Technical Appendix for Supply, Demand, and Equilibrium in the Market for CRNAs

Econometric Methods Used in Analyses Presented

Let \( c_{at} \) be the number of CRNAs practicing at age \( a \) in year \( t \). Then the net exit rate for CRNAs at age \( a \) in year \( t \) is estimated as

\[
n_{at} = 1 - (c_{at}/c_{a-1,t+1}).
\]

Define \( e_{at} \) as the entry rate of CRNAs at age \( a \) in year \( t \). Then the exit rate is

\[
x_{at} = n_{at} + e_{at}.
\]

The survivor function for CRNAs in year \( t \) at age \( a \) who entered at age \( b \) is

\[
S_{abt} = \prod_{i=b+1}^{a} (1-x_{it}).
\]

Given estimates of entry rates and net exit rates, one can simulate future stocks of CRNAs. The predicted number of CRNAs of age \( a \) in some future year \( \tau \) is

\[
\hat{s}_{a\tau} = \sum_{i=a}^{\tau} \hat{e}_{i,\tau-i} \hat{S}_{a\tau},
\]

where \( \hat{e}_{i,\tau} \) is the estimated entry rate, \( \hat{S}_{a\tau} \) is the estimated survivor curve, and \( a \) is the youngest age one can become a CRNA. An estimate of the total stock of CRNAs in some future year \( \tau \) is

\[
\sum_{a=\overline{a}}^{\tau} \hat{s}_{a\tau}
\]

where \( \overline{a} \) is an assumed upper limit on the age of a CRNA. An estimate of the average age of CRNAs at time \( \tau \) is
\[
\sum_{a=a}^{\tau} \frac{a \hat{s}_{ar}}{\sum_{a=a}^{\tau} \hat{s}_{ar}},
\]

and an estimate of the density of CRNAs at age \( a \) in year \( \tau \) is

\[
\frac{\hat{s}_{ar}}{\sum_{b=a}^{\tau} \hat{s}_{br}}.
\]

**Smoothing**

There are counties with no surgeries as surgeries are reported by the hospitals where the surgery takes place. When a resident of a rural county requires (or demands) a surgery, he or she travels to a nearby county where surgical services are provided. Thus, in order to observe a more accurate picture of the surgeries performed for residents of each county, a “smoothing function” was constructed. Let \( d_{ik} \) be the distance between two counties \( i \) and \( k \). Let \( \phi(d_{ik}) \) be a function (somewhat like a kernel function) such that

\[
\arg \max_{d} \phi(d) = 0, \\
\frac{\partial \phi(d)}{\partial d} \leq 0, \\
\phi(d) = 0 \forall d : |d| \geq d_{\max}.
\]

The smoothing function smoothes data by taking weighted averages of each variable \( y \) over nearby counties

\[
y_{i}^{*} = \frac{\sum_{k} \phi(d_{ik}) y_{k}}{\sum_{k} \phi(d_{ik})}
\]

where the weights satisfy equation (2). The specific weighting function used is a normal density function with a standard deviation of \( \sigma \). Different values of \( \sigma \) were experimented with, and it was found that \( \sigma = 500 \) fit the data well.
For example, consider Gosper County in central Nebraska. Even though counties far away such as in southern South Dakota receive positive weight, only counties nearby receive significant weight. The use of the weighted average for Gosper County assumes that people in the county have access to medical care in Omaha and Lincoln, but, for the most part, it behaves like a rural county far from any metropolitan area.