Do Medicare Payments Influence Physicians' On-the-Job Investments?

Jeffrey Clemens
UCSD and NBER

Joshua D. Gottlieb
UBC and NBER

Jeffrey Hicks*
UBC

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Abstract

We examine how physicians' on-the-job investments and time caring for patients respond to a policy-driven payment shock. Using a substantial decline in Medicare reimbursements for surgeons relative to other physicians we show that patient care hours respond negatively to prices, while on-the-job investments respond positively. This suggests that seemingly backward-bending labor supply can be driven by on-the-job investment dynamics, rather than income targeting. The effects are strongest among physicians whose productivity directly influences their compensation. As a result, short-run supply curves can differ from the long-run supply curves that reflect these continuing investments.

*Clemens: jeffclemens@ucsd.edu, Gottlieb: Joshua.Gottlieb@ubc.ca. Hicks: Jeffrey.Hicks@ubc.ca.
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Government payment policies influence investments in physical capital and innovation throughout the health care system (Acemoglu and Finkelstein, 2008; Clemens and Gottlieb, 2014; Finkelstein, 2004; Acemoglu and Linn, 2004). But the health sector is intensive in both labor and human capital. Physicians' investments in their human capital and entrepreneurial capital may thus be as consequential as traditional capital investments. We study how physicians' on-the-job investments respond to administratively set reimbursement rates, which in turn drive doctors' wage rates.

Existing knowledge about physicians' responses to payment rates focuses on time spent treating patients. An extensive, controversial literature argues for backward-bending labor supply—that when payment rates are cut, the supply of physician care expands. More recent work tends to find standard upward-sloping responses.[1]

We argue that both of these views miss an important element of physician labor supply: the choice between current earnings and investments in future productivity. As the literature on human capital theory has long understood (Becker, 1962; Ben-Porath, 1967; Mincer, 1974a,b), overall work effort includes both revenue-generating activities and investments in human capital, which influence future productivity. We propose that physician behavior can be better understood through the lens of human capital theory, as doctors face a time allocation tradeoff reminiscent of Ben-Porath (1967) throughout their working lives.

We exploit time use data that divide physicians' overall working time into patient care hours, which generate revenues, and time spent on other medical activities. These other activities include the recruitment of new patients, investments in physicians' professional

[1]The classic cites on backward-bending labor supply include Rice and Labelle (1989), Rice (1983; 1984), Gruber and Owings (1996), Yip (1998), and Jacobson et al. (2013). McGuire and Pauly (1991) provide the canonical model and McGuire (2000) and Chandra et al. (2011) review this literature. The physician literature has also found evidence of standard upward-sloping labor supply, especially in more recent work (Gruber, Kim and Mayzlina, 1999; Hadley and Reschovsky, 2006; Clemens and Gottlieb, 2014; Alexander, 2015; Johnson and Rehavi, 2016; Brekke, Holmås, Monstad and Straume, 2017; Foo, Lee and Fong, 2017). Nevertheless, the traditional view, that physicians have backward-bending labor supply and offset payment cuts with increased volume, is embedded in policymaking (Codespote et al., 1998).

networks, and investments in continuing education, such as studying to maintain board certification. Many of these investments augment the physician's human capital as usually understood. Others, like the development of new patient relationships or investments in managerial capacity, set the stage for increases in care provision over longer time horizons. In both cases, the key feature of investments is that they increase the physician's future earnings potential. We examine how investments and labor supply vary over a physician's career and in response to government-induced price shocks, which influence physicians' earnings per treatment.

In models of investment over the life cycle, workers can substitute between current earnings and on-the-job training. We study this margin empirically using a Medicare policy shock that changed the price of physicians' output—that is, the care they provide—differentially across specialties. This shock allows us to test whether physicians behave in the way that human capital theory would predict. We find that a substantial reduction in reimbursements led physicians in adversely affected specialties to reduce the extent of their investment activities and increase their time spent on revenue-generating patient care. These responses are stronger among older physicians than younger physicians. We also document that investment activity decreases over a physician's career, consistent with life cycle models of training and labor supply.

Our results demonstrate that physicians face the tradeoff contemplated by human capital theory. Physician labor supply thus ought to be analyzed with this tradeoff in mind. In some contexts, the supply of care may be backward-bending in the short run—but care provision reflects only a part of physicians' overall work effort. What appears to be backward-bending labor supply may actually reflect the tradeoff doctors face between on-the-job investments and short-run income generation.

Our results are consistent and complementary with existing evidence on investments in physical capacity. The literature finds that both hospitals' and physicians' capital investments respond positively to payment rates, consistent with standard profit maximization (Acemoglu and Finkelstein, 2008; Finkelstein, 2007; Clemens and Gottlieb, 2014).[2] We find the same for human capital investments. If these investments increase care-giving capacity in the future, overall health care supply responses can be very different in the short-run and long-run. Policy decisions based exclusively on the short-run responses would miss a crucial part of their impacts.

In addition to its direct relevance for understanding physician markets, our analysis provides a concrete illustration of classical human capital theory. Becker (1962), Ben-Porath (1967), and Mincer (1974a,b) emphasize that, beyond schooling, training may continue both on and off the job throughout the working life. The empirical literature, however, has long lamented the paucity of data on human capital investment margins beyond formal schooling and accumulated work experience (Lynch, 1992; Kuruscu, 2006).[3] Absent data on ongoing investments, the long-hypothesized life cycle profiles of these investments have been inferred from wage and earnings profiles rather than estimated directly.[4] We make progress by using uniquely informative data on physicians' ongoing investments in their practices and human capital.

Physicians are an appropriate setting for examining human capital theory and labor supply because doctors have substantial autonomy in their time allocation and investment decisions. Researchers study taxi cab drivers (Camerer et al., 1997; Farber, 2005, 2015),

[2]Additional related work has considered the effects of reimbursements and other payments on the types of patients physicians choose to treat (Chen, 2014; Garthwaite, 2012; Baker and Royalty, 2000), the drugs they choose to prescribe (Carey et al., 2015), the number of staff members they hire (Buchmueller et al., 2016), and whether they enter private practice and/or sub-specialize (Chen et al., 2018).

[3]Lynch (1992) emphasizes that "Due to the lack of appropriate data, researchers have been unable to examine directly the impact of private-sector training on wages in any comprehensive way. Consequently, many have had to infer this impact from the shape of wage profiles." The impact of Kuruscu (2006) was partly due to the fact that it contributed to the inferences that could be drawn in the absence of data on training activities themselves. Those formal post-schooling job training activities that the previous literature considers (Barron, Black and Loewenstein, 1989) are often chosen by firms as much as by workers, making them imperfect for testing models of workers' investment decisions.

[4]Oster and Hamermesh (1998, 156) note that even the study of economists' incentives and productivity is hampered by the lack of time use data.

stadium vendors (Oettinger, 1999), and bicycle couriers (Fehr and Goette, 2007) because these occupations have the flexibility to adjust the intensive margin of labor supply. Many physicians run individual or small practices, and can also choose how to allocate their time and resources.[5] This makes them an ideal context for studying labor supply and on-the-job training behavior. Physician behavior also has broad implications for aggregate welfare. In 2016, the United States spent $665 billion, or 3.6 percent of GDP, on physician care and similar medical services alone.[6] Recurrent concerns about physician shortages (Cooper et al., 2002; Staiger et al., 2009; Petterson et al., 2012) highlight the need to understand doctors' investments.

The remainder of the paper is structured as follows: Section 1 describes the data and measures of on-the-job investments and labor supply. Section 2 demonstrates that the life cycle behavior of these measures is consistent with standard human capital theory. Section 3 introduces the Medicare policy change and our empirical strategy for identifying how investments and labor supply respond to pricing changes. Section 4 presents the results and section 5 concludes.

1 Measuring Physicians' On-the-Job Investments and Labor Supply

We use data from the Community Tracking Study (CTS) to study physicians' investment and labor supply behavior. The CTS measures a variety of characteristics of physicians' practices and time use, and was conducted over four two-year waves: 1996/97, 1998/99, 2000/01, and 2004/05. In each wave, the CTS surveyed roughly 12,000 physicians across 60 ran-

[5]In recent years, physician practices have been merging and growing (Welch et al., 2013). But this trend mostly occurred after the time period we consider (Liebhaber and Grossman, 2007; Robinson, 1998), and even now one-third of physicians work in small practices (Muhlestein and Smith, 2016). Appendix Table A.1 shows the distribution of practice types for our sample.

[6]This comes from the "Physician and Clinical Services" component of the 2016 National Health Expenditure Data (Centers for Medicare and Medicaid Services, 2018).

domly chosen geographic areas (Center for Studying Health System Change, 1999). We use the restricted-use data, which contain detailed responses to certain questions, plus a linked identifier that allows us to create a panel of physicians.[7] The survey focuses on physicians whose primary focus is direct patient care; research and federally-employed physicians are excluded, as are specialties not providing direct patient care. We examine three measures of investment behavior:

Non-Patient Hours: Physicians report their weekly total medical hours and the time spent providing direct patient care. We define non-patient hours as the difference between total and patient care hours. To clarify the substance of this measure, we present the exact wording of the questionnaire that is used to elicit time allocation. For total hours, the survey asks:

> Thinking of your last complete week of work, approximately how many hours did you spend in all medically related activities? Please include all time spent in administrative tasks, professional activities and direct patient care. Exclude time on call when not actually working.

For patient care hours, respondents are asked:

> Thinking of your last complete week of work, about how many hours did you spend in direct patient care activities? (If necessary, read:) INCLUDE time spent on patient record-keeping, patient-related office work, and travel time connected with seeing patients. EXCLUDE time spent in training, teaching, or research, any hours on-call when not actually working, and travel between home and work at the beginning and end of the work day.

[7]Each wave contains a subset of respondents from the previous wave, resulting in an unbalanced panel. Appendix Table A.2 shows that observable characteristics are balanced across individuals of differing panel lengths.

The residual measure of non-patient hours therefore includes training, professional activities, and only administrative work unrelated to direct patient care.[8] This includes obtaining or maintaining board certification, recruiting patients, building professional relationships, attending conferences, staying apprised of new treatment procedures, adopting and implementing new physical capital, remaining compliant with evolving medical regulations, hiring and managing employees, and building overall organizational capacity within one's practice. Each of these endeavors contribute towards individual human capital and broader practice capacity over the long-run. So we adopt this broad definition of non-patient hours as ongoing investments throughout the paper.

Board Certification: Physicians can obtain board certifications in their primary specialty and sub-specialties, neither of which is legally required to practice medicine. Instead, these certifications may act as a signal of quality, making the physician more attractive to potential clients or employers.[9] Obtaining board certification entails fees ranging from $1,000 to $3,000 (Drolet and Tandon, 2017), an initial written and oral exam, re-certifying exams at intervals of 6–10 years, and other maintenance of certification requirements.[10] Given certification's voluntary nature, and the associated time and monetary costs, it proxies effectively for ongoing investments in practice capacity. Appendix Figure A.1 provides evidence that physicians with board certification have higher earnings than physicians without board certification.[11] This confirms that, at least as a matter of correlation, the continuing education

[8]Research is unlikely to constitute a meaningful component of non-patient hours because the CTS explicitly excludes doctors focused on research from its samples. The questionnaire wording also excludes from non-patient hours the time physicians spend on-call but not actually working.

[9]In a survey of internists, Lipner et al. (2006) find that a majority of those maintaining certification report doing so for "positive professional reasons," with a minority reporting that certification is required by an employer.

[10]Maintenance of certification (MOC) often entails online training modules in medical knowledge or activities that are supposed to improve patient quality. For instance, the American Board of Internal Medicine requires physicians to earn 100 points every five years, by undertaking either online training modules, or "Quality Improvement/Practice Improvement" activities, each of which typically garners 10–20 points. MOCs became a regular part of certification beginning in the early 2000s.

[11]This holds both within age groups and when examining surgeons or non-surgeons separately.

associated with board certification predicts higher incomes.[12]

Willingness to Accept New Patients: Respondents report their willingness to accept new patients, on a four point integer scale, for each type of patient: Medicare, Medicaid, and privately insured. We construct a summary index by adding together the response for each patient type, and rescaling such that it ranges from zero to one. One indicates a complete willingness to accept new patients of any type, and zero a complete refusal. Building and maintaining a customer base is one form of ongoing investment physicians often must make to ensure current and future profitability. As such, a physician's desire to accept new patients proxies for ongoing investments, and in turn, long-term care supply.[13]

In addition to on-the-job investment measures, we examine income-generating patient care hours, total labor supply, and annual income:

Patient Care Hours: As described above, patient care hours involve direct face-to-face time with patients, patient record-keeping and related office work, and travel time connected with seeing patients. These are the activities that generate revenue for a practice.[14]

Total Labor Supply and Income: We measure total labor supply as the time spent on all medically-related activities. This is the sum of patient care hours and non-patient hours. Respondents also report their total income net of expenses for the year preceding the survey wave. So in the 1996/97 survey wave, income is requested for the 1995 calendar year.[15]

The restricted-use CTS data provide each respondent's primary specialty at a detailed

[12]Cassel and Holmboe (2008) provide a history and overview of board certifications. The evidence is mixed on whether certification affects clinical outcomes, health care costs, or other aspects of care. Lipner et al. (2013) provides an overview of some of this research, largely correlation-based, and concludes that there are positive correlations between board certification and knowledge, practice infrastructure, and communication. Conversely, Gray et al. (2014) and Haynes et al. (2014) find no effect of MOC requirements or re-certification, respectively, on clinical outcomes.

[13]Appendix B.2 discusses the details of the original question and how we rescale it.

[14]Patient care hours are an imperfect proxy for the supply of medical care. For a given amount of time, a more efficient doctor can supply more medical care. Thus variation across doctors in treatment hours may understate variation in medical care supply. Medical care is also vaguely defined. Time spent answering patients' questions may not constitute medical treatment in the strict sense, but does improve the quality of service provided.

[15]The questionnaire phrasing for income is reported in Appendix B.2.

level—specifying 126 unique specialties—as opposed to the aggregated categories available in the public-use version. This allows us to leverage disaggregated variation in Medicare reimbursement rates across specialties. Similarly, income in the restricted-use data is reported to the nearest $1,000, while the public-use version reports income in $50,000 bins. Appendix Tables A.1 and A.2 show summary statistics for the variables discussed above, and for additional variables that describe physicians' practice types.

2 Life Cycle Patterns of Human Capital Investments

Figure 1 shows cross-sectional life cycle patterns for non-patient hours, willingness to take new patients, and board certification. After modest upticks early in physicians' careers, the investment activities we track decline nearly monotonically with age. This lines up with theoretical predictions (Ben-Porath, 1967), since the horizons over which investments pay off decline with age, and the opportunity cost of time increases when productivity is high.

On average, physicians in their late 30s spent just over 11 hours per week on non-patient hours. This level persists for a number of years, falling to just under 11 hours per week for physicians in their early 50s. Among those in their late 50s and early 60s, physicians spend just under 9.5 hours per week on such activities. Older physicians spend an average of 8.5 hours per week on these activities. While the gradient is not steep, the pattern is clear: physicians gradually devote less time to medical activities other than patient care as they approach retirement. By comparison, patient care hours hit a high mark during the same age, but do not begin a strong descent until age 60. That non-patient hours decline earlier than revenue-generating patient hours is consistent with on-the-job investments being crowded-out when the time horizon for investments to payoff is shorter.

The willingness to take new patients also decreases nearly monotonically with age. Our measure declines from just under 0.8 for physicians 29–39 years old to 0.72 for doctors 65 or older. Because most physicians report taking "all" or "most" new patients of all insurance types, the index's range is modest. The decline we observe from the youngest physicians to the oldest physicians is equivalent to 1 standard deviation of the index. To the extent that a patient relationship is an ongoing commitment, this signals a desire to decrease practice activity both in the present and in the future.

Board certification follows a similar trajectory. Figure 1 Panel D shows that 90 percent of physicians in their late 30s and early 40s are board certified. The share falls to 80 percent among those in their early 50s, 70 percent among those in their early 60s, and 60 percent among older physicians. Maintaining board certification, which maps quite directly into the time investments contemplated by theory, thus matches the predictions well. That said, board certification rates have risen over time, which could contribute to the observed age gradient if younger doctors are leading the trend. Furthermore, a precondition for declining certification rates in old age is the ability to lose one's certification. However, a segment of the CTS sample hold lifetime certifications which are exempt from recertification requirements. For both these reasons, the age profile of board certification should be interpreted with caution. We discuss robustness of the life cycle profiles in Section 4.4.

The returns to investments in physicians' practices and human capital may accrue over a variety of different time horizons. So it is not clear which age groups should be most sensitive to the expected returns from these different investment activities. As a signal of quality, for example, board certification may generate returns by both increasing a physician's capacity to recruit new patients and improving their bargaining position in negotiations with private insurers. While improved bargaining position may be valuable through the last years of a physician's career, the need to recruit new patients may decline in advance of retirement. The precise timing with which the return to board certification might fall below its costs is thus unclear and may vary substantially across physicians.

The remaining panels of Figure 1 show life cycle profiles for total hours, patient care hours, and income. All three exhibit an inverse U-shape. Total hours peak between age 40 and 50, and then begin a steady decline. Patient care hours peak around age 40, remain steady until age 60, then trend downwards. Finally, income follows the trajectory of labor supply. It rises until age 50, then begins to decline. Consistent with a point made early by Heckman (1976), declines in earnings are driven in no small part by declines in labor supply.

Age is an imperfect measure of career horizon. To further support our interpretation that non-patient hours reflect ongoing investments, we leverage the panel component of the CTS to measure the decline in non-patient hours as physicians approach their year of attrition from the panel.[16] The survey does not explicitly measure retirement, but Appendix Figure A.4 shows that attrition increases steeply with age, from a base hazard rate of 40–45 percent for mid-career doctors, to 60 percent for old physicians. The steady increase in attrition rates with age suggests that attrition from the panel among older physicians is partially attributable to retirement.

To quantify the relationship between retirement hazard and investment decisions, we estimate the following descriptive regression:

$$\begin{aligned} y_{it} = \alpha_0 &+ \alpha_2 \cdot (\text{Two Years Before Attrition}_{it}) + \alpha_4 \cdot (\text{Four Years Before Attrition}_{it}) \\ &+ \alpha_8 \cdot (\text{Eight or More Years Before Attrition}_{it}) \\ &+ \psi \, \text{Surgeon}_i + \varphi_{a,s} \, \text{Age}_{it} \times \text{Surgeon}_i + \epsilon_{it} \end{aligned} \tag{1}$$

The outcome variable y_{it} in equation (1) is non-patient hours, either in levels or as a share of total hours, for physician i of specialty $s(i)$ in survey wave t. We include a fixed effect ψ for whether a physician is classified as a Surgeon or Non-Surgeon based on the CTS classification, and differential age fixed effects $\varphi_{a,s}$ for Surgeons and Non-Surgeons.[17] The

[16] Only the restricted-use version of the CTS provides physician identifiers, enabling us to exploit the panel component.

[17] Allowing age fixed effects to vary with specialty assuages concerns that the decrease as physicians approach retirement is driven by differing retirement patterns *and* different levels of non-patient hours

estimates of interest are the fixed effects for years-to-attrition. The base group is physicians in their final period in the sample. So the coefficients $\hat{\alpha}_2$, $\hat{\alpha}_4$, and $\hat{\alpha}_8$ estimate the differences in investment levels for physicians 2, 4, or $\geq$8 years prior to attrition, relative to those making their final appearance. If attrition partly reflects retirement, and investments decline in the years approaching retirement, then the estimates should be positive, and declining towards zero as the physician approaches attrition.[18]

Figure 2 plots the estimates of how years-to-attrition relate to non-patient hours, both in levels and as a share of total working hours. Both hours measures decline monotonically as an individual approaches her final year in the panel. This is consistent with the interpretation of these non-patient hours as activities that contribute to the physician's long-run earnings capacity. Some of these activities, like the continuing education required to maintain board certification, can be described as classic investments in human capital. Others, like time spent cultivating new patient relationships, may more generally set the stage for continued work in future periods. We will emphasize these interpretations throughout the rest of the paper.

Figure 2 also shows that the decline in investments prior to attrition only holds for physicians aged 60 or greater. For physicians younger than 45, non-patient hours do not vary with years to attrition.[19] So Figure 2 also suggests that higher attrition rates among older doctors reflect retirement decisions to a much greater extent than among mid-career

between Surgeon and Non-Surgeons.

[18]The four waves of the CTS took place in 1996/97, 1998/99, 2000/01, and then 2004/05. The gap between waves 3 and 4 slightly complicates the analysis of behavior in the years leading up to attrition from the sample, as estimated in equation (1) and plotted in Figure 2. To deal with the gap, we use the structure of fixed effects shown in equation (1): 2, 4, and $\geq$ 8 years prior to attrition. The first two fixed effects are in 2-year intervals due to the bi-annual frequency of the CTS. The final fixed effect is for 8 or more years because the difference between third and final CTS wave was 4 years (2000/01 to 2004/05). To avoid confounding the interpretation of the fixed effects, we restrict the sample to (i) all individuals observed in the first wave, and (ii) individuals who initially appeared in the second wave, but drop out of the sample before the final wave.

[19] Appendix Figure A.5 shows a similar pattern for total hours worked and patient care hours. Appendix Figure A.6 reveals a similar pattern for certification status, while physicians' propensity to take new patients is flat over the years immediately preceding retirement.

physicians.

3 Empirical Model for Testing Comparative Statics

Having traced out the basic life-cycle pattern of physicians' investment activities, we next analyze how these investments respond to changes in their expected returns. We rely on a large Medicare reimbursement change that took place in 1998 and was not reversed. In order to reduce payment discrepancies and support primary care, Congress eliminated a policy that had increased reimbursements per unit of effort for surgical procedures relative to non-surgical services. This change reduced payments for all procedures by 10.4 percent while increasing payments for non-procedural services by an average of 5 percent.[20] Because this change was almost simultaneously adopted by many private insurers (Clemens and Gottlieb, 2017), the effect on the average prices—and hence hourly wages—for surgeons relative to non-surgeons was substantial.[21] Forward-looking physicians would thus have anticipated a large and persistent change in the returns to practicing in surgery-intensive specialties relative to other specialties.

We adapt Clemens and Gottlieb's (2017) approach to analyzing this payment shock to more fully exploit the resulting variation in payments across physician specialties. The payment change applies at the level of each individual service — so an office visit experiences a price increase, while a cataract surgery would face a price decline. Since many specialties provide a combination of procedural and non-procedural services, each specialty's overall price change reflects the share of procedures in its output mix.

We obtain estimates of the overall percent change in payments by specialty from a report by the Congressional Research Service (1998).[22] These values, reproduced in Table 1, provide

[20] Clemens and Gottlieb (2017) present a more detailed description of the institutional history and decision-making behind this payment change. In Appendix Figure A.3, we show how the payment rates per unit of effort (called "Conversion Factors") evolved for surgical and non-surgical care during this time period.

[21] The 1998/99 CTS began in August 1998, well after the policy's announcement and implementation.

[22] Table 2 in Congressional Research Service (1998) provides two estimates of the percent change in

a specialty-level payment shock and hence wage shock for twenty-four different specialty groups. We use the specialty-level payment change to estimate two types of regressions. The first is a dynamic difference-in-differences specification:

$$\begin{aligned} y_{it} = {} & \beta_{98-99}\,\Delta p_{s(i)} \times \mathbb{1}_{t=1998-99} + \beta_{00-01}\,\Delta p_{s(i)} \times \mathbb{1}_{t=2000-01} + \beta_{04-05}\,\Delta p_{s(i)} \times \mathbb{1}_{t=2004-05} \\ & + \phi_s \mathbb{1}_{s(i)} + \phi_{98-99}\,\mathbb{1}_{t=1998-99} + \phi_{00-01}\,\mathbb{1}_{t=2000-01} + \phi_{04-05}\,\mathbb{1}_{t=2004-05} + \varepsilon_{it}. \end{aligned} \tag{2}$$

The unit of observation for this regression is the physician (i)-by-survey wave (t); in other words, each observation in this regression is one survey response ($N = 43{,}669$ in our baseline regression). Each physician reports her specialty $s(i)$ and the main regressor of interest is that specialty's Medicare price change $\Delta p_{s(i)}$ interacted with survey wave fixed effects. Specialty fixed effects are denoted by $\mathbb{1}_{s(i)}$ and time fixed effects by $\mathbb{1}_t$ for each wave t. The omitted time category is the 1996/97 survey wave prior to the policy change; as this is the only wave of the CTS prior to the policy change, we cannot separately estimate pre-trends. The resulting coefficients $\hat{\beta}_{98-99}$, $\hat{\beta}_{00-01}$, and $\hat{\beta}_{04-05}$, which we will present graphically, are our estimates of how the price change impacts physicians' choice of the outcome variable y_{it} in each time period after the change. We estimate all regressions using survey weights that account for the CTS sampling design,[23] and cluster standard errors at the individual (panel unit) level to account for autocorrelation of individual-level shocks.[24]

We also estimate a pooled regression that combines all of the post-implementation survey waves and controls for flexible age trends. Letting $\text{PostImplementation}_t$ be a dummy variable

payments by specialty: one that only incorporates the Conversion Factor change, and one that also accounts for contemporaneous changes in the weights (Relative Value Units) assigned to different procedures. We use the latter, more comprehensive, measure of payment changes in order to maximize precision. All results are virtually identical when using the former measure, which is not surprising as Appendix Figure A.7 shows that the two are extremely tightly correlated.

[23]The survey oversamples primary care physicians and some regions.

[24]There is substantial turnover of individual physicians across survey waves (see Appendix Table A.2). To avoid losing substantial power, we do not include individual fixed effects. Since payment shocks occur at the specialty level, the specialty fixed effects that we do include will account for any underlying differences correlated with payment shocks.

indicating $t \geq 1998$, we estimate:

$$y_{it} = \beta\, \Delta p_{s(i)} \times \text{PostImplementation}_t + \xi_s \mathbb{1}_{s(i)} + \phi_{t,a}\, \mathbb{1}_t \mathbb{1}_a$$
$$+ \phi_{98-99}\, \mathbb{1}_{t=1998-99} + \phi_{00-01}\, \mathbb{1}_{t=2000-01} + \phi_{04-05}\, \mathbb{1}_{t=2004-05} + \varepsilon_{it}. \tag{3}$$

This equation includes a full set of age-by-wave effects $\mathbb{1}_t \mathbb{1}_a$, where $\mathbb{1}_a$ is a set of indicators for each discrete age measured in years. Interacting these age indicators with survey wave indicators estimates a fully non-parametric age profile of outcome y_{it} separately for each wave. This eliminates any potential for spurious findings if the age composition of our sample differs across waves and interacts with differential age trends by specialty.

To better illustrate the cross-specialty variation that underlies our results, we also estimate an aggregated specialty-level regression that lends itself to plotting. We aggregate the three post-policy waves into one post-implementation time period, and aggregate the outcome variables to specialty-level averages for the pre-implementation and post-implementation periods, respectively.[25] Letting Δy_s denote the post-implementation average minus the pre-implementation average for an outcome variable, we estimate:

$$\Delta y_s = \gamma \Delta p_s + \epsilon_s \tag{4}$$

at the specialty level, weighting each observation by the sum of the weights of all individual physicians in that specialty. The regressor of interest is Δp_s, *i.e.* the specialty-level price change from Congressional Research Service (1998, Table 2).

We further investigate how payment shocks shape investments by physicians at different points in their careers. To do so, we estimate equation (3) separately on three age groups: "Youngest," "Middle," and "Oldest".[26] Cavounidis and Lang (2017) find that young work-

[25]These averages account for the same CTS sampling weights used in the individual-level regression, equation (2).

[26]"Young" physicians are those under age 50, "Middle-Aged" are 50–59, and "Oldest" are 60 or greater.

ers are more responsive in simulations of an extended version of the canonical Ben-Porath model. In medicine, young workers may be more constrained in their hours, thus reducing responsiveness, or differ in their financial incentives. Similarly, the various forms of investment in human capital and practice capacity may differ in their relevance at different career stages. Consequently, we are agnostic about which physician age groups are expected to respond most elastically to payment shocks. In section 4 we elaborate further on what may influence the age profile of responsiveness among medical care providers.

4 Empirical Results

4.1 Baseline Results on Investment Margins

Figure 3 shows the basic pattern of responses we observe when estimating equation (4) across specialties. Each panel shows the relationship between the Medicare payment change and one outcome variable of interest. Each circle represents one specialty, and the sizes are proportional to the number of doctors observed in that specialty. Each panel also shows the regression estimate for that relationship. The negative slope of the data and regression line in Panel A suggests that increased Medicare reimbursements for a specialty lead physicians of that specialty to spend fewer hours on patient care. At first glance, this finding appears consistent with the target-income view, in which physicians have backward-bending labor supply.

Panels B, C, and D call the target-income interpretation into question. In contrast to patient care hours, Panel B shows that non-patient hours subsequently increased for specialties experiencing payment bumps. Based on our previous finding that non-patient hours behave like investments, we interpret this as an increase in on-the-job investments. Panels C and D test this explanation by looking at more direct investment margins that we observe in

Section 4.4 shows that results are fairly robust to different cutoffs.

the CTS. Panel C examines board certification, while Panel D looks at physicians' willingness to take new patients. Both of these panels display stark upward sloping relationships, consistent with the idea that investments increase in response to a price increase.

To see if these estimates are related, Appendix Figure A.8 checks whether the same physicians and specialties that increase their non-patient hours reduce their patient care hours. We indeed find a strong negative relationship between changes in patient care hours and non-patient hours. This suggests that, rather than increasing overall labor supply as the target-income hypothesis would suggest, doctors facing payment cuts reallocate time from investments towards current earnings.

Figure 4 shows the dynamic results we obtain from estimating equation (2) at the individual level (physician-by-CTS wave), for the same set of outcome variables. In each panel, 1996/97 is the omitted base year. Subsequent dots indicate the coefficient for survey waves after the price change, and blue bars indicate the 95 percent confidence interval. We confirm the patterns from Figure 3. Payment increases lead to increased non-patient hours, higher rates of board certification, and increases in the propensity to accept new patients. Estimated effects on board certification and the acceptance of new patients are much larger over the medium run than over the short run. In contrast, payment increases lead to declining patient care hours. Like the investment responses, the magnitude of this response is much larger over the medium run than over the short run. Productivity gains linked to investment responses may contribute to this result. Like patient hours, the response of total hours is indistinguishable from zero until the significant drop in the 2004/2005 wave.

The CTS reports two key variables for which we can assess the potential relevance of pre-existing trends: net income and annual weeks worked. These variables are reported for the years prior to the respective survey waves: 1995, 1997, 1999, and 2003. This provides two pre-periods and two post-periods surrounding the 1998 policy change. Panels A and B of Figure 5 show the dynamic responses of these variables around the payment change by estimating equation (2)'s dynamic difference-in-differences model with 1997 as the base period. Income and weeks of work for specialties for which payment rates rose in 1998 were on downward trajectories before the reimbursement shock, as shown by the decline from 1995 to 1997. This is consistent with policy makers' stated motivation for enacting the 1998 payment changes — primary care was in decline relative to specialties that provide intensive procedures. Panels C and D report estimates from specifications in which we control for a linear time trend interacted with the size of each specialty's payment change. While the resulting estimates lack precision, we observe that the negative association between payment changes and both income and weeks of work disappear when we control for the possibility of a pre-existing trend.

It is difficult to know with certainty how these patterns might extend to the outcomes on which we focus. Pre-existing downward trajectories in the labor supply of primary care physicians relative to surgical specialists would tend to bias our analysis towards observing spurious negative correlations between the 1998 changes in payment rates and measures of physicians' work hours and investment activities. Consequently, we suspect that our estimates understate the overall response of physician labor supply to this period's payment changes. If this is true, total labor supply may have increased in response to the payment increases we analyze.

Because the dynamic estimates in Figure 4 are noisy, especially for hours, we now turn to pooled results that combine all post-implementation waves into a single period. Each panel in Table 2 reports the coefficient estimates $\hat{\beta}$ from equation (3) for the same four outcome variables. The coefficient should be interpreted as a semi-elasticity, as it relates a percentage change in Medicare reimbursements (on the right-hand side) to the level of an outcome (such as, in Panel A, patient care hours). The table also reports the sample means of the outcome variables in the pre-policy period and uses them to convert the estimates to elasticities.

Column (1) in each panel reports the pooled result for all physicians. The coefficient of

-11.4 in Panel A implies that a ten percent increase in prices reduces patient care time by 1.14 hours per week, an elasticity of -0.26. Panel B shows that non-patient hours increase by 35 minutes (58.9 percent of one hour) in response to the same change, an elasticity of 0.55, which is marginally significant in the full sample. The estimated responses are thus of similar magnitudes, in offsetting directions. The elasticities for both outcomes are moderate in size, while the elasticity for total work hours (shown in Table 3) is quite modest and statistically indistinguishable from zero at conventional significance levels.

Panels C and D show that board certification and new patient acceptance respond significantly to the future profitability of one's practice. These investment outcomes have similar positive elasticities of 0.35 and 0.48, respectively. Both coefficients are statistically distinguishable from zero with $p < 0.01$. The magnitude of the estimate for board certification implies that a 10 percent increase in prices increases physicians' probability of holding board certification by 3 percentage points (on a base of 80 percent). We similarly estimate that a 10 percent increase in prices results in a 3.6 percentage point increase in our index that describes physicians' propensity to take new patients. This is roughly one half of a standard deviation of the index across the full set of physicians in our sample.

Appendix Table A.3 provides further details on the new patients that physicians are willing to accept. Payment declines predict declines in the propensity to accept new patients across all major insurance categories—Medicare, private, and Medicaid. This indicates that changes in practice patterns do not merely reflect shifts in supply of care to patients covered by different payers. Instead, the evidence suggests a broad-based intention to change the number of patients treated over the long run.

Table 3 presents results for total hours, log income, and weeks worked. The elasticity of -0.106 for total hours is statistically insignificant and economically modest, consistent with offsetting responses of non-patient and patient hours. The estimated elasticity on weeks worked, an additional margin of labor supply, is -0.068 and statistically significant. The estimated elasticity for log income is also negative and statistically indistinguishable from zero. As discussed previously, weeks worked and total income are two variables for which we are able to examine the possibility of pre-existing trends.[27] The evidence reported in Figure 5 suggests that specialties that experienced payment increases had declining trends in both of these outcomes prior to the Medicare reimbursement shock. As reported in Figure 5 Panels B and D, the estimated effect on income goes to zero and the estimated effect on weeks worked becomes positive when we control directly for the potential relevance of pre-existing trends. So adjustment for any potential pre-existing trends makes labor supply appear to be more positively responsive to the payment shocks we analyze than the unadjusted estimates would suggest. The estimates in Table 2 should thus likely be interpreted as lower bounds.

The results presented in this section highlight the importance of distinguishing between revenue-generating work hours and overall labor supply. Revenue-generating patient care hours exhibit a negative wage elasticity in the years following the payment shock, which could be interpreted as backward-bending labor supply. Yet the positive relation between wages and investments contradicts the notion that physicians scale back overall work in response to increased wages. This raises the question of how current policy affects long-run service supply. If investments increase the efficiency or quality of care in the long-run, then price changes will have longer-lasting effects that are missed by examining short-run responses.

4.2 Evidence on the Age Profile of Investment Responses

We now turn to the life cycle patterns of investment responses. We estimate equation (3) on subsets of the data cut by physician age. This allows us to investigate whether responses

[27]This is feasible because the CTS specifically asks about these variables for calendar year 1995 during the first CTS wave, and calendar year 1997 during the second wave. Thus data for two reference periods are recorded prior to the policy change we analyze. In contrast, the reference period for most variables captured during the second CTS wave is 1998 or 1999, placing the outcomes after the policy change we analyze.

of investment activities and labor supply to prices differ systematically across physicians' career stages. The estimates appear in columns (2)–(4) in each panel of Table 2.

Responsiveness of both non-patient hours and patient care hours is larger among older physicians. The point estimate in column (2) of Panel B suggests that the oldest physicians increase non-patient hours by two hours in response to a ten percent increase in payment rates. This corresponds to an elasticity of 2.3. The estimate for young physicians suggest no response at all. The coefficients for oldest and young are statistically distinguishable from one another at $p < 0.05$. The same pattern holds for patient care hours. The estimated elasticity is -0.54 for the oldest, -0.33 for middle-aged, and nil for young physicians.

In contrast, late-career physicians are the least responsive group on the margins of board certification and the willingness to take new patients. The elasticities for taking new patients are 0.64 and 0.43 for middle-aged and young physicians, relative to 0.05 among old physicians. For board certification, middle-aged and young physicians have estimated elasticities of 0.38 and 0.32 respectively, while the oldest physicians have an economically modest and statistically insignificant elasticity of 0.22.

A variety of forces likely contribute to the age heterogeneity we observe. Many physicians near retirement have devoted decades to developing their practices. If such physicians no longer need to recruit new patients, for example, they will have become inframarginal (and hence non-responsive) along this margin. Similarly, if the quality signal associated with board certification is most relevant for attracting new patients or for developing relationships with new insurance companies, this margin may also be irrelevant to those at the ends of their careers. In contrast, young physicians are still building their clientele. As the returns to taking more patients rise, young physicians may thus stand to benefit most from taking on activities that enhance their signals of quality. A more mechanical explanation for the muted certification response among old physicians is the higher prevalence of lifetime certificates among this age group, which effectively removes the recertification requirement.

4.3 Do Different Compensation Schemes Drive Investment Responses?

In a final cut of the data, we investigate whether investment responses vary depending on how physicians are compensated. Nearly 80 percent of physicians in the CTS data either work in solo practice or report that their compensation is linked to their own productivity. We investigate whether these physicians' investment responses differ from those of physicians who report that their compensation has no link to their productivity.[28]

Table 4 and Figure 7 analyze whether investment responses are larger when physicians' current compensation is linked to their productivity. While the response of hours differs fairly sharply with the structure of current compensation, the responses of board certification and the willingness to take new patients only differ marginally. When reimbursement rates rise, our estimates of positive responses of non-patient hours and negative responses of patient hours load entirely onto physicians whose compensation is linked to their productivity. Somewhat surprisingly, physicians with weaker links between compensation and productivity exhibit the opposite responses. The responses of board certification and willingness to take new patients load disproportionately onto physicians with strong contemporaneous incentives, but only modestly so.

Two key aspects of the data lead us to interpret these results with caution. First, the sample of physicians who report no link between their compensation and productivity is small. So the differences between their investment responses and the investment responses of physicians with seemingly stronger incentives are only statistically distinguishable from one another in the case of non-patient hours. Differential responses of board certification rates and willingness to take new patients are statistically indistinguishable and economically

[28]In the physician compensation context, the term "productivity" is used to mean what economists would call "output"—the number of patients treated, weighted by the intensity of that treatment. "Productivity" here does not mean total factor productivity. The specific questionnaire item is shown in Appendix B.2.

similar across these groups. Second, this is not a sharp test of the relevance of incentives because compensation schemes can change over time. Physicians whose compensation is not contemporaneously linked to their productivity may well have such a link in the future. Indeed, the CTS data reveal that physicians nearest retirement age are more likely than younger physicians to have compensation linked to their productivity.[29]

4.4 Robustness Checks

This section discusses additional extensions and robustness checks. First, we investigate whether cohort trends confound the interpretation of the age profiles from Section 2 by plotting the profile of labor supply and investment within each survey wave in Figure A.10. Encouragingly, the age profiles for patient hours, total hours, taking new patients, and income are invariant over time. In contrast, the profile for non-patient hours shifts downwards for all age groups. The late-career decline diminishes slightly, but remains visible in later waves. The percent decline from age 45-49 to age 60-85 in 1996/97 was 18 percent; in 2000/01, it was 12 percent. Finally, board certification propensity increased among older age groups, but remained constant among the young. This indicates higher certification rates among younger cohorts, which would overstate the old-age decline apparent in 1996/97.

Some physicians, particularly older ones, hold lifetime certificates that do not expire and are exempt from re-certification exams. Over a four decade period from the 1970s to early 2000s, certifying boards began reforming this practice, mandating recertification on a 6-to-10-year cycle. We test whether the responsiveness of certification to reimbursement changes depends on the presence of time-limited certificates. In Appendix Table A.4, we replicate the baseline difference-in-difference result for board certification (column (1) of Table 2, Panel C), and then limit the sample to specialties that switched to time-limited

[29]Appendix Figure A.9 plots the age profile of the propensity for a physician's current productivity to be linked their current compensation. The proportion reporting a link rises modestly from roughly 76 to 83 percent from young to old.

certificates prior to a specific date. Columns (2), (3), and (4) estimate the responsiveness of board certification rates to the Medicare payment change for physicians in specialties that switched to time-limited certificates by 1990, 1985, and 1980 respectively. Responsiveness to the payment change is larger among physicians in specialties that introduced time-limited certificates earlier, as shown by the increase in coefficients from (2) to (3) and (3) to (4). This suggests that the response of board certification to the Medicare payment shock is driven by physicians who were likely to face time-limited certifications.

This finding could arise from two channels. First, certification may respond to the payment shock via differential changes in *initial* certification. Physicians may be more price sensitive to time-limited certifications, which are implicitly more costly to obtain and maintain because they require ongoing time and monetary investments. relative to lifetime certificates. Second, differential changes in *recertification* rates may also be driving the estimated certification response. By definition, recertification is only relevant for time-limited certificates. Removing this margin translates to lower elasticities.

Finally, we examine whether the age heterogeneity results (Tables 2 and 3) are robust to different cutoffs for our "Young," "Middle-Aged," and "Oldest" groupings. We find in A.1.2 that the profile of responses for time allocation, which shifted considerably more for old than for the young physicians, is robust to several alternative age groupings. The age profiles of the other responses we estimate are less robust and should thus be interpreted less strongly.

5 Conclusion

This paper uses human capital theory to understand how physicians make on-the-job investment decisions. We present data on physicians' practices that are unique in their ability to trace out the life cycle profiles of investments in human capital or activities that develop the long-run profitability of a physician's practice. As theory predicts, we find that physicians' investments decline over the life cycle, across a variety of measures. These life cycle profiles provide a novel look at human capital theory in practice.

We use this rich setting to investigate how Medicare payment changes affect human capital investments. We find that these investments respond positively to their returns. Over the medium run, physicians respond to an increase in reimbursement rates by shifting time towards investment activities at the expense of hours spent on patient care.

Our analysis can help to reconcile seemingly conflicting findings in the literature on physician labor supply. Like other investments, those in human capital respond positively to increases in physicians' reimbursement rates. But a physician's time investments subtract from the time available for providing clinical care. An increase in investments can thus decrease the time allocated to patient care—a phenomenon that resembles backward-bending labor supply. But the increased investments explain why the literature finds that overall care supply responds positively to reimbursements in the long-run (Gruber, Kim and Mayzlina, 1999; Clemens and Gottlieb, 2014).

Our results imply that policymakers and researchers must pay close attention to physicians' investments in human capital and overall practice capacity, and to the intended lengths of their careers, which drive the health system's long-run capacity to deliver services. Because investments respond positively to payment rates, a policymaker seeking to alleviate a shortage will have long-run success by increasing payment rates rather than decreasing them. In contrast, payment reductions make sense when one thinks too much care is being provided—even if short-run responses might suggest otherwise.

References

Acemoglu, Daron and Amy Finkelstein, "Input and Technology Choices in Regulated Industries: Evidence from the Health Care Sector," *Journal of Political Economy*, October 2008, *116* (5), 837–880.

_ **and Joshua Linn**, "Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry," *The Quarterly Journal of Economics*, August 2004, *119* (3), 1049–1090.

Alexander, Diane, "Does physician pay affect procedure choice and patient health? Evidence from Medicaid C-section use," Working Paper 2017-07, Federal Reserve Bank of Chicago 2015. Available online at https://www.chicagofed.org/publications/working-papers/2017/wp2017-07 (accessed April 12, 2018).

Baker, Laurence C and Anne Beeson Royalty, "Medicaid policy, physician behavior, and health care for the low-income population," *Journal of Human resources*, 2000, pp. 480–502.

Barron, John M., Dan A. Black, and Mark A. Loewenstein, "Job matching and on-the-job training," *Journal of Labor Economics*, 1989, *7* (1), 1–19.

Becker, Gary S., "Investment in Human Capital: A Theoretical Analysis," *Journal of Political Economy*, October 1962, *70* (5), 9–49.

Ben-Porath, Yoram, "The production of human capital and the life cycle of earnings," *Journal of Political Economy*, 1967, *75* (4, Part 1), 352–365.

Brekke, Kurt R., Tor Helge Holmås, Karin Monstad, and Odd Rune Straume, "Do Treatment Decisions Depend on Physicians' Financial Incentives?," *Journal of Public Economics*, November 2017, *155*, 74–92.

Buchmueller, Thomas, Sarah Miller, and Marko Vujicic, "How do providers respond to changes in public health insurance coverage? Evidence from adult Medicaid dental benefits," *American Economic Journal: Economic Policy*, 2016, *8* (4), 70–102.

Camerer, Colin, Linda Babcock, George Loewenstein, and Richard Thaler, "Labor supply of New York City cabdrivers: One day at a time," *The Quarterly Journal of Economics*, 1997, *112* (2), 407–441.

Carey, Colleen Marie, Ethan Lieber, and Sarah Miller, "Drug Firms' Payments and Physicians' Prescribing Behavior in Medicare Part D," *Unpublished Working Paper*, 2015.

Cassel, Christine K. and Eric S. Holmboe, "Professionalism and Accountability: The Role of Specialty Board Certification," *Transactions of the American Clinical and Climatological Association*, 2008, *119.*

Cavounidis, Costas and Kevin Lang, "Ben-Porath Meets Lazear: Lifetime Skill Investment and Occupation Choice with Multiple Skills," *NBER Working Paper Series*, 2017.

Center for Studying Health System Change, "Physician Survey Summary File: User's Guide and Codebook," 1999. Community Tracking Study Physician Survey, 1996–1997 (ICPSR 2597). Available at http://doi.org/10.3886/ICPSR02597.v3.

Centers for Medicare and Medicaid Services, "National Health Expenditures Fact Sheet," https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet.html 2018.

Chandra, Amitabh, David Cutler, and Zirui Song, "Who Ordered That? The Economics of Treatment Choices in Medical Care," in Thomas G. Mcguire Mark V. Pauly and Pedro P. Barros, eds., *Handbook of Health Economics, Volume 2*, Amsterdam: North-Holland, 2011, chapter 6, pp. 397–432.

Chen, Alice, "Do the poor benefit from more generous Medicaid physician payments," 2014. University of Southern California, mimeo.

_ , Anthony T Lo Sasso, and Michael R Richards, "Supply-side effects from public insurance expansions: Evidence from physician labor markets," *Health economics*, 2018, *27* (4), 690–708.

Clemens, Jeffrey and Joshua D. Gottlieb, "Do Physicians' Financial Incentives Affect Medical Treatment and Patient Health?," *American Economic Review*, April 2014, *104* (4), 1320–1349.

_ and _ , "In the Shadow of a Giant: Medicare's Influence on Private Payment Systems," *Journal of Political Economy*, February 2017, *125* (1), 1–39.

Codespote, Suzanne M., William J. London, and John D. Shatto, "Physician Volume & Intensity Response," Memorandum to Richard S. Foster, Office of the Actuary, Health Care Financing Administration August 13 1998. Available at https://www.cms.gov/ActuarialStudies/downloads/PhysicianResponse.pdf (accessed April 12, 2018).

Congressional Research Service, "Medicare: Payments to Physicians," Technical Report, Congressional Research Service: Education and Public Welfare Division January 28 1998. Available online at http://www.law.umaryland.edu/marshall/crsreports/crsdocuments/98-75_EPW.pdf (accessed April 12, 2018).

Cooper, Richard A., Thomas E. Getzen, Heather J. McKee, and Prakash Laud, "Economic and demographic trends signal an impending physician shortage," *Health Affairs*, January/February 2002, *21* (1), 140–154.

Drolet, Brian C. and Vikram J. Tandon, "Fees for Certification and Finances of Medical Specialty Boards," *JAMA*, 2017, *318* (5), 477–479.

Farber, Henry S., "Is tomorrow another day? The labor supply of New York City cabdrivers," *Journal of Political Economy*, 2005, *113* (1), 46–82.

_ , "Why you can't find a taxi in the rain and other labor supply lessons from cab drivers," *The Quarterly Journal of Economics*, 2015, *130* (4), 1975–2026.

Fehr, Ernst and Lorenz Goette, "Do Workers Work More if Wages Are High? Evidence from a Randomized Field Experiment," *American Economic Review*, 2007, *97* (1), 298–317.

Finkelstein, Amy, "Static and dynamic effects of health policy: Evidence from the vaccine industry," *The Quarterly Journal of Economics*, 2004, *119* (2), 527–564.

_ , "The Aggregate Effects of Health Insurance: Evidence from the Introduction of Medicare," *Quarterly Journal of Economics*, February 2007, *122* (1), 1–37.

Foo, Patricia K., Robin S. Lee, and Kyna Fong, "Hospital and Physician Prices and Treatment Choice in Labor and Delivery," *American Journal of Health Economics*, Summer 2017, *3* (3), 422–453.

Garthwaite, Craig L, "The doctor might see you now: The supply side effects of public health insurance expansions," *American Economic Journal: Economic Policy*, 2012, *4* (3), 190–215.

Gray, Bradley M., Jonathan L. Vandergrift, Mary M. Johnston, James D. Reschovsky, Lorna A. Lynn, Eric S. Holmboe, Jeffrey S. McCullough, and Rebecca S. Lipner, "Association Between Imposition of a Maintenance of Certification Requirement and Ambulatory Care-Sensitive Hospitalizations and Health Care Costs," *JAMA*, 2014, *312*, 2348–2357.

Gruber, Jon, John Kim, and Dina Mayzlina, "Physician Fees and Procedure Intensity: the Case of Cesarean Delivery," *Journal of Health Economics*, August 1999, *18* (4), 473–490.

Gruber, Jonathan and Maria Owings, "Physician Financial Incentives and Cesarean Section Delivery," *RAND Journal of Economics*, Spring 1996, *27* (1), 99–123.

Hadley, Jack and James D. Reschovsky, "Medicare fees and physicians. medicare service volume: Beneficiaries treated and services per beneficiary," *International Journal of Health Care Finance and Economics*, June 2006, *6* (2), 131–150.

Haynes, John, Jeffrey L. Jackson, Gail M. McNutt, Brian J. Hertz, Jeffrey J. Ryan, and Scott A. Pawlikowski, "Association Between Time-Unlimited vs Time-Limited Internal Board Certification and Ambulatory Patient Care Quality," *JAMA*, 2014, *312* (22), 2358–2363.

Heckman, James J., "A life-cycle model of earnings, learning, and consumption," *Journal of Political Economy*, 1976, *84* (4, Part 2), S9–S44.

Jacobson, Mireille, Tom Y. Chang, Joseph P. Newhouse, and Craig C. Earle, "Physician Agency and Competition: Evidence from a Major Change to Medicare Chemotherapy Reimbursement Policy," Working Paper No. 19247, National Bureau of Economic Research July 2013.

Johnson, Erin and Marit Rehavi, "Physicians Treating Physicians: Information and Incentives in Childbirth," *American Economic Journal: Economic Policy*, February 2016, *8* (1), 115–141.

Kuruscu, Burhanettin, "Training and lifetime income," *American Economic Review*, 2006, *96* (3), 832–846.

Liebhaber, Allison and Joy M. Grossman, "Physicians Moving to Mid-Sized, Single-Specialty Practices," Tracking Report 18, Center for Studying Health System Change August 2007. Available online at http://www.hschange.com/CONTENT/941.html (accessed April 12, 2018).

Lipner, Rebecca S., Brian J. Hess, and Robert L. Phillips, "Specialty Board Certification in the United States: Issues and Evidence," *Journal of Continuing Education in the Health Professions*, 2013, *33* (S1), 520–535.

_ , Wayne H. Bylsma, Gerald K. Arnold, Gregory S. Fortna, John Tooker, and Christine K. Cassel, "Who is maintaining certification in internal medicine—and why? A national survey 10 years after initial certification," *Annals of Internal Medicine*, 2006, *144* (1), 29–36.

Lynch, Lisa M., "Private-sector training and the earnings of young workers," *American Economic Review*, 1992, *82* (1), 299–312.

McGuire, Thomas G., "Physician Agency," in Anthony J. Culyer and Joseph P. Newhouse, eds., *Handbook of Health Economics, Volume 1A*, Amsterdam: North-Holland, 2000, chapter 9, pp. 461–535.

_ and Mark V. Pauly, "Physician response to fee changes with multiple payers," *Journal of Health Economics*, 1991, *10* (4), 385–410.

Mincer, Jacob, "Progress in Human Capital Analysis of the Distribution of Earnings," Working Paper No. 53, National Bureau of Economic Research August 1974.

_ , *Schooling, Experience, and Earnings*, New York: Columbia University Press for National Bureau of Economic Research, 1974.

Muhlestein, David B. and Nathan J. Smith, "Physician Consolidation: Rapid Movement From Small To Large Group Practices, 2013–15," *Health Affairs*, September 2016, *35* (9), 1638–1642.

Oettinger, Gerald S., "An Empirical Analysis of the Daily Labor Supply of Stadium Vendors," *Journal of Political Economy*, 1999, *107* (2), 360–392.

Oster, Sharon M. and Daniel S. Hamermesh, "Aging and productivity among economists," *Review of Economics and Statistics*, 1998, *80* (1), 154–156.

Petterson, Stephen M., Winston R. Liaw, Robert L. Phillips, David L. Rabin, David S. Meyers, and Andrew W. Bazemore, "Projecting US primary care physician workforce needs: 2010-2025," *The Annals of Family Medicine*, 2012, *10* (6), 503–509.

Rice, Thomas H., "The Impact of Changing Medicare Reimbursement Rates on Physician-Induced Demand," *Medical Care*, August 1983, *21* (8), 803–815.

_ , "Physician-Induced Demand for Medical Care: New Evidence from the Medicare Program," *Advances in Health Economics and Health Services Research*, 1984, *5*, 129–160.

_ **and Roberta J. Labelle**, "Do Physicians Induce Demand for Medical Services?," *Journal of Health Politics, Policy and Law*, Fall 1989, *14* (3), 587–601.

Robinson, James C., "Consolidation of Medical Groups Into Physician Practice Management Organizations," *JAMA*, 1998, *279* (2), 144–149.

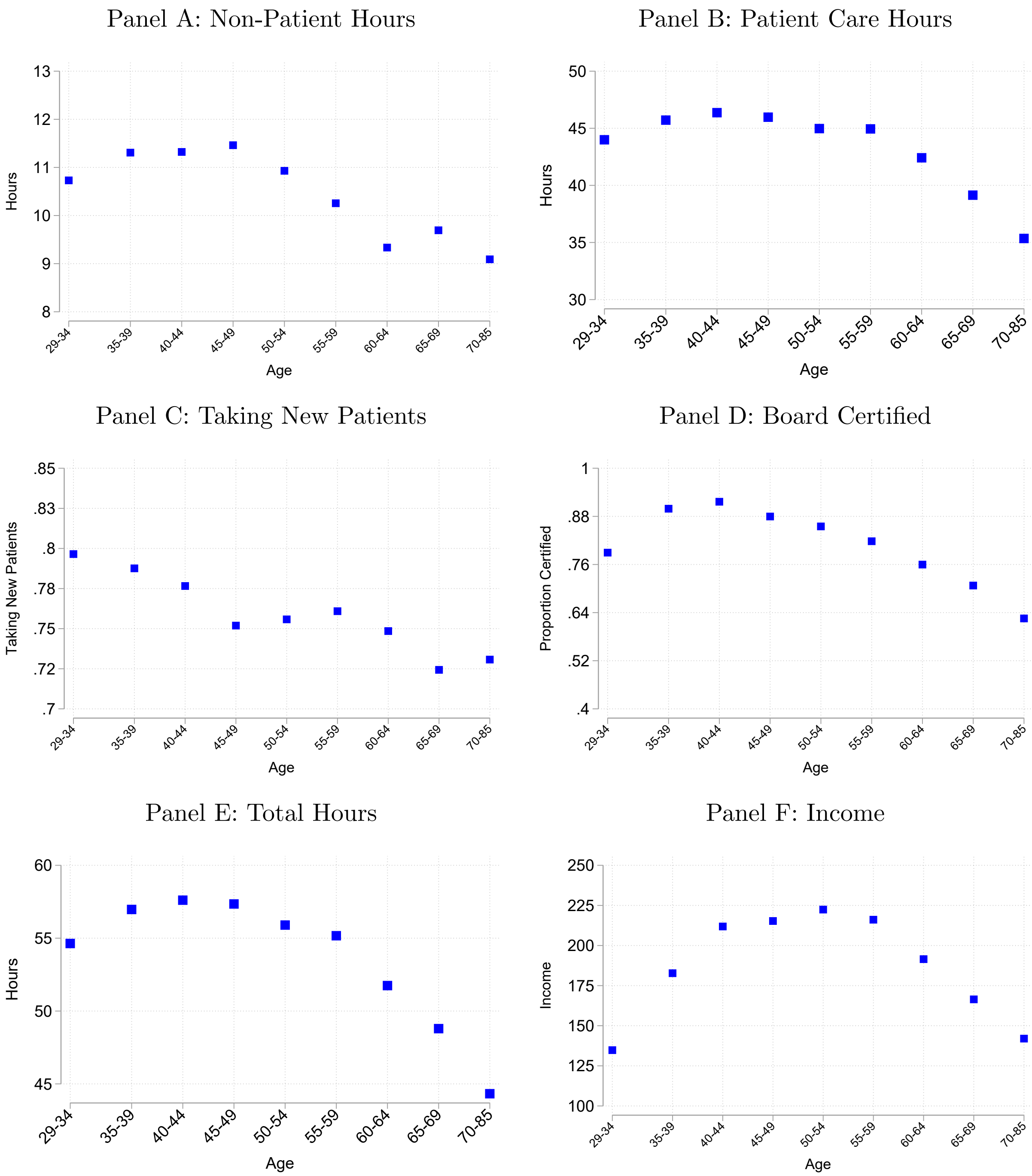
Silver, Michelle Pannor, Angela D. Hamilton, Aviroop Biswas, and Natalie Irene Warrick, "A systematic review of physician retirement planning," *Human Resources for Health*, 2016, *67* (14).

Staiger, Douglas O., David I. Auerbach, and Peter I. Buerhaus, "Comparison of Physician Workforce Estimates and Supply Projections," *JAMA*, October 21 2009, *302* (15), 1674–1680.

Welch, W. Pete, Alison Evans Cuellar, Sally C. Stearns, and Andrew B. Bindman, "Proportion Of Physicians In Large Group Practices Continued To Grow In 2009–11," *Health Affairs*, September 2013, *32* (9), 1659–1666.

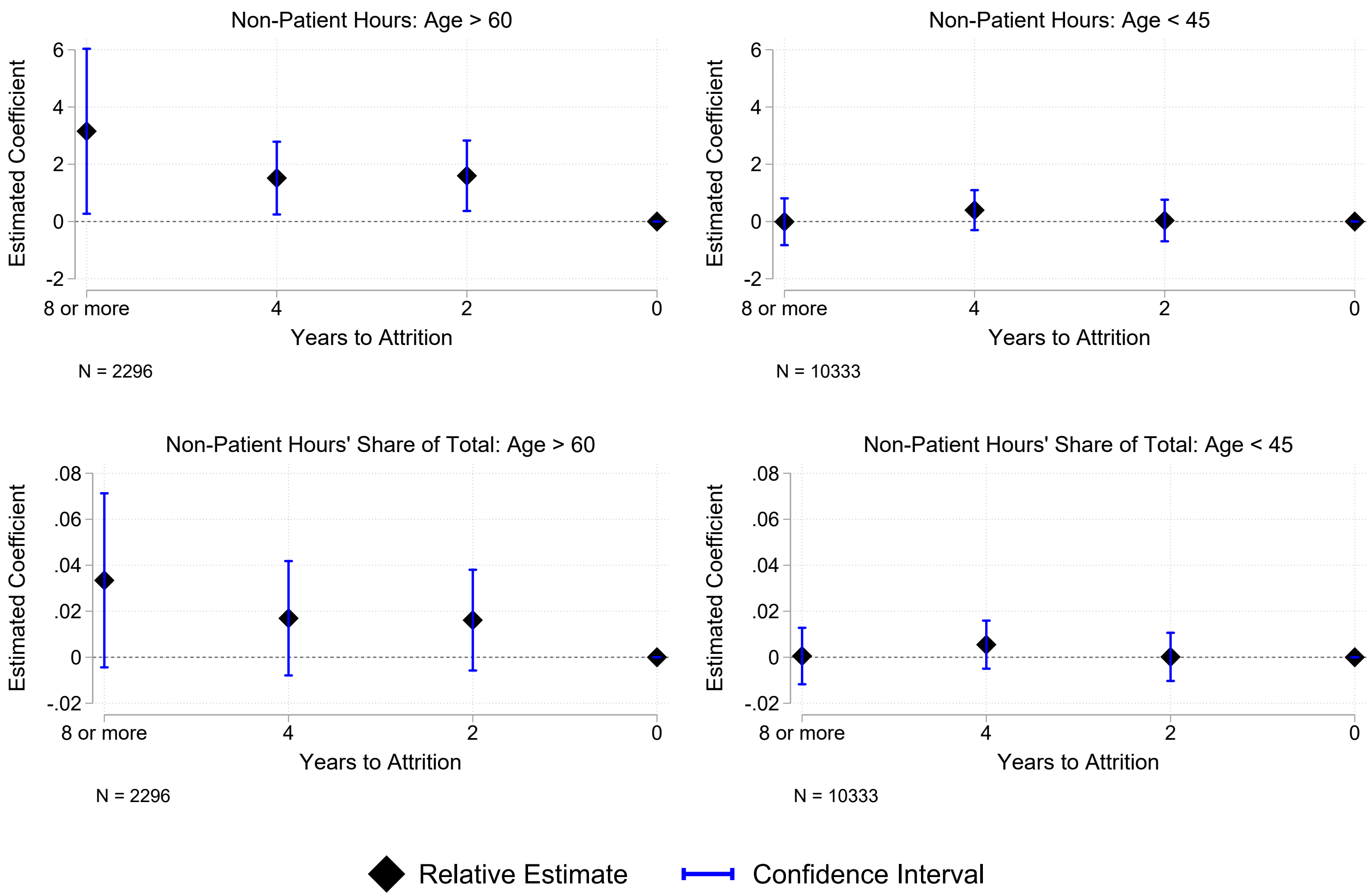
Yip, Winnie C., "Physician response to Medicare fee reductions: changes in the volume of coronary artery bypass graft (CABG) surgeries in the Medicare and private sectors," *Journal of Health Economics*, 1998, *17* (6), 675–699.

Figure 1: Age Profile of Investment Activities and Labor Supply



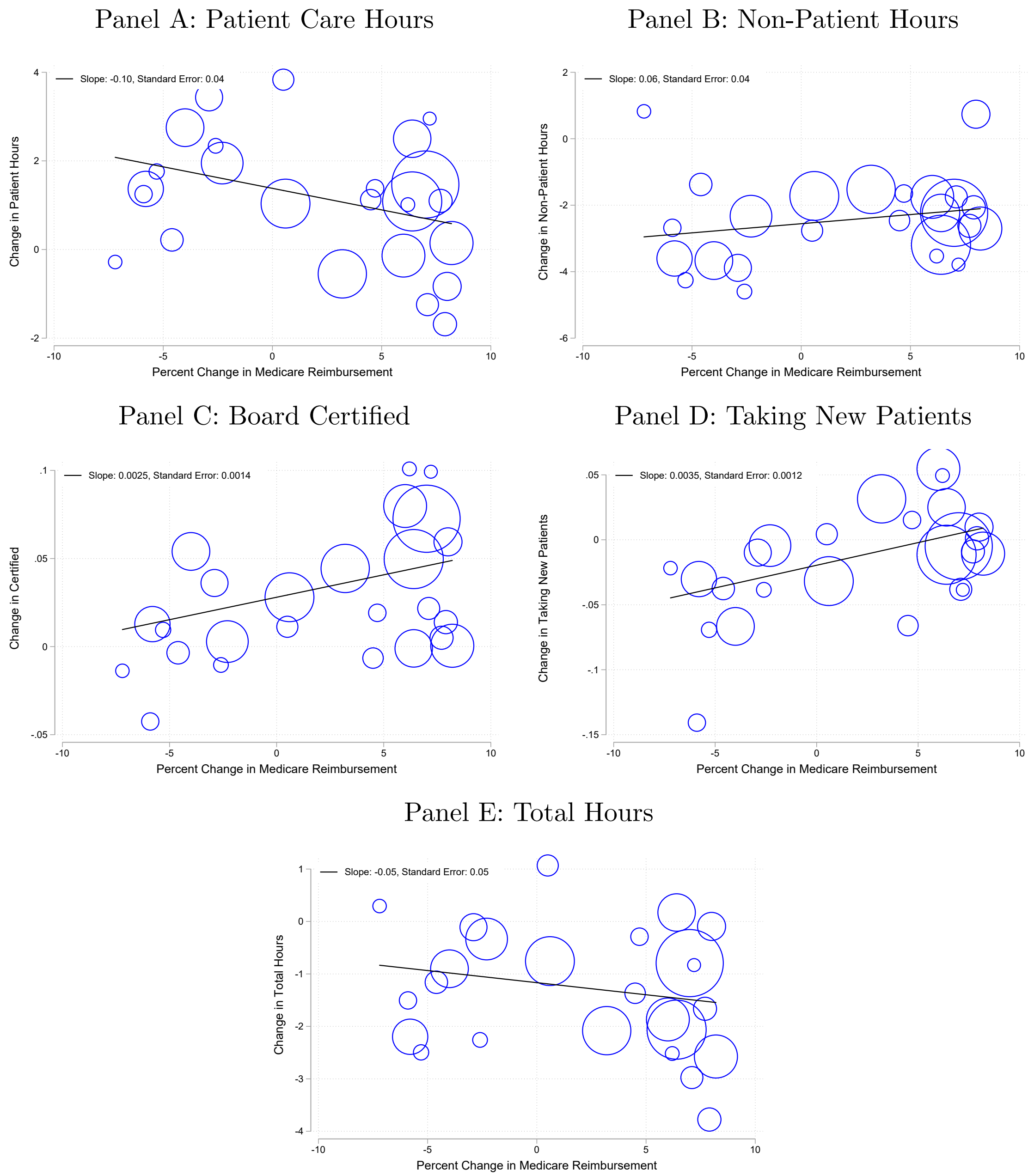
Note: This figure plots the age profile of investment activities and labor supply. Physicians are binned into five-year age bins, and the upper tail groups together those aged 70 to 85. For each variable, the mean values within each bin are plotted. Only data from the 1996-97 wave is used. Source: Authors' calculations based on data from the Community Tracking Study, 1996/97 wave only (Center for Studying Health System Change, 1999).

Figure 2: Non-Patient Hours Before Retirement



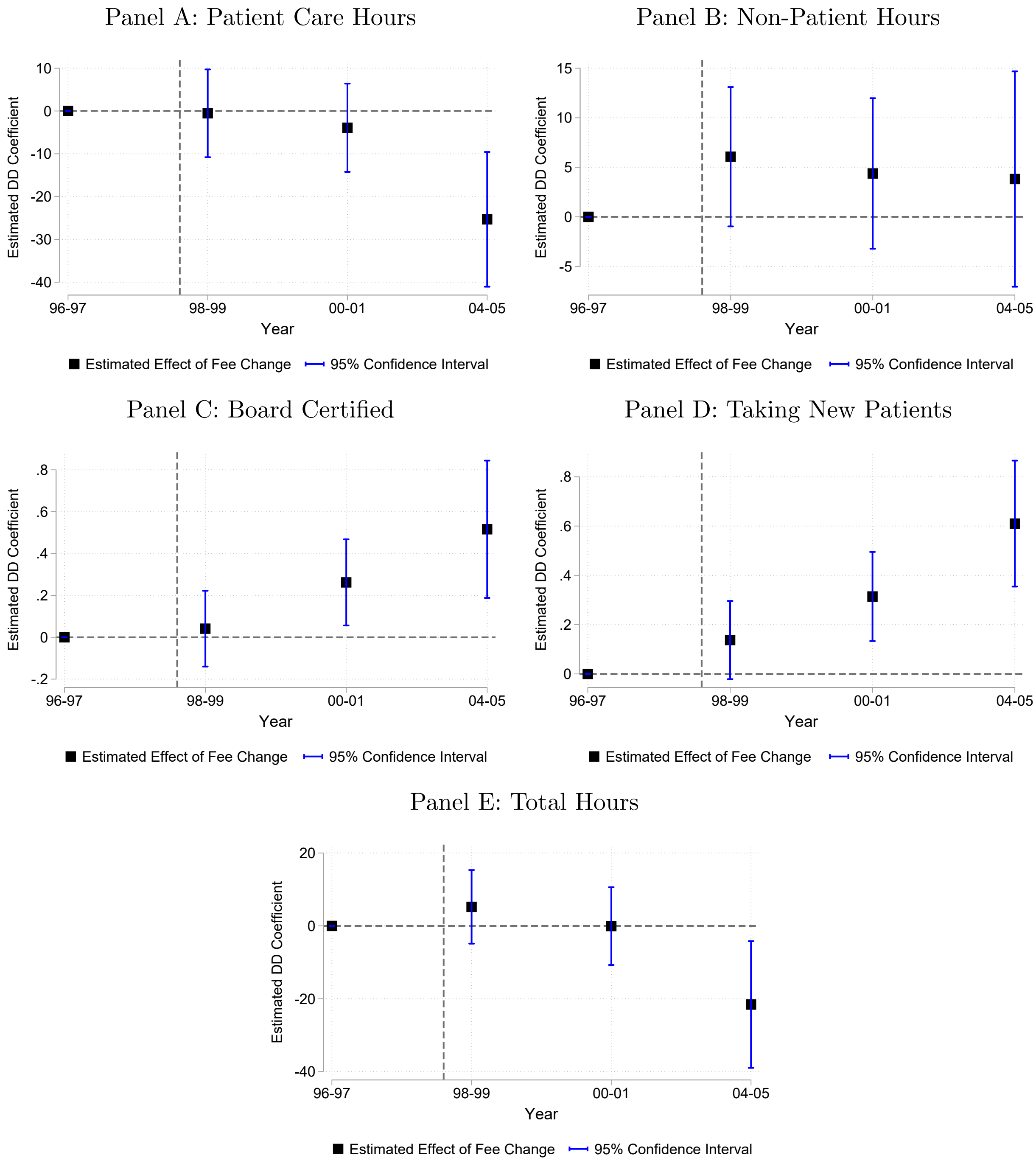
Note: The estimated coefficients from equation (1) are shown above for non-patient hours in levels and as a share of total hours. The base group is physicians who are in their final observed period. So coefficients $\hat{\alpha}_2$, $\hat{\alpha}_4$, and $\hat{\alpha}_8$ estimate the differences in the outcome variable for physicians 2, 4, or $\geq$8 years *prior* to attrition, relative to those making their final appearance in the sample. For physicians age 60 or older, weekly non-patient hours decline as they approach their final year in the Community Tracking Study panel. For young physicians, the number of years until attrition from the panel does not predict non-patient hours. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Figure 3: Change in Investments and Labor Supply by Specialty



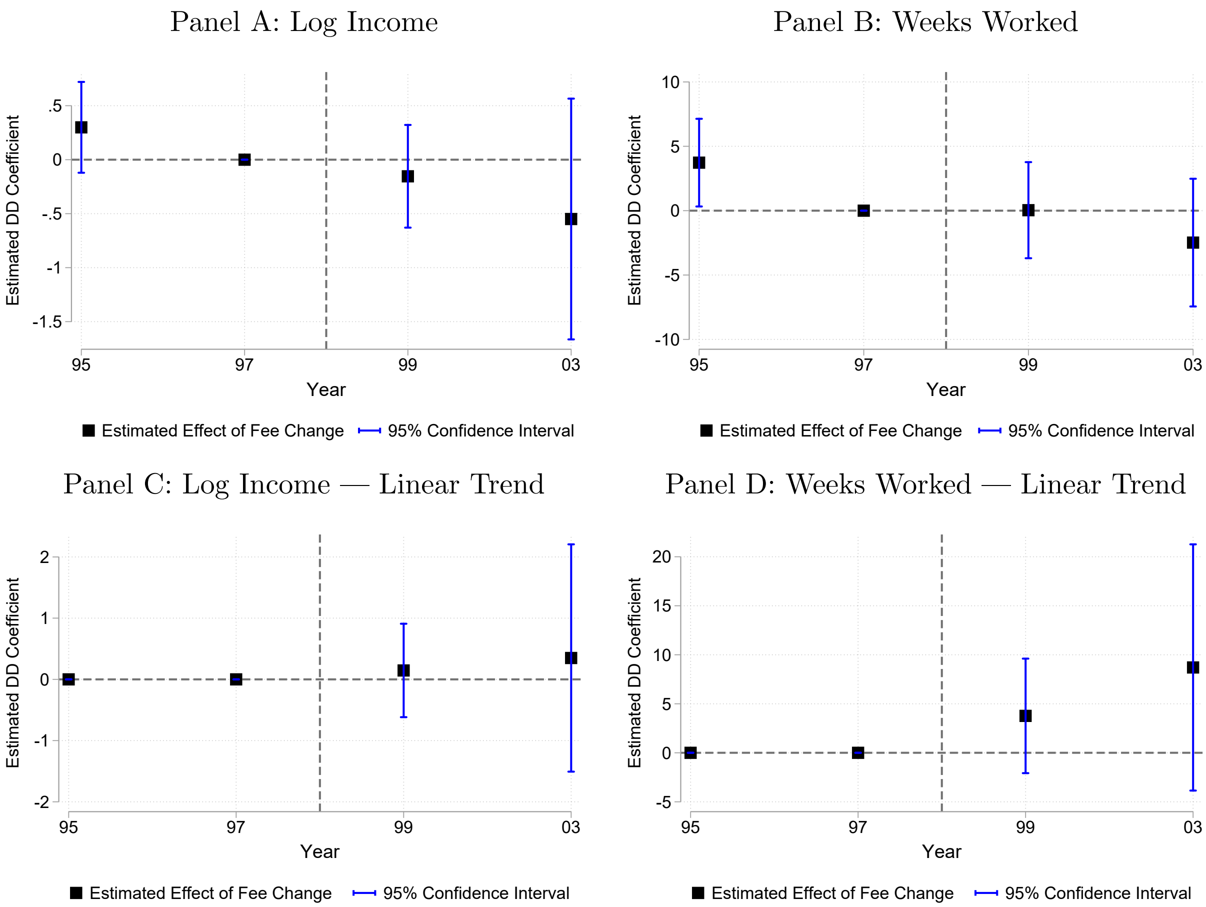
Note: This figure plots the raw data and estimates of equation (4). We aggregate the three post-policy waves into one post-implementation time period, and aggregate the outcome variables to specialty-level averages for the pre-implementation and post-implementation periods, respectively. We then plot the pre-post change in these averages against the estimated Medicare payment change from Congressional Research Service (1998). The circle size is proportional to the sum of sample weights for that specialty in the Community Tracking Study data. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Figure 4: Dynamic Responses to Medicare Fee Change



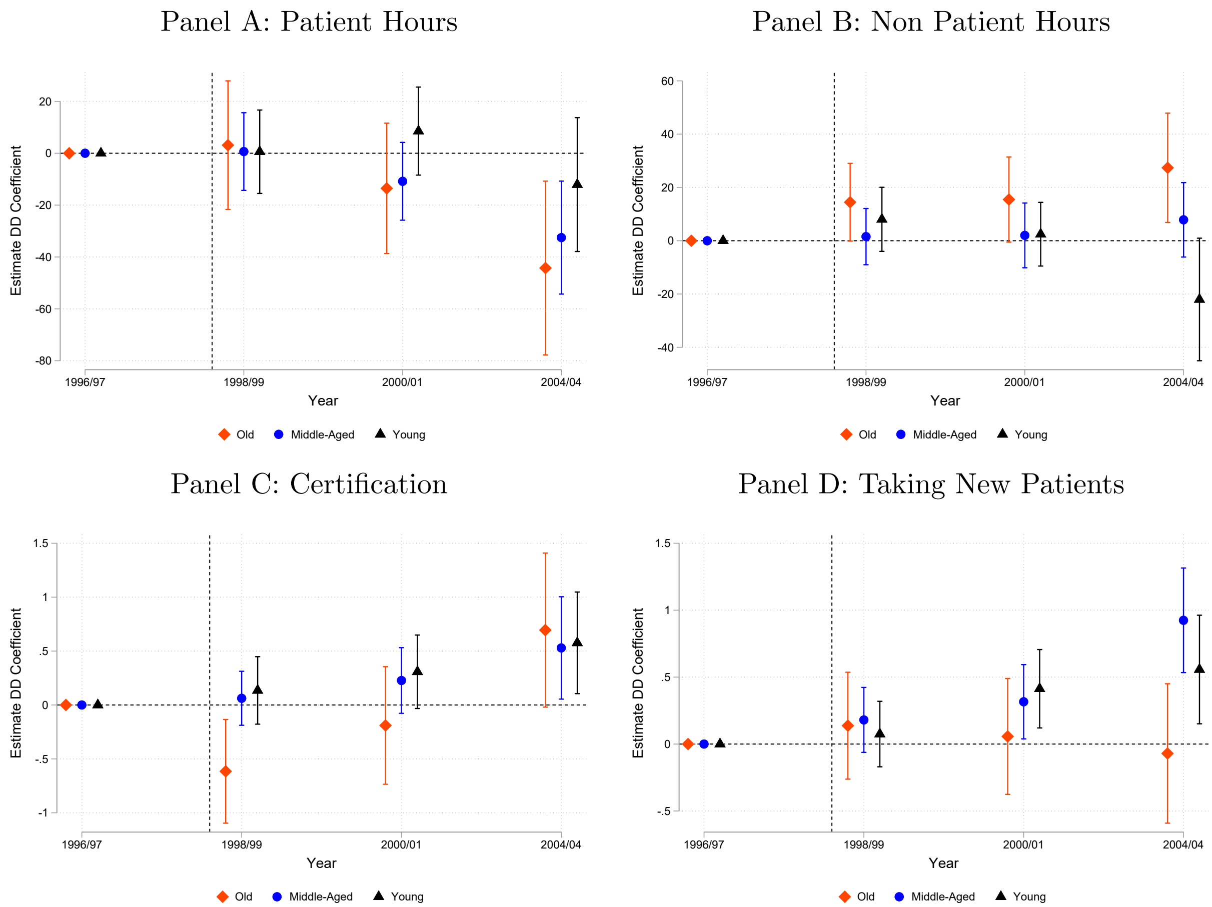
Note: This figure plots the estimates of $\hat{\beta}_{98-99}$, $\hat{\beta}_{00-01}$, and $\hat{\beta}_{04-05}$ from equation (2). The coefficients represent the change in the outcome variable associated with a 1 percentage point increase in the Medicare reimbursement rate for each wave after the change. Standard errors are clustered at the individual (panel unit) level and 95 percent confidence intervals are shown in blue. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Figure 5: Income and Weeks Worked Responses to Medicare Fee Change



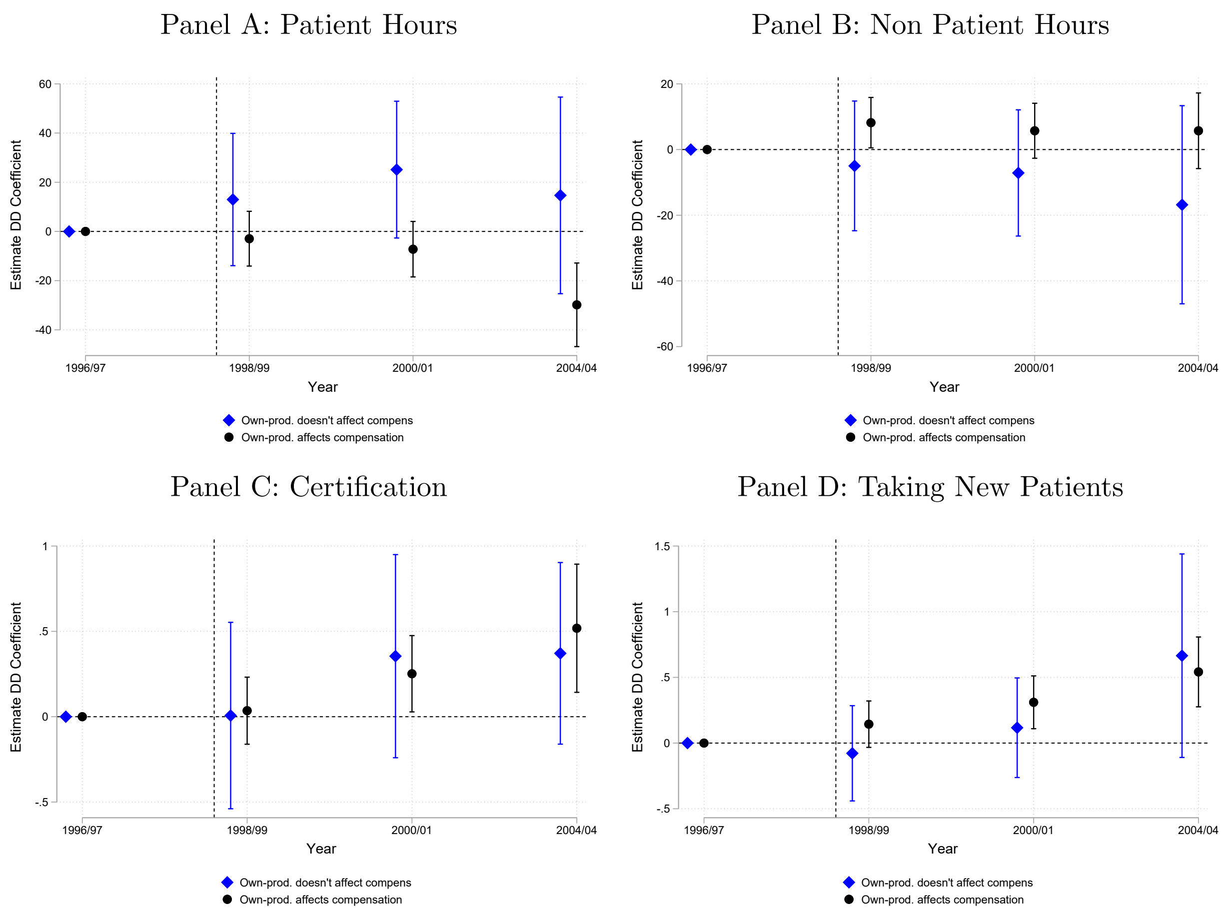
Note: Income and weeks worked are reported for the years 1995, 1997, 1999, 2003, allowing only a narrow look at potential differing pre-trends. Panels A and B plot the dynamic estimates from equation (2), except the coefficients of interest are $\hat{\beta}_{95}$, $\hat{\beta}_{99}$, and $\hat{\beta}_{03}$. The coefficients represent the change in the outcome variable associated with a 1 percentage point increase in the Medicare reimbursement rate for each year relative to 1997. Panels C and D control for the interaction of a linear time trend and estimated payment change from Congressional Research Service (1998). Standard errors are clustered at the individual (panel unit) level and 95 percent confidence intervals are shown in blue. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Figure 6: Dynamic Responses by Age Group



Note: These figures plot the estimates of $\hat{\beta}_{98-99}$, $\hat{\beta}_{00-01}$, and $\hat{\beta}_{04-05}$ from equation (2) separately for each age group: young, middle-aged, and old physicians. The coefficients represent the change in the outcome variable associated with a 1 percentage point increase in the Medicare reimbursement rate for each wave after the change. Standard errors are clustered at the individual (panel unit) level and 95 percent confidence intervals are shown in blue. Source: Authors' calculations based on data from the Community Tracking Study

Figure 7: Dynamic Responses by Compensation Type



Note: These figures plot the estimates of $\hat{\beta}_{98-99}$, $\hat{\beta}_{00-01}$, and $\hat{\beta}_{04-05}$ from equation (2) separately for those physicians that report a contemporaneous link between their own-productivity and their current compensation, and those physicians that report no link. The coefficients represent the change in the outcome variable associated with a 1 percentage point increase in the Medicare reimbursement rate for each wave after the change. Standard errors are clustered at the individual (panel unit) level and 95 percent confidence intervals are shown in blue. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Table 1: Predicted Medicare Fee Changes by Specialty

Specialty	Estimated Medicare Payment Change (%)
Radiation Oncology	8.4
Chiropractic	8.4
Suppliers	8.2
Radiology	8.2
Psychiatry	8.2
Pathology	8.1
Hematology/Oncology	8.0
Neurology	7.9
Pulmonary	7.7
Rheumatology	7.2
Gastroenterology	7.1
Internal Medicine	7.0
Family Practice	6.4
Cardiology	6.4
Other physician	6.2
General Practice	6.0
Optometry	5.8
Nephrology	4.7
Nonphysicians Practioners	4.5
Clinics	4.4
Emergency medicine	3.2
Anesthesiology	2.1
Obstetrics/Gynecology	0.6
Otolarynology	0.5
General Surgery	-2.3
Vascular surgery	-2.6
Urology	-2.9
Orthopedic Surgery	-4.0
Podiatry	-4.4
Dermatology	-4.6
Plastic Surgery	-5.3
Opthamology	-5.8
Neurosurgery	-5.9
Thoracic Surgery	-7.2
Cardiac Surgery	-8.8

This table shows the predicted change in payments by specialty based on the Conversation Factor and RVU changes that took effect in 1998. Since most specialties perform a mix of surgical and non-surgical procedures, the effect of the conversion factor change on total incomes differs according to the share of surgical vs. non-surgical procures a specialty performs on average. These estimates are from Congressional Research Service (1998), and explicitly ignore potential behavioral responses.

Table 2: Changes in Hours and Investments

	Patient Hours				Non-Patient Hours			
	All Ages	Old	Middle-Age	Young	All Ages	Old	Middle-Age	Young
Price Change × Post	-11.39*	-21.63*	-14.91*	-1.03	5.89+	20.45**	5.51	-1.64
	(4.55)	(10.49)	(6.73)	(7.41)	(3.30)	(6.86)	(4.92)	(5.74)
N	43,669	6,608	19,279	17,782	43,669	6,608	19,279	17,782
Mean of Dep. Var. (1996/97)	43.94	39.83	44.95	44.56	10.62	8.93	10.83	11.08
Implied Elasticity	-0.259	-0.543	-0.332	-0.023	0.555	2.291	0.508	-0.148

	Certified				Taking New Patients			
	All Ages	Old	Middle-Age	Young	All Ages	Old	Middle-Age	Young
Price Change × Post	0.29**	0.14	0.32*	0.29*	0.36**	0.04	0.47**	0.33**
	(0.09)	(0.24)	(0.14)	(0.14)	(0.07)	(0.18)	(0.11)	(0.11)
N	43,662	6,607	19,277	17,778	43,669	6,608	19,279	17,782
Mean of Dep. Var. (1996/97)	0.83	0.65	0.84	0.89	0.74	0.72	0.73	0.76
Implied Elasticity	0.354	0.217	0.379	0.324	0.483	0.055	0.643	0.432

Note: Estimates from equation (3) are shown for Patient Care Hours, Non-Patient Hours, Board Certification, and Willingness to Take New Patients. The coefficients displayed are from the interaction between a Post-1997 indicator and the predicted percentage change in Medicare payments by specialty, scaled to be between zero and one. The coefficients thus represent the change in the outcome variable associated with a 100 percent increase in the Medicare reimbursement rate. The implied elasticities are obtained by dividing the coefficient by the mean of the outcome variable in the 1996/97 wave. Age-specific estimates are obtained by estimating equation (3) on each age subgroup. Standard errors are clustered at the individual level. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^{+}$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Table 3: Changes in Labor Supply and Income

	Total Hours			
	All Ages	Old	Middle-Age	Young
Price Change × Post	-5.79	-1.31	-9.84	-2.86
	(4.63)	(10.92)	(6.61)	(8.08)
N	43,669	6,608	19,279	17,782
Mean of Dep. Var. (1996/97)	54.50	48.71	55.73	55.56
Implied Elasticity	-0.106	-0.027	-0.177	-0.051

	Log Income			
	All Ages	Old	Middle-Age	Young
Price Change × Post	-0.50	-1.11+	-0.21	-0.81
	(0.30)	(0.58)	(0.40)	(0.64)
N	43,472	6,566	19,216	17,690
Mean of Dep. Var. (1996)	5.06	4.93	5.17	5.01
Implied Elasticity	-0.498	-1.111	-0.209	-0.806

	Weeks Worked			
	All Ages	Old	Middle-Age	Young
Price Change × Post	-3.22*	1.40	-5.01*	-3.44
	(1.59)	(3.09)	(2.03)	(3.45)
N	43,578	6,594	19,241	17,743
Mean of Dep. Var. (1996)	47.22	47.50	47.65	46.69
Implied Elasticity	-0.068	0.029	-0.105	-0.074

Note: Estimates from the baseline pooled difference-in-difference are shown for total hours and log income. The coefficients displayed are from the interaction between a Post-1997 indicator and the predicted percentage change in Medicare payments by specialty. Income and weeks worked are reported for the years 1995, 1997, 1999, 2003, so the Post-1997 indicator captures two survey waves. For total hours, the Post-1997 indicator captures three survey waves. The predicted change is scaled between zero and one. The coefficients represent the change in the outcome variable associated with a 100 percent increase in the Medicare rate. The implied elasticities are obtained by dividing the coefficient by the mean of the outcome variable in the 1996/97 wave. Age-specific estimates are obtained from a fully saturated model, allowing all coefficients to vary by age group. Standard errors are clustered at the individual level. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^{+}$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Table 4: Changes in Hours and Investments According to Whether Own-Productivity Affects Compensation

	Patient Hours			Non-Patient Hours		
	All	Own-Prod. does not affect pay	Own-Prod. affects pay	All	Own-Prod. dpes not affect pay	Own-Prod. affects pay
Price Change × Post	-11.39*	19.14	-14.89**	5.89+	-8.31	7.39*
	(4.55)	(11.84)	(4.85)	(3.30)	(8.65)	(3.58)
N	43,669	9,176	34,493	43,669	9,176	34,493
Mean of Dep. Var. (1996/97)	43.94	42.02	44.43	10.62	9.87	10.81
Implied Elasticity	-0.259	0.456	-0.335	0.555	-0.842	0.684

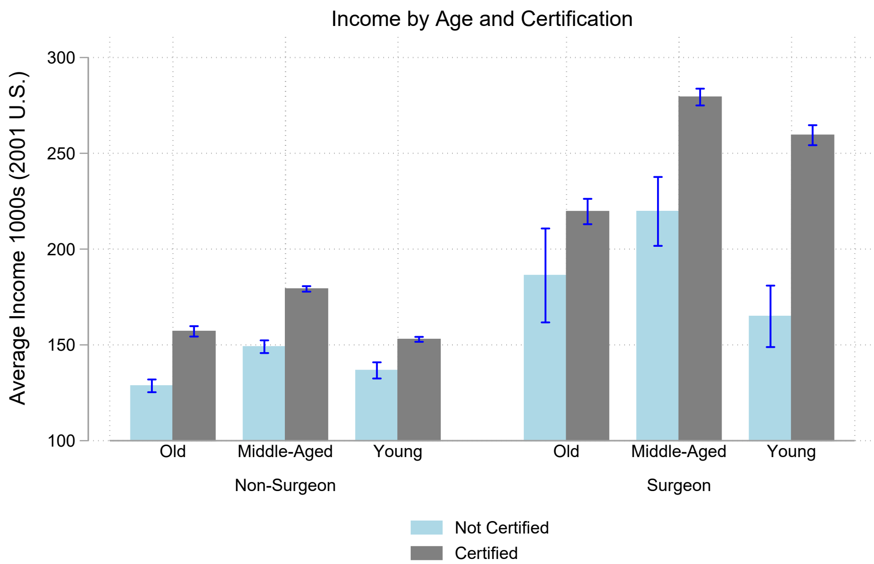
	Certification			Taking New Patients		
	All	Own-Prod. does not affect pay	Own-Prod. affects pay	All	Own-Prod. dpes not affect pay	Own-Prod. affects pay
Price Change × Post	0.29**	0.13	0.31**	0.36**	0.20	0.33**
	(0.09)	(0.24)	(0.10)	(0.07)	(0.18)	(0.08)
N	43,662	9,175	34,487	43,669	9,176	34,493
Mean of Dep. Var. (1996/97)	0.83	0.84	0.83	0.74	0.79	0.73
Implied Elasticity	0.354	0.152	0.370	0.483	0.250	0.448

Note: This table shows estimates of equation (3) are for Patient Care Hours, Non-Patient Hours, Board Certification, and Willingness to Take New Patients. The coefficients displayed are from the interaction between a Post-1997 indicator and the predicted percentage change in Medicare payments by specialty, scaled to be between zero and one. The coefficients thus represent the change in the outcome variable associated with a 100 percent increase in the Medicare reimbursement rate. The implied elasticities are obtained by dividing the coefficient by the mean of the outcome variable in the 1996/97 wave. We report subgroup estimates for those physicians whose own-productivity affects current compensation, and for those physicians for whom it does not, obtained by estimating equation (3) on each subgroup. Standard errors are clustered at the individual level. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^{+}$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix for Online Publication Only

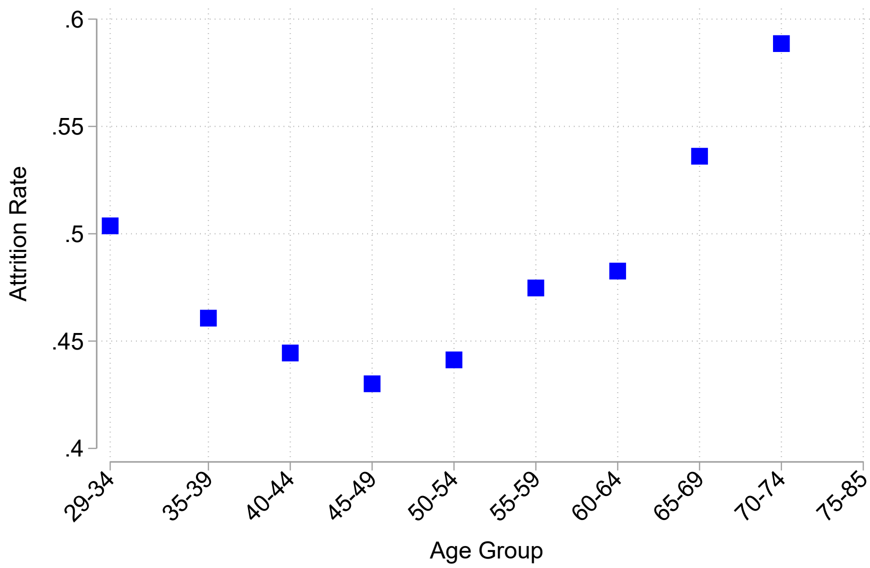
A Supplementary Results and Robustness

Appendix Figure A.1: **Cross-Sectional Relationship between Certification Status and Income**



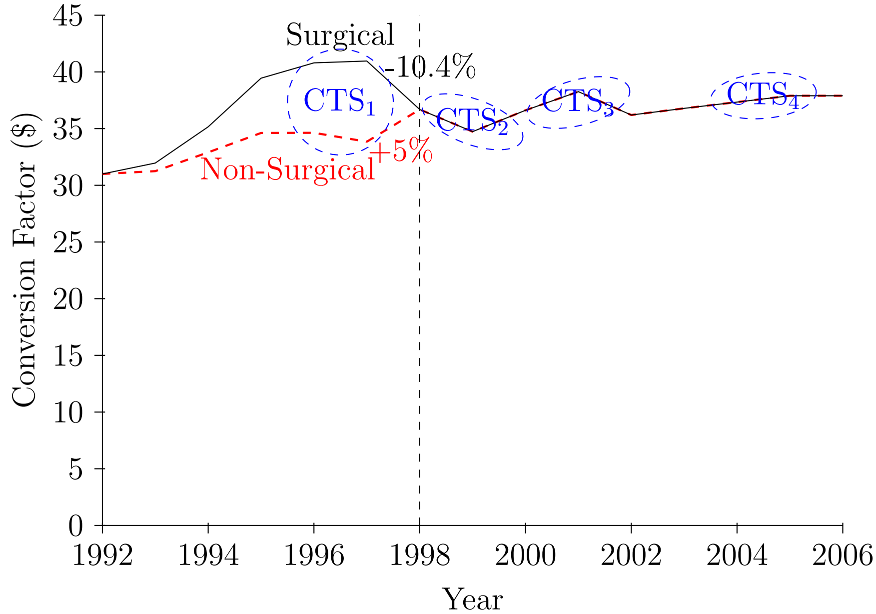
Note: This figure presents data on the incomes of physicians with and without board certification across age groups and specialties. At all age groups, and for both surgical and non-surgical specialties, certification is correlated with higher incomes. 95 % confidence intervals of the means are shown. Source: Authors' calculations based on data from the Community Tracking Study, 1996/97 wave only (Center for Studying Health System Change, 1999).

Appendix Figure A.2: Attrition Rates by Age



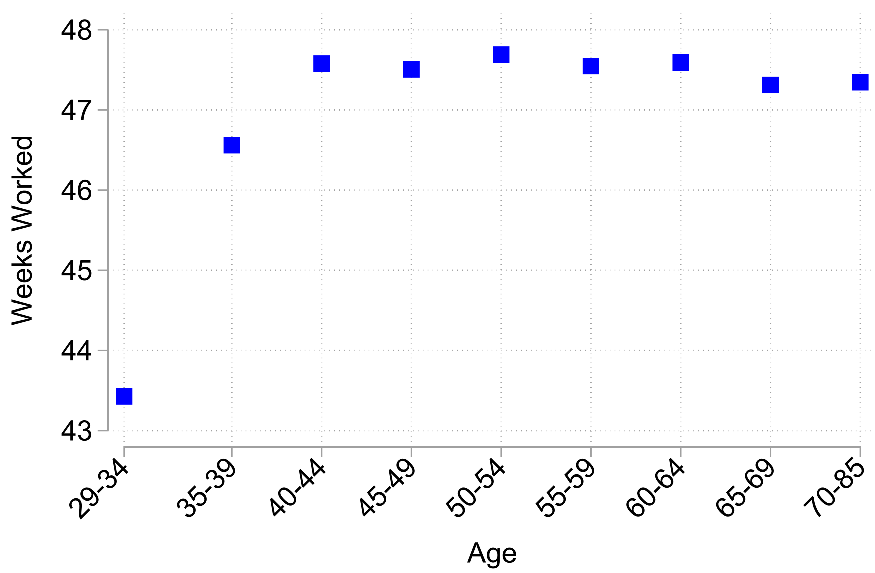
Note: This figure plots raw sample attrition rates by age group. Doctors aged 40–55 have a hazard rate of between 0.4 and 0.45, with this rate steadily rising to 0.65 by ages 75–85. This is suggestive of retirement driving increases in sample attrition for older physicians. Assuming that attrition among doctors aged 45–49 is unrelated to retirement, and that retirement is the sole reason for increased attrition among older physicians, then we can infer that 19% of attrition among doctors aged 65–69, and 25 percent among physicians aged 70–74, is caused by retirement. To see this, note that the 10 percentage point differential between ages 45–49 and 65–69 is 19% of total attrition for the 65–69 age group. Similarly, the 15 percentage point differential between ages 45–49 and 70–74 is 25% of attrition among the 70–74 group. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Figure A.3: Evolution of Medicare Conversion Factors



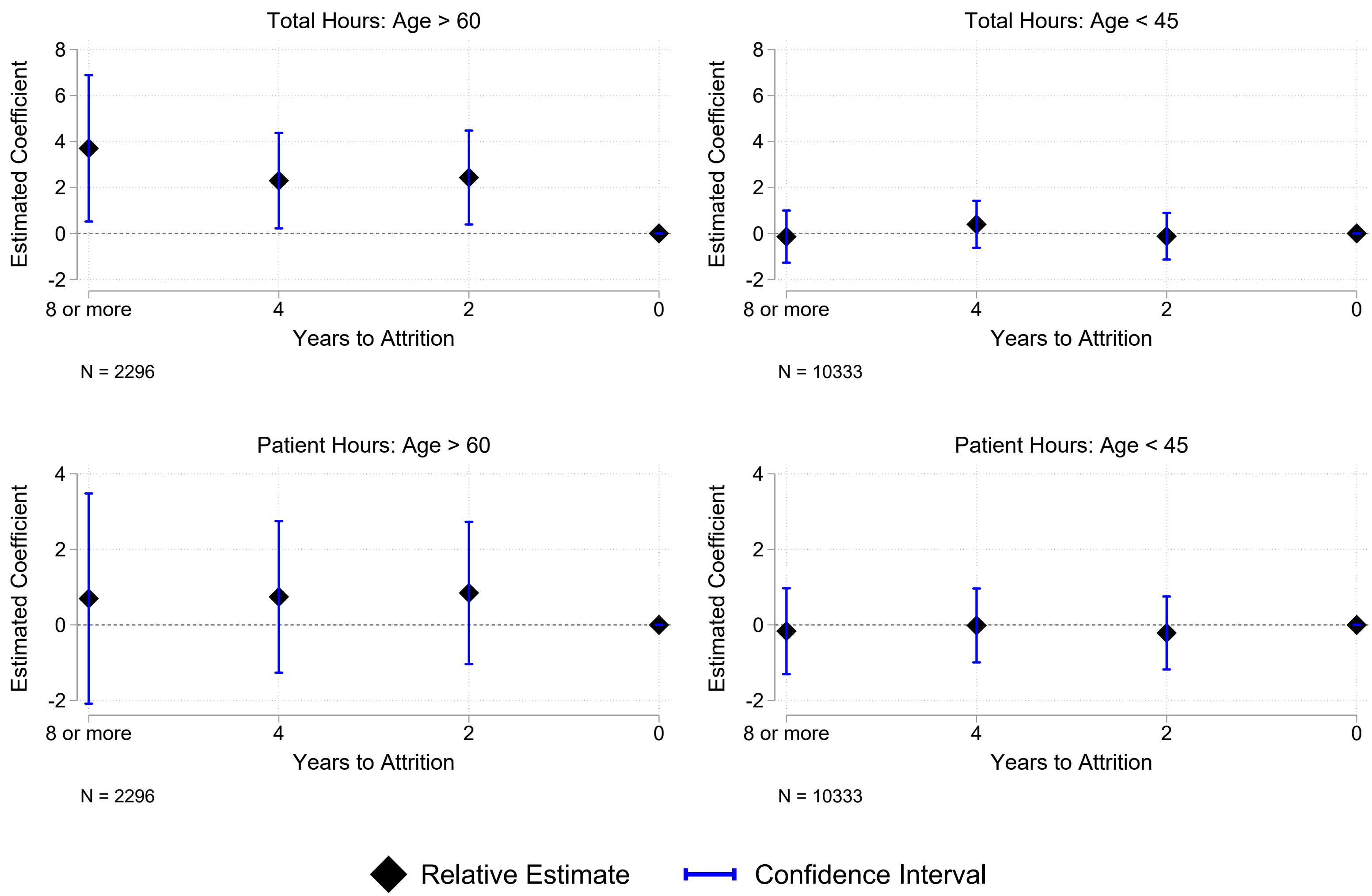
Note: This figure is adapted from Clemens and Gottlieb (2017). It plots the evolution of the Conversion Factors for surgical and non-surgical procedures in the Medicare payment schedule. The dotted circles show the survey waves of the Community Tracking Study. Original source: *Federal Register*, various issues

Appendix Figure A.4: Weeks Worked by Age



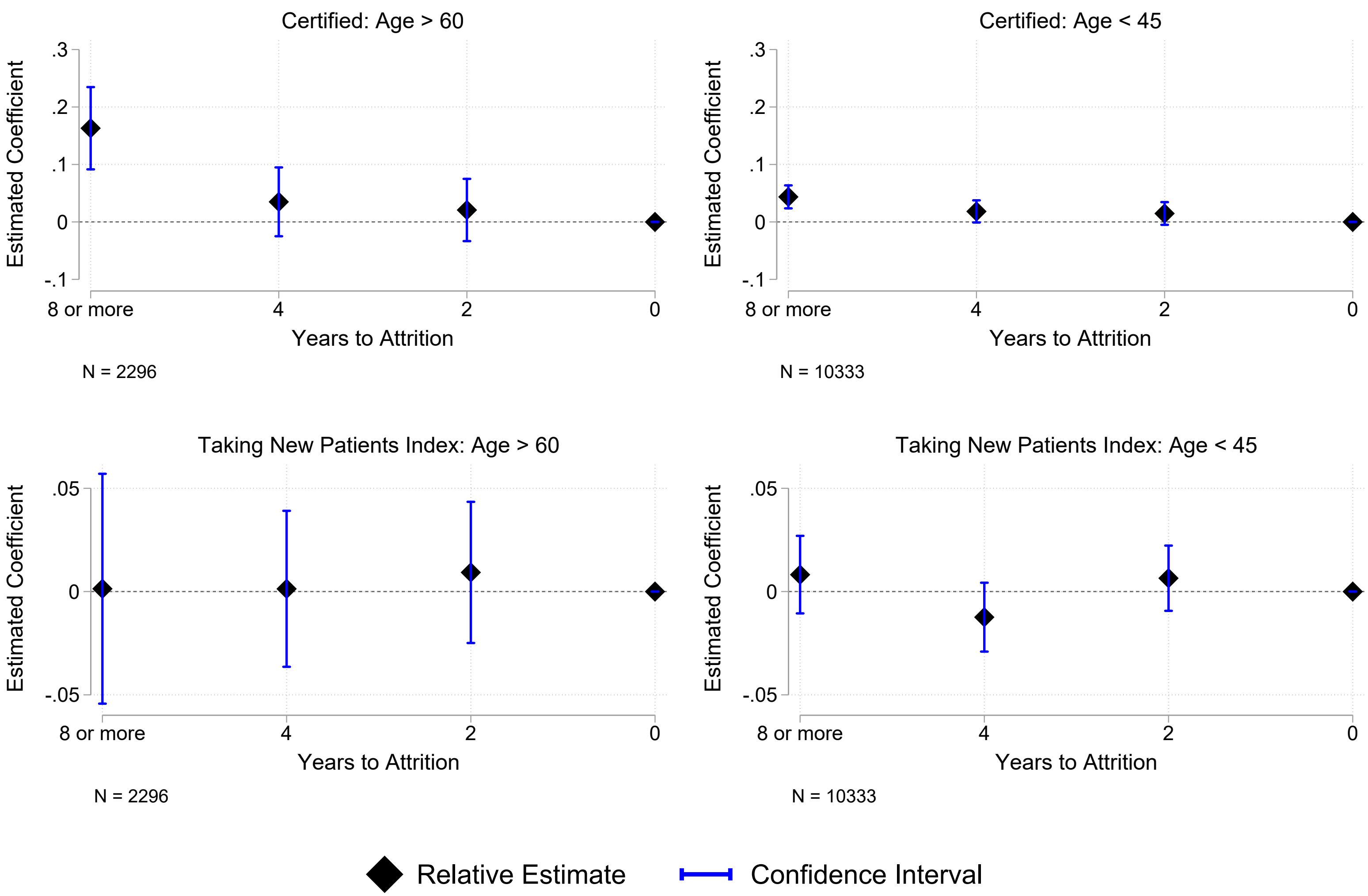
Note:

Appendix Figure A.5: Labor Supply Before Retirement



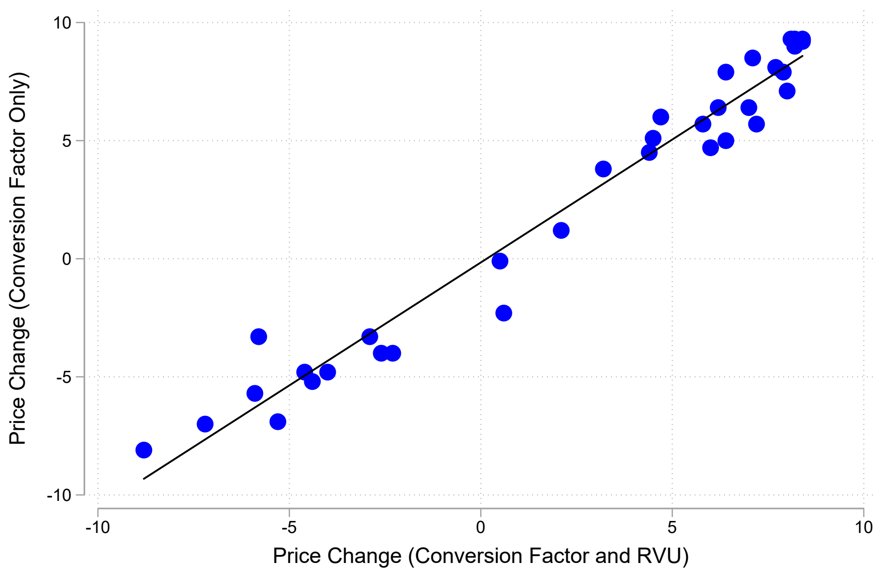
Note: The estimated coefficients from equation (1) are shown above for total hours and patient care hours as the outcome variables. Each dot represents the difference in the outcome variable relative to the base group that attrits immediately. For physicians age 60 or older, non-patient hours decline as they approach their final year in the Community Tracking Study panel. For young physicians, the number of years until attrition from the panel does not predict non-patient hours. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Figure A.6: Other Investments Before Retirement



Note: The estimated coefficients from equation (1) are shown above for board certification and taking new patients as the outcome variables. Each dot represents the difference in the outcome variable relative to the base group that attrits immediately. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

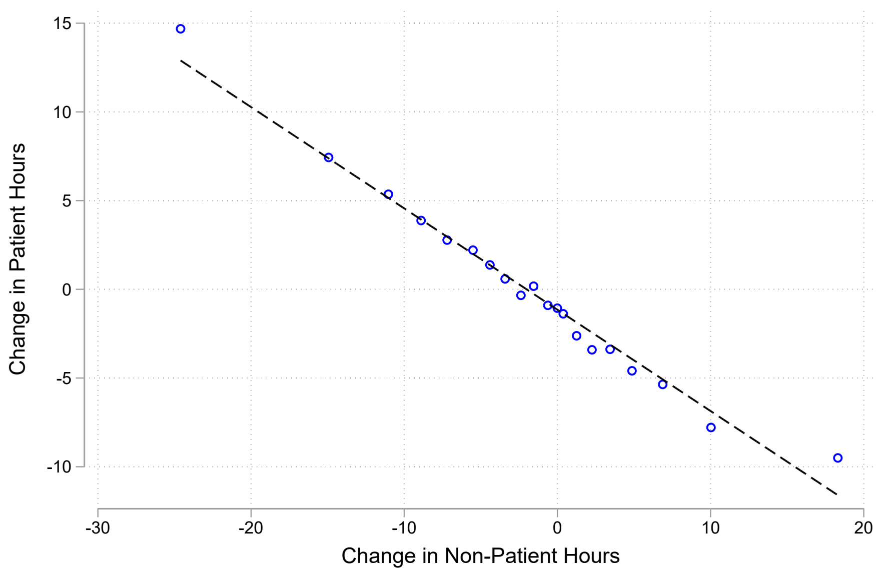
Appendix Figure A.7: **Medicare Fee Change from Conversion Factor and RVU Changes**



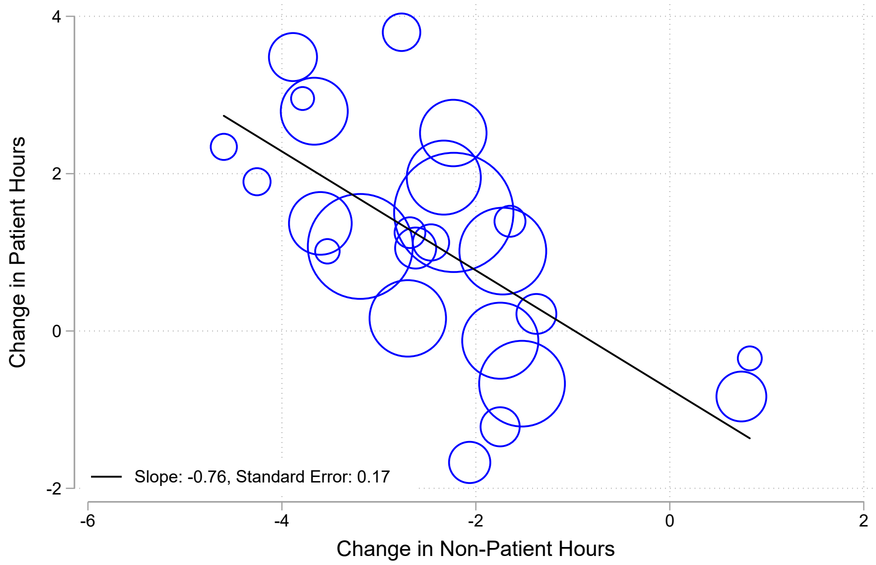
Note: This figure plots the relationship between two measures of the predicted change in Medicare payments by specialty, both from Congressional Research Service (1998). The vertical axis shows predicted payment changes attributable to the Conversion Factor change, and the horizontal axis shows the predicted change from the combination of the Conversion Factor change and changes in procedure weights (Relative Value Units). We use the latter (the combined change) for the main results in this paper, but all results are robust to using changes based solely on the Conversion Factor. Source: Congressional Research Service (1998, Table 2).

Appendix Figure A.8: Changes in Patient Care and Non-Patient Hours

Panel A: Individual Physician Changes



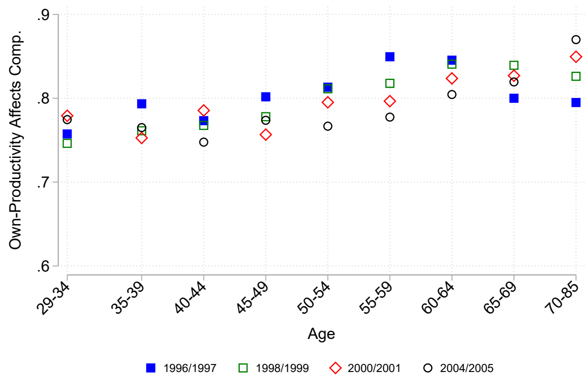
Panel B: Specialty Aggregates



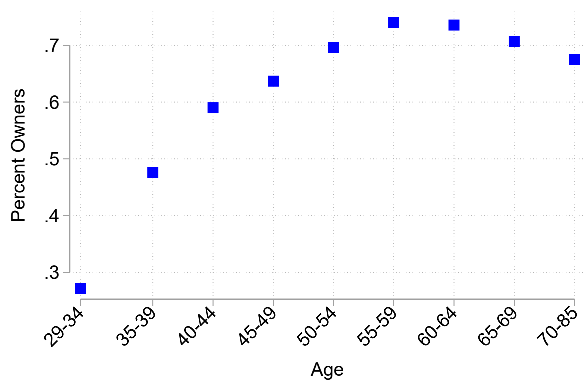
Note: In order to investigate whether physicians are trading off patient care against non-patient hours, Panel A plots the change in patient hours against that in non-patient hours by physician. We restrict the sample to physicians observed in both the 1996/97 wave at least one subsequent wave. For these physicians, we calculate the changes in patient hours and in non-patient hours between the 1996/97 response and the average of all responses in subsequent waves. We display a binned scatterplot of this relationship, by forming 20 equally sized bins grouped based on the change in non-patient hours. Panel B shows the same exercise, but where changes are calculated at the specialty level, following the procedure for computing the Δy_s used in equation (4). Aggregating to the specialty level should mitigate the effects of any potential measurement error that might create a bias in the individual-level relationship shown in Panel A.

Appendix Figure A.9: **Cross-Sectional Age Profile of Ownership and Salary Structure**

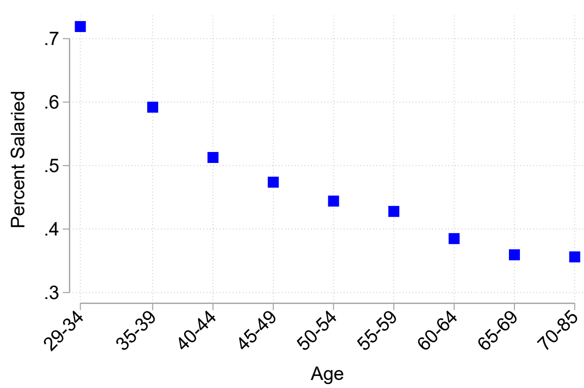
Panel A: Own-Productivity Affects Compensation



Panel B: Ownership Stake in Primary Practice



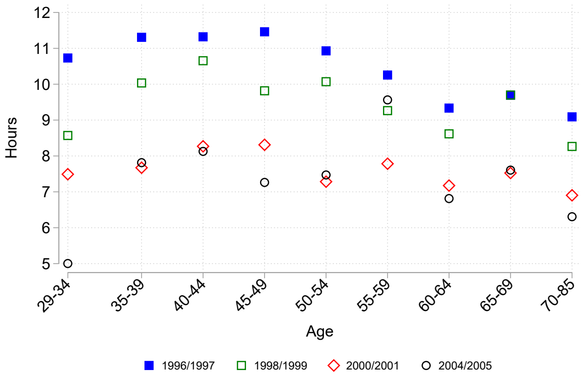
Panel C: Remunerated on a Salary Basis



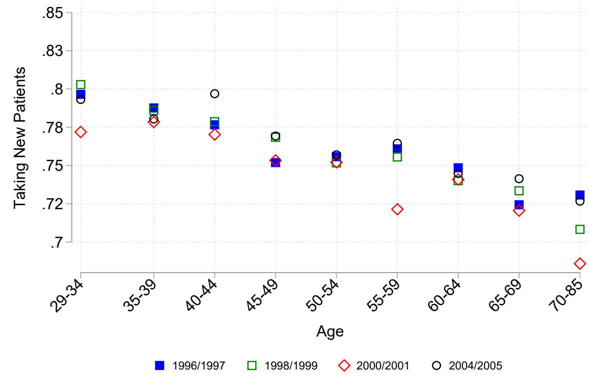
Note: Panel A plots the proportion of physicians that are full or partial owners of their practice and Panel B the proportion of physicians that report being remunerated on a salary basis, each by age group. Both ownership and salary status may affect a physician's incentive and ability to adjust on-the-job investments in response to price changes. Given the strong correlations with age, these factors could influence the age gradient of how on-the-job investments respond to Medicare payment changes. Source: Authors' calculations based on data from the Community Tracking Study, 1997–98 wave only (Center for Studying Health System Change, 1999).

Appendix Figure A.10: Age Patterns by Survey Wave

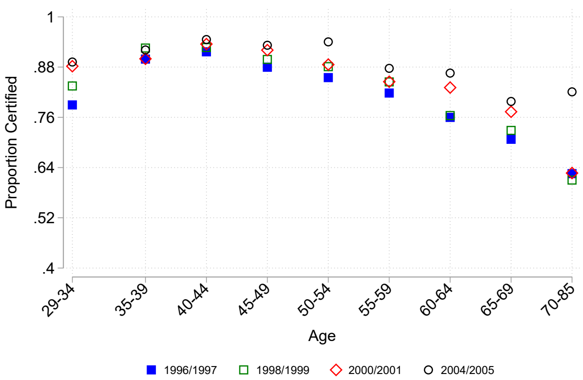
Panel A: Non-Patient Hours



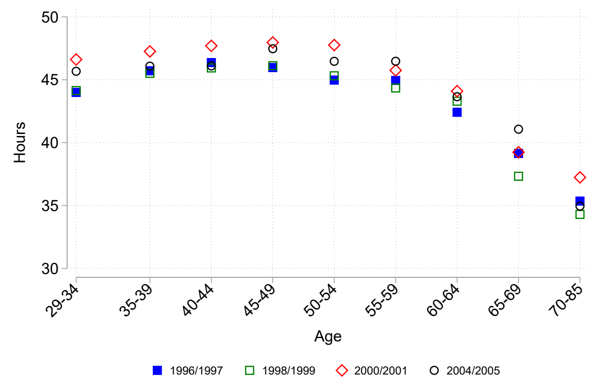
Panel B: Taking New Patients



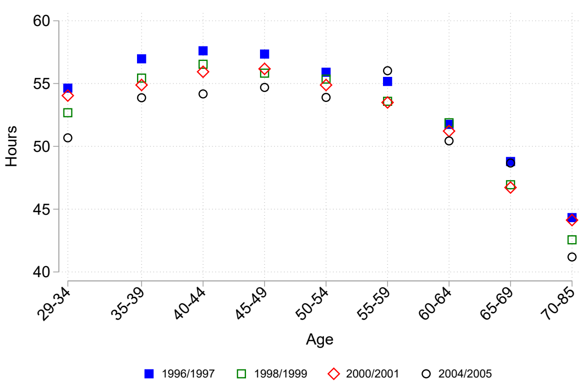
Panel C: Board Certified



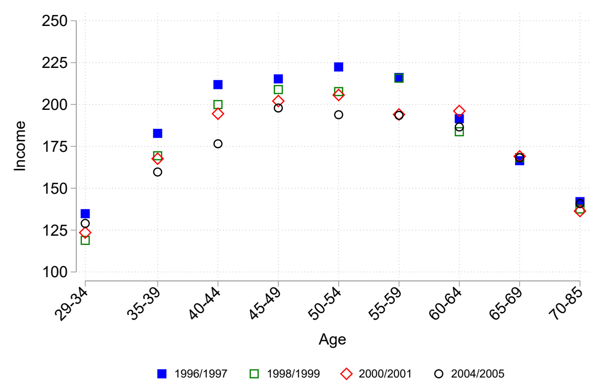
Panel D: Patient Care Hours



Panel E: Total Hours



Panel F: Income



Note: This figure plots average weekly patient care hours, and total weekly hours worked, by age group. Source: Authors' calculations based on data from the Community Tracking Study, 1996/97 wave only (Center for Studying Health System Change, 1999).

Appendix Table A.1: **Practice Type**

	Count
Solo Practice	12540
Group Practice	12084
Privately-Owned Hospital	5010
Medical School/Univ	3402
Two Physician Practice	3008
Group Model HMO	1255
Free-Standing Clinic	1147
Staff Model HMO	1134
State/local Government Hospital	617
State/local Government Clinic	531
Other	508
Integrated Health System	466
PPM	455
Community Health Center	367
Independent Contractor	319
State/local Government Other	211
PHO	185
Foundation	99
MSO	89
Locum Tenens	89
Other Insurance	79
Employer-based Clinic	74
Total	43669

This table displays the frequency of different practice types as reported by respondents. Solo practice, two-physician, and group practice make up the large majority of respondents. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Table A.2: **Descriptive Statistics by Panel Length**

	Number of Times Observed in Panel			
	1	2	3	4
Patient Hours	44.30	44.19	44.30	45.09
Non-Patient Hours	9.28	8.91	9.16	9.00
Total Hours	53.50	53.06	53.40	54.04
Weeks Worked	46.68	47.21	47.48	47.47
Certified	0.83	0.86	0.86	0.91
Taking New Patients	0.75	0.74	0.73	0.74
Income	167	169	174	188
Age	46.76	47.66	49.38	49.95
Gender (Male 0 Female 1)	0.27	0.26	0.23	0.20
Full/Partial Owner	0.50	0.51	0.56	0.61
Salaried	0.56	0.55	0.52	0.48
Own-Productivity Affects Compensation	0.78	0.78	0.80	0.81
N	11970	5511	4331	1921

This table reports means by the number of survey waves in which the physician appeared. The maximum is four, corresponding to being observed in all four survey waves. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Table A.3: **Difference-in-difference results: Willingness to Take New Patients by Patient Type**

	New Patients	New Medicare	New Private	New Medicaid
Price Change × Post	0.357**	0.340**	0.127	0.605**
	(0.074)	(0.085)	(0.082)	(0.119)
N	43,669	43,669	43,669	43,669
Mean of Dep. Var. (1996/97)	0.74	0.77	0.83	0.62
Implied Elasticity	0.48	0.44	0.15	0.98

Note: Estimates from the baseline pooled difference-in-difference are shown for willingness to take new patients by patient type: Private, Medicare, and Medicaid. The coefficients displayed are from the interaction between a Post-1997 indicator and the predicted percentage change in Medicare payments by specialty. The predicted change is scaled between zero and one. The coefficients represent the change in the outcome variable associated with a 100 percent increase in the Medicare rate. The implied elasticities are obtained by dividing the coefficient by the mean of the outcome variable in the 1996/97 wave. Standard errors are clustered at the individual level. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^+$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Table A.4: **Eliminating Lifetime Certificate Holders**

Dependent variable:	Board Certified			
	(1)	(2)	(3)	(4)
Year time-limited certificates introduced:	Baseline	$\leq$ 1990	$\leq$ 1985	$\leq$ 1980
Price Change × Post	0.29**	0.38**	0.58**	0.69**
	(0.09)	(0.12)	(0.16)	(0.17)
N	43,362	35,953	14,874	14,372
Mean of Dep. Var. (1996/97)	0.83	0.82	0.79	0.78
Implied Elasticity	0.352	0.461	0.733	0.879

Note: Between 1970 and the early 2000s, the twenty-four certifying boards under the umbrella of the American Board of Medical Specialties each shifted from issuing lifetime certificates to issuing certificates that expire if the physician fails to undergo re-certification. In columns (2), (3), and (4), we estimate the responsiveness of board certification rates to the Medicare payment change for physicians who are in specialties that switched to time-limited certificates by 1990, 1985, and 1980 respectively. Responsiveness to the payment change is larger among physicians in specialties that introduced time-limited certificates earlier, as shown by the increase in coefficients from (2) to (3) and (3) to (4). Column (1) presents the full sample estimate for comparison. Standard errors are clustered at the physician level. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^{+}$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Table A.5: **Age Bin Cutoffs**

	Equal Width		Equal Frequency		Manual	
	Lower	Upper	Lower	Upper	Lower	Upper
Old	60	85	67	85	53	85
Middle	45	59	48	66	44	52
Young	29	44	29	47	29	43

This table reports the age cutoffs for grouping physicians into Old, Middle-Aged, and Young categories. Baseline refers to the age binning used in the main text: less than age 45, between 45 and 59, and 60 or greater. Equal frequency splits the sample into three equal frequency bins—as much as possible given integer values—and equal width splits the sample into three equal width age bins. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

Appendix Table A.6: Robustness to Different Age Bins

	Patient Hours			Other Hours		
	Baseline	Equal Freq	Equal Width	Baseline	Equal Freq	Equal Width
Price Change × Post	-21.63*	-10.64	-23.01	20.45**	12.82*	26.95*
	(10.42)	(7.02)	(16.50)	(6.82)	(5.15)	(10.79)
Price Change × Post × Middle-Aged	6.71	-11.23	4.68	-14.94+	-11.74	-17.21
	(12.49)	(10.99)	(17.82)	(8.42)	(7.95)	(11.89)
Price Change × Post × Youngest	20.60	9.23	19.16	-22.09*	-10.58	-28.62*
	(12.79)	(10.56)	(17.74)	(8.92)	(7.95)	(11.90)
N	43,669	43,669	43,669	43,669	43,669	43,669

	Board Certified			Taking New Patients		
	Baseline	Equal Freq	Equal Width	Baseline	Equal Freq	Equal Width
Price Change × Post	0.14	0.32*	-0.20	0.04	0.38**	-0.33
	(0.24)	(0.15)	(0.40)	(0.18)	(0.13)	(0.29)
Price Change × Post × Middle-Aged	0.17	-0.07	0.69	0.43*	-0.18	0.73*
	(0.28)	(0.23)	(0.43)	(0.21)	(0.19)	(0.31)
Price Change × Post × Youngest	0.15	0.01	0.38	0.29	0.06	0.74*
	(0.28)	(0.21)	(0.43)	(0.21)	(0.17)	(0.31)
N	43,662	43,662	43,662	43,669	43,669	43,669

This table reports robustness of the age heterogeneity results to different binning procedures. Baseline refers to the age binning used in the main text. Equal frequency splits the sample into three equal frequency bins—as much as possible given age is in integer values—and equal width splits the sample into three equal width age bins. Table A.5 shows the effective age cutoffs for each. Stars indicate coefficients statistically distinguishable from zero, with **: $p < 0.01$, *: $p < 0.05$, $^{+}$: $p < 0.10$. Source: Authors' calculations based on data from the Community Tracking Study (Center for Studying Health System Change, 1999).

A.1 Extensions and Robustness Checks

This section presents in detail the robustness checks and extensions summarized in section **??** of the text.

A.1.1 Time-Limited Board Certificates

In Appendix Table A.4, we replicate column (1) of Table 2, Panel C, and then limit the sample to specialties that switched to time-limited certificates prior to a specific date. Columns (2), (3), and (4) estimate the responsiveness of board certification rates to the Medicare payment change for physicians in specialties that switched to time-limited certificates by 1990, 1985, and 1980 respectively. Responsiveness to the payment change is larger among physicians in specialties that introduced time-limited certificates earlier, as shown by the increase in coefficients from (2) to (3) and (3) to (4). This suggests that the response of board certification to the Medicare payment shock is driven by physicians who were likely to face time-limited certifications.

A.1.2 Robustness to Age Bin Definitions

Next, we re-estimate the age profiles of the responsiveness of investments to payment rates using alternative approaches to defining young, middle-aged, and old physicians. Our baseline age bins defined young physicians as those less than 50, middle-age as between 50 and 59, and old as 60 or older. We chose age 60 as a natural cutoff since physicians commonly report retiring between the ages of 60 and 69 (Silver et al., 2016). We chose age 49 as the cutoff between young and middle-age as many physicians do not fully finish training until their mid to late 30s. To check the robustness of these results, we report estimates of equation (3) in which the age bins are defined to either capture equal numbers of physicians or equal width of the age band associated with each bin. Appendix Table A.5 shows the different cutoffs. Appendix Table A.6 shows the corresponding estimates for the responsiveness of patient hours and non-patient hours' to the payment shock. The age gradients are largely similar across age bin specifications. Table **??** shows the results for board certification and new patient acceptance, which are noisier.

B Data Appendix

B.1 Questionnaire Wording

Total Labor Supply

The CTS uses the following wording to elicit total hours of work:

> Thinking of your last complete week of work, approximately how many hours did you spend in all medically related activities? Please include all time spent

> in administrative tasks, professional activities and direct patient care. Exclude time on call when not actually working.

Patient Care Hours

Immediately after asking about total hours, the following question is asked to measure patient care hours:

> Thinking of your last complete week of work, about how many hours did you spend in direct patient care activities? (If necessary, read:) INCLUDE time spent on patient record-keeping, patient-related office work, and travel time connected with seeing patients. EXCLUDE time spent in training, teaching, or research, any hours on-call when not actually working, and travel between home and work at the beginning and end of the work day.

Income

In each survey wave, respondents are ask to report their income net of expenses for the calendar year preceding the survey wave:

> During 1995 [**authors' note: or 1997, 1999, 2003**], what was your own net income from the practice of medicine to the nearest $1,000, after expenses but before taxes? Please include contributions to retirement plans made for you by the practice and any bonuses as well as fees, salaries and retainers. Exclude investment income. (If code "2" in # A4, read:) Also, please include earnings from ALL practices, not just your main practice. (If necessary, read:) We define investment income as income from investments in medically related enterprises independent of a physician's medical practice(s), such as medical labs or imaging centers.

Weeks Worked

Similarly, respondents report their number of weeks worked in the year prior to the survey wave:

> Considering all of your practices, approximately how many weeks did you practice medicine during 1995 [**authors' note: or 1997, 1999, 2003**]? Exclude time missed due to vacation, illness and other absences. (If necessary, read:) Exclude family leave, military service, and professional conferences. If your office is closed for several weeks of the year, those weeks should NOT be counted as weeks worked.

B.2 Variable Construction

We winsorize each of the hours variables at 105 hours per week. This is equivalent to 15 hour work days seven days a week. This is a fairly extreme upper bound on what a "usual" work week can feasibly look like.

Willingness to Accept New Patients

The original survey asks:

Medicare:

> Is the practice accepting all, most, some, or no new patients who are insured through Medicare, including Medicare managed care patients?

Medicaid:

> Is the practice accepting all, most, some, or no new patients who are insured through Medicaid, including Medicare managed care patients?

Private:

> Is the practice accepting all, most, some, or no new patients who are insured through private or commercial insurance plans including managed care plans and HMOs with whom the practice has contracts? This includes both fee for service patients and patients enrolled in managed care plans with whom the practice has a contract. It excludes Medicaid or Medicare managed care.

All, most, some, and none correspond respectively to 4, 3, 2, and 1 in the survey coding. We sum the responses to each of the three questions, subtract 3, and divide by 9 so that the resulting index ranges from 0 to 1.

Board Certification

In the 1996/97, 1998/99, and 2000/01 waves, we use the derived variable BDCERT. Physicians are classified into one of four mutually-exclusive categories: (i) Board certified in any specialty, (ii) Board eligible in any specialty, (iii) Neither, (iv) Not Ascertained. If the physician fell in group (ii), (iii), or (iv) we classified them as not certified.

In the 2004/05 wave, the BDCERT variable was replaced by BDCTANY, which simply classifies respondents into two mutually-exclusive categories: (i) Board certified in any specialty, (ii) Not board certified in any specialty.

Does Productivity Determine Compensation

The survey specifically asks physicians if their own productivity influences compensation. We capture this use a binary variable derived from the answer to the following question:

> I am now going to read you a short list of factors that are sometimes taken into account by medical practices when they determine the compensation paid to physicians in the practice. For each factor, please tell me whether or not it is EXPLICITLY considered when your compensation is determined:
>
> YOUR OWN productivity
>
> (If necessary, read:) Examples include the amount of revenue you generate for the practice, the number of relative value units you produce, the number of patient visits you provide, or the size of your enrollee panel.