Commute Costs and Labor Supply: Evidence from a Satellite Campus

Fu, Shihe and Viard, Brian

Research Institute of Economics and Management, Southwestern University of Finance and Economics, Cheung Kong Graduate School of Business

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Abstract

Whether, and how much, increased commute costs decrease labor supply is important for transport policy, city growth, and business strategies. Yet empirical estimates are limited and biased downward due to endogenous choices of residences, workplaces, commute modes, and wages. We use the transition of undergraduate teaching from a Chinese university's urban to suburban campus and ten years of complete course schedule data to test how teachers' labor supply responds to a longer commute. Exogeneity is ensured because few faculty change residences, nearly all faculty use a free shuttle service, and we control for wage changes.

Comparing before and after, the 1.0 to 1.5-hour (40-kilometer) increase in round-trip commute time reduces annual undergraduate teaching by 56 hours or 23%. Consistent with higher per-day commute costs annual teaching days decrease by 27 while daily teaching hours increase by 0.49. Difference-in-difference estimates using faculty-specific changes in commute time corroborate these results ruling out aggregate confounders.

Faculty substitute toward graduate teaching but decrease research output. The university accommodated the reduced teaching time primarily by increasing class sizes implying that education quality declined.

Keywords: commuting; commute costs; labor supply; satellite campus
JEL Classification: J22, R41, I23, I25, R11, R23.

Shihe Fu
Research Institute of
Economics and Management
Southwestern University of
Finance and Economics
Chengdu 610074 China
fush@swufe.edu.cn

V. Brian Viard
Cheung Kong Graduate
School of Business
Beijing 100738 China
brianviard@ckgsb.edu.cn

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1. Introduction

Because commute costs are variable with respect to work days but fixed within a work day, a longer commute can either increase or decrease total work time depending on the relative changes in days worked and daily hours (Cogan, 1981; Parry and Bento, 2001).[1] In what direction, and how much, commute costs affect work time is therefore an empirical question. The question is important but difficult.

The question is important because significant labor supply responses to commute costs have important ramifications for government policy, city growth, and business strategies.[2] Non-trivial effects imply that cost-benefit analyses of transportation infrastructure investments and traffic congestion policies should consider not only the opportunity cost of commute time changes but also the accompanying change in output. If commute costs and work time are negatively related, this would help explain the positive relationship between transportation investment and long-run employment growth (Hymel, 2009). The presence of coordination and knowledge spillovers in cities (Moretti, 2004) implies that commute time plays a role in city growth. The impact is particularly relevant given the longer commute times and distances caused by urban sprawl (Glaeser and Kahn, 2001). For firms, understanding the causal effects of commute costs on labor supply helps them design policies to attract talent. By locating closer to employees or easing their commutes, firms can influence employees' work time and productivity.

The question is difficult because commute costs are endogenous and suitable instruments are scarce.[3] Workers consider commute costs when choosing residences, job locations, and commute modes and firms consider them when choosing wages and locations.[4] Workers with high commute-cost sensitivity are likely to choose residence-job combinations with short commutes while those with low sensitivity are likely to tolerate longer commutes. Failing to correct for this will understate commute costs' effect on work time. Measuring commute costs is also difficult. Commute costs can include time, monetary costs, and disutility and even commute time and distance are usually measured very imprecisely.[5]

As a consequence, most extant evidence on this question is either indirect or subject to endogeneity. Gibbons and Machin (2006) state there is no direct empirical evidence of commute time's causal effect on labor supply. The only subsequent papers we know of that deal with the endogeneity issue are Gutierrez-i-Puigarnau and van

[1] Daily work hours could also change as workers adjust their start and end times to avoid congested periods of the day. These "bottleneck" theories are examined in Vickrey (1969); Arnott, de Palma, and Lindsey (1990, 1993); and Arnott, Tilman, and Schöb (2005).
[2] Commute time may also influence labor supply through the labor participation rate. In this paper we are only able to measure the increase in work time of already-employed workers.
[3] Burchfield, *et al.* (2006) emphasize quantifying the consequences of urban sprawl but note the necessity of using good instruments.
[4] Many papers examine these equilibrium outcomes. Manning (2003) provides empirical evidence on the positive relationship between commute costs and wages and Gin and Sonstelie (1992) on residential location changes due to commute cost changes. Van Ommeren and Rietveld (2005) provide a theoretical relationship between commute time and wages in a job-matching model. White (1988) provides a theoretical model of location choice (and therefore commute costs) with endogenous residence and work locations. Zax (1991) and Zax and Kain (1996) empirically examine residence and job changes in response to commute cost changes.
[5] Examples of monetary commute costs are gasoline, depreciation, and tolls. Disutility includes discomfort from noise, pollution, or effort.

Ommeren (2010a) and Gershenson (2013). In the former the authors use workplace relocations by employers and exclude workers who change residences to maintain exogeneity. While this solves the in-sample endogeneity problem, it understates the out-of-sample effects because workers who change residences are those with high commute-cost sensitivity. The authors find small effects: fifteen fewer work minutes per week from an extra forty kilometers in round-trip commute distance. These commute distance measures also involve error because transport mode is unobserved. Our setting addresses both these concerns and, in contrast, predicts a large drop in work time from increased commute time. Gershenson (2013) uses random daily assignments of substitute teachers to Michigan schools to overcome the endogeneity problem. The author can estimate only commute time's effect on teachers' daily acceptance probabilities whereas our paper quantifies the total effect on annual work time and decomposition into days worked and daily hours.

To identify the causal effect of commute time on work time, we examine the addition of a suburban satellite to a main urban campus at a typical, well-established Chinese university. For classes taught at the satellite campus, commute time increases exogenously since virtually no faculty move. Moreover, the increased time (30 to 45 minutes one-way) and distance (20 kilometers one-way) are known and homogeneous across teachers[6] since virtually all faculty ride a university shuttle bus. Faculty chose their teaching time within an internal labor market subject to a liner wage[7] allowing us to measure the market response of work time. The bus is free to faculty so estimates reflect the effect of commute time and disutility but not monetary costs.

The new campus opens in academic year 2004[8] (throughout the paper a "year" refers to an "academic year" unless otherwise noted) but undergraduate students transition one class level per year until all four levels are taught there in 2007. Wages change over the sample period but are fixed within a year allowing us to control for them using year fixed effects.

Using data on the university's undergraduate course offerings from 2000 to 2009, we identify the causal effects of commute time on teachers' undergraduate teaching time employing two approaches. First, we estimate comparing before (2000 to 2003) versus after (2007 to 2009) the transition of all four class levels to the new campus and control for unobservable confounding factors using teacher and year fixed effects. Compared with an estimated elasticity of -0.009 for work time with respect to commute distance in Gutierrez-i-Puigarnau and van Ommeren (2010a), we estimate -0.10,[9] consistent with their excluding workers with high commute-cost sensitivity. The 1.0 to 1.5 hour increase in commute time per teaching day reduces annual undergraduate teaching time by 56 "class hours" or 22% of the pre-transition average of 249. Since faculty average 80 undergraduate teaching days per year before the transition, teachers value commute time at 47 to 70% of their hourly wage.[10]

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[6] For brevity, we will use the terms "teacher" and "teachers" interchangeably with "faculty member" and "faculty" even though our sample includes faculty who both teach and research.
[7] We discuss later the possibility of administrators intervening in the market and applying non-wage pressures.
[8] As in U.S. universities, academic year t spans fall semester of calendar year t to spring semester of calendar year $t+1$.
[9] Calculated using the midpoint method and a decrease of 56 annual work hours from an average of 249 pre-transition, a commute of zero kilometers pre-transition, and a round-trip commute of 40 kilometers post-transition.
[10] Many studies estimate the value of commute relative to work time. However, these only estimate the equilibrium trade-off and do not provide structural parameters for evaluating transport policy or labor market outcomes

Since the before-after approach relies on aggregate variation it could be subject to confounding factors. To address this, we employ a second approach using teacher-level variation in commute time during the transition years. The incremental transition to the satellite campus imposes different commute times on different teachers in different years during the transition depending on their course schedule. Those that teach class levels transitioning earlier face longer commutes earlier. Faculty teaching freshmen courses[11] incur a longer commute sooner because freshmen transition first. Those teaching sophomores incur a longer commute next soonest, followed by those teaching juniors, and finally those teaching seniors. This allows a difference-in-differences (DD) analysis comparing work time effects for teachers with differential changes in commute time. This is immune to confounding factors not correlated with individual-level commute time.

Using the DD approach, undergraduate teaching time falls more for teachers exposed to longer commutes in a given year. Each additional commute day decreases annual work time by 0.79 "class hours" per transition year. Given an average increase of 16.7 commute days per transition year, we estimate a cumulative decrease in annual undergraduate teaching time of 52 "class hours." Since commute time is endogenous during the transition (teachers with high commute-cost sensitivity will work harder to shift away from teaching class levels that transition earlier) this represents a lower bound.[12] Nonetheless, this is only slightly below the before-after estimate of 56 "class hours." The before-after estimates are not subject to this endogeneity problem because before and after the transition there is no means to alter commute time for undergraduate teaching. Therefore, the two approaches offer a tradeoff between confounding factors and endogeneity but yield similar estimates.

We offer two other pieces of corroborating evidence to further rule out confounding factors. First, we use theoretical labor supply predictions. Commute costs vary with days worked but are fixed with respect to daily hours conditional on working that day. Therefore the campus transition should decrease work days but increase daily hours. Consistent with this, before-after estimates indicate annual undergraduate teaching days fall by 27.2 while daily undergraduate "class hours" increase by 0.49. DD estimates are similar – a decrease of 17.7 work days and an increase of 0.16 daily "class hours." In contrast, Gutierrez-i-Puigarnau and van Ommeren (2010a) find no significant effect on days worked. Thus, confounding factors must decrease days worked but increase daily hours. These particular results have ramifications for theoretical labor supply models. Some assume that work days are fixed and daily hours chosen (Cogan, 1981) while others assume the opposite (Parry and Bento, 2001). Our results imply that models should allow both margins to respond.

Our second piece of evidence relies on the increased incentive to teach larger classes post-transition. The university paid a higher per-"class hour" wage for larger classes.

(Gibbons and Machin, 2006, p. 7). This literature has yielded a large range for the tradeoff: from 0.5 to 3 times the wage rate (Small, 1992; Timothy and Wheaton, 2001, Small and Verhoef, 2007). Gibbons and Machin (2006) place the center of these estimates at 50% which is at the low-end of our estimates.

[11] When we use the term "course," we allow for the possibility of multiple sections of the same course. The term "class" can therefore refer to a course with a single section or a single section of a course with multiple sections.

[12] This endogenous avoidance behavior is separate from consolidating classes in fewer days to avoid longer commutes – the causal effect we estimate. It is also separate from the substitution toward graduate teaching discussed below.

Teaching larger classes is more appealing after the transition than before because daily commute costs can be amortized over a higher hourly wage. To test this we adjust "class hours" by the wage multiple to generate "paid hours." For example, if a class is large enough to be paid at a 1.5 rate then one "class hour" is equal to 1.5 "paid hours." Consistent with teachers' increasing the proportion of larger classes post-transition we find that "paid hours" decline by less than "class hours."

Besides leisure, faculty may substitute toward graduate teaching, research, and consulting in response to increased commute time for undergraduate teaching. Since the location of these other work activities is unaffected by the campus transition,[13] they become relatively more attractive once undergraduate teaching transitions. However, time spent on these activities might decrease if increased time and fatigue from commuting crowds them out. While we do not observe consulting activities, we find substitution toward graduate teaching and away from research. Before-after estimates imply that the transition increased graduate teaching by 27 "class hours" annually per teacher engaged in graduate teaching and decreased published academic research papers by 0.59 annually per capita (58.3%).

We find that teaching time subject to a longer commute substantially decreases. Since we do not observe all work time (in particular consulting) and we do not know how much preparation time outside of class changes we cannot say with certainty whether the longer commute for undergraduate teaching decreases work time including sources not subject to commute costs.[14] However, two aspects of our results strongly suggest that total work time decreases significantly. First, the campus transition increases graduate teaching time by much less than it decreases undergraduate teaching time while decreasing research output. Therefore, unless consulting time has increased dramatically or research productivity has fallen dramatically total work time has fallen substantially. Second, undergraduate teaching time falls at all faculty ranks due to the campus transition and assistant professors teach fewer graduate courses and rarely engage in consulting.[15]

A large work time response to increased commute time has implications for transport investments, city growth, business strategies, and higher education policies in China. Cost-benefit analyses of transportation design should include labor supply responses to changed commute costs. Similarly, evaluations of policies alleviating traffic congestion, such as driving restrictions, staggered work hours, and reversible lanes, should include the resulting work time changes. It has been suggested that congestion taxes replace income taxes because the former reduces the negative externalities from driving even though both distort labor supply. An extensive theoretical literature discusses the welfare implications of doing so in a revenue-neutral way (Parry and Bento 2001; De Borger and van Dender, 2003; and Mayeres and Proost, 2001 discuss endogenizing work time in these models). Our results imply that faster commutes under a congestion tax will offset some of the labor market distortion due to monetary commute costs.

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[13] A small exception is that graduate students moved starting in 2008. We comment on this in the results.

[14] Commute hours increase by 80 to 120 hours annually while undergraduate "class hours" decrease by 56; however, we do not observe preparation time outside the classroom. This problem is faced by any study of work time since unofficial work is unobserved as is sharing of household chores and paid work within the household.

[15] Assistant professors average 63 graduate "class hours" annually compared to 73 for associate and 103 for full professors assuming that courses with identical names and taught by faculty in the same department are co-taught.

Our results also imply a role for commute time in the long-run level and rate of city growth. Longer commutes will directly negatively impact a city's productivity and therefore output. In addition, there is empirical evidence that knowledge spillovers occur in the workplace (Fu, 2007; Rosenthal and Strange, 2008) implying that productivity growth would also suffer from less time spent in the workplace. This is particularly relevant given the longer commute times caused by urban sprawl (Brueckner, 2001 assesses consequences of urban sprawl to which reduced work time should be added). Our results imply that an additional factor to consider in the competition between "edge" and core cities is the decreased work time of workers who commute between the two (Henderson and Mitra, 1993).

For businesses, our results suggest that locating close to employees or easing their commutes (*e.g.*, providing free shuttles) can yield more time at work and likely higher productivity (Gutiérrez-i-Puigarnau and van Ommeren, 2010b; Ross and Zenou, 2008). Glaeser (1994) considers externalities between proximately-located firms created by information networks. Our results imply that commute times are an important factor in creating these externalities.

As teachers have more flexibility on the intensive margin of labor supply and better substitute sources of work income we are cautious in extrapolating our results to workers with less flexibility. However, there are several reasons why those with discretionary work time are particularly important for many of the implications above. The proportion of "knowledge workers," who generally have more flexible schedules, is projected to increase over time (Moretti, 2012). Relatedly, Florida (2004) argues that a "creative class," about thirty percent of the U.S. workforce, sets their own hours and is critical to development of post-industrial U.S. cities. High human-capital and high-technology workers tend to have flexible schedules and have been found to exert a multiplier effect on local employment due to increased demand for local goods and services (see Moretti, 2010 and Moretti and Thulin, 2013). City growth is particularly sensitive to the presence of high human-capital workers due to spillovers from knowledge sharing (Jovanovic, 1992 and Glaeser, 2003).

The self-employed, especially entrepreneurs, create positive employment spillovers (van Praag and Versloot, 2008) and have significant work time discretion. Their work time and these spillovers are affected by longer commutes (Viard and Fu, 2013 provides evidence that self-employed work time is reduced by commute costs).

Our particular setting has implications for higher education quality. Total undergraduate enrollment in China increased from 2.0 million in 1998 to 8.7 million in 2010.[16] The number of universities has not kept pace leading to higher enrollments: about 14,000 students per university in 2006 compared to 4,000 in 1997. Universities have accommodated this expansion by increasing campus sizes – often by adding satellite campuses. As of 2009, more than sixty universities had established satellite campuses.[17] Our results suggest that use of satellite campuses will lead to reduced teaching supply which must be accommodated through some combination of more

[16] According to Ministry of Education data available at http://www.moe.gov.cn/.
[17] "Development Patterns of College Towns in China," Wei Zhou (2009), M.A. Thesis (in Chinese), Zhongshan University.

faculty, higher salaries, and larger classes. In our setting, we find that the university accommodates the decreased teaching time primarily by increasing average class size, suggesting that educational quality likely suffers (Angrist and Lavy, 1999; Arias and Walker, 2004; DeGiorgi, Pellizzari, and Woolston, 2012).

2. Empirical Setting

We examine commute costs created from transitioning the location of undergraduate teaching at a well-established Chinese university.[18] Teaching moved from the main campus in the city center to a newly-opened suburban satellite campus 20 kilometers away. Transition planning began in calendar year 2000 with a search for land and the university signed a contract with the city government to buy a parcel the next calendar year. Bidding for the campus design was held in calendar year 2002 and later that year a national newspaper announced that incoming freshman would live and be taught at the new campus beginning in 2003, later postponed to 2004. The timing of this announcement is critical because it means that prior to late 2002 faculty was aware that a new campus was being built but unaware of how the transition would proceed. Any faculty efforts to change their teaching schedule away from teaching freshman classes (to delay commuting) began in academic year 2003 at the earliest.

The school held a groundbreaking ceremony in early calendar year 2003 and in academic year 2004 the entering freshmen lived and took courses at the satellite campus while higher class levels remained at the main campus. In 2005, the entering class again lived and took courses at the new campus so that freshman and sophomores took courses at the satellite campus while juniors and seniors remained at the main campus. In 2006 only seniors remained at the main campus while the other class levels lived and took courses at the satellite campus. From 2007 onward all four class levels lived and took courses at the satellite campus.

Graduate courses remained at the main campus during most of the sample period. Entering Master's students began taking courses at the satellite campus in 2008. Since they generally study for two years, one-half of them were at the satellite campus in 2008 and all of them in 2009.[19] Entering Ph.D. students began taking courses at the satellite campus in 2009. Since most Ph.D. students study for three years approximately one-third took courses at the satellite campus in 2009.

Almost all teachers resided at the main campus during the sample period. The university continued to provide subsidized housing at the main campus and did not complete construction of faculty housing at the satellite campus until after 2010.[20] The university provided a free, convenient shuttle bus between the two campuses which virtually all faculty used to commute. Therefore, we estimate the effect of increased commute time but not monetary costs. The shuttle trip takes about thirty minutes one way plus up to fifteen minutes of walking and waiting on each end. Since

[18] For confidentiality reasons we cannot identify the university nor can we provide references for the background information on the campus opening all of which were obtained from local newspapers.
[19] Most Master's programs in China take three years but some universities, including the one studied here, have two-year programs.
[20] Availability of faculty offices and overnight dorms at the satellite campus might limit the work time decline due to the longer commute.

the time required depends on random variation in weather, traffic, and wait times we assume that commute time increased 1.0 to 1.5 hours round-trip per commute day.

Our primary data consists of the university's complete undergraduate class schedule from 2000 to 2009. This provides four years before the transition and three years in which all four class levels took courses at the satellite campus. For each class we know its course title, academic semester, teacher, class level (freshman, sophomore, junior, senior, other), number of students (class size), day and time of meeting,[21] weekly "class hours," and number of weeks. We can identify class level because in China most courses are taught to a single undergraduate class level. This is important for our transition period estimates (2004 to 2007) since it allows us to determine which classes were taught at which campus during these years.

Our primary measure of labor supply is a "class hour" – the amount of class time a faculty member spends in the classroom to receive one "hour" of pay (fifty minutes before the transition and forty-five minutes after). Since we do not observe time spent outside of class on tasks such as preparation and grading, we cannot quantify the effect on total time devoted to teaching. Since the "hourly" wage compensates teachers for time spent both inside and outside the classroom "class hours" accurately summarizes total effort.

Teachers allocate their time between five major activities: undergraduate teaching, graduate teaching, research, consulting, and leisure. A teacher's total annual compensation can be represented as $F + B(T^R) + w^U T^U + w^G T^G$. F is a fixed payment based on seniority, position, and administrative duties. It is primarily based on a nationwide standard and is fairly uniform across faculty. B is an annual bonus paid for research publications where T^R is time spent on research and we assume that $B(0) = 0$, $B' > 0$ and $B'' \leq 0$. That is, there are diminishing or constant returns to research. Research also provides non-pecuniary benefits such as prestige, personal satisfaction, and future career advancement and we can think of B as including these effects as well.[22] The last two components are the linear payments for teaching where w^U and w^G are hourly wages for undergraduate and graduate teaching and T^U and T^G are annual "class hours" taught for each.[23] The hourly undergraduate wage increased over time: RMB 20 in 2001 and 2002, RMB 40 in 2003 and 2004, RMB 60 from 2005 to 2007, and RMB 90 from 2008 onward.[24] Domestic faculty were compensated for a graduate "class hour" at 1.5 times the rate for undergraduate "class hours" and those with a foreign Ph.D. (from a non-mainland China university) were compensated at the same rate for both. Since F, B, w^U, and w^G do not change within academic years, we control for changes in them using academic-year fixed effects in our estimation.

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[21] The one exception to this is that for classes taught prior to 2005 and meeting on weekends the day and time is not available. We discuss how we handle this when we discuss our results.

[22] Faculty with an overseas Ph.D. and domestic faculty hired since 2006 have three-year contracts. All other domestic faculty has permanent contracts. Regardless of contract length, research output affects promotion from an assistant to an associate or from an associate to full professor.

[23] We discuss one exception to this linearity below in our robustness check for "paid hours."

[24] We do not believe that faculty anticipates wage changes because they are determined by human resources or a university-level committee and only then announced to faculty members. Therefore, they will not change their teaching schedules dynamically in anticipation of wage changes.

Since we do not observe the returns to outside activities such as consulting we do not know how the effective teaching wage changes over time. However, because of two aspects in the way teaching schedules are set we are able to control for the effective teaching wage using academic-year fixed effects in our before-after estimation. First, the teaching wage itself is constant within an academic year. Second, teachers commit to a teaching schedule prior to the academic year and therefore must rely on the expected return to outside activities over the academic year in choosing their teaching time. Since the DD estimates rely on teacher-specific variation in commute time they are immune to aggregate wage changes. Individual-level changes in returns to outside activities could bias these estimates, a possibility we discuss when introducing the DD model.

Subject to the wage and a minimum teaching load (there is no maximum) a teacher chooses their teaching hours to maximize their utility. The process is the following. Each faculty member submits their teaching choices to their department staff which figures out course scheduling. The schedule is submitted to a university-wide administrative office that assigns classrooms. In the background, department heads may influence the choices of individual faculty who may have differing levels of bargaining power. We control for this by including variously teacher fixed effects, teacher-specific time trends, and controlling for faculty rank.

The minimum annual teaching load was 240 "class hours" from 2001 to 2004 and 225 hours from 2005 onward.[25] Teachers are paid for classes both used to satisfy their teaching load and those above. The minimum teaching load change during the transition may confound our before-after estimates. To control for this we include variously year fixed effects, flexible time trends, and teacher-specific time trends. We also estimate using a subsample of faculty that exceeded the minimum before the transition and find similar results. Our DD estimates are immune to this.

Ideally, we would control for the minimum teaching load using a Tobit regression. We cannot because teachers may fulfill this requirement through other activities (and get paid for them) that we do not observe. These include supervising graduate theses, administrative tasks, and supervising student internships and study trips.[26] To the extent that the minimum teaching load binds for some faculty it will bias us against finding an effect from the increased commute time because the campus transition does not affect these other activities' locations.

Faculty size, student enrollment, graduation requirements, and class sizes could affect university-level teaching demand. However, for an individual teacher demand is summarized by the wage which we control for using academic-year fixed effects. Although the faculty chose their teaching time within an internal labor market, other market-clearing mechanisms besides wage may operate. In particular, department heads may pressure faculty to teach more or less. We control for this at the aggregate

[25] This is for department-specific courses. For "university-wide" and "sports" courses the minimum was 320 hours per year from 2001 to 2004 and 300 from 2005 onward. These courses are taught primarily by faculty in the English, sports, and math departments. For the few teachers with a foreign Ph.D. the minimum was 160 hours per year. The university did not allow faculty to carry-forward or carry-back teaching credits and examined faculty workload year-by-year. The financial penalties for not meeting the teaching load were fairly severe.

[26] The activities available for meeting the minimum teaching load vary by rank. For example, only associate and full professors can supervise Masters' theses and only full professors can supervise Ph.D. theses. We check the robustness of our results to this by including faculty rank controls in some specifications.

level in each year using academic-year fixed effects and at the teacher level by including teacher-specific fixed effects (or time trends). Moreover, such pressure would bias our results away from zero only if department heads pressured faculty to teach less after the transition. The opposite seems more likely. Our DD results are immune to this unless department heads systematically exerted more pressure to teach less on faculty facing longer commutes.

3. Theoretical Background

We model the effect of increased commute time on daily hours, annual days, and annual hours.[27] We first consider a model with no graduate teaching or research ($T^G = T^R = 0$) for manageability and consider an alternative model which reintroduces these in Appendix B. Because additional commute time increases fixed costs per work day workers will concentrate more hours per day in fewer days. Total work time could increase or decrease. We show this using a modified version of the model in Gutierrez-i-Puigarnau and van Ommeren (2009). They generalize a labor supply model with commute costs to allow for the choice of days worked and daily hours. We adapt their model to our setting in two main ways. Their model allows for a concave wage function due to declining marginal productivity. We instead use a linear wage function and assume a convex effort cost diminishes the value of leisure. We also exclude monetary commute costs consistent with the university's free shuttle service. The two models' implications are qualitatively similar.

A teacher's annual utility is $v = V(C, L)$ where C is annual consumption, L is annual leisure time, and V is differentiable with $V_{LL} < 0, V_{CC} < 0$, and $V_{CL} > 0$. Without graduate teaching and research, annual compensation is $F + w^U DH$ where annual undergraduate "class hours" (T^U) is decomposed into annual days (D) and daily "class hours" (H). A teacher's annual budget constraint is $C = Y + F + w^U DH$ where Y is annual non-labor income. Annual time is divided between undergraduate teaching and leisure and each teaching day requires round-trip commute time of t.[28] Daily "class hours" require effort that decreases utility from daily leisure by $e(H)$ with $e'(H) > 0$ and $e''(H) > 0$ denominated in leisure hours. The disutility can be interpreted as diminishing the quality of each leisure hour or time spent resting which reduces time available for other activities. Since annual days, daily "class hours," and annual "class hours" refer to in-class time, the effect of preparation time outside the classroom is subsumed in the effort function.

A teacher's annual time constraint is $\bar{T} = L + D\big(H + t + e(H)\big)$ where $\bar{T}$ is total annual hours. Substituting the budget and time constraints:[29]

(1) $v = V\left(Y + F + w^U DH, \bar{T} - D\big(H + t + e(H)\big)\right)$.

[27] In our empirical setting the minimum teaching requirement and moral suasion from the department head may constrain work time. We do not model these constraints but as discussed above these both bias us against finding an effect. Either of these might bind differentially across faculty so we include teacher fixed effects in estimation.
[28] As discussed earlier, teachers may have other work obligations besides teaching such as consulting. Time spent on these is subsumed into leisure and income from these are subsumed in Y. Our model assumes an equal number of "class hours" across days. In our data they are unevenly distributed but this does not qualitatively change the model's implications.
[29] The problem should also include a constraint on the maximum number of daily hours. For simplicity, we assume an interior solution.

The two first-order conditions are

(2) $F_H \equiv \partial v/\partial H = V_C w^U D - V_L D\big(1 + e'(H)\big) = 0$, and
(3) $F_D \equiv \partial v/\partial D = V_C w^U H - V_L\big(H + t + e(H)\big) = 0$.

Equation (2) says that the marginal utility of consumption from an extra hour of daily work equals the foregone marginal utility of daily leisure including the effect of fatigue. Equation (3) says the same from working an extra day during the year. Combining these two the optimally chosen daily work time fulfills

(4) $e'(H) = \frac{t+e(H)}{H}$.

The teacher equates the marginal disutility of effort to the average daily disutility of working (including commute time and effort). The teacher smoothes daily "class hours" across days to avoid escalating the costs from working very long days (*e.g.*, it is better to have two ten-hour days than one twenty-hour day). Similarly, Connolly (2008) finds that male workers increase their work time on rainy days and decrease it the following day to equalize the marginal utility of leisure across days. If we totally differentiate Equation (4) letting daily hours adjust to a change in commute time it follows that an increase in daily commute time increases daily "class hours"

(5) $\frac{dH}{dt} = \frac{1}{e"(H)H} > 0$.

Given a longer daily commute, teachers spend more "class hours" teaching once at the satellite campus so as to avoid additional trips on other days. In Appendix A we show that increased commute time decreases annual days worked. Teachers concentrate their teaching in fewer days to avoid the extra commute time incurred each work day. Thus, increased commute time increases daily "class hours" but decreases annual work days. In Appendix A we show that increased commute time could increase or decrease annual "class hours" (DH). Which happens depends in particular on the curvature of the effort costs. If effort costs do not increase too rapidly with daily "class hours" then increased commute time may increase annual "class hours."

In Appendix B we modify the model to consider two work activities – one affected by commute time (undergraduate teaching) and the other not. The other activity could either be paid according to a wage linear in hours worked (as with graduate teaching) or increase a teacher's annual bonus according to a weakly concave function of hours worked (as with research). To simplify the analysis we collapse the separate choices of days and daily hours into a single choice of total hours for each activity. The model shows that time spent on the other activity could increase or decrease with commute time when undergraduate teaching time decreases. Faculty may substitute toward these activities since they do not require commuting; however, they may be crowded out by the increased commute time.

4. Econometric Model

We model the work time for teacher i in academic year $2000 \leq t \leq 2009$ as:

(6) $Y_{it} = \alpha_i + g_i(t) + \tilde{\beta}_i\left[\bigcup_{c\in Q}(Tr_t^c CD_{it-1}^c)\right] + X_{it} + \tilde{\varepsilon}_{it}$,

where Y_{it} is one of three measures of work time (annual "class hours," annual days, and daily "class hours"), α_i is a teacher fixed effect which absorbs time-constant unobserved work-time preferences, and $g_i(t)$ is a potentially teacher-specific function of academic years that captures time-specific unobserved factors affecting work time. The term in brackets captures a teacher's commute time in year t where $Q = \{Fr, So, Ju, Se\}$ is the set of four class levels (freshman, sophomore, junior, and senior), CD_{it}^c is the number of days teacher i would have to commute to the satellite campus based on their academic-year t schedule and assuming that class level c students had transitioned to the satellite campus, and Tr_t^c is a dummy variable set equal to one beginning in the academic year in which level c has transitioned to the satellite campus and zero before. We control for teacher/year-specific characteristics X_{it} such as rank. We do not allow for time-varying, university-wide characteristics because they are subsumed in $g_i(t)$. These include wages, student enrollment, faculty size, class size, curriculum, graduation course requirements, and national education policies. $\tilde{\beta}_i$ captures the effect of increased commute time on work time for teacher i. $\tilde{\varepsilon}_{it} \sim N(0, \sigma_\varepsilon^2)$ is an error distributed independently across teachers and years.

The model assumes that year t commute time is proportional to the commute days a teacher would incur based on their year $t-1$ teaching schedule. For example, in 2004 freshmen transitioned to the satellite campus. We assume that the expected number of commute days in 2004 is equal to the number of unique dates that a teacher taught a freshman-level class in 2003. Consider a teacher who taught twenty weeks in 2003 and taught two freshman classes on Tuesday, one freshman class on a Thursday, and only non-freshman classes all other weekdays. Their expected number of commute days in 2004 would be forty (two unique commute days per week for twenty weeks). We use the union of commute days across all class levels that have transitioned to the satellite campus because teaching two different class levels that have transitioned to the new campus on the same day requires only one commute.

We believe lagged teaching schedules are the best basis for expected commute time in the current year. A teacher's current schedule is invalid because it is simultaneously determined (if commute time decreases a teacher's work time it will also decrease their contemporaneous number of commute days). Using the lagged teaching schedule is problematic in that teachers' schedules may change over time for random and non-random reasons. Random reasons such as changes in students' or teachers' interests will introduce noise and make estimates less precise but are not of major concern since they will make it less likely we find an effect. Of more serious concern is that teachers may alter their schedule in non-random ways that introduce bias. Teachers may attempt to shift away from teaching class levels that impose a longer commute. For example, between 2003 and 2004 teachers will try to change their schedule to avoid teaching freshman-level classes. This avoidance behavior is separate from the causal effect of teachers attempting to consolidate their teaching into fewer days, for example by swapping time slots with other teachers. The former biases estimates of the casual effect while the latter is the causal effect we want to estimate.[30]

We believe that lagged schedule is a reasonable proxy because teaching a different course to avoid commuting is costly in two ways. First, teachers must convince the department head to allow them to do so and all other faculty has an incentive to make similar competing appeals. Second, it requires incurring fixed costs to develop a new course. Tables 1 and 2 provide suggestive data that avoidance behavior is not significant. The upper panel of Table 1 shows the year-to-year change in the fraction of annual "class hours" averaged across teachers. We focus on freshman and sophomore classes since these are where avoidance behavior is most likely to surface. For example, in 2001 teachers on average decrease the fraction of freshmen "class hours" by 0.0074 and increase the fraction to sophomores by 0.0080 although neither is significant. The lower panel repeats the same calculations but excludes teacher-year observations in which the fraction was zero in both the current and previous year to avoid a downward bias from teachers not actively teaching. If avoidance behavior were significant we should see a significant decline in freshman and sophomore "class hours" beginning in 2003 when the transition sequence became known and continuing into the transition period. Neither the freshman nor sophomore data exhibits evidence of avoidance behavior. The only significant changes occur in 2007 or later, after the transition is completed.

Table 2 uses an alternative approach to look for avoidance behavior. It shows the results of regressing the fraction of freshman or sophomore annual "class hours" on academic-year fixed effects. We also include teacher fixed effects to control for teacher-specific unobservables. Significant coefficients indicate a difference in the fraction that year relative to 2000 (the omitted year). A specification using all years shows no evidence of avoidance behavior for freshman classes (Column 1) – the only significant effect is an above-average fraction in 2006. For sophomores (Column 3) there is weak evidence of avoidance behavior. When sophomores transition to the new campus in 2005 the fraction of sophomore "class hours" is 3.8 percentage points below average. It is also below average in 2006 although avoidance had become difficult by then as only seniors had not transitioned to the new campus. Columns 2 and 4 use only pre-transition years. There is no evidence of avoidance behavior for either freshman or sophomore classes. This suggests only a small downward bias in the DD results.

Our before-after estimates are not subject to this endogeneity issue because they compare only pre- and post-transition data. Since all four class levels are taught at the satellite campus post-transition, avoidance behavior is impossible. We use a transformed model which does not depend on commute days and thereby avoids even the noise due to random schedule changes. Our DD estimates will be affected because they use data during the transition years. However, they will be biased toward zero because teachers with higher commute-cost sensitivity will work harder to shift their schedule away from class levels that transition earlier. This same bias could result

[30] A similar issue arises in the environmental literature. In estimating the causal effect of pollution on health outcomes it is important to control for the fact that people will avoid the impact of pollution by, for example, spending less time outside or wearing protective masks (see Zivin and Neidell, 2013).

from individual-level differences in returns to outside activities – those with high opportunity costs will work harder to shift away from courses with a longer commute.

We assume that commute-cost sensitivity across teachers is $\tilde{\beta}_i = \tilde{\beta} + \sigma_{i\beta}$ with $\sigma_{i\beta} \sim N(0, \sigma_\beta^2)$ independently across teachers and independent of $\tilde{\varepsilon}_{it}$. This heterogeneity occurs because teachers have different schedules for non-teaching activities or family situations such as number of dependents.

Before-After Model: In our before-after model we use the "before and "after" years:

(7) $Y_{it} = \alpha_i + g_i(t) + \tilde{\beta}_i[D_t x CD_{it-1}^{To}] + X_{it} + \tilde{\varepsilon}_{it};\ t \in \{00, \dots, 03; 07, \dots, 09\}$,

where $CD_{it}^{To} = \bigcup_{c \in Q} CD_{it}^{c}$ is total commute days in year t across all class levels and $D_t = Tr_t^{Fr} \times Tr_t^{So} \times Tr_t^{Ju} \times Tr_t^{Se}$ is a dummy variable equal to one after all class levels have transitioned $(t \in \{07, \dots, 09\})$ and zero before $(t \in \{00, \dots, 03\})$. Importantly, teacher commute-cost sensitivity $(\tilde{\beta}_i)$ is uncorrelated with the number of commute days except possibly in 2003 because the university did not announce the transition sequence until after academic year 2002 had begun and teaching schedules had been finalized for that year. To avoid relying on a lagged measure of commute days and the associated measurement noise we transform Equation (7):

(8) $Y_{it} = \alpha_i + g_i(t) + \beta D_t + X_{it} + \varepsilon_{it};\ t \in \{00, \dots, 03; 07, \dots, 09\}$.

Under this formulation, $\beta = \tilde{\beta}\overline{CD}^{To}$ where $\overline{CD}^{To}$ is the average number of commute days across all teachers and years after the full completion of the campus transition (2007 – 2009). It captures the average effect across all teachers on the outcome variable Y_{it} of moving all class levels to the satellite campus. The change captured by β depends on the time controls included. We estimate two main specifications. If we include no time controls ($g_i(t) = 0$) then β captures the average effect in years 2007 to 2009 relative to that in years 2000 to 2003. This could be considered the long-run effect of the policy. If $g_i(t)$ includes academic-year fixed effects omitting years 2003 and 2007 then β captures the short-run effect from 2003 to 2007. We also consider a shorter time window including only 2003 and 2007 data to see if the short-run effects are robust.

The error structure in Equation (8) is heteroskedatistic and serially correlated within teacher but independent across teachers (Appendix C1 provides details). We accommodate this structure by clustering standard errors in cells defined by a teacher before versus after the transition and allowing for heteroskedasticity.

Transition (DD) Model: Although we include academic-year fixed effects, the before-after model could still be subject to time-varying confounding factors. We can further rule this out by examining the transition years 2004 to 2007. Here we take advantage of individual commute-cost variation by using the fact that class levels transition one at a time each year to the satellite campus. Work time should be disproportionately affected for those who teach class levels that have transitioned relative to those who teach levels that have not.

Taking first differences using Equation (6):

(9) $\Delta Y_{it} = \delta_i + f(t) + \tilde{\beta}\left(\bigcup_{c \in Q} Tr_t^c CD_{it-1}^c - \bigcup_{c \in Q} Tr_{t-1}^c CD_{it-2}^c\right) + \Delta\varepsilon_{it};\ t = 04, \ldots, 07,$

where we have decomposed $g_i(t) - g_i(t-1)$ into δ_i, a teacher-specific fixed effect that captures a linear teacher-specific time trend, and $f(t)$ a function of years that captures aggregate time-specific unobserved factors. We drop X_{it} because we do not estimate the transition regressions controlling for teacher demographics.[31] The error is $\Delta\varepsilon_{it} = \Delta\tilde{\varepsilon}_{it} + \sigma_{i\beta}\left(\bigcup_{c \in Q} CD_{it-1}^c - \bigcup_{c \in Q} CD_{it-2}^c\right)$. The second term arises because $\tilde{\beta}$ contains a random component across individuals. This random component is scaled up or down by the change in commute days. The covariance structure (details in Appendix C2) can be accommodated by clustering standard errors by teacher and allowing for heteroskedasticity.

Equation (9) allows for random changes in the distributions of classes across academic years (*i.e.*, CD_{it}^c may randomly differ from CD_{it-1}^c) but does not allow purposeful changes by teachers to avoid teaching classes with a longer commute. However, this will tend to understate the effects. If teachers on average substitute away from teaching classes held on the satellite campus then our lagged measure of commute days will be overstated. Then the regression will attribute too small an effect (in absolute value) of commute days on work time.[32] This substitution away from courses that transition earlier is distinct from consolidating teaching into fewer work days to lower commute time – the effect we wish to capture.

5. Data

Our primary sample contains the university's complete undergraduate course schedule provided by the university's Undergraduate Education Administrative office. We supplemented this data with rank, gender, and Ph.D. source for each teacher from the university's website. A teacher is included in this sample as long as they taught at least one undergraduate course during the sample period. If a teacher taught only graduate level courses or no classes at all they are not included.[33]

For each class, we use weekly "class hours" and number of weeks taught to compute total "class hours." For co-taught classes, we divide total "class hours" by the number of co-teachers to obtain "class hours" for each teacher. We then aggregate across all classes for a teacher in a year to obtain annual "class hours" for each teacher-year observation. To determine the number of teaching days for each teacher we use the days of week for each class they teach to identify all the dates on which their classes

[31] Gender and foreign Ph.D. status do not change over time and few teachers change ranks during the transition.
[32] We estimated a regression using as an instrument for lagged commute days in Equation (9) the commute days in academic years prior to the announcement of the campus transition. The results were statistically insignificant likely due to noise introduced by such a long time lag and a much smaller sample.
[33] We drop class-year observations from the data with missing or unclear information: those taught by faculty appearing in only one year that would be dropped with the inclusion of teacher fixed effects and those missing a teacher name or with a department or school name as the teacher. We also drop those taught by teachers under short-term contracts who are not permanent staff of the university including foreign, retired, rehired (after retirement), and adjunct faculty. We also drop class-year observations with fewer than two "class hours" per semester because these are one-time seminars or lectures rather than courses. The number of observations for faculty rank information is slightly lower because we were unable to collect this information for some faculty.

are taught during the semester. We then identify any overlap in these dates to obtain unique teaching dates for each semester. Aggregating across the two semesters we obtain annual teaching days for each teacher-year observation. Finally, we compute average daily "class hours" (conditional on teaching that day) for each teacher-year observation by dividing the number of total "class hours" by "teaching days"

Panel A1 of Table 3 shows descriptive statistics for the 1,057 faculty teaching undergraduates and present in at least one year before or after the transition. An observation is a teacher-year. For annual days and daily hours we drop 241 teacher-class (27 teacher-year) observations because of missing information on day of the week taught. These are included for annual hours because hours are available even if day of week is not. Classes meeting on weekends are identified as such beginning only in the second semester of 2005. Before that they are indistinguishable from other observations missing day of week. This will understate days worked prior to 2006 and bias us against finding a decrease in annual work days due to the transition. There are dramatically fewer "class hours" at the senior class level consistent with Chinese universities requiring more field projects and independent work in that year. Some of our specifications divide faculty into an "early" (joined during or before 2000) and a "late" (joined from 2001 to 2003) cohort. Fifty-six percent are in the early and 19% are in the late cohort. About twenty five percent are in neither category because they joined after 2003.

Panel A2 summarizes data for the 477 faculty who taught undergraduates and were present in at least one year both before and after the transition. Since we include teacher fixed effects in our before-after estimation, this sample identifies the before-after effects. The summary statistics are very similar to those for the full sample except that somewhat fewer occur after the transition and they are more evenly distributed across years consistent with the faculty growth over time.

We supplement our primary sample with graduate course information. Since we were unable to obtain complete graduate course data from the university's administration we downloaded it from its graduate school website. As a result, we do not observe day and time of meeting or class size but we do observe course title, academic semester, teacher, weekly "class hours" and number of weeks. A teacher is included in this sample if they taught at least one graduate course. Teachers who taught only undergraduate courses or no classes at all are not in this sample.

Panel A3 summarizes graduate "class hours" for the 520 faculty who taught at least one graduate class before or after the transition. We measure annual graduate "class hours" in the same way as undergraduate; however, we are unable to decompose this into annual days and daily hours because we do not observe the days on which classes meet. Panel A4 summarizes the same for faculty who taught at least one graduate course both before and after the transition. These teachers taught more graduate "class hours" consistent with more senior faculty in this sub-sample.

We also supplement our primary sample with data on faculty research output from the university's Research Support Office website. Because it is important in both determining faculty salaries and promotions and establishing the university's reputation we are confident that the data is accurate and comprehensive. During our sample period, China's Ministry of Education attributes research output only to the first author's affiliation. The university applied this same criterion in evaluating faculty so we count a paper only toward the first author. A teacher is included in this sample if they produced at least one paper during the sample period. We exclude faculty producing no papers because they are likely not engaged in research. We observe author's name, journal name, and publishing date. We designate papers as appearing in either "top" or "non-top" journals.[34] We use annual research output per teacher as our dependent variable. Panel B1 of Table 3 summarizes the "before-after" data for the 1,036 teachers who have at least one publication either before or after the transition[35] while panel B2 does the same for those with at least one both before and after.

Panel C shows descriptive statistics for the four transition years. Panel C1 summarizes the data for undergraduate teaching for the 726 teachers who taught in at least two contiguous years from 2003 to 2007. Panel C2 summarizes the transition data for graduate teaching for the 275 faculty who taught undergraduate students in at least two contiguous years from 2003 to 2007 (necessary to compute the change in expected commute days) and taught graduate students in at least one of the transition years. Panel C3 summarizes the research output data during the transition years. This includes the 771 teachers who taught undergraduate students in at least two contiguous years from 2003 to 2007 and produced at least one research paper during the transition.

Table 4 summarizes how various teaching variables evolve over time – the top panel for undergraduate teaching and the bottom for graduate. The aggregate "class hour" data in Column 11 of the top panel of Table 4 hint at the effect that our formal tests reveal. Prior to the transition "class hours" increase each year. They drop significantly in 2004 when the transition begins and again in 2007 when all four class levels have transitioned. At the same time, the bottom panel shows that graduate "class hours" increase dramatically in all of the transition years and remains high through 2009 (Column 7).[36]

Column 2 in the top panel of Table 4 shows that class-specific courses comprise a large and stable fraction of all classes over the sample period until 2009.[37] Three categories of courses are taught to more than one class level – "sports," "university," and "double degree" courses – which we classify as "other." "Sports" courses teach athletics and are offered to all class levels. "University" courses are open to all class levels and relate to culture or personal development. Courses are usually taught only to students within a major (corresponding to a university department) and only to a single class level. The exceptions to this, "double-degree" courses, are offered to students outside of the major. Since non-majors may take these courses at a different

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[34] The Research Support Office ranks Chinese journals as "A1," "A2," "B1," "B2", or "C" and English journals as "A," "B," or "C." "A1" and "A2" Chinese journals are the top general interest and field journals in China. English "A" journals are top general interest journals and "B" are top field journals. Since publishing papers in English is difficult, we designate Chinese "A1" and "A2" and English "A" and "B" journals as "top." All other journals we designate as "non-top."

[35] There are more teachers than in our teaching sample because some hold research-only positions, hold administrative positions, only supervise graduate students, or do not teach in any year for other reasons such as visiting abroad.

[36] The drop in 2009 may be due to the transition of some graduate students to the satellite campus by that time.

[37] The drop in 2009 occurs because the university re-classified some courses that were department-specific and offered separately to the four class levels as university-wide courses taught to the four class levels collectively.

class level they cannot be allocated to a single level. It is unnecessary to allocate "other" courses to a class level for our before-after estimation because all undergraduate courses were taught at the main campus before the transition and all at the new campus after. For our DD estimation we exclude "other" courses in our calculation of expected commute days because we cannot infer their location. This will understate expected commute days and bias against finding an effect.[38]

Table 5 shows the effect of commute time in the raw data. For all faculty teaching undergraduates present either before or after the transition (Panel A), annual "class hours" drop by 28.0 hours after the transition while annual teaching days drop by 26.5 and daily "class hours" increase by 0.9. The effects are similar in the sub-sample present both before and after the transition (Panel B). Panel C shows that annual "class hours" for graduate teaching increased by 1.5 after the transition for faculty involved in teaching graduate students either before or after the transition and by 19.4 in the subsample present in both (Panel D). For classes taught by faculty teaching undergraduates either before or after the transition, class sizes increase by 6.5 students after the transition (Panel E). Among faculty with at least one publication during the sample period, the total number of publications drops by 0.30 per year after the transition and non-top publications by 0.33 while the number of top publications increases by 0.03 (Panel F).

6. Results

Our results for undergraduate teaching confirm the theoretical predictions in Section 3. Annual teaching days decrease and daily "class hours" increase consistent with a longer commute imposing higher daily fixed costs. Although the effect on total work time could be positive or negative we find a decrease. Our preferred estimates indicate a decrease of 27.2 annual days, an increase of 0.49 daily "class hours" conditional on working that day, and a decrease of 56.3 annual "class hours" for undergraduate teaching. These estimates are internally consistent. Teachers worked 3.0 daily "class hours" before the transition so a decline of 27.2 work days implies decreased work time of 81.6 "class hours." Work days averaged 79.8 before the transition so an increase in daily "class hours" of 0.49 implies an increase of 39.1 annual "class hours." The net decrease is 42.5 "class hours" – close to our estimate of 56.3 fewer "class hours."

Since an undergraduate "class hour" lasts 50 minutes prior to the transition and 45 minutes after, these results understate the work time decrease by 10% if expressed in class minutes.[39] This extra decline should not necessarily be attributed to the increased commute time given the indivisibility of classes. Whether educational output is ten percent lower depends on whether that much less knowledge is conveyed per "class hour." The average teacher in our data would pay RMB 52 – 77 (USD 8.1 – 12.2)[40] to avoid one commute hour given their year 2011 hourly wage of RMB 90 (USD 14.2). Put differently, faculty on average dislike undergraduate teaching more

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[38] This could also bias our results if "other courses" were systematically taught by teachers with low or high commute-cost sensitivity and also systematically located at the original or satellite campus. We have no means to check for this possibility.

[39] Our DD results are affected by this only in 2007.

[40] The ranges of estimates allow for the uncertainty of commute time described earlier. Throughout the paper we use an exchange rate as of August 2012: 6.35 USD:RMB.

than commuting and would prefer 1.2 to 1.7 hours commuting to one hour teaching. This is consistent with greater dis-amenity from undergraduate teaching than commuting (Becker, 1965).

It is also possible that shirking increases as a substitute for leisure time lost to longer commutes.[41] Such effects are likely small in our setting given that teachers work in front of a class. It is also possible that the longer commute time increases absenteeism (Gutierrez-i-Puigarnau and van Ommeren, 2010b) but this is unlikely since teachers must make up any missed classes.

Annual Hours Worked – Undergraduate Teaching (Before-After Estimates): Table 6 shows the results of estimating Equation (8) with annual undergraduate "class hours" as the dependent variable. Column 1 includes teacher fixed effects to control for unobserved teacher preferences for working that are time-invariant, such as the quality of outside options, but no time controls $(g_i(t) = 0)$. Annual "class hours" decline by 33.3 due to the transition. Since this is only slightly larger than the 28.0 decline shown in the descriptive statistics in Table 5, teacher-specific unobservables have a small effect. Column 2 adds academic-year fixed effects to control for time-varying unobserved factors $(g_i(t) = \sum_t \rho_t \mathrm{I}_t)$ where I_t is a dummy variable set to one in year t and zero otherwise and ρ_t are coefficients to be estimated.[42] These include wages, faculty size, student enrollment, class size, and graduation requirements since these are fixed within an academic year. The omitted years are 2003 and 2007 so that the coefficient on D_t (the dummy variable for "after transition") captures the change in teaching time between these two years.

Annual "class hours" decline by 56.3 due to the transition – 22.6% of the average pre-transition "class hours" of 249.0. This is our preferred, or baseline, specification. Comparing to Column 1, academic-year unobservables have a large effect. Since a "class hour" fell from 50 minutes before the transition to 45 after this implies teaching minutes fell by 25.1%. Since new teachers hired after the transition announcement may be less sensitive to commute costs than those hired before, in Column 3 we include only teachers who taught in all ten years of our sample. The results from this balanced panel are lower but not statistically different. Incentives for faculty hired before the transition may have changed over time due to a change in faculty composition. To see if this is the case we interact the "after transition" variable with a dummy variable if the teacher was hired during or before 2000 (early cohort) versus from 2001 to 2003 (late cohort). The drop is larger for the early cohort but the difference is not statistically significant (Column 4). Excluding teachers with foreign Ph.D.'s whose contracts may differ from other faculty does not change the results appreciably (Column 5).

To see if the results are robust to a change in the time window, Column 6 estimates using only data from 2003 – immediately prior to the transition – and 2007 – immediately after – including teacher fixed effects. Since this includes only two years of data no time controls are included $(g_i(t) = 0)$. The results are very similar to the baseline. This implies that the short- and long-run effects of the commute time change

[41] Ross and Zenou (2008) find evidence for this among highly-supervised blue-collar workers.
[42] This is identical to a fully-saturated model with asymmetric time trends before and after the transition (*i.e.*, 3rd-order time trend before and 2nd-order time trend after).

are similar. An individual teacher's desire to work may change over time due to promotions, changes in research productivity, changes in negotiation power to schedule courses, changing financial conditions, or changes in the attractiveness of outside options. To accommodate time-varying individual characteristics we add an asymmetric, quadratic teacher-specific time trend to the balanced-panel regression ($g_i(t) = (1 - D_t)\sum_{l=1}^{2} \gamma_{il}^{B}(t - 2003)^l + D_t \sum_{l=1}^{2} \gamma_{il}^{A}(t - 2007)^l$ where γ_{il}^{B} and γ_{il}^{A} are vectors of parameters to be estimated). The results in Column 7 are similar to those for the balanced panel.

Table 7 shows robustness checks. Column 2 tests whether the reduction in the minimum teaching load during the transition from 240 "class hours" to 225 affects the results. It includes only teachers with more than 240 "class hours" (the pre-transition threshold) in all pre-transition years in which they taught. This subsample is less likely to be affected by the drop to the even lower post-transition threshold. Annual "class hours" declines by 76.6 which is above the estimate using the full sample (Column 1); however, the effects are similar in percentage terms – 22.6% versus 17.6% (the sub-sample averages 435.3 annual pre-transition "class hours"). Column 3 estimates using the subsample of teachers with more than 290 "class hours" in all pre-transition years in which they taught to make sure that the minimum threshold does not bind due to class indivisibilities (the average class pre-transition lasts about 43 "class hours"). The transition reduces "class hours" by 89.6 annually or 19.5% of the 458.7 annual pre-transition "class hours" for this subsample.

Teachers were paid more for larger classes on a sliding scale.[43] The increased commute time makes teaching larger classes more appealing after the transition relative to before. A larger class potentially entails more time than a smaller class (*e.g.*, grading and answering emails) but these tasks can be performed at the old campus. Therefore, teaching a larger class allows a teacher to spread the same commute time over a higher wage. We adjust "class hours" by the wage multiple to obtain "paid hours." For example, if a large class is paid at a 1.5 rate then one "class hour" is equal to 1.5 "paid hours." Column 4 estimates the effect of the transition on annual "paid hours." Consistent with a shift toward larger, higher-paying classes after the transition annual "paid hours" decreases by 38.5 (13.2%) compared to 56.3 (22.6%) for "class hours;" however, this effect may be overstated since class size is not unilaterally chosen by the teacher and the university moved toward larger classes in equilibrium.

Annual Days Worked – Undergraduate Teaching (Before-After Estimates): Table 8 shows the results of estimating Equation (8) with annual undergraduate teaching days as the dependent variable. The columns follow the format of Table 6 so we do not fully describe them again. We lose 27 teacher-year observations in these and the daily hour regressions because we do not observe day of week.[44] Our preferred, or baseline,

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[43] If a class size was below sixty then a teacher was paid the per-"class hour" wage. If a class size was between 60 and 120 the per-"class hour" wage was multiplied by (1 + (class size – 60)/100) so that each additional student increased the wage by 1%. If the class size exceeded 120 the per-"class hour" wage was multiplied by 1.6.

[44] The data only identifies weekend teaching days beginning in the second semester of 2005. Before this, we have no way of determining whether a missing value is due to the class being taught on a weekend or some other reason. To be conservative, we include weekend days taught as a work day after second semester 2005 but drop missing values both prior to and after this. This will bias us against finding a decrease in work days.

specification in Column 2 shows a drop of 27.2 days or 34.1% of the pre-transition 79.8 days. The results in the other columns are very similar.

Daily Hours Worked – Undergraduate Teaching (Before-After Estimates): Table 9 shows the results of estimating Equation (8) using average annual undergraduate daily "class hours" as the dependent variable. The average is conditional on teaching that day consistent with commute time being incurred only on days worked. Our baseline specification in Column 2 shows that daily hours increase by 0.49 due to the transition or 16.2% of the 3.0 pre-transition average. Since a "class hour" fell from 50 to 45 minutes after the transition this implies an increase of 14.5% class minutes due to the transition. The results in the other columns vary somewhat but they are not statistically different.

Transition (DD) Analysis – Undergraduate Teaching: Table 10 shows the results of estimating Equation (9) taking advantage of individual-level changes in commute time during the transition years. The top panel shows results for change in annual "class hours," the middle for annual days, and the bottom for daily "class hours" for undergraduate teaching. All models include teacher fixed effects. Column 1 in the top panel includes no time controls and shows that an increase of one additional expected commute day in a transition year decreases annual "class hours" by 0.60. Column 2 adds academic-year fixed effects (our preferred specification) increasing the estimate to -0.79. The remaining three columns show that this result is robust up to a third-order time trend.[45]

Since commute days increase by an average of 16.7 per transition year, our preferred specification implies a decrease of 13.2 annual "class hours" per transition year. Multiplying by the number of transition years (four) implies annual "class hours" are reduced by 52.7 from the full transition. This is similar to the before-after estimate of 56.3 suggesting that the DD bias toward zero is small or equivalently that it is difficult for faculty to substitute away from teaching class levels that transition earlier. These estimates indicate that teachers facing longer commutes reduce their work time more. This makes confounding factors unlikely – they must coincide with the transition and be correlated with individual-level commute times.

For annual days worked our preferred specification with academic-year fixed effects implies a decrease of 0.26 days per transition year for each additional expected commute day in a transition year. The estimate is somewhat larger than without controlling for time-specific unobservables and is robust to replacing academic-year dummies with a time trend. Grossing this up in the same way as for annual "class hours" implies a decrease of 17.7 days annually from the full transition. This is below our before-after estimate of 27.2 consistent with endogeneity bias toward zero.

The preferred specification in the bottom panel shows a decrease of 0.0023 daily "class hours" for each additional expected commute day in a transition year. These estimates are significant although less so than for the other two work time measures. Grossing up these changes over the full transition yields an increase of 0.16 daily "class hours." This is below our before-after estimate of 0.49 consistent with a

[45] Including higher-order time trends creates collinearities because the model is fully saturated.

downward bias. Overall, the DD results corroborate the before-after results and rule out confounding factors not correlated with teacher-specific commute time.

Role of Demographics – Undergraduate Teaching: Table 11 examines the role of faculty demographics in the response of annual undergraduate "class hours" to commute time. Column 1 allows for a differential effect of the transition by gender. The effect is nearly the same. This result contrasts with previous evidence that female work time is more sensitive to commute costs.[46] Column 2 controls for rank. Outside options to teaching may differ with position for several reasons. Titles are important in China and senior faculty has greater consulting opportunities. Graduate courses are usually taught by associate or full professors and full professors are the only faculty rank legally allowed to supervise Ph.D. theses. The baseline effects show no difference between assistant professors and associate professors but full professors teach less consistent with them having more alternatives. The transition has a negative and statistically significant effect on all faculty levels. Full professors respond somewhat more but the difference is not statistically significant.

It is possible that we find no significant difference between genders because a disproportionate fraction of senior faculty are male and the increased bargaining power that conveys offsets higher commute cost sensitivity among female faculty. Simply controlling for rank (Column 3) does not reveal this effect; however, interacting rank and gender (Column 4) provides weak evidence that male assistant professors respond less than female assistant professors.

Appendices D1 and D2 decompose the effects on annual days and daily "class hours" for undergraduate teaching by demographic groups. Faculty demographics play no significant role in the responsiveness of annual days worked to commute time. Whether controlling for rank or not, there is weak evidence that female faculty adjust daily "class hours" more than male faculty. Assistant and associate professors increase their daily "class hours" while full professors do not.

Possible University Responses: How did the university accommodate the decreased per-teacher work time? Teachers unilaterally control their work time which means that the university must accommodate the decreased teaching time by adjusting other margins. We cannot precisely answer this question but we offer some evidence based on the annual demand for and supply of undergraduate student-"class hours:"

(10a) $Demand = (Number\ of\ Students) * (Class\ Hours/Student)$,
(10b) $Supply = (Number\ of\ Teachers) * (Class\ Hours/Teacher) * (Class\ Size)$.

There are four possible margins of adjustment which are not mutually exclusive. The university could reduce demand for teaching time by: 1) admitting fewer students or 2) reducing the number of "class hours" required per student; or it could increase supply

[46] Blau and Kahn (2007) provide evidence of significant female labor supply changes from 1980 to 2000 but also conclude that female labor supply characteristics converge toward those of males. Black, Kolesnikova, and Taylor (2014) find that female work time is more sensitive to commute costs although they acknowledge that their results represent an equilibrium not structural relationship. White (1986) finds evidence that male and female commute times respond differently to income, home ownership, and presence of children.

by: 3) hiring more teachers or 4) increasing class sizes.[47] In Appendix E we approximate these margins of adjustment by taking differentials of Equations (10a) and (10b) and evaluating the changes using average values for 2003 (just before the transition) and 2007 (just after).

Demand for undergraduate teaching time increased by 2.83 million "class hours" annually between 2003 and 2007. A large increase in the student body increased demand by 3.32 million "class hours" which was offset by 0.49 million due to a decline in "class hours" taken per student. Such a large increase in demand implies that the university was likely encouraging faculty to teach more rather than applying pressure for them to teach less or effectively demoting them by reducing their teaching time and therefore wages.

Increasing the size of the faculty increased the supply of teaching time by 1.87 million student "class hours" annually. However, decreased work time per faculty member decreased aggregate supply by 1.42 million student "class hours" annually. Therefore, without accounting for class size changes, supply increased by 0.45 million student "class hours" annually and demand exceeded supply by 2.38 million. This excess was met primarily by a dramatic increase in class size. The university increased average class size 14.7 students per class between 2003 and 2007.

Graduate Teaching and Research Output: Since the ratio of the graduate teaching wage to the undergraduate teaching wage did not change over our sample period, our before-after estimation with teacher fixed effects identifies the substitution toward graduate teaching. Column 1 of Table 12 shows that graduate teaching increased by 26.8 "class hours" annually per teacher involved in graduate teaching controlling for teacher-specific and academic-year unobservables (our preferred specification). This is 25.5% of the average graduate "class hours" pre-transition. Graduate teaching increases by 26.8 "class hours" per teacher and 206 teachers are involved in graduate teaching pre-transition for a total increase of 5,514 "class hours" (8,271 "paid hours"). Undergraduate teaching fell by 56.3 "class hours" per teacher and 745 teachers are involved in undergraduate teaching pre-transition for a total decrease of 41,935 "class hours." Therefore, substitution toward graduate teaching represents about 13% of the decrease in undergraduate teaching time or 20% of the decrease in terms of "paid hours."

The data does not indicate whether a graduate class is co-taught. Column 2 re-estimates assuming that multiple observations with the same course name in the same semester taught by teachers in the same department comprise one co-taught class rather than multiple sections of a single course. The point estimate decreases to 17.1. Since this may over-count co-taught classes this is a lower bound and the estimate in Column 1 an upper bound. Since all Master's and approximately one third of Ph.D. students had transitioned to the satellite campus in 2009, Column 3 estimates dropping 2009 data. The results are similar to those in Column 1.[48]

[47] The number of teachers and students and "class hours" required per student are clearly determined by the university. Class size is less clear. Teachers indirectly influence class size through their teaching quality and class requirements; however, the equilibrium effects are determined university-wide.
[48] We also estimated dropping both 2008 and 2009 since Master's students had begun transitioning in 2008. The point estimate for the effect of the transition was 31.2 with a t-statistic of 3.8.

The top panel of Table 13 presents estimates from a DD specification using Equation (9) with change in graduate "class hours" as the dependent variable and expected commute days based on undergraduate teaching as the explanatory variable. Because few faculty teach both graduate and undergraduate courses in consecutive years there is little data. Although there is a positive and significant relationship between the change in graduate teaching and expected commute days without any controls (Column 1) the estimates are not significant with academic-year fixed effects (Columns 2 and 3).

We estimate the effect on annual research output using our before-after specification:

(13) $Y_{it} = \alpha_i + g_i(t) + \beta D_{t-1} + UT_{it-1} + GT_{it-1} + \varepsilon_{it};\ t \in \{01,02,03,08,09\}$,[49]

where Y_{it} is a measure of annual research output (total publications, top publications, and non-top publications), α_i is a teacher fixed effect controlling for individual research ability and interest, and $g_i(t)$ is a potentially teacher-specific function of academic years that captures time-specific unobserved factors affecting research output.

We control separately for undergraduate (UT_{it}) and graduate (GT_{it}) "class hours" taught by teacher i in year t. Faculty heavily involved in undergraduate teaching may have insufficient time to be active researchers. Graduate teaching time might either detract from research since it takes time or enhance research if there are sufficient synergies. We lag teaching hours by one year since we estimate it takes about one year to write and publish a paper in a Chinese journal and 96.5% of the publications in our sample appear in such journals. The research output data are available from 2001 to 2009. Since we must lag the transition dummy to reflect the time to publish we must drop the 2007 data.

Column 1 of Table 14 estimates the effect on annual total journal publications. A teacher is included in this sample if they taught at least one undergraduate or graduate course during the sample period regardless of whether they published any papers. Commuting appears to "crowd out" research. Journal publications drop by 0.59 or 58.3% of the pre-transition output. Column 2 estimates using the sub-sample of faculty actively engaged in research – those with at least one publication during the sample period. The effect is somewhat greater – a reduction of 0.64 annual papers. Column 3 shows similar effects using a Poisson model to allow for the discreteness of the publication data (the number of observations is lower because a Poisson with fixed effects drops teachers with a single observation or no publications in all years). The ratio of the incidence rate before and after the transition is 0.55. Given an average of 1.0 annual publication before the transition, this implies an annual decrease of 0.44 publications.

Column 4 shows the results for top journal publications for all faculty. Top journal publications increase slightly in absolute terms (0.03 annual publications) although this is a big effect relative to the small number prior to the transition (0.01). The effect

[49] Since we allow teaching time to affect research we would ideally estimate research output and teaching time jointly using a seemingly-unrelated regression (SUR); however, this does not allow us to include fixed effects in the estimation. SUR results are similar to our single-equation estimates without including fixed effects.

becomes insignificant when we restrict the sample to those teachers with non-zero publications (of any kind) suggesting that for those faculty actively engaged in research there is no significant change in top publication output. Columns 6 and 7 show estimates using non-top journal publications as the dependent variable. The results are similar to those for all publications consistent with most publications being outside the top journals.

We also estimate a DD specification based on first differences during the transition:

$$(14)\ \Delta Y_{it} = \delta_i + f(t) + \tilde{\beta}\left(\bigcup_{c\in Q} Tr_{t-1}^{c} CD_{it-2}^{c} - \bigcup_{c\in Q} Tr_{t-2}^{c} CD_{it-3}^{c}\right) + \Delta UT_{it-1} + \Delta GT_{it-1} + \Delta\varepsilon_{it};\ t \in \{05,06,07\},$$

where we have re-introduced a teacher-specific fixed effect to control for teacher-specific linear trends in unobserved factors affecting research output. This specification exploits individual variation in commute time to explain individual research output. Therefore, to bias the results any confounding factors must be correlated with commute time and research productivity at the individual level. The results are shown in the bottom panel of Table 13. The results for all and non-top journal publications are significant. Focusing on the results for all publications using academic-year fixed effects, each additional expected commute day reduces publications produced a year later by 0.0026 publications. The average expected change in commute days is 16.1 implying a marginal effect of -0.04 annual publications. Cumulatively over the four transition years this implies a decrease of 0.17 publications or 16.8% of the average number of publications pre-transition.

7. Conclusion

There is little evidence about the causal effect of commute costs on labor supply. The sparse results that do exist are subject to endogeneity, imprecise measures of commute costs, or lack of comparability in predicting out of sample. Subject to these caveats, previous results indicate small changes in labor supply from commute costs changes. In contrast, we find that increased commute time leads to a significant drop in undergraduate teaching time for a sample of university faculty. We estimate the commute distance elasticity of work time to be -0.10 which is more than ten times larger than previous estimates. We test for differential effects on work time by gender and faculty rank and find similar effects across groups.

Vis-à-vis the previous literature, our results suggest caution in concluding that work time is relatively unresponsive to commute costs. The significant effects that we find imply that evaluations of transport infrastructure investments and traffic congestion policies should consider labor supply as should evaluations of the relative efficacy of congestion and income taxes. It also means that shortening commutes can stimulate long-run labor supply and employment in cities. This is especially important for cities in attracting high human capital workers or knowledge workers. Previous work shows that firms must compensate workers who have longer commutes with higher wages (Timothy and Wheaton, 2001; Fu and Ross, 2013) thus suggesting an added benefit for a firm in shortening workers' commutes.

Our findings also have implications for the expansion of higher education via satellite campuses in China. Educational quality may suffer if reduced teaching time is accommodated by universities increasing class sizes and faculty reducing research output as we find. With fewer teaching days at a satellite campus and bigger classes, faculty-student interaction may be significantly reduced. This is consistent with previous work that teacher absence correlates with daily incentives to attend work (Kremer, *et al.*, 2005).

While our setting sacrifices generality – we examine only one type of "knowledge worker" – it ensures exogeneity of the policy and allows precise measurement of commute time and labor responses. Our infra-marginal estimates do not directly apply to the extensive margin for those with fixed work schedules, but the large effects that we obtain suggest the importance of studying this in a more controlled setting than previous studies afford. Since the disutility of commuting depends on the commute mode our results apply to commuting by shuttle bus. And since it is free we are only able to examine the effect of commute time and disutility and not monetary costs. Further studies are needed to estimate the effect under other transportation modes and the effect of monetary commute costs such as congestion tolls and parking fees.

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Table 1 Change in Fraction Freshman and Sophomore "Class Hours" across Academic Years

		2001	2002	2003	2004	2005	2006	2007	2008	2009
All Teachers										
Freshman	Mean	-0.0074	0.0047	-0.0221	-0.0232	0.0166	0.0199	-0.0269 *	-0.0061	0.0068
	St. Dev.	(0.0188)	(0.0184)	(0.0188)	(0.0179)	(0.0173)	(0.0163)	(0.0161)	(0.0147)	(0.0115)
	N	394	441	452	490	505	525	549	634	709
Sophomore	Mean	0.0080	-0.0085	0.0197	-0.0311	-0.0089	-0.0266	0.0265 *	0.0246 *	-0.0028
	St. Dev.	(0.0201)	(0.0183)	(0.0192)	(0.0191)	(0.0175)	(0.0166)	(0.0160)	(0.0140)	(0.0124)
	N	394	441	452	490	505	525	549	634	709
Excluding "Zeros"										
Freshman	Mean	-0.0131	0.0081	-0.0384	-0.0416	0.0290	0.0314	-0.0430 *	-0.0105	0.0129
	St. Dev.	(0.0331)	(0.0319)	(0.0326)	(0.0322)	(0.0301)	(0.0256)	(0.0258)	(0.0253)	(0.0218)
	N	224	255	260	273	290	333	343	369	375
Sophomore	Mean	0.0125	-0.0134	0.0297	-0.0482	-0.0155	-0.0484	0.0453 *	0.0408 *	-0.0048
	St. Dev.	(0.0315)	(0.0290)	(0.0289)	(0.0296)	(0.0308)	(0.0302)	(0.0273)	(0.0233)	(0.0207)
	N	251	278	300	316	288	289	321	382	424

Change in fraction of freshman or sophomore annual "class hours" from previous year. The top panel calculates changes for all teachers present in the two adjacent years. The bottom panel calculate changes excluding teachers who have zero values in both adjacent years.

Table 2 Estimates of Fraction Freshman and Sophomore "Class Hours"

	1	2	3	4
	Freshman		Sophomore	
	Full Sample	Pre-Transition	Full Sample	Pre-Transition
Constant	0.2633 ***	0.2874 ***	0.2700 ***	0.2717 ***
	(0.0163)	(0.0139)	(0.0168)	(0.0158)
Academic Year 2001	0.0087	-0.0001	0.0097	0.0088
	(0.0199)	(0.0217)	(0.0210)	(0.0233)
Academic Year 2002	0.0217	0.0112	-0.0027	-0.0053
	(0.0191)	(0.0204)	(0.0209)	(0.0230)
Academic Year 2003	0.0055	-0.0106	0.0125	0.0167
	(0.0211)	(0.0230)	(0.0221)	(0.0249)
Academic Year 2004	0.0022		-0.0304	
	(0.0209)		(0.0219)	
Academic Year 2005	0.0186		-0.0382 *	
	(0.0224)		(0.0222)	
Academic Year 2006	0.0397 *		-0.0726 ***	
	(0.0216)		(0.0213)	
Academic Year 2007	0.0132		-0.0482 **	
	(0.0225)		(0.0221)	
Academic Year 2008	0.0071		-0.0256	
	(0.0217)		(0.0223)	
Academic Year 2009	0.0074		-0.0304	
	(0.0221)		(0.0223)	
Teacher Fixed Effects	Yes	Yes	Yes	Yes
Number of Teachers	1,086	618	1,086	618
N	6,068	1,933	6,068	1,933
R^2	0.573	0.667	0.452	0.557

Dependent variable is teacher's annual freshman "class hours" as a fraction of total "class hours" in Columns 1 and 2, and teacher's annual sophomore "class hours" as a fraction of total "class hours" in Columns 3 and 4. Standard errors in parentheses. Standard errors allow for clustering by teacher and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Columns 1 and 3 include teachers present in at least one year from 2000 to 2009. Columns 2 and 4 include teachers present in at least one year between 2000 and 2003.

Table 3 Descriptive Statistics – "Before-After" and Transition Samples

Variable	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
PANEL A: Before and After Sample (2000 - 2003; 2007 - 2009)										
PANEL A1: Undergraduate Teaching; 1,057 Teachers						*PANEL A2: Present Both Before & After; 477 Teachers*				
"Class Hours" Per Year	4,226	233.81	169.68	2.00	1,088.00	2,770	256.20	167.64	2.00	1,088.00
Freshman "Class Hours" Per Year	4,226	76.40	135.48	0.00	1,008.00	2,770	82.59	139.97	0.00	1,008.00
Sophomore "Class Hours" Per Year	4,226	71.33	115.48	0.00	720.00	2,770	82.94	122.38	0.00	720.00
Junior "Class Hours" Per Year	4,226	48.53	74.01	0.00	656.00	2,770	54.58	79.53	0.00	656.00
Senior "Class Hours" Per Year	4,226	9.33	27.01	0.00	258.00	2,770	10.19	28.09	0.00	258.00
Days Taught Per Year[1]	4,199	65.49	38.68	3.00	196.00	2,765	72.43	38.96	3.00	196.00
"Class Hours" Per Day[1]	4,199	3.51	1.48	0.21	9.95	2,765	3.48	1.43	0.21	9.50
After Transition	4,226	0.543	0.498	0.000	1.000	2,770	0.442	0.497	0.000	1.000
Academic Year 2000	4,226	0.098	0.297	0.000	1.000	2,770	0.114	0.318	0.000	1.000
Academic Year 2001	4,226	0.115	0.318	0.000	1.000	2,770	0.136	0.343	0.000	1.000
Academic Year 2002	4,226	0.118	0.323	0.000	1.000	2,770	0.145	0.353	0.000	1.000
Academic Year 2003	4,226	0.127	0.333	0.000	1.000	2,770	0.162	0.369	0.000	1.000
Academic Year 2007	4,226	0.170	0.376	0.000	1.000	2,770	0.148	0.355	0.000	1.000
Academic Year 2008	4,226	0.190	0.392	0.000	1.000	2,770	0.149	0.356	0.000	1.000
Academic Year 2009	4,226	0.183	0.386	0.000	1.000	2,770	0.145	0.353	0.000	1.000
Male	4,226	0.600	0.490	0.000	1.000	2,770	0.572	0.495	0.000	1.000
Position - Assistant Professor	3,720	0.498	0.500	0.000	1.000	2,682	0.469	0.499	0.000	1.000
Position - Associate Professor	3,720	0.325	0.469	0.000	1.000	2,682	0.341	0.474	0.000	1.000
Position - Full Professor	3,720	0.177	0.381	0.000	1.000	2,682	0.189	0.392	0.000	1.000
Early Cohort	4,226	0.558	0.497	0.000	1.000	2,770	0.742	0.438	0.000	1.000
Late Cohort	4,226	0.189	0.391	0.000	1.000	2,770	0.258	0.438	0.000	1.000
Foreign PhD	4,226	0.029	0.167	0.000	1.000	2,770	0.003	0.050	0.000	1.000
"Paid Hours" Per Year	4,226	258.46	185.43	3.00	1,183.89	2,770	282.44	183.18	3.00	1,183.89
PANEL A3: Graduate Teaching; 520 Teachers						*PANEL A4: Present Both Before & After; 196 Teachers*				
"Class Hours" Per Year	1,856	105.82	73.33	3.00	696.00	1,055	120.10	80.42	18.00	696.00
PANEL B: Before and After Sample (2001 - 2003; 2008 - 2009)										
PANEL B1: Research Output; 1,036 Teachers						*PANEL B2: Present Both Before & After; 516 Teachers*				
Annual Publications	2,947	0.85	1.64	0.00	17.00	2,047	0.98	1.65	0.00	17.00
Annual Top Publications	2,947	0.03	0.18	0.00	4.00	2,047	0.02	0.15	0.00	2.00
Annual Non-Top Publications	2,947	0.83	1.59	0.00	16.00	2,047	0.95	1.61	0.00	16.00
PANEL C: Transition Sample (2004 - 2007)										
PANEL C1: Undergraduate Teaching; 726 Teachers										
Change in Expected Commute Days	2,034	16.70	37.69	-132.00	162.00					
Change in "Class Hours" Per Year	2,034	-6.50	148.65	-981.00	971.00					
Change in Days Taught Per Year	2,029	-5.70	36.19	-129.00	134.00					
Change in "Class Hours" Per Day	2,029	0.17	1.48	-6.20	6.55					
PANEL C2: Graduate Teaching; 275 Teachers										
Change in Expected Commute Days	674	6.96	64.85	-225.00	328.00					
Change in "Class Hours" Per Year	674	12.08	31.86	-105.00	156.00					
PANEL C3: Research Output: 771 Teachers										
Change in Lagged Expected Commute Days	1,795	16.10	34.71	-112.00	162.00					
Change in Annual Publications	1,795	-0.01	1.55	-9.00	10.00					
Change in Annual Top Publications	1,795	0.00	0.18	-2.00	3.00					
Change in Annual Non-Top Publications	1,795	-0.01	1.55	-9.00	10.00					

Panel A1 includes data for any faculty who teach at least one undergraduate class either before or after the transition. Panel A2 includes data for any faculty who teach at least one undergraduate class both before and after the transition. Panel A3 includes any faculty who teach at least one graduate class either before or after the transition. Panel A4 includes any faculty who teach at least one graduate class both before and after the transition. Panel B1 includes data for any faculty who taught at least one undergraduate or graduate course before or after the transition. Panel B2 inclues data for any faculty who taught at least one graduate or undergraduate course both before and after the transition. Panel C1 includes data for any faculty who teach undergraduates in at least two contiguous years from 2003 to 2007. Panel C2 includes data for any faculty who teach undergraduate students in at least two contiguous years from 2003 to 2007 and graduate students in at least one year. Panel C3 includes data for any faculty who teach undergraduates in at least two contiguous years from 2003 to 2007 and produced a research paper in at least one year. [1] Number of observations for days taught per year and hours worked per day is less than 4,227 because some class-year observations are missing day-of-week information.

Table 4 Student Enrollments, "Class Hours," Faculty Size, Classes and Class Size across Academic Years (2000 – 2009)

Undergraduate

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Class-Specific			Other[1]			Total									
Academic Year	# of Classes	% of Total Undergrad	"Class Hours" (1000s)	# of Classes	% of Total Undergrad	"Class Hours" (1000s)	# of Students	# of Teachers2	Student-Teacher Ratio	# of Classes	"Class Hours" (1000s)	"Class Hours" (millions)	"Class Hours" Per Student	Classes Per Student	"Class Hours" Per Class	Class Size
2000	1,448	85.2%	65.5	252	14.8%	6.9	7,370	664	11.1	1,700	72.5	5.76	781	0.23	42.6	62.8
2001	2,121	88.9%	92.8	265	11.1%	7.8	8,846	708	12.5	2,386	100.6	7.46	843	0.27	42.2	62.6
2002	2,140	87.8%	101.5	298	12.2%	10.0	10,415	718	14.5	2,438	111.6	7.80	749	0.23	45.8	61.8
2003	2,517	87.3%	119.0	366	12.7%	12.2	11,366	745	15.3	2,883	131.2	7.87	692	0.25	45.5	55.4
2004	2,310	85.3%	104.7	398	14.7%	13.5	12,506	804	15.6	2,708	118.1	8.15	652	0.22	43.6	60.4
2005	2,437	85.2%	102.5	423	14.8%	12.7	13,692	846	16.2	2,860	115.1	8.75	639	0.21	40.3	61.8
2006	2,793	82.0%	103.2	614	18.0%	13.9	14,893	884	16.8	3,407	117.1	10.90	732	0.23	34.4	67.9
2007	3,036	86.9%	88.5	457	13.1%	7.2	16,289	872	18.7	3,493	95.7	10.70	657	0.21	27.4	70.0
2008	3,471	86.2%	89.5	554	13.8%	8.4	16,201	914	17.7	4,025	97.8	11.90	735	0.25	24.3	67.5
2009	3,066	69.9%	80.9	1,323	30.1%	19.2	15,910	1,030	15.4	4,389	100.1	12.30	773	0.28	22.8	63.3

Graduate

	1	2	3	4	5	6	7	8	9
Academic Year	# Masters Students	# Ph.D. Students	Total # Students	# of Teachers3	Student-Teacher Ratio	# of Classes	"Class Hours" (1000s)	Classes Per Student	"Class Hours" Per Class
2000	408	83	491	168	2.9	359	16.0	0.73	44.5
2001	536	121	657	167	3.9	338	17.2	0.51	50.9
2002	674	135	809	176	4.6	353	18.5	0.44	52.4
2003	973	197	1,170	206	5.7	405	20.3	0.35	50.0
2004	1,225	205	1,430	245	5.8	550	28.8	0.38	52.4
2005	1,332	211	1,543	286	5.4	685	34.1	0.44	49.8
2006	1,501	222	1,723	335	5.1	843	38.8	0.49	46.1
2007	1,590	214	1,804	392	4.6	917	40.4	0.51	44.0
2008	1,710	221	1,931	430	4.5	966	43.2	0.50	44.7
2009	1,905	220	2,125	456	4.7	1,056	40.9	0.50	38.7

Data for all classes taught at the university. Data on number of students assumes no attrition in enrollment by students over time. Data on number of students from the university's Dean of Undergraduate Education office. Data on number of teachers from the university's Human Resources Department. Number of graduate students includes M.A., Ph.D., MBA, MPA, MPAcc. Some of these are not full-time students. [1] Other classes include university-wide, double degree, and sports classes as described in the text. [2] Total number of teachers regardless of whether involved in undergraduate or graduate teaching or not. [3] Number of teachers involved in teaching graduate classes.

Table 5 Changes in Work Time, Class Sizes, and Research Output in “Before-After” Samples (2000 – 2003; 2007 – 2009)

Variable	N	Mean	Std. Dev.	Change
A: Undergraduate Teaching; 1,057 Teachers				
"Class Hours" Per Year Before Transition	1,933	248.98	163.97	
"Class Hours" Per Year After Transition	2,293	221.02	173.36	-27.96
Days Taught Per Year Before Transition	1,930	79.82	41.20	
Days Taught Per Year After Transition	2,269	53.29	31.66	-26.53
"Class Hours" Per Day Before Transition[1]	1,930	3.02	1.17	
"Class Hours" Per Day After Transition[1]	2,269	3.92	1.59	0.90
"Paid Hours" Per Year Before Transition	1,933	269.37	173.66	
"Paid Hours" Per Year After Transition	2,293	249.26	194.37	-20.11
B: Undergraduate Teaching; Present Both Before & After; 477 Teachers				
"Class Hours" Per Year Before Transition	1,546	269.11	162.88	
"Class Hours" Per Year After Transition	1,224	239.90	172.16	-29.22
Days Taught Per Year Before Transition	1,543	84.30	40.46	
Days Taught Per Year After Transition	1,222	57.45	31.07	-26.85
"Class Hours" Per Day Before Transition[1]	1,543	3.13	1.15	
"Class Hours" Per Day After Transition[1]	1,222	3.92	1.62	0.79
"Paid Hours" Per Year Before Transition	1,546	290.92	172.92	
"Paid Hours" Per Year After Transition	1,224	271.73	194.91	-19.19
C: Graduate Teaching; 520 Teachers				
"Class Hours" Per Year Before Transition	686	104.87	67.74	
"Class Hours" Per Year After Transition	1,170	106.38	76.44	1.51
D: Graduate Teaching; Present Both Before & After; 196 Teachers				
"Class Hours" Per Year Before Transition	522	110.31	70.61	
"Class Hours" Per Year After Transition	533	129.68	88.01	19.37
E: Undergraduate Class-Level Data				
Class Size Before Transition	9,407	60.22	26.87	
Class Size After Transition	11,907	66.69	34.44	6.46
F: Research Output; 1,036 Teachers				
Annual Publications Before Transition	1,421	1.01	1.68	
Annual Publications After Transition	1,526	0.71	1.59	-0.30
Annual Top Publications Before Transition	1,421	0.01	0.10	
Annual Top Publications After Transition	1,526	0.04	0.24	0.03
Annual Non-Top Publications Before Transition	1,421	1.00	1.65	
Annual Non-Top Publications After Transition	1,526	0.67	1.52	-0.33

Table displays data for the "Before" and "After" samples (2000 - 2003; 2007 - 2009). Panel A includes any faculty who teach at least one undergraduate class either before or after the transition. Panel B includes any faculty who teach at least one undergraduate class both before and after the transition. Panel C includes any faculty who teach at least one graduate class either before or after the transition. Panel D includes any faculty who teach at least one graduate class both before and after the transition. Panel E includes all undergraduate classes. Panel F includes any faculty who produced at least one research paper either before or after the transition.

Table 6 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Annual "Class Hours"

	1	2	3	4	5	6	7
		Academic-Year Fixed Effects					Individual Asymmetric
	All Teachers All Years	All Teachers All Years	Balanced Panel	Early/Late Cohort	Domestic PhD Only	2003 & 2007 Data	Quadratic Time Trend
After Transition	-33.3031 ***	-56.2891 ***	-45.8316 ***		-55.8638 ***	-55.1727 ***	-44.1058 ***
	(5.1366)	(7.4871)	(11.1243)		(7.5049)	(10.7271)	(14.8927)
Early Cohort*After Transition				-59.6177 ***			
				(8.4054)			
Late Cohort*After Transition				-36.5746 ***			
				(10.4957)			
Teacher Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Teachers	1,057	1,057	192	618	1,007	868	192
Academic-Year Fixed Effects	No	Yes	Yes	Yes	Yes	No	No
N	4,226	4,226	1,344	3,157	4,105	1,255	1,344
R^2	0.687	0.691	0.609	0.646	0.688	0.852	0.881

Dependent variable is annual "class hours." Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Columns 1 and 2 include teachers present in at least one year either before or after the transition. Columns 3 and 7 include teachers present in all years before and after the transition. Column 4 includes only teachers who joined the university prior to 2004. Column 5 includes all faculty with a domestic Ph.D. present in at least one year either before or after the transition. Column 6 includes teachers present in academic years 2003 and 2007. Column 7 includes an asymmetric, quadratic time trend interacted with the teacher fixed effects.

Table 7 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Annual "Class Hours" – Robustness Checks

	1	2	3	4
	Full Sample	Above Pre-Transition Threshold	Above Pre-Transition Threshold + 50	"Paid Hours"
After Transition	-56.2891 ***	-76.5870 ***	-89.6046 ***	-38.5369 ***
	(7.4871)	(17.5639)	(20.2411)	(8.3929)
Teacher Fixed Effects	Yes	Yes	Yes	Yes
Number of Teachers	1,057	133	105	1,057
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes
N	4,226	726	576	4,226
R^2	0.691	0.415	0.403	0.675

Dependent variable in Columns 1 through 3 is annual "class hours" and in Column 4 is annual "paid hours." Columns 1 and 4 include teachers present in at least one year either before or after the transition while Columns 2 (3) include those with more than 240 (290) "class hours" in all pre-transition years in which they taught. Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 8 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Annual Days Worked

	1	2	3	4	5	6	7
		Academic-Year Fixed Effects					Individual Asymmetric
	All Teachers All Years	All Teachers All Years	Balanced Panel	Early/Late Cohort	Domestic PhD Only	2003 & 2007 Data	Quadratic Time Trend
After Transition	-26.6909 ***	-27.2424 ***	-28.9895 ***		-27.1863 ***	-28.9948 ***	-28.6326 ***
	(1.1393)	(1.8244)	(2.7675)		(1.8300)	(2.5580)	(3.5026)
Early Cohort*After Transition				-29.1834 ***			
				(2.0512)			
Late Cohort*After Transition				-22.9180 ***			
				(2.6586)			
Teacher Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Teachers	1,044	1,044	190	618	994	866	190
Academic-Year Fixed Effects	No	Yes	Yes	Yes	Yes	No	No
N	4,199	4,199	1,330	3,152	4,078	1,253	1,330
R^2	0.619	0.620	0.503	0.571	0.613	0.830	0.856

Dependent variable is annual days worked. Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Columns 1 and 2 include teachers present in at least one year either before or after the transition. Columns 3 and 7 include teachers present in all years before and after the transition. Column 4 includes only teachers who joined the university prior to 2004. Column 5 includes all faculty with a domestic Ph.D. present in at least one year either before or after the transition. Column 6 includes teachers present in academic years 2003 and 2007. Column 7 includes an asymmetric, quadratic time trend interacted with the teacher fixed effects.

Table 9 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Daily "Class Hours"

	1	2	3	4	5	6	7
		Academic-Year Fixed Effects					Individual Asymmetric
	All Teachers All Years	All Teachers All Years	Balanced Panel	Early/Late Cohort	Domestic PhD Only	2003 & 2007 Data	Quadratic Time Trend
After Transition	0.7292 ***	0.4880 ***	0.6971 ***		0.4872 ***	0.6033 ***	0.7145 ***
	(0.0492)	(0.0700)	(0.0995)		(0.0703)	(0.1027)	(0.1339)
Early Cohort*After Transition				0.4844 ***			
				(0.0826)			
Late Cohort*After Transition				0.7406 ***			
				(0.0950)			
Teacher Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Teachers	1,044	1,044	190	618	994	866	190
Academic-Year Fixed Effects	No	Yes	Yes	Yes	Yes	No	No
N	4,199	4,199	1,330	3,152	4,078	1,253	1,330
R^2	0.610	0.615	0.543	0.565	0.614	0.819	0.882

Dependent variable is daily "class hours" (conditional on working that day). Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Columns 1 and 2 include teachers present in at least one year either before or after the transition. Columns 3 and 7 include teachers present in all years before and after the transition. Column 4 includes only teachers who joined the university prior to 2004. Column 5 includes all faculty with a domestic Ph.D. present at least one year either before or after the transition. Column 6 includes teachers present in academic years 2003 and 2007. Column 7 includes an asymmetric, quadratic time trend interacted with the teacher fixed effects.

Table 10 Effect of Change in Expected Commute Days on Change in Annual "Class Hours," Annual Days, and Daily "Class Hours" during Campus Transition (2004 – 2007) – Teacher Fixed Effects Estimates

Annual "Class Hours" (# Teachers = 726, N = 2,034)

	1	2	3	4	5
Δ Commute Days	-0.5950 ***	-0.7887 ***	-0.7468 ***	-0.7926 ***	-0.7887 ***
	(0.1310)	(0.1347)	(0.1353)	(0.1349)	(0.1347)
Time Trend	None	None	1st	2nd	3rd
Academic-Year Fixed Effects	No	Yes	No	No	No
R^2	0.207	0.244	0.223	0.241	0.244
Prob > F (Time Trend)			0.000	0.000	0.000

Annual Days Worked (# Teachers = 713, N = 2,029)

	1	2	3	4	5
Δ Commute Days	-0.2131 ***	-0.2644 ***	-0.2580 ***	-0.2647 ***	-0.2644 ***
	(0.0314)	(0.0319)	(0.0320)	(0.0319)	(0.0319)
Time Trend	None	None	1st	2nd	3rd
Academic-Year Fixed Effects	No	Yes	No	No	No
R^2	0.231	0.260	0.254	0.260	0.260
Prob > F (Time Trend)			0.000	0.000	0.000

Daily "Class Hours" (# Teachers = 713, N = 2,029)

	1	2	3	4	5
Δ Commute Days	0.0021 *	0.0023 *	0.0026 **	0.0023 *	0.0023 *
	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Time Trend	None	None	1st	2nd	3rd
Academic-Year Fixed Effects	No	Yes	No	No	No
R^2	0.099	0.257	0.237	0.245	0.257
Prob > F (Time Trend)			0.079	0.000	0.000

Dependent variable is: change in annual "class hours" in top panel, change in annual days in middle panel, and change in daily "class hours" (conditional on teaching that day) in bottom panel. Standard errors in parentheses. Standard errors allow for clustering within teacher and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. All regressions include teacher fixed effects. The F-test is the p-value for the joint significance level of the time trend variables.

Table 11 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Annual "Class Hours" – Role of Demographics

	1	2	3	4
	Effect of Gender	Effect of Position	Gender Control for Position	Gender-Position Interaction
Female*After Transition	-54.9731 ***		-50.0566 ***	
	(9.4084)		(9.6589)	
Male*After Transition	-57.2788 ***		-54.0844 ***	
	(8.7954)		(8.9423)	
Associate Professor		-14.7333	-9.1247	-13.9897
		(11.8975)	(9.8206)	(11.9092)
Full Professor		-38.0405 **	-44.4406 ***	-39.7034 **
		(18.7641)	(16.7708)	(18.8679)
Assistant Professor*After Transition		-50.6185 ***		
		(9.9274)		
Associate Professor*After Transition		-45.7091 ***		
		(10.4218)		
Full Professor*After Transition		-65.9779 ***		
		(12.6728)		
Female Assistant Professor*After Transition				-65.1897 ***
				(13.3925)
Male Assistant Professor*After Transition				-35.2891 ***
				(12.6377)
Female Associate Professor*After Transition				-35.4075 ***
				(12.5259)
Male Associate Professor*After Transition				-53.0979 ***
				(12.6743)
Female Full Professor*After Transition				-49.5406 ***
				(17.7965)
Male Full Professor*After Transition				-71.2253 ***
				(13.8125)
Teacher Fixed Effects	Yes	Yes	Yes	Yes
Number of Teachers	1,057	839	839	839
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes
N	4,226	3,720	3,720	3,720
R^2	0.691	0.670	0.670	0.671

Dependent variable is annual "class hours." Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. All columns include teachers present in at least one year either before or after the transition. Number of observations for regressions involving position is lower due to missing values.

Table 12 "Before-After" Estimates (2000 – 2003; 2007 – 2009) of Effect of Campus Transition on Graduate Annual "Class Hours"

	1 Academic Year Dummies	2 Co-Teaching	3 Drop 2009
After Transition	26.7651 ***	17.1387 ***	28.2413 ***
	(6.6848)	(5.2513)	(7.0954)
Teacher Fixed Effects	Yes	Yes	Yes
Number of Teachers	520	520	517
Academic-Year Fixed Effects	Yes	Yes	Yes
N	1,856	1,856	1,472
R^2	0.584	0.592	0.591

Dependent variable is annual graduate "class hours." Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Regressions include faculty teaching at least one graduate class either before or after the transition.

Table 13 Effect of Change in Expected Commute Days on Change in Graduate Annual "Class Hours" and Faculty Research Output during Campus Transition (2004 – 2007)

Graduate "Class Hours" (2004 - 2007)

	1	2	3
Δ Commute Days	0.1260 *	0.0771	0.0227
	(0.0695)	(0.0702)	(0.1143)
Teacher Fixed Effects	No	No	Yes
Academic-Year Fixed Effects	No	Yes	Yes
N	674	674	674
R^2	0.071	0.035	0.272

Research Output (2005 - 2007)

	1	2	3	4	5	6
	Total Publications		Top Publications		Non-Top Publications	
Lagged Δ Commute Days	-0.0020 **	-0.0026 *	0.0000	0.0000	-0.0019 **	-0.0026 *
	(0.0009)	(0.0015)	(0.0001)	(0.0001)	(0.0009)	(0.0015)
Lagged Δ Undergraduate Teaching Hours	-0.0001	-0.0003	0.0000	0.0000	-0.0001	-0.0003
	(0.0002)	(0.0004)	(0.0000)	(0.0000)	(0.0002)	(0.0004)
Lagged Δ Graduate Teaching Hours	0.0000	-0.0004	-0.0002	-0.0002	0.0001	-0.0002
	(0.0010)	(0.0019)	(0.0002)	(0.0004)	(0.0010)	(0.0019)
Teacher Fixed Effects	No	Yes	No	Yes	No	Yes
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	1,795	1,795	1,795	1,795	1,795	1,795
R^2	0.003	0.214	0.004	0.074	0.004	0.213

Dependent variable is change in graduate annual "class hours" in top panel and change in annual research output in bottom panel. Standard errors in parentheses. Standard errors allow for clustering within teacher and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. All columns in top panel include any faculty who teach undergraduate students in at least two contiguous years and teach graduate students in at least one year. All columns in the bottom panel include any faculty who teach undergraduate students in at least two contiguous years and produce a research paper in at least one year.

Table 14 "Before-After" Estimates (2001 – 2003; 2008 – 2009) of Effect of Campus Transition on Faculty Research Output

	1	2	3	4	5	6	7
	All Journal Publications			Top Journal Publications		Non-'Top Journal Publications	
	Academic Year Dummies	Non- Zero Publications	Poisson Marginal Effects	Academic Year Dummies	Non- Zero Publications	Academic Year Dummies	Non- Zero Publications
After Transition	-0.5871 ***	-0.6400 ***	0.5542 ***	0.0279 **	-0.0009	-0.6150 ***	-0.6391 ***
	(0.0921)	(0.1226)	(0.0383)	(0.0125)	(0.0157)	(0.0912)	(0.1205)
Lagged Undergraduate Teaching Hours	-0.0003	-0.0005	0.9995 ***	0.0000	0.0000	-0.0003	-0.0005
	(0.0003)	(0.0004)	(0.0003)	(0.0000)	(0.0000)	(0.0003)	(0.0004)
Lagged Graduate Teaching Hours	-0.0005	-0.0004	0.9998 ***	-0.0001	-0.0002	-0.0004	-0.0003
	(0.0008)	(0.0009)	(0.0004)	(0.0001)	(0.0001)	(0.0008)	(0.0009)
Teacher Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Teachers	1,036	543	489	1,036	543	1,036	543
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,947	1,874	1,739	2,947	1,874	2,947	1,874
R^2	0.668	0.611		0.536	0.533	0.656	0.598
Log-Likelihood			-1494.0				

Dependent variable is total annual journal publications for each teacher in Columns 1 through 3, total annual top journal publiations for each teacher in Columns 4 and 5, and total annual non-top journal publications for each teacher in Columns 6 and 7. Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions except the Poisson model. Standard errors in the Poisson model are robust standard errors. * = 10% significance, ** = 5% significance, *** = 1% significance. Columns 1, 4, and 6 include any faculty who teach undergraduate students in at least one year either before or after the transition. Columns 2, 3, 5, and 7 include any faculty who teach undergraduate students in at least one year either before or after the transition and produce a research paper in at least one year. Number of observations in Column 3 are lower because teacher-year observations with zero papers are dropped.

Online Appendix A Theoretical Results

Effect of Commute Time on Annual Days Worked

This appendix follows Gutierrez-i-Puigarnau and van Ommeren (2009) with modifications for our setting as described in the main text. The effect of an increase in commute time on annual days worked can be determined by totally differentiating Equation (3) in the main text with respect to commute time allowing days and hours worked to vary

(A1) $$\frac{dD}{dt} = \frac{V_{LC}w^U DH + V_L - \frac{dH}{dT}D\left[V_{CC}\left(w^U\right)^2 H - V_{LC}\left(1+e'(H)+w^U\left(H+t+e(H)\right)\right) - V_{LL}\left(1+e'(H)\right)\left(H+t+e(H)\right)\right]}{V_{CC}\left(w^U H\right)^2 - 2V_{LC}w^U H\left(H+t+e(H)\right) + V_{LL}\left(H+t+e(H)\right)^2}.$$

This is negative since: Equation (5) in the main text shows that dH/dt is positive, the first term in the numerator is positive by concavity of the utility function, the term in brackets in the numerator is negative by concavity of the utility function and convexity of the effort function, and the denominator is negative by concavity of the utility function and convexity of the effort function.

Effect of Commute Time on Annual Hours Worked

The effect of an increase in commute time on annual hours worked is given by

(A2) $$\frac{d(DH)}{dt} = H\frac{dD}{dt} + D\frac{dH}{dt}.$$

Totally differentiating Equations (2) and (3) from the main text and allowing daily hours and days worked adjust to a change in commute time

(A3a) $$\frac{dH}{dt} = \frac{\begin{vmatrix} \frac{-\partial F_H}{\partial t} & \frac{\partial F_H}{\partial D} \\ \frac{-\partial F_D}{\partial t} & \frac{\partial F_D}{\partial D} \end{vmatrix}}{|Hessian|},$$

(A3b) $$\frac{dD}{dt} = \frac{\begin{vmatrix} \frac{\partial F_H}{\partial H} & \frac{-\partial F_H}{\partial t} \\ \frac{\partial F_D}{\partial H} & \frac{-\partial F_D}{\partial t} \end{vmatrix}}{|Hessian|}.$$

A local maximum requires that the Hessian be negative definite

(A4) $\frac{\partial F_H}{\partial H} < 0$, and

(A5) $|Hessian| = \frac{\partial F_H}{\partial H}\frac{\partial F_D}{\partial D} - \frac{\partial F_H}{\partial D}\frac{\partial F_D}{\partial H} > 0.$

Given Equations (A2) and (A5)

(A6) $$sign\left[\frac{d(DH)}{dt}\right] = sign\left[H\left(\frac{\partial F_D}{\partial H}\frac{\partial F_H}{\partial t} - \frac{\partial F_H}{\partial H}\frac{\partial F_D}{\partial t}\right) + D\left(\frac{\partial F_H}{\partial D}\frac{\partial F_D}{\partial t} - \frac{\partial F_D}{\partial D}\frac{\partial F_H}{\partial t}\right)\right],$$

where:

(A7a) $\partial F_H/\partial H = V_{CC}(w^U D)^2 - 2V_{LC}w^U D^2\left(1+e'(H)\right) + V_{LL}D^2\left(1+e'(H)\right)^2 - V_L De''(H),$

(A7b) $\partial F_D/\partial H = \partial F_H/\partial D = V_{CC}(w^U)^2 DH - V_{LC}w^U D\left[H\left(1+e'(H)\right) + \left(H+t+e(H)\right)\right] + V_{LL}D\left(1+e'(H)\right)\left(H+t+e(H)\right),$

(A7c) $\partial F_D/\partial D = V_{CC}(w^U H)^2 - 2V_{LC}w^U H\left(H+t+e(H)\right) + V_{LL}\left(H+t+e(H)\right)^2,$

and:

(A8a) $\partial F_H/\partial t = -V_{LC}w^U D^2 + V_{LL}D^2(1+e'(H))$,

(A8b) $\partial F_D/\partial t = -V_{LC}w^U DH + V_{LL}D(H+t+e(H)) - V_L$.

Case 1: To show that $d(DH)/dt$ can be negative consider $V_{LC} = 0$ and $V_{LL} \approx 0$ (close to zero). Then

(A9a) $\partial F_H/\partial H = V_{CC}(w^U D)^2 - V_L De''(H)$,

(A9b) $\partial F_D/\partial H = \partial F_H/\partial D = V_{CC}(w^U)^2 DH$

(A9c) $\partial F_D/\partial D = V_{CC}(w^U H)^2$,

and

(A10a) $\partial F_H/\partial t = 0$,

(A10b) $\partial F_D/\partial t = -V_L$.

In this case

(A11) $sign\left[\frac{d(DH)}{dt}\right] = sign[-V_L^2 DHe''(H)]$,

which is negative.

Case 2: To show that $d(DH)/dt$ can be positive consider $V_{LC} = 0$, $V_{CC} \approx 0$ (close to zero) and $e''(H) \approx 0$ (close to zero). Then

(A12a) $\partial F_H/\partial H = V_{LL}D^2(1+e'(H))^2$,

(A12b) $\partial F_D/\partial H = \partial F_H/\partial D = V_{LL}D(1+e'(H))(H+t+e(H))$,

(A12c) $\partial F_D/\partial D = V_{LL}(H+t+e(H))^2$,

and

(A13a) $\partial F_H/\partial t = V_{LL}D^2(1+e'(H))$,

(A13b) $\partial F_D/\partial t = V_{LL}D(H+t+e(H)) - V_L$.

In this case

(A14) $sign\left[\frac{d(DH)}{dt}\right] = sign[-V_{LL}V_L D^2(1+e'(H))(t+e(H)-He'(H))]$.

which is positive as long as long as effort does not increase too quickly: $e'(H) < \frac{t+e(H)}{H}$.

Online Appendix B Theoretical Models with Two Activities

A Model with Undergraduate Teaching and Research Time

We modify the model in Appendix A to consider two activities (undergraduate teaching and research) with only one of the activities (undergraduate teaching) affected by commute time. To keep the analysis manageable we collapse the choices of days and daily hours into a single choice of total hours for each activity. A teacher's annual utility after substituting out the budget and time constraints (Equation (1) in the main text) is now

(B1) $v = V\left(Y + F + B(T^R) + w^U T^U, \bar{T} - T^U(1+t) - T^R - e(T^U + \gamma T^R)\right)$,

where γ allows a research hour to affect effort differentially from a teaching hour. The two first-order conditions are now

(B2) $F_U \equiv \frac{\partial v}{\partial T^U} = V_C w^U - V_L\left(1 + t + e'(T^U + \gamma T^R)\right) = 0$, and
(B3) $F_R \equiv \frac{\partial v}{\partial T^R} = V_C B'(T^R) - V_L\left(1 + \gamma e'(T^U + \gamma T^R)\right) = 0$.

Equation (B2) says that the marginal utility of consumption from an extra hour of undergraduate teaching equals the foregone marginal utility of leisure including the effect of fatigue and commute time. Equation (B3) says that the marginal utility from an extra hour of research time equals the foregone utility of leisure including the effect of fatigue.

A local maximum requires that the Hessian be negative definite

(B4) $\frac{\partial F_U}{\partial T_U} < 0$, and
(B5) $|Hessian| = \frac{\partial F_U}{\partial T^U}\frac{\partial F_R}{\partial T^R} - \frac{\partial F_U}{\partial T^R}\frac{\partial F_R}{\partial T^U} > 0$.

Combining Equations (B2) and (B3) the optimally chosen work times fulfill

(B6) $\frac{w^U}{B'(T^R)} = \frac{1+t+e'(T^U+\gamma T^R)}{1+\gamma e'(T^U+\gamma T^R)}$.

The teacher equates the ratio of the marginal return to undergraduate teaching (the wage) and research (the marginal increase in annual bonus) to the ratio of the foregone marginal utility of leisure due to undergraduate teaching and research time. To see how time spent on undergraduate teaching and research depends on the commute time we apply the implicit function theorem and totally differentiate Equations (B2) and (B3) letting undergraduate teaching and research time adjust to a change in commute time

(B7a) $\frac{dT^U}{dt} = \frac{\begin{vmatrix} \frac{-\partial F_U}{\partial t} & \frac{\partial F_U}{\partial T^R} \\ \frac{-\partial F_R}{\partial t} & \frac{\partial F_R}{\partial T^R} \end{vmatrix}}{|Hessian|}$,
(B7b) $\frac{dT^R}{dt} = \frac{\begin{vmatrix} \frac{\partial F_U}{\partial T^U} & \frac{-\partial F_U}{\partial t} \\ \frac{\partial F_R}{\partial T^U} & \frac{-\partial F_R}{\partial t} \end{vmatrix}}{|Hessian|}$.

Now

(B8a) $\frac{\partial F_U}{\partial t} = -V_{CL}T^U w^U + V_{LL}T^U[1 + t + e'(T^U + \gamma T^R)] - V_L < 0$,
(B8b) $\frac{\partial F_R}{\partial t} = -V_{CL}T^U B'(T^R) + V_{LL}T^U[1 + \gamma e'(T^U + \gamma T^R)] < 0$.

And

(B9a) $\frac{\partial F_U}{\partial T^U} = V_{CC}(w^U)^2 - 2V_{LC}w^U[1 + t + e'] + V_{LL}[1 + t + e']^2 - V_L e'' < 0$,
(B9b) $\frac{\partial F_R}{\partial T^R} = V_{CC}(B')^2 - 2V_{LC}B'[1 + \gamma e'] + V_{LL}[1 + \gamma e']^2 + V_C B'' - V_L \gamma^2 e'' < 0$,

(B9c) $\frac{\partial F_U}{\partial T^R} = \frac{\partial F_R}{\partial T^U} = V_{CC}w^U B' - V_{LC}B'[1+t+e'] - V_{LC}w^U[1+\gamma e'] + V_{LL}[1+\gamma e'][1+t+e'] - V_L\gamma e'' < 0,$

where we suppress the arguments of e and B for clarity. We now consider two cases of the model to illustrate that even though undergraduate teaching time decreases in commute time it is possible for research time to either increase (Case 1) or decrease (Case 1) depending on the relative effect of research and undergraduate teaching time on effort (*i.e.*, the magnitude of γ).

Case 1: Suppose $V_{CL} = 0$, $V_{CC} \approx 0$ (close to zero), $B''(T^R) = 0$, and $\gamma > 1$ then

(B10a) $\frac{\partial F_U}{\partial t} \approx V_{LL}T^U\left(1+t+e'(T^U+\gamma T^R)\right) - V_L,$
(B10b) $\frac{\partial F_R}{\partial t} \approx V_{LL}T^U\left(1+\gamma e'(T^U)\right).$

And

(B11a) $\frac{\partial F_U}{\partial T^U} \approx V_{LL}\left(1+t+e'(T^U+\gamma T^R)\right)^2 - V_L e''(T^U+\gamma T^R),$
(B11b) $\frac{\partial F_R}{\partial T^R} \approx V_{LL}\left(1+\gamma e'(T^U+\gamma T^R)\right)^2 - V_L\gamma^2 e''(T^U+\gamma T^R),$
(B11c) $\frac{\partial F_R}{\partial T^U} = \frac{\partial F_U}{\partial T^R} \approx V_{LL}\left(1+\gamma e'(T^U+\gamma T^R)\right)\left(1+t+e'(T^U+\gamma T^R)\right) - V_L\gamma e''(T^U+\gamma T^R).$

It can be verified that parameter values exist for which the second-order condition is met. Now

(B12a) $\frac{dT^U}{dt} \approx \frac{V_L V_{LL} T^U \gamma e''(T^U+\gamma T^R)(\gamma-1+\gamma t) + V_L V_{LL}\left(1+\gamma e'(T^U+\gamma T^R)\right)^2 - (V_L)^2\gamma^2 e''(T^U+\gamma T^R)}{|Hessian|} < 0,$
(B12b) $\frac{dT^R}{dt} \approx \frac{V_L V_{LL} T^U e''(T^U+\gamma T^R)(1-\gamma-\gamma t) - V_L V_{LL}\left(1+\gamma e'(T^U+\gamma T^R)\right)\left(1+t+e'(T^U+\gamma T^R)\right) + (V^L)^2\gamma e''(T^U+\gamma T^R)}{|Hessian|} > 0.$

The second and third terms in the numerator of Equation (B12a) are negative. Given that $\gamma > 1$ the first term in the numerator is also negative and undergraduate teaching time decreases with commute time. The second and third terms in the numerator of Equation (B12b) are positive. Given that $\gamma > 1$ the first term in the numerator is also positive and research time increases in commute time. Therefore, undergraduate teaching time decreases with commute time, while research time increases with commute time. Relatively little time is spent on research because research effort costs are high and highly convex ($\gamma > 1$). This implies a relatively large amount of leisure time. Therefore, as commute time causes the teacher to scale back undergraduate teaching time some of this is replaced with research time.

Case 2: Suppose $V_{CL} = 0$, $V_{CC} \approx 0$ (close to zero), $B''(T^R) = 0$, and $\gamma \approx 0$ (close to zero) then

(B13a) $\frac{\partial F_U}{\partial t} \approx V_{LL}T^U\left(1+t+e'(T^U)\right) - V_L,$
(B13b) $\frac{\partial F_R}{\partial t} \approx V_{LL}T^U.$

And

(B14a) $\frac{\partial F_U}{\partial T^U} \approx V_{LL}\left(1+t+e'(T^U)\right)^2 - V_L e''(T^U),$
(B14b) $\frac{\partial F_R}{\partial T^R} \approx V_{LL},$
(B14c) $\frac{\partial F_R}{\partial T^U} = \frac{\partial F_U}{\partial T^R} \approx V_{LL}\left(1+t+e'(T^U)\right).$

It can be verified that the second-order condition is met for all parameter values. Now

(B15a) $\frac{dT^U}{dt} \approx \frac{V_L V_{LL}}{|Hessian|} < 0,$

(B15b) $\frac{dT^R}{dt} \approx \frac{V_L V_{LL}\left(T^U e''(T^U)-1-t-e'(T^U)\right)}{|Hessian|}$.

If $e''(T^U)$ is sufficiently large relative to t/T^U and $e'(T^U)/T^U$ then research time decreases with commute time. In this case, undergraduate teaching time and research time both decrease with commute time. Significant time is spent on research because research effort costs are low and increase slowly ($\gamma \approx 0$). This implies a relatively small amount of available leisure time. Therefore, as commute time increases the leisure time of the teacher is further squeezed. Since the marginal returns to research are so low it is optimal to free up leisure time by decreasing research time.

A Model with Undergraduate and Graduate Teaching Time

A model with undergraduate and graduate teaching time is isomorphic to a model with undergraduate teaching and research time. This can be seen by making the following substitutions in the above model

$T^R = T^G$ and
$B(T^G) = w^G T^G$;

where T^G is the time spent on graduate teaching, w^G is the wage for graduate teaching, and γ now allows for different levels of effort for graduate relative to undergraduate teaching. Note that we have eliminated the dependence of the annual salary on research output.

Since $B'(T^G) = w^G > 0$ and $B''(T^G) = 0 \leq 0$ the results from the model above all follow. Also since $w^G = 1.5w^U$, Equation (B6) implies

(B16) $\gamma = 1.5 + \frac{0.5+1.5t}{e'(T^U+\gamma T^G)} > 1.5$.

Therefore this corresponds to Case 1 above and undergraduate teaching declines in commute time while graduate teaching increases as we find empirically.

Online Appendix C Error Structure of Estimating Equations

Appendix C1 Error Structure of Before-After Estimates

The error structure of Equation (8) in the main text is:

(C1a) $E[\varepsilon_{it}|D_t] = 0$
(C1b) $E[\varepsilon_{it}^2|D_t] = D_t(\overline{CD}^{To})^2\sigma_\beta^2 + \sigma_\varepsilon^2$
(C1c) $E[\varepsilon_{it}\varepsilon_{is}|D_t, D_s] = [1 + D_t D_s((\overline{CD}^{To})^2 - 1)]\sigma_\beta^2$, $t \neq s$
(C1d) $E\left[\varepsilon_{it}\varepsilon_{js}|D_t, D_s\right] = 0, i \neq j, \forall s, t$

Appendix C2 Error Structure of DD Estimates

The error structure of Equation (9) in the main text is:

(C2a) $E\left[\Delta\ \varepsilon_{it}|CD_{it-1}^c, CD_{it-2}^c\right] = 0,$
(C2b) $E\left[\Delta\ \varepsilon_{it}^2|CD_{it-1}^c, CD_{it-2}^c\right] = \left(\bigcup_{c\in Q} Tr_t^c CD_{it-1}^c - \bigcup_{c\in Q} Tr_{t-1}^c CD_{it-2}^c\right)^2\sigma_\beta^2 + 2\sigma_\varepsilon^2$
(C2c) $E\left[\Delta\ \varepsilon_{it}\Delta\ \varepsilon_{is}|CD_{it-1}^c, CD_{it-2}^c, CD_{is-1}^c, CD_{is-2}^c\right] =$
$\left(\bigcup_{c\in Q} Tr_t^c CD_{it-1}^c - \bigcup_{c\in Q} Tr_{t-1}^c CD_{it-2}^c\right)\left(\bigcup_{c\in Q} Tr_s^c CD_{is-1}^c - \bigcup_{c\in Q} Tr_{s-1}^c CD_{is-2}^c\right)\sigma_\beta^2$, $t \neq s$
(C2d) $E\left[\Delta\ \varepsilon_{it}\Delta\ \varepsilon_{js}|CD_{it-1}^c, CD_{it-2}^c, CD_{js-1}^c, CD_{js-2}^c\right] = 0, i \neq j, \forall s, t,$

Online Appendix D Empirical Robustness Checks

Appendix D1 "Before-After" Estimates of Effect of Campus Transition on Annual Days Worked – Role of Demographics (2000 – 2003; 2007 – 2009)

	1	2	3	4
	Effect of Gender	Effect of Position	Gender Control for Position	Gender-Position Interaction
Female*After Transition	-28.8980 ***		-28.9100 ***	
	(2.2101)		(2.2413)	
Male*After Transition	-25.9972 ***		-26.3763 ***	
	(2.0894)		(2.1482)	
Associate Professor		-0.9234	-2.8832	-0.8941
		(3.2419)	(2.2568)	(3.2397)
Full Professor		-7.4856	-5.7506	-7.1937
		(4.8043)	(3.9605)	(4.8339)
Assistant Professor*After Transition		-27.8866 ***		
		(2.3245)		
Associate Professor*After Transition		-29.7590 ***		
		(2.7585)		
Full Professor*After Transition		-23.2384 ***		
		(3.2335)		
Female Assistant Professor*After Transition				-28.7189 ***
				(2.8613)
Male Assistant Professor*After Transition				-26.9747 ***
				(3.1026)
Female Associate Professor*After Transition				-31.0173 ***
				(3.0636)
Male Associate Professor*After Transition				-28.8414 ***
				(3.2060)
Female Full Professor*After Transition				-25.0076 ***
				(4.8352)
Male Full Professor*After Transition				-22.6948 ***
				(3.3519)
Teacher Fixed Effects	Yes	Yes	Yes	Yes
Number of Teachers	1,044	837	837	837
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes
N	4,199	3,711	3,711	3,711
R^2	0.620	0.583	0.583	0.584

Dependent variable is annual days worked. Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Number of observations for regressions involving position lower due to missing values. All regressions include teacher fixed effects and academic-year fixed effects.

Appendix D2 "Before-After" Estimates of Effect of Campus Transition on Daily "Class Hours" – Role of Demographics (2000 – 2003; 2007 – 2009)

	1	2	3	4
	Effect of Gender	Effect of Position	Gender Control for Position	Gender-Position Interaction
Female*After Transition	0.6351 ***		0.7158 ***	
	(0.0891)		(0.0899)	
Male*After Transition	0.3773 ***		0.4495 ***	
	(0.0823)		(0.0850)	
Associate Professor		-0.0111	0.1284	-0.0037
		(0.1168)	(0.0903)	(0.1147)
Full Professor		-0.0242	-0.2952 *	-0.0805
		(0.1891)	(0.1655)	(0.1821)
Assistant Professor*After Transition		0.6601 ***		
		(0.0903)		
Associate Professor*After Transition		0.7383 ***		
		(0.1136)		
Full Professor*After Transition		0.0835		
		(0.1257)		
Female Assistant Professor*After Transition				0.5581 ***
				(0.1212)
Male Assistant Professor*After Transition				0.7654 ***
				(0.1192)
Female Associate Professor*After Transition				0.9292 ***
				(0.1346)
Male Associate Professor*After Transition				0.6003 ***
				(0.1300)
Female Full Professor*After Transition				0.5225 ***
				(0.1855)
Male Full Professor*After Transition				-0.0562
				(0.1337)
Teacher Fixed Effects	Yes	Yes	Yes	Yes
Number of Teachers	1,044	837	837	837
Academic-Year Fixed Effects	Yes	Yes	Yes	Yes
N	4,199	3,711	3,711	3,711
R^2	0.616	0.598	0.596	0.601

Dependent variable is daily "class hours" (conditional on teaching that day). Standard errors in parentheses. Standard errors allow for clustering within teacher-transition cell and general heteroskedasticity in all regressions. * = 10% significance, ** = 5% significance, *** = 1% significance. Number of observations for regressions involving position lower due to missing values. All regressions include teacher fixed effects and academic-year fixed effects.

Online Appendix E Quantifying University's Response to Decreased Work Time

Taking differentials of the supply and demand of undergraduate "class hours" (Equations (10a) and (10b) in the main text):

(E1a) $\Delta\, Demand = \Delta\,(Number\ of\ Students) * \overline{(Class\ Hours/Student)} + \overline{(Number\ of\ Students)} * \Delta\,(Class\ Hours/Student),$

(E1b) $\Delta\, Supply = \Delta\,(Number\ of\ Teachers) * \overline{(Class\ Hours/Teacher)} * \overline{(Class\ Size)} + \overline{(Number\ of\ Teachers)} * \Delta\,(Class\ Hours/Teacher) * \overline{(Class\ Size)} + \overline{(Number\ of\ Teachers} * \overline{(Class\ Hours/Teacher)} * \Delta\,(Class\ Size),$

where bars indicate average values between 2003 and 2007. We can approximate the adjustment margins on the demand side using Equation (E1a) and the data in Table 4. The number of students increased 4,923 between 2003 and 2007.[1] Multiplying by the average "class hours" per student implies annual demand for teaching time increased by 3.32 million "class hours." "Class hours" per student declined from 692 in 2003 to 657 in 2007. Multiplying by the average number of students, demand decreased by 0.49 million student "class hours" annually. The net increase in demand between 2003 and 2007 was therefore 2.83 million "class hours" annually.

We can similarly approximate the adjustment margins on the supply side using Equation (E1b), the data in Table 4, and the "class hours" per year per teacher data in Table 5 (for consistency we use the raw data rather than our estimates). The number of teachers increases 127 between 2003 and 2007. Multiplying by the average "class hours" per teacher and average class size, this increased annual supply of teaching time by 1.87 million student "class hours." "Class hours" taught per faculty member declined by 28.0 hours per year. This decreased supply by 1.42 million student "class hours" annually given the average number of teachers and class size. Therefore, without accounting for class size changes, supply increased by 0.45 million student "class hours" annually and demand exceeded supply by 2.38 million. This excess was met primarily by a dramatic increase in class size. The university increased average class size 14.7 students per class between 2003 and 2007. This increased supply by 2.78 million student "class hours" annually given the average number of teachers and "class hours" taught per teacher.[2]

[1] Table 4 assumes that student attrition rates are zero. While we do not have annual attrition data, it appears to be quite low. For example, 2,598 students were admitted in academic year 2000 and 2,586 graduated four years later implying an attrition rate of 0.5%. Similarly, 2,750 students were admitted in academic year 2001 and 2,718 graduated four years later implying an attrition rate of 1.2%.

[2] This is 0.41 million student "class hours" higher than the shortfall because the differentials involve large changes and we approximate the change point by the average value before versus after the change.