) + \frac{\left(\overline{\alpha}_1(\hat{\alpha})\right)^2}{\delta} \right] f(\hat{\alpha};\theta) \frac{\partial \hat{\alpha}}{\partial \ell} \qquad (24)$$

The second term is positive since $\partial\hat{\alpha} / \partial\ell < 0$ but, since $\partial\overline{\alpha}_1 / \partial\hat{\alpha} > 0$, the first term in the first square bracket is negative, and effect on the average price is ambiguous.

d) It is immediate from (15) that an increase in ℓ reduces the quality q_0 supplied to bulk billed patients and, since from (23) $\partial\overline{\alpha}_1 / \partial\ell < 0$, q_1 is also reduced, the average quality for all patients $\overline{q}$ is also reduced.

The top part of Table 1 shows the comparative static responses of these five variables to changes in distance between GPs and other model parameters for solutions where no patient is bulk billed ($F^b = 0$), some are bulk billed ($F^b \in (0,1)$) and all patients are bulk billed $F^b = 1$.

3.3 Endogeneity of competition measure

We test for the effects of reduced competitive pressure (increased ℓ) by estimating cross-section regression models of the prices and qualities chosen by GPs in different markets with differing amounts of competitive pressure. 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 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. GP profit at the Nash equilibrium with a given number of GPs is $\pi^*(\ell;\delta,t,m,h,\theta)$. 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).

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

$$\pi^*(\ell;\delta,t,m,h,\theta) - K = 0 \tag{25}$$

so that in equilibrium the distance between GPs is

$$\ell = \ell(\delta,t,m,h,K,\theta) \tag{26}$$

Using the implicit function rule on (25) 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 bottom part of Table 1.[3]

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 $F^b = F(\hat{\alpha}(\ell,t,m,\delta);\theta)$ = $F^b(\ell(m,\delta,\theta,h,K),t,m,\delta,\theta)$. If the regression fails to include variables like t which affect both F^b and ℓ negatively, the estimated effect of ℓ will be positively biased. Omission of measures of variables like θ 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 how we implement 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 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

[3] When the some but not all patients are bulk billed, use the fact that the profit per patient is the same for bulk billed and non-bulk billed patients, so that $m - \frac{1}{2}\delta q_0^2$ = $p + m - \frac{1}{2}\delta q_1^2$ and substitute in the optimal values of p, q_0, q_1 from (16), (15), (17) to get $\pi^* = h\ell^2 t$. When no patient is bulk billed, π^* = $h\ell\left(p + m - \frac{1}{2}\delta q_1^2\right)$, and substitution for the optimal p and q_1 also gives $\pi^* = h\ell^2 t$. When all patients are bulk billed profit is $h\ell\left(m - \frac{1}{2}\delta q_0^2\right)$ and optimal q_0 is determined by (40) and so π^* is now function of m and δ as well as h, t and ℓ.

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 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 1925 GPs.

Prices

The survey asks two questions about consultation fees. The first is *"Approximately what percentage of patients do you bulk bill/charge no co-payment?"* We use this measure the proportion of patients who are bulk billed (F^b). Patients who are bulk-billed are charged 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 co-payment. Please write amount in dollars; write 0 if you bulk bill 100% of your patients)"* which we use as a measure of the price 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.[4] However, in 2008 level B consultations represented 88.4% of all GP consultations and we believe the answer to this question will be a good measure of a GP's

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[4] 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 B consultations were the most common (88.4% of all GP attendances), followed by Level C (10.5%), with the others Levels A and D just over 1%.

price setting behaviour for non-bulk billed patients relative to other GPs facing different market conditions.

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 studies have used the approach of Kessler and McClellen (2000) and Gowrisankaran and Town (2003), to avoid the endogeneity problem that market share depends on a prices and qualities, by calculating 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 a measure of physician density (Bradford and Martin 2000, Richardson et al 2006) in an area. This has the disadvantage that it is endogenous and that all providers in an area are assumed to face the same competitive pressure.

We construct an individual-level variable measuring 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 literature in Industrial Organisation has emphasised the importance of distance to competitors, rather than market share measures (eg the HHI) on pricing decisions (Thomadsen 2005, Alderighi and Piga 2012). Drawing on Bresnahan and Reiss (1991), who show in a variety of industries that only the first three additional competitors in a given market have a large effect on prices, we use specifications of ℓ using the distance to the 3rd and 5th nearest other 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 only those who responded to the MABEL survey. We calculated the road distances between GP practices' street addresses. For each MABEL respondent we calculated the distance to the nearest, third nearest, and fifth nearest other GP practice in the AMPCo data (whether or not they were MABEL respondents).

GP and GP practice covariates

We control for a number of individual GP and GP practice characteristics to allow for differences in costs or preferences across practices which may influence pricing decisions. First, we control for GP gender and whether they have a spouse or dependent children. Second, we control for professional characteristics of the GP: whether they went to an Australian medical school, their level of experience (in ten year bands), and whether they are a partner or associate in a practice. Being a partner or associate indicates a direct financial (ownership) relationship with the practice which may give incentives to charge higher prices. Partner or associate status also indicates seniority of the GP within the practice. Third, we control for the characteristics of the practice itself. These include practice size (number of GPs) and whether the practice is taxed as a company or not. Practice size may influence pricing decisions either via economies of scale or via its incentive effects (Gaynor and Pauly, 1990). Being a company may reflect the extent of 'for-profit' objectives of the GP's practice.

Local area characteristics

We use data on area characteristics to capture factors which may affect demand and cost conditions for GPs. There are two definitions of areas we use in the analysis, Statistical local areas (SLAs) and postcode areas. The 1925 GPs in the estimation sample are located in 412 Statistical Local Areas (SLAs) with an average population of 33,023. The postcode areas are slightly smaller, there are 628 postcode areas. We attribute Census data on the postcode age distribution, ethnicity, self reported disability and socio-economic status through 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. There are two additional measures which are not available at postcode that we can include at SLA level: house prices and population density. We include a measure of median house prices which may capture higher premise costs for GPs and richer populations who have a higher willingness to pay for GP services. In a small proportion of study SLAs there are additional incentives for bulk billing. We therefore include a dummy variable to indicate these SLAs.

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

4.2 Estimation

Specification of Dependent Variable

We use the log transformation of the price variable p_j to allow for skewness. We model the log of the gross price $ln(p_j+m)$, rather than the net price $ln(p_j)$so that for $p_j \in [0,\infty)$ we can therefore define our dependent variable for the models as $\ln\left(p_j + m\right) \in [\ln(m),\infty)$. To simplify our estimation process we actually use the transformation $y_j = \ln\left(\frac{p_j + m}{m}\right) \in [0,\infty)$ which is identical for regression purposes because there is no variation in m between GPs. We use y_j as the dependent variable in the examples of empirical models, but will also conduct the analysis using the bulk-billing rate, F^b, the log average gross price, $ln[m + (1-F^b)*p]$ and the log of our measure of quality q, consultation time.

Linear models

Our baseline model is a linear regression of y on several groups of explanatory variables:

$$y_{jr} = \beta_1 GPdist_{jr} + \beta_2 GPchars_{jr} + \beta_3 Areachars_r + \upsilon_{jr} \qquad (27)$$

where we have introduced a further subscript, r, to index ‘areas’. There are three groups of explanatory 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, $GPchars_{jr}$ are the characteristics of the GP, her practice and the GP’s patients; and *Areachars* are characteristics of the area in which the GP is located.

The variable of particular interest is $GPdist_{jr}$, measuring the effect of differences in GP density faced by the GPs on the prices they charge. Our first approach is to identify this effect through variation in prices and competition across GPs j and areas r. The key identification problem with this approach is related to GPs' ability to choose their practice location. If there are unobserved factors which affect GPs choice of location and are correlated with both y_{jr} and $GPdist_{jr}$ then the error term υ_{jr} will not be conditionally uncorrelated with $GPdist_{jr}$ thereby biasing the OLS estimate of β_1.

We attempt to overcome this problem by taking advantage of the fact that the GP specific competition measure (distance to rival GPs) varies both between areas (over r) and within areas (over j). We estimate three types of models which incorporate area effects in different ways. The area effects specification adds an area effect, γ_r which picks up the across-area variation in all the observed ($Areachars_j$) and unobserved area variables. The area effects model is:

$$y_{jr} = \beta_1 GPdist_{jr} + \beta_2 GPchars_{jr} + \beta_3 Areachars_r + \gamma_r + \upsilon_{jr} \qquad (28)$$

where, in the random effects model, γ_r is a $N(0,\sigma^2)$ random variable. The fixed effects specification is where γ_r is instead a fixed parameter for each area r and $Areachars_r$ are omitted from the model as they are not separately identified from the fixed effects.

Our third specification uses the approach of Mundlak (1978):

$$y_{jr} = \beta_1 GPdist_{jr} + \beta_2 GPchars_{jr} + \beta_3 Areachars_{ij} + \lambda_1 \overline{GPdist_r} + \lambda_2 \overline{GPchars_r} + \gamma_r + \upsilon_{jr} \qquad (29)$$

where γ_r is a $N(0,\sigma^2)$ random effect and $\overline{GPdist_j}$, $\overline{GPchars_j}$ are the area means (for each r) of $GPdist_{ij}$ and $GPchars_{ij}$.

The random effects specification will yield a consistent estimate of β_1 if the unobserved area effect γ_j is conditionally uncorrelated with $GPdist_{ij}$. The fixed effects estimation is consistent for β_1 if υ_{ij} is uncorrelated with $GPdist_{ij}$ given γ_j and $GPchars_{ij}$. Consistency for the Mundlak estimation requires that γ_j and υ_{ij} are uncorrelated with $GPdist_{ij}$ conditional on $GPchars_{ij}$ and $\overline{GPdist_j}$, $\overline{GPchars_j}$. This is more stringent than the requirement for fixed effects since it requires that the included area mean variables are correlated sufficiently with the area means of omitted variables to absorb their entire effects. The fixed effect estimator ensures that the across area effects of omitted variables are picked up by the area effect γ_j.

Using the Mundlak or fixed effects specification means that β_1 is identified only from *within-area* variation and we need sufficient variation in both y_{jr} and $GPdist_{jr}$ within 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 such as socio-economic status, age-gender composition of the population, 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).

In section 4.1 we discussed the two alternative area definitions we use for attributing area characteristics (such as ethnicity and socio-economic status). For the Mundlak and area fixed effects models ((28) and (29)) we use the slightly larger SLA definition of areas to estimate the models, as these provide more within-area variation (an average of 4.7 GPs per SLA in the sample, rather than 3.1 GPs per postcode). We include a robustness check using the smaller postcode areas for these models.

Tobit model of GP prices

In addition to the linear models, we exploit the availability of data on the price to non bulk billed patients p_j and the proportion of patients bulk-billed, F_b in a tobit model.

We derive our estimation approach from the patient-level model where i and j index respectively patient $i \in S_j$, where S_j patients are treated by GP_j and GP $j=1,...,N$. Let p_{ij} denote the fee charged by GP j to patient i.

Let $\Phi(.)$ and $\phi(.)$ denote respectively the normal cdf and pdf. The log-likelihood of the tobit model is:

$$\ln L = \sum_{j=1}^{N} \sum_{i=1}^{S_j} d_{ij} \left[-\ln \sigma + \ln \phi \left(\frac{p_{ij} - X_j \beta}{\sigma} \right) \right] + \left(1 - d_{ij}\right) \ln \left[1 - \Phi \left(\frac{X_j \beta}{\sigma} \right) \right] \qquad (30)$$

where d_{ij}=1 if $p_{ij}>0$ (if the price is non-censored), and d_{ij}=0 otherwise.

We adapt the standard tobit framework at the patient-level given in (30) to allow data at the GP level which includes the proportion of patients bulk-billed (for whom p_{ij}^* censored at zero) and the price for non bulk-billed patients (for whom $p_{ij}^* = p_j$ is not censored). To apply the tobit model we assume all patients are either charged the same price by a GP, or are bulk-billed by that GP ($p_{ij}=0$). We then split each GP observation into two observations: one for the patients who are bulk-billed, and one for non bulk-billed patients. This approach can be derived by rearranging the likelihood function in (30) to take the form:

$$\ln L = \sum_{j=1}^{N} \left\{ \left(\sum\nolimits_i d_{ij} \right) \left[-\ln\sigma + \ln\phi\left(\frac{p_j - X_j\beta}{\sigma} \right) \right] + \left(S_j - \sum\nolimits_i d_{ij} \right) \ln\left[1 - \Phi\left(\frac{X_j\beta}{\sigma} \right) \right] \right\} \quad (31)$$

Let π_j be the proportion of non-bulkbilled patients seen by GP j, $\pi_j = \sum_i d_{ij} / S_j$. Now we can write the likelihood:

$$\ln L = \sum_{j=1}^{N} S_j \left\{ \pi_j \left[-\ln\sigma + \ln\phi\left(\frac{p_j - X_j\beta}{\sigma} \right) \right] + \left(1 - \pi_j \right) \ln\left[1 - \Phi\left(\frac{X_j\beta}{\sigma} \right) \right] \right\} \quad (32)$$

In our implementation of the model we set $S_j=S$ for all GP's so that it is just a scalar multiplying the likelihood and can be removed. In other words, we do not weight each GP's observation by the number of patients treated by that GP, we just use the proportion of patients bulk-billed to weight. We can use data on π_j, p_j and X_j for each GP to estimate the model. Following from our approach with linear models we can replace p_j with $y_j = \ln\left(\frac{p_j + m}{m} \right)$. The proportion of bulk-billed patients π_j, is the quantity F_b in the theory model.

The following three quantities will be of interest in our results:

1) The probability that a patient is bulk-billed by GP j:

$$\Pr(y_j = 0) = 1 - \Phi\left(X_j\beta / \sigma \right) \quad (33)$$

2) The average log price for non-bulk-billed patients

$$E[y_j \mid y_j > 0] = X_j\beta + \sigma\lambda(X_j\beta / \sigma) \quad (34)$$

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

3) The average log price for all patients

$$E[y_j] = \Pr(y_j > 0) * E[y_j \mid y_j > 0] = \Phi(X_j\beta / \sigma)\left[X_j\beta + \sigma\lambda(X_j\beta / \sigma) \right] \quad (35)$$

The vector of explanatory variables, *X*, will be specified as in the linear model in equation (27). We also estimate a version of the tobit with the Mundlak area-average terms as in equation (29).

5 Results

Linear Models

Table 3 presents detailed results for the regression models with the dependent variable log average price from the four linear estimation methods. All models have standard errors corrected to allow for clustering at area (SLA) level.[5] The first row of coefficients (and associated standard errors) are for our main competition measure *GPdist*, the log of the distance to the third-nearest GP practice. There are statistically significant positive coefficients for the distance to the third-nearest GP practices in all estimated models: the further the distance to nearby competitors, 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 the unobserved area-level characteristics.

Tobit models

Table 4 presents results from tobit models with the same dependent variable - log average price. Two versions of the model are presented, first the standard tobit, then the tobit with within-area Mundlak terms. The pattern of results are similar to the linear models but the estimated marginal effects (in Table 5) are larger, 0.019 and 0.017 for the tobit models compared to 0.017 and 0.015 for the equivalent linear models. This larger marginal effects represents the fact that the tobit accounts for censoring in the GP pricing decision.

Alternative price and quality outcomes

Table 5 presents the estimates of the coefficient on *GPdist* from linear regression and tobit models for the four other measures of GP pricing and quality decisions (the proportion bulk billed F^b, log average price to those not bulk billed $ln(p + m)$ the log average price over all patients $\ln\left[m+\left(1-F_b\right)p\right]$, and average quality $\overline{q}$). The signs of the estimated coefficients are in line with a key prediction of the theory model: greater distance to rival GPs is associated with a lower bulk billing rate. Distance to rivals is also associated with a higher

[5] The 1798 GPs are located in 1296 practices. We also allowed for clustering at practice level but this made little difference to the results.

price to non bulk billed patients and a higher average price, although the theory model was ambiguous about these coefficients. Finally distance to rivals is associated with lower quality (consultation time) although this is only marginally statistically significant in the area fixed effects and Mundlak models, and not at all in the other models. The estimated coefficient for the bulk billing rate is the most highly statistically significant across all models, suggesting that the main effect of distance to nearby competitors on the average price $m + (1-F^b)p$ is through the bulk billing rate F^b.

Interaction terms

Table 6 presents the same models as Table 5 with one additional coefficient – an interaction term between *GPdist* and the socio-economic status of the local area. In the fixed effects and Mundlak models the interaction with the index of local area advantage is statistically significant in the models for price for non bulk billed patients, average price, and bulk billing. In each case, the socio-economic advantage of the area strengthens the effects of distance to local competitors on the price or quality outcome. As such, distance to local competitors has a stronger positive effect on price and average price 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.

Other explanatory variables

Whether the GP graduated from an Australian medical school, and whether they are a partner or associate in the practice, also predicts higher average price in all models. More experienced GPs, and those in larger practices, appear to have higher average prices in general, but this effect is not consistently statistically significant across the models. Family and personal characteristics, and whether the practice is taxed as a company, does not appear to influence quality standardised prices.

GPs in advantaged areas and areas with higher house prices are more likely to charge higher prices, as are those in areas with a high proportion of 65 year olds. GPs in areas that have a higher proportion of the population from south east Europe tend to charge lower average prices.

6 Discussion

Our results broadly support the hypotheses generated by the model in section 3 (given in Table 1). The baseline measure of *GPdist* (ℓ) as the log of distance to third-nearest GP practice, is significantly negatively associated with the proportion of patients who are bulk billed F^b and with the average price. Because the baseline dependent variable (log average gross price) and the explanatory variable of interest are both in logs, we can interpret the coefficient (in the linear models) or marginal effect (in the tobit models) as an elasticity. The tobit model (with Mundlak adjustment) estimates an elasticity of 0.022, which is a small effect of distance to competitors on prices charged. When we consider a 1 standard deviation (1.5km) increase in the distance to the third nearest GP this predicts a $0.91 increase in the average gross price and a 3.2 percentage point fall in the number of patients bulk-billed. As we are using distance to measure competitive pressure, we might be interested in the extremes of the distribution of competition. Shifting a GP from the lowest decile of the distribution of distance to third nearest GP (0.28km) to the top decile (3.0km) is associated with $2.18 increase in the average price and a 7.7 percentage point reduction in the proportion of patients who are bulk billed (ie face zero copayment).

We also find that the interaction between local area socio-economic status and distance to local competitors is statistically significant. In areas with higher socio-status an increase in the distance to rival GPs is associated with a larger increase in the average price and a larger reduction in the proportion of patients who are bulk billed. This is in line with the results of Johar (2012) who uses patient-level data and finds an interaction between patient income and the effect of GP density. While Johar uses area-level GP density, we find the same result with our GP-level measure of distance to other GP practices.

We interpret the results from the fixed effect 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 on average price in the 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 align with recent literature emphasising the importance of distance between competitors in measuring competitive pressure (Thomadsen 2005, Alderighi and Piga 2012). They also add support to the research which shows distance to competitors affects prices in the healthcare market (Gaynor and Town 2003). The results are also broadly in agreement with previous studies of the Australian market using area-level data which shows a higher GP density increases the bulk-billing rate (Richardson et al 2006, Savage and Jones 2004).

Our results suggest that the trends to increasing concentration in markets for physician services in the US and Australia where physicians can set prices as well as quality may lead to higher prices and lower quality. The trend in Australia has arisen, not because of fewer physicians, but because of an increase in the number of physicians per practice so that the number of practices per head of population has fallen. This trend is in part due to government policy to encourage larger practices in the belief that there are benefits by way of cost reductions associated with economies of scale in larger practices. With data from a single cross-section we cannot tell if the overall welfare effects of larger firms are positive or negative but it does seem that patients of GPs facing less competition will, at any point in time, face higher average prices.

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Table 1. Comparative static properties

Fixed ℓ		Exogenous factor						
Case	Endogenous	ℓ	t	m	δ	θ	h	K
$0<F^b<1$	F^b	–	–	+	+	?	0	0
$F^b=0$	p	+	+	–	–	+	0	0
$0<F^b<1$	p	?	?	–	?	?	0	0
$F^b=0$	$\overline{p}$	+	+	–	–	+	0	0
$0<F^b<1$	$\overline{p}$	?	?	?	?	?	0	0
$F^b=0$	$\overline{q}$	0	0	0	–	+	0	0
$0<F^b<1$	$\overline{q}$	–	–	?	?	?	0	0
$F^b=1$	$\overline{q}$	–	–	+	–	+	0	0
Endogenous ℓ								
$F^b=0$	ℓ	na	–	0	0	0	–	+
$0<F^b<1$	ℓ	na	–	0	0	0	–	+
$F^b=1$	ℓ	na	–	–	?	+	–	–

p average 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); $\overline{p} = (1 - F^b)p$ average over all patients of price paid (in excess over Medicare fee m); $\overline{q}$: average quality (consultation length); ; $\overline{p}/\overline{q}$: average over all patients of price paid, adjusted by average quality; ℓ : distance between GPs; t: patient travel cost; m: Medicare reimbursement; δ: quality cost parameter; K: GP fixed costs net of value of local amenities. Top part of table shows effect of exogenous factors on endogenous bulk billing proportion, average price and average quality when distance between GPs is held constant. Lower part of table shows effects of exogenous factors on distance between GPs when there is free entry of GPs.

Table 2. Summary statistics

Variable	Mean	S.D.	Min	Max
Dependent Variables				
Average price ($): $(1\text{-}F^b) \times (p + m)$	42.297	9.719	32.800	150.000
Bulk-billed (%): F^b	60.029	31.172	0.000	100.000
Price ($): p + m	50.289	11.383	32.800	150.000
Consult time (mins)	16.635	5.460	5.000	60.000
Closest GP Practice (km)	0.703	0.998	0.000	9.434
Third closest GP practice (km)	1.527	1.589	0.003	17.448
Fifth closest GP practice (km)	2.171	1.958	0.067	19.005
GP and Practice Variables				
Female GP	0.474	0.499	0.000	1.000
Spouse	0.868	0.339	0.000	1.000
Children	0.643	0.479	0.000	1.000
Australian Medical School	0.821	0.384	0.000	1.000
Experience 10-19 years	0.209	0.407	0.000	1.000
Experience 20-29 years	0.368	0.482	0.000	1.000
Experience 30-39 years	0.265	0.442	0.000	1.000
Experience 40+ years	0.089	0.285	0.000	1.000
GP registrar	0.034	0.182	0.000	1.000
Partner or associate	0.454	0.498	0.000	1.000
Practice taxed as company	0.274	0.446	0.000	1.000
Practice size: 2-3 GPs	0.167	0.373	0.000	1.000
Practice size: 4-5 GPs	0.201	0.401	0.000	1.000
Practice size: 6-9 GPs	0.328	0.470	0.000	1.000
Practice size: 10+ GPs	0.162	0.368	0.000	1.000
Area Variables				
Index of advantage/disadvantage	-0.032	0.988	-4.510	2.194
Incentive area	0.228	0.420	0.000	1.000
Median House price ($000,000)	55.312	29.231	15.500	302.250
Proportion of residents U15	0.176	0.049	0.025	0.296
Proportion 65+	0.133	0.046	0.017	0.432
Proportion disabled	0.039	0.014	0.004	0.110
Proportion NW Europe	0.081	0.039	0.011	0.269
Proportion SE Europe	0.048	0.042	0.002	0.301
Proportion SE Asia	0.042	0.051	0.000	0.332
Proportion Other	0.097	0.083	0.002	0.496
Popn density (pop/km2) ('000)	2.056	1.640	0.000	8.757

Notes: Descriptive statistics given for estimation sample of 1925 GPs

Table 3: Full regression results for average price

	OLS			R.E.			Mundlak			F.E.		
Variable	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
ln(3rd closest GP pr)	0.016	0.005	***	0.016	0.005	***	0.017	0.006	***	0.016	0.006	***
Female GP	0.043	0.009	***	0.042	0.009	***	0.041	0.010	***	0.042	0.010	***
Spouse	0.010	0.012		0.013	0.012		0.015	0.013		0.014	0.013	
Children	0.004	0.010		0.005	0.009		0.009	0.010		0.013	0.010	
Australian Medical School	0.069	0.011	***	0.070	0.011	***	0.069	0.012	***	0.072	0.012	***
Experience 10-19 years	0.031	0.019		0.029	0.019		0.024	0.021		0.024	0.021	
Experience 20-29 years	0.020	0.018		0.017	0.017		0.015	0.018		0.013	0.019	
Experience 30-39 years	0.020	0.020		0.023	0.019		0.025	0.021		0.025	0.021	
Experience 40+ years	-0.025	0.020		-0.022	0.020		-0.015	0.022		-0.015	0.022	
Registrar	-0.004	0.023		0.000	0.022		0.006	0.023		0.005	0.024	
Partner or associate	0.037	0.010	***	0.035	0.010	***	0.031	0.011	***	0.031	0.011	***
Company	0.013	0.009		0.011	0.009		0.009	0.010		0.010	0.010	
Practice size: 2-3 GPs	-0.009	0.016		-0.010	0.016		-0.011	0.016		-0.012	0.016	
Practice size: 4-5 GPs	0.019	0.015		0.022	0.015		0.030	0.016	*	0.031	0.017	*
Practice size: 6-9 GPs	0.028	0.015	*	0.022	0.014		0.016	0.016		0.017	0.016	
Practice size: 10+ GPs	0.022	0.017		0.014	0.017		0.003	0.018		-0.005	0.019	
SEIFA adv/disadv	0.045	0.013	***	0.049	0.012	***	0.046	0.013	***			
Incentive Area	0.035	0.015	**	0.034	0.016	**	0.032	0.016	*			
Median house price	0.001	0.000	***	0.001	0.000	**	0.001	0.000	**			
Percentage U15	-0.490	0.163	***	-0.397	0.173	**	-0.380	0.173	**			
Percentage 65+	0.350	0.207	*	0.364	0.201	*	0.389	0.196	**			
Percentage disabled	-1.290	0.766	*	-1.179	0.730		-1.266	0.736	*			
Percentage NW Europe	0.015	0.186		-0.020	0.188		-0.044	0.196				
Percentage SE Europe	-0.588	0.175	***	-0.502	0.160	***	-0.488	0.162	***			
Percentage SE Asia	0.280	0.192		0.198	0.205		0.200	0.204				
Percentage Other	-0.027	0.115		0.012	0.121		0.012	0.116				
Pop per km2	0.002	0.005		0.002	0.005		0.001	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	1925			1925			1925			1925		
R2	0.298			0.296			0.306			0.069		

Notes: Table presents results for four alternative specifications of the linear model with dependent variable ln(Average Gross Price) = $\ln[m + (1-F^b)*p]$

Table 4: Full Tobit results for price

Dependent variable: log price = ln(m + p) weighted by the bulk billing rate	Tobit			Tobit with Mundlak		
Variable	Coeff.	S.E.		Coeff.	S.E.	
ln(3rd closest GP pr)	0.046	0.013	***	0.051	0.015	***
Female GP	0.097	0.020	***	0.095	0.022	***
Spouse	0.040	0.027		0.049	0.028	*
Children	0.005	0.022		0.014	0.022	
Australian Medical School	0.193	0.030	***	0.195	0.033	***
Experience 10-19 years	0.061	0.044		0.061	0.046	
Experience 20-29 years	0.038	0.042		0.042	0.043	
Experience 30-39 years	0.039	0.046		0.059	0.048	
Experience 40+ years	-0.071	0.050		-0.025	0.052	
Registrar	-0.008	0.056		0.014	0.056	
Partner or associate	0.092	0.022	***	0.074	0.024	***
Company	0.029	0.021		0.020	0.023	
Practice size: 2-3 GPs	-0.004	0.037		-0.003	0.039	
Practice size: 4-5 GPs	0.062	0.035	*	0.087	0.038	**
Practice size: 6-9 GPs	0.071	0.032	**	0.046	0.035	
Practice size: 10+ GPs	0.051	0.039		0.005	0.040	
SEIFA adv/disadv	0.126	0.026	***	0.119	0.026	***
Incentive Area	0.089	0.034	***	0.087	0.035	**
Median house price	0.001	0.001	**	0.001	0.001	**
Percentage U15	-1.172	0.352	***	-1.176	0.368	***
Percentage 65+	0.991	0.442	**	1.112	0.427	***
Percentage disabled	-3.487	1.573	**	-3.945	1.553	**
Percentage NW Europe	-0.252	0.423		-0.345	0.429	
Percentage SE Europe	-1.507	0.488	***	-1.418	0.485	***
Percentage SE Asia	0.296	0.449		0.263	0.444	
Percentage Other	-0.081	0.277		-0.062	0.270	
Pop per km2	0.006	0.010		0.003	0.010	
State dummies	Yes			Yes		
Local area random effects	No			No		
Local area averages	No			Yes		
Local Area FE's	No			No		
Obs	1925			1925		
Pseudo - R2	0.298			0.296		

Notes: Table provides estimates from two specifications of the tobit model. The dependent variable is log gross price where this is weighted by the bulk billing rate (proportion of patients charged zero price) as described in section 4.2

Table 5: Models for alternative measures of GP pricing behaviour: ln(3rd closest GP pr) coefficient

	OLS			R.E.			Mundlak			F.E.			Tobit			Tobit with Mundlak		
Dependent Variable	Marg eff	S.E.		Marg ef	S.E.		Marg e	S.E.		Marg eff	S.E.		Marg eff	S.E.		Marg eff	S.E.	
Log price = ln(p+m)	0.017	0.007	**	0.015	0.007	**	0.014	0.009	*	0.013	0.009		0.015	0.004	***	0.017	0.005	***
Bulk billing rate = F^b	-2.853	0.809	***	-2.889	0.767	***	-3.130	0.923	***	-3.056	0.884	***	-3.000	0.837	***	-3.328	0.955	***
Log average price = ln[m+(1-F^b)*(p)]	0.016	0.005	***	0.016	0.005	***	0.017	0.006	***	0.016	0.006	***	0.020	0.006	***	0.022	0.006	***
Log of consult time = ln(q)	-0.004	0.007		-0.005	0.008		-0.012	0.011		-0.014	0.011		N/A			N/A		

Notes: Table provides the marginal effect of the log distance to the 3rd closest other GP practice variable for 22 alternative models (each coefficient estimate represents one model), spread over four alternative dependent variables.

Table 6: Interaction with socio-economic status

	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.
Dep Var: log price = ln(p+m)												
ln(3rd closest GP pr)	0.017	0.007 ***	0.017	0.007 ***	0.021	0.009 **	0.021	0.009 ***	0.015	0.004 ***	0.019	0.005 ***
x SEIFA adv/disadv	0.002	0.008	0.004	0.007	0.016	0.009 *	0.018	0.008 **	-0.001	0.005	0.007	0.004
Dep Var: bulk billing rate = F^b												
ln(3rd closest GP pr)	-3.080	0.879 ***	-3.268	0.835 ***	-3.930	1.018 ***	-4.026	1.034 ***	-2.960	0.849 ***	-3.620	0.949 ***
x SEIFA adv/disadv	-0.620	0.790	-0.967	0.716	-1.876	0.793 **	-2.244	0.779 ***	0.224	0.884	-1.357	0.859
Dep Var: log average price = $\ln[m+(1-F^B)*(p)]$												
ln(3rd closest GP pr)	0.016	0.006 ***	0.017	0.006 ***	0.021	0.007 ***	0.021	0.007 ***	0.020	0.006 ***	0.024	0.006 ***
x SEIFA adv/disadv	0.001	0.005	0.004	0.005	0.010	0.005 **	0.013	0.005 **	-0.001	0.006	0.009	0.006
Dep var: log consult time = ln(q)												
ln(3rd closest GP pr)	-0.005	0.007	-0.006	0.007	-0.017	0.011	-0.019	0.010 *	N/A		N/A	
x SEIFA adv/disadv	-0.001	0.008	-0.003	0.008	-0.011	0.011	-0.012	0.011				

Notes: All models have the same specification as the respective model reported in Table 3 with one additional interaction coefficient, the SEIFA index of relative advantage/disadvantage in an area.

Table 7: Alternative measures of distance to nearby practices

Dep Var: log average price = ln[m+ (1-F^B)*(p)]	OLS			R.E.			Mundlak			F.E.		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
ln(closest GP pr)	0.006	0.003	**	0.005	0.003	*	0.005	0.003	*	0.005	0.003	
ln(3rd closest GP pr)	0.016	0.005	***	0.016	0.005	***	0.017	0.006	***	0.016	0.006	***
ln(5th closest GP pr)	0.022	0.007	***	0.023	0.007	***	0.028	0.009	***	0.028	0.009	***

Appendix A

We derive these results by noting that, at the Nash equilibrium, the condition (10) on p is

$$h\ell\left[1-F\left(\hat{\alpha};\theta\right)\right]-\left[p+m-\tfrac{1}{2}\delta q_1^2\right]\frac{h}{t}\left[1-F\left(\hat{\alpha};\theta\right)\right]=0$$

so that $p=\ell t-m+\tfrac{1}{2}\delta q_1^2$. Substituting into the condition (11) on q_1 gives

$$-\delta q_1\ell h\left[1-F\left(\hat{\alpha};\theta\right)\right]+\ell h\int_{\hat{\alpha}_i}^{\alpha_1}\alpha f(\alpha;\theta)d\alpha=0$$

and so cancelling and dividing by $1-F(\hat{\alpha};\theta)$ gives (17) and substituting (17) into the expression for p gives (16). The condition (12) on the bulk billing threshold $\hat{\alpha}$ implies that with an interior solution $\hat{\alpha}\in(\alpha_0,\alpha_1)$ the profit on the marginal patient type is the same whether they are bulk billed or not bulk billed so that $m-\tfrac{1}{2}\delta q_0^2 = p+m-\tfrac{1}{2}\delta q_1^2$, or using (16), $m-\tfrac{1}{2}\delta q_0^2 = \ell t$, and this yields the expression (15) for q_0. Condition (9) can be written as $\delta q_0 h\ell\left[1-F\left(\hat{\alpha};\theta\right)\right] = \left[m-\tfrac{1}{2}\delta q_0^2\right]\frac{h}{t}\int_{\alpha_0}^{\hat{\alpha}_i}\alpha f(\alpha;\theta)d\alpha$, so that cancelling h, dividing through by $(1-F)$, and substituting for q_0 from (15), gives the expression (18) for the expected value of α for bulk billed patients.

If the Nash equilibrium has no patient being bulk billed ($F^b = 0$, $\hat{\alpha} = \alpha_0$) the first order conditions on price and quality imply

$$\ell t-\left(p+m-\tfrac{1}{2}\delta q_1^2\right)=0 \tag{36}$$

$$-\delta q_0\ell t+\left[p+m-\tfrac{1}{2}\delta q_1^2\right]\bar{\alpha}\left(\theta\right)=0 \tag{37}$$

where $\bar{\alpha}\left(\theta\right)$ is the unconditional expectation of α. Hence we can solve for

$$p=t\ell-m+\frac{\left(\bar{\alpha}\left(\theta\right)\right)^2}{2\delta} \tag{38}$$

$$q_1=\frac{\bar{\alpha}\left(\theta\right)}{\delta} \tag{39}$$

If the Nash equilibrium has GPs bulk billing all their patients ($F^b = 1, \hat{\alpha} = \alpha_1$) the first order condition on quality implies

$$-\delta q_0\ell t+\left(m-\tfrac{1}{2}\delta q_0^2\right)\bar{\alpha}\left(\theta\right)=0 \tag{40}$$

where $\bar{\alpha}\left(\theta\right)$ is the unconditional mean of the marginal valuation of quality.