Welfare Effects of Changes in College Pricing*

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Abstract

A large body of research studies effects of grant aid and other changes in college prices. This research tends to focus on enrollment and attainment effects, estimates price elasticities, and assesses whether grants have intended effects. Reducing college prices requires public expenditures, however, and thus grant aid could reduce welfare even if it also achieves some degree of the intended effects. We present a theoretical model showing that welfare effects of changes in college prices depend on (1) externalities from recipients' behavioral responses and (2) facilitation of intertemporal consumption smoothing. We show that the first factor varies considerably across grant programs, and we use consumption data to calibrate the second factor for students of multiple income levels. Application to empirical results from a variety of U.S. settings shows that welfare effects are mixed but generally appear to be positive for programs that target students from families with low incomes. *JEL codes: H21, H52, I22, D14, D15.*

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1 Introduction

The price of higher education varies substantially across students, geography, and sectors. Colleges vary in their posted "sticker price" and use institutional resources to price discriminate at the student-level by offering discounts in the form of scholarships. Federal and state governments provide grants to encourage college attendance and completion. In recent years, such grant programs provided around $40 billion in aid across the United States (Baum et al. 2016). While many studies examine how grants and other changes to the price of college affect student educational outcomes, such effects are not sufficient for determining whether reducing higher education prices raises social welfare. Welfare analysis requires accounting for the full cost and benefit of a program or reform, including its effects on students' well-being and on externality-producing educational choices.

We evaluate the welfare implications of changes in grant aid through a theoretical model that allows for a general set of choice variables and potential constraints, including credit constraints. Our model generates sufficient statistics for the welfare effect of changes in grant generosity, and more generally, changes in the price of a set of colleges. Welfare effects depend on the net externalities generated by behavioral responses to grant aid and the direct welfare gains when grants reduce consumption-smoothing frictions. Estimated fiscal externalities provide a lower bound for net externalities if non-fiscal externalities are positive on net.[1] A simple ratio of marginal utilities fully captures direct welfare effects, regardless of the source of consumption-smoothing frictions. Using consumption data to estimate this ratio suggests that for common choices of utility parameters, a $1 transfer from unconstrained post-college years to college years would generate positive welfare gains of over $0.50 for the average college student. Direct benefits for low-income students are at least 30 percent larger.

We follow the "sufficient statistics" approach described by Chetty (2009), focusing on a small change in grant aid in order to derive welfare implications under relatively weak assumptions. Potential students make discrete choices over whether to enroll, in which college, and at what intensity. These choices may vary with both the size of current subsidies and the extent to which subsidies are affected by the reform under scrutiny. Thus, the model allows grants to affect a variety of intermediate outcomes, e.g. reducing borrowing (Goldrick-Rab et al. 2016; Marx and Turner 2018) and in-school labor supply (Denning forthcoming; Park and Scott-Clayton 2018), crowding out other sources of grant aid (Turner 2017; Bettinger and Williams 2015), and altering choice of institution (Cohodes and Goodman 2014). Such effects have first-order welfare implications if they alter the amount of taxes paid or educational subsidies received by students.

[1] Oreopoulos and Salvanes (2011) discuss evidence for positive, non pecuniary benefits of schooling which supports the assumption that fiscal externalities are a lower bound.

In our model, constraints are of a general form that allows for lack of information, market-imposed credit limits, or self-imposed constraints. This generality is useful when studying higher education, as past empirical research on traditional credit constraints is mixed (e.g., Lochner and Monge-Naranjo 2012), and recent studies provide evidence of less-commonly-modeled barriers, such as transaction costs and debt aversion (Boatman et al. 2017; Marx and Turner 2018; Marx and Turner forthcoming). The ratio of marginal utilities within and after college is a sufficient statistic for the direct welfare effects of grant aid, and thus it is not necessary to know the underlying cause of any failures to smooth consumption. We use the Consumer Expenditure Survey (CEX) to estimate the relevant ratio of marginal utilities for several values of the real discount rate and the degree of relative risk aversion. On average, recent college attendees consume more than current college students, implying that direct welfare gains should be considered in other settings and may be pivotal in those where grants generate smaller (or negative) net externalities. We present estimated upper and lower bounds of direct welfare effects for high-, average-, and low-income populations to facilitate application to other settings. As an illustration, we apply these direct effects and our welfare formula to effects of federal and state grant aid estimated by Marx and Turner (2018), Denning et al. (forthcoming), and Bettinger et al. (2016). Estimated welfare gains are largest when grant aid targets low-income students.

Numerous papers that examine the effect of higher education subsidies also consider costs and benefits from the government's perspective.[2] We build upon this literature by considering social welfare effects. Dynamic public finance papers calculate optimal education subsidies accounting for the same types of direct and indirect welfare effects that come out of our model (Findeisen and Sachs 2016; Lawson 2017; Stantcheva forthcoming). This literature focuses on the tax effects of the enrollment decision, a margin that is unaffected by changes in grants in many empirical settings, and we show that other margins and other fiscal externalities can determine whether any particular education subsidy enhances welfare. Our approach shows how a small number of statistics can be used to infer the welfare effect of a policy change in an area of major government expenditure, similar to applications in health insurance markets (Einav et al. 2010) and place-based subsidies (Busso et al. 2013).

[2] As examples, Dynarski et al. (2013) discuss the cost-effectiveness of initiatives intended to increase college graduation and Hoxby and Turner (2013) compare cost-benefit ratios across interventions designed to increase college-going and/or the college quality. Relatedly, Hoxby (forthcoming) quantifies the relative average productivity of institutions by selectivity, where productivity is measured by the average private (earnings) and social gains (public service and innovation) per dollar of social expenditures.

2 Theoretical Framework

In this section, we present a general model and derive sufficient statistics for the welfare implications of changes in the price of schooling. While our model is similar conceptually to that of Chetty (2006a), it differs in key aspects that make it relevant for analyzing the welfare implications of changes in financial aid and higher education pricing. In particular, we generalize from a constant unemployment insurance benefit to a nonlinear college pricing scheme, introduce student choices over which college (if any) to attend, and allow for multiple forms of externalities. The generality of the model allows for application to a variety of policies that alter college prices.[3]

2.1 The individual's problem

An individual lives for up to $T+1$ periods, indexed by $t \in \{0, 1, ..., T\}$. In each period, she chooses consumption $c_t \geq 0$, a vector $\mathbf{s_t}$ of schooling investments $s_t^k \geq 0$ at colleges $k \in \{1, 2, ..., K\}$, and a length-X vector $\mathbf{x_t}$ of other choices. For example, schooling investment might be denominated in credits attempted and other choices could include the amount of leisure to consume and the number of hours to study or to work. Each college k charges tuition and fees η_t^{km} when schooling investment s_t^k falls within a range μ^{km}, of which there are $M^k \geq 1$. This structure accounts for the fact that many postsecondary institutions have flat pricing within a set range of credits attempted (e.g., 0-6, 6-12, 12 or more) and that some grant programs adjust aid for recipients' courseloads. Heterogeneous individuals i have continuously distributed characteristics; to reduce notation, we omit i subscripts. Choices are made for each value of a state variable ω_t that evolves according to an arbitrary stochastic process and may govern factors such as wages and schooling costs. Expectations $E[\cdot]$ are taken with respect to this state variable (and over individuals in the government's problem). Let $\mathbf{c} = \{c_t(\omega_t)\}_{0 \leq t \leq T}$, $\mathbf{s} = \{\mathbf{s_t}(\omega_t)\}_{0 \leq t \leq T}$, and $\mathbf{x} = \{\mathbf{x_t}(\omega_t)\}_{0 \leq t \leq T}$ denote an individual's full set of state-contingent choices.

The individual chooses consumption, schooling, and any other choices represented by $\mathbf{x_t}$ (e.g., labor supply) to maximizes expected utility $u_t(c_t, \mathbf{s_t}, \mathbf{x_t})$, subject to several constraints. Each period's utility function reflects the individual's preferences and information set at time t, is strictly quasi-concave, and we assume standard Inada conditions with respect to consumption to ensure an interior solution. Though not all price changes have been found to affect enrollment, the model allows any and all components of $\mathbf{s}$ and $\mathbf{x}$ to take the value of zero; an individual need not ever attend college, and this mar-

[3]While our approach can only provide evidence on the welfare effect of a marginal change in higher education prices, it imposes minimal assumptions regarding the functional form of agents' utility, time preferences, or degree of risk aversion. In contrast, an approach that adds more structure to the individual's optimization problem would allow for estimates (and comparisons) of the magnitude of welfare gains or losses from a variety of counterfactual policies that involve larger changes in prices or other parameters.

gin may be affected by a policy change. The budget constraint in each period t is: $c_t = a_t - \sum_{k=1}^{K}\sum_{m=1}^{M^k}\left(\eta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right) + f_t\left(\mathbf{s},\mathbf{x}\right) + \theta_t + g_t - \tau_t\left(\mathbf{s},\mathbf{x}\right) - \frac{1}{R}a_{t+1}$, where a_t is the level of assets at the beginning of period t, η_t^{km} is the student's price of enrollment at college k at intensity μ^{km}, indicated by the dummy $\mathbf{1}\left(s_t^k \in \mu^{km}\right)$, $f_t\left(\mathbf{s},\mathbf{x}\right)$ is income received in the period (possibly negative), θ_t is a transfer received from the government, π_t is the consumption value of public goods, $\tau_t\left(\mathbf{s},\mathbf{x}\right)$ is the tax paid to the government, and $R \geq 1$ is the gross interest rate.

The individual faces asset constraints $a_t \geq \underline{a_t}$, which imply that borrowing may be constrained. Such constraints can be imposed by either the market or the individual. In addition to the budget and asset constraints, we allow for $J < X - 2$ generic constraints, $g_{jt}\left(c_t + \sum_{k=1}^{K}\sum_{m=1}^{M^k}\left(\eta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right) - \theta_t, \mathbf{s}, \mathbf{x}\right) \geq 0$, in each period.[4] As examples, such constraints might include restrictions on the number of hours spent working, rules relating to income-based loan repayment, or the fact that certain grant programs require a minimum number of credits attempted. Lagrange multipliers on all constraints are denoted with λ_{ω_t} and the relevant superscript. Indirect utility depends on the price of schooling across colleges and years, which we denote by $\boldsymbol{\eta}$, defined analogously to the other such vectors.

The indirect utility function at time $t = 0$ is

$$V\left(a_0|\boldsymbol{\eta}\right) = \max_{\mathbf{c},\mathbf{s},\mathbf{x}}\left\{\sum_{t=0}^{T} E\left[\lambda_{\omega_t}^{c}\left(a_t - \sum_{k=1}^{K}\sum_{m=1}^{M^k}\left(\eta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right) + f_t\left(\mathbf{s},\mathbf{x}\right) + \theta_t + \pi_t - \tau_t\left(\mathbf{s},\mathbf{x}\right) - \frac{1}{R}a_{t+1} - c_t\right)\right]\right.$$

$$\left. + \sum_{t=0}^{T} Eu_t\left(c_t, \mathbf{s_t}, \mathbf{x_t}\right) + \sum_{t=1}^{T} E\left[\lambda_{\omega_t}^{a}\left(\underline{a_t} - a_t\right)\right] + \sum_{t=0}^{T}\sum_{j=1}^{J} E\left[\lambda_{\omega_t}^{g_j} g_{jt}\left(c_t + \sum_{k=1}^{K}\sum_{m=1}^{M^k}\left(\eta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right) - \theta_t, \mathbf{s}, \mathbf{x}\right)\right]\right\}$$

The first-order condition with respect to consumption in period t' for each value of $\omega_{t'}$ is

$$0 = \frac{\partial}{\partial c_{t'}}u_{t'}\left(c_{t'}, \mathbf{s_{t'}}, \mathbf{x_{t'}}\right) - \lambda_{\omega_{t'}}^{c} + \sum_{j=1}^{J}\lambda_{\omega_{t'}}^{g_j}\frac{\partial}{\partial c_{t'}}g_{jt'}. \tag{1}$$

2.2 The government's problem

The government must balance its budget in expectation (i.e., expected government revenue must equal expected tax revenue). The balanced-budget requirement allows us to consider whether a self-funded reform would enhance welfare, rather than comparing the gross benefits to the cost of various financing

[4]This structure requires that schooling expenditures enter into the constraints everywhere that consumption expenditures enter. For example, a tax on consumption would also need to apply to spending on schooling, but spending on schooling may be subject to constraints that do not involve consumption. With this structure, the constraints satisfy the assumptions required by Chetty (2006a).

options, and it avoids the complication of interpersonal comparisons.[5] The government makes transfers θ_t and spends G_t on public goods, the level of which can be affected by educational investment externalities. The government must cover any difference between the social (resource) cost $\nu_t^{km}\mathbf{1}\left(s_t^k \in \mu_t^{km}\right)$ of schooling level s_t^k and the payments made by the student. This requirement is most intuitive for public institutions (as in our empirical setting), and is a reasonable assumption for private institutions. This is because in U.S. higher education, the for-profit sector is relatively small with students' tuition payments disproportionately funded through federal aid, while the nonprofit sector is publicly supported through exemption from corporate income tax and donations that alternatively could purchase other resources. Our formulation follows Andreoni (2006) and Diamond (2006) in that we exclude the utility obtained from making donations and providing nonprofit schooling from welfare analysis.

We are interested in a policy reform that reduces higher education prices through the parameters η_t^{km}. This formulation can be applied to a variety of reforms, including changes to the pricing of public institutions or changes in generosity of student grant aid, and such reforms may apply equally to all enrolled students or vary in generosity across programs or number of credits attempted. Grants may be portable across all colleges, as is the case for the Pell Grant, or they may only be relevant for certain institutions or sectors, as is often the case with state grants that can only be used in public institutions.

To allow for these variants, we consider a policy change that reduces a student's cost of enrolling at one or more institutions at intensity μ_t^{km}. We parameterize a multi-faceted policy using a scalar p that we define as representing units of the present-value expected cost to the government. We do so by denoting the reductions to the values of μ_t^{km} by $\Delta_t^{km} p$ and requiring that $p = \sum_{t=0}^{T} R^{T-t} \sum_{k=1}^{K} \sum_{m=1}^{M^k} \Delta_t^{km} E\left[\mathbf{1}\left(s_t^k \in \mu_t^{km}\right)\right]$.[6] We derive a general solution and then show how the formula can be simplified for several grant programs in the U.S.[7]

We require that the reform maintain budget neutrality and a fixed level of public goods to capture the full welfare effect of both receiving and paying for any change in schooling expenses. For notational simplicity, we consider a policy that offsets changes to expected education costs by adjusting the final transfer θ_T; we will note how the resulting formula for welfare effects would differ if instead the government spread

[5]Hendren (2016) provides an alternative approach to evaluate welfare that consists of calculating the marginal value of public funds (MVPF) for an uncompensated policy change for a given population and then comparing the MVPF with that of other policy reforms to determine the welfare weights that would need to be applied to different populations to justify one reform over another. For example, estimated effects of increasing Pell Grant aid are smaller for higher income students (Marx and Turner 2018) than for first-time-in-college students with low family incomes (Denning et al. 2017). Hendren's approach would produce an estimate of how much larger the welfare weights for the high-income population would need to be to rationalize providing the marginal dollar of aid to that group.

[6]As an example, suppose there is a single period, a single college, and students who are evenly split between full-time and part-time enrollment with respective tuition levels of \$2000 and \$1000. A policy to eliminate tuition for all students would have an expected cost of $1500 = .5\,(1000) + .5\,(2000)$ per student. In this example we would have $\Delta^1 = \frac{1000}{1500} \approx 0.67$, and $\Delta^2 = \frac{2000}{1500} \approx 1.33$, and $p \in [0, 1500]$, so that a one-unit increase in p reduces μ^1 by \$0.67 and μ^2 by \$1.33, yielding an expected cost to the government of \$1.

[7]We do not model general equilibrium effects, such as congestion at schools that students are induced to attend. A marginal change in prices should only generate a marginal change in enrollments and so would have limited external effects.

any offsets to transfers over multiple years. Paying for the policy by adjusting future transfers is akin to providing students with loans. If instead the transfer was funded by increasing income taxes, as in Lawson (2017), then the distortions caused by these taxes would be reflected in the behavioral responses and in negative multiples of taxed incomes in the derivative of the welfare function with respect to the policy.

The government's budget constraint is

$$\theta_T = \sum_{t=0}^{T} R^{T-t} \left(E \left[\tau_t(\mathbf{s}, \mathbf{x}) - \theta_t - \pi_t - \sum_{k=1}^{K} \sum_{m=1}^{M^k} \left(\nu_t^{km} - \eta_t^{km} \right) \mathbf{1} \left(s_t^k \in \mu_t^{km} \right) \right] \right).$$

Differentiating the budget constraint with respect to the school-price-reducing parameter p yields

$$\frac{d\theta}{dp} = -R^T p + \sum_{t=0}^{T} R^{T-t} E \left[\frac{d}{dp} \tau_t(\mathbf{s}, \mathbf{x}) - \frac{d}{dp_t} \pi_t - \sum_{k=1}^{K} \sum_{m=1}^{M^k} \left(\nu_t^{km} - \eta_t^{km} \right) \frac{d}{dp} \Pr \left(s_t^k \in \mu_t^{km} \right) \right] \tag{2}$$

Equation (2) represents the changes in future transfers needed to offset any budgetary impacts of changing a student's cost of schooling. The first term captures the direct impact on the government's budget – transfers to inframarginal students – which will depend on the amount of educational investment at affected schools under the status quo. The remaining terms capture the effects of behavioral responses, which may occur in any year. For example, the reform might increase schooling and reduce tax payments in one year but increase tax revenues and the level of public goods in later years. Induced changes in schooling will affect the government's budget if there is a difference between the private and social costs of educational investments. For example, students may be induced to switch between colleges that differ in the degree to which the colleges are subsidized, or students may increase the number of credits they attempt if grant generosity increases with enrollment intensity.[8]

The government maximizes the individual's indirect utility. By invoking the Envelope Theorem, we can ignore behavioral responses other than those that arise through the government budget constraint. The welfare effect of reducing prices through parameter p (and offsetting the budgetary effects through transfers in period T) is

$$\frac{dV(a_0|\boldsymbol{\eta})}{dp} = -\sum_{t=0}^{T} E \left[\left(\sum_{j=1}^{J} \lambda_{\omega_t}^{g_j} \frac{\partial}{\partial c_0} g_{jt} - \lambda_{\omega_t}^{c} \right) \sum_{k=1}^{K} \sum_{m=1}^{M^k} \Delta_t^{km} \mathbf{1} \left(s_t^k \in \mu^{km} \right) \right] + \frac{d\theta}{dp} E \left[\left(\lambda_{\omega_T}^{c} - \sum_{j=1}^{J} \lambda_{\omega_T}^{g_j} \frac{\partial}{\partial c_0} g_{jT} \right) \right].$$

Using the first-order condition for consumption in equation (1), , we can rewrite this as

[8]At the student level, there may be discrete changes in institution attended, which would create points of nondifferentiability, but continuity of the distribution of student characteristics ensures differentiability and gives the change in the probability of enrollment (over states of the world) as the derivative.

$$\frac{dV\left(a_0|\boldsymbol{\eta}\right)}{dp} = \sum_{t=0}^{T} E\left[\left(\sum_{k=1}^{K}\sum_{m=1}^{M^k} \Delta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right)\frac{\partial}{\partial c_t}u_t\right] + \frac{d\theta}{dp}E\left[\frac{\partial}{\partial c_T}u_T\right].$$

in the expression from the budget constraint in equation (2), and normalizing by expected marginal utility at time T yields

$$\begin{aligned}\frac{dV(a_0|\boldsymbol{\eta})/dp}{R^T E\left[\frac{\partial}{\partial c_T}u_T\right]} = &\left\{\sum_{t=0}^{T} E\left[\left(\sum_{k=1}^{K}\sum_{m=1}^{M^k} \Delta_t^{km}\mathbf{1}\left(s_t^k \in \mu^{km}\right)\right)\left(\frac{\frac{\partial}{\partial c_0}u_0}{R^T E\left[\frac{\partial}{\partial c_T}u_T\right]} - 1\right)\right]\right. \\ &\left. + \sum_{t=0}^{T} R^{-t}E\left[\frac{d}{dp}\tau_t\left(\mathbf{s},\mathbf{x}\right) - \frac{d}{dp_t}\pi_t + \sum_{k=1}^{K}\sum_{m=1}^{M^k}\left(\eta_t^{km} - \nu_t^{km}\right)\frac{d}{dp}\Pr\left(s_t^k \in \mu^{km}\right)\right]\right\}.\end{aligned} \tag{3}$$

Equation (3) illustrates the welfare effects of a marginal change in the price of school. The first expectation captures direct utility effects. The dollars that a student receives in school are transfers that will have to be paid back in the future. Multiplying the current value of the in-school transfer by marginal utility in the year of receipt or in a future period provides the relative utility value of those dollars at each point in time. If $s_t = 0$, then the entire term in period t equals zero: a change in the price of schooling for any particular period only directly affects students who would be enrolled with some probability in that period. Second, if there is no uncertainty, and if the individual's asset and other constraints never bind, then the first-order conditions for future assets imply that $\frac{\partial}{\partial c_t}u_t = R^{T-t}\frac{\partial}{\partial c_T}u_T$, another case in which the entire term is equal to zero. Because the policy is a transfer from one year to another, an unconstrained individual has already adjusted borrowing and saving so as to be indifferent to the timing of a marginal dollar. Thus, lowering the cost of schooling will only have a direct benefit to students who face constraints that elevate their in-school marginal utility of consumption.

The remaining sum in equation (3) captures the value of externalities generated by behavioral responses to the policy change. These include both traditional externalities on the level of public goods and fiscal externalities on taxes and public spending on education. Net externalities theoretically could be either positive or negative and may arise through changes in behavior in years other than the year of policy change (e.g., if changing the cost of schooling in one year affects government-subsidized schooling investment for multiple years). For our expositionally-simple policy, these effects are all incorporated into period-T transfers and therefore valued according to the marginal utility in that period. If instead, the fiscal externalities were spread over multiple periods, then the change in each year's transfer would be multiplied by marginal utility in that year.

3 Estimation of the Direct Welfare Effect

The first sum in equation (4) captures direct welfare effects that arise when marginal utility in college (when the grant is received) differs from marginal utility in later years (when transfers are adjusted to satisfy the government's budget constraint). Marginal utility should increase after college if constraints prevent students from fully smoothing consumption. Our model shows that we do not need to know the underlying cause of any failures to smooth consumption because the ratio of marginal utilities within and after college is a sufficient statistic for the direct welfare effects of grant aid.

We measure consumption at different ages for current and former college students using data from the Consumer Expenditure Survey (CEX) 2011 through 2015 interview panels. We focus on two groups: current college students aged 18-24 and former students who have completed at least some college that are 25 to 30 years old.[9] By restricting our attention to this relatively young group, instead of individuals at peak earnings ages, we will likely generate an underestimate of the welfare gains of grant aid that moves income from later to earlier periods. Following Meyer and Sullivan (2011), we define consumption to include all expenditures except educational investments, medical expenses, charitable contributions, and retirement savings. We also exclude home production expenditures and use the expected rental value reported by homeowners as a proxy for housing consumption in place of expenditures on mortgage payments, interest, and home maintenance and repairs. Mean and median consumption, expenditures, and household AGI for 18-24 year old students and former students within 5-year age groups are reported in Table 1. We adjust consumption to account for household size.[10]

In the case of a one-time increase in grant aid provided to first-time college freshmen, the direct welfare effect in equation (4) simplifies to $\left(\frac{\frac{\partial}{\partial c_0}u_0}{R^T E\left[\frac{\partial}{\partial c_T}u_T\right]} - 1\right)$. Calibration is straightforward with the constant relative risk aversion (CRRA) utility function. If utility exhibits CRRA with risk aversion parameter γ and discount rate β, marginal utility is $\beta^t c_t^{-\gamma}$. We allow for uncertainty by calculating the average marginal utility of consumption (rather than the marginal utility of average consumption) for a given level of risk aversion. Table 2 contains estimated mean marginal utility of consumption in the college student population (Panel A) and the post-college population (Panel B).

Expected future marginal utility may vary across students, and is likely positively correlated with current marginal utility, but this correlation cannot be observed without panel data on consumption. We therefore calculate upper and lower and bounds for this ratio by assuming zero and perfect correlation, re-

[9]We exclude students with advanced degrees. Approximately 52 percent of the remaining sample has a bachelor's degree; the remainder have an associate degree, other credential, or left college without receiving a credential.

[10]Following Meyer and Sullivan (2011), adjusted household consumption equals annual household consumption divided by $(adults + 0.7 * children)^{0.07}$.

spectively. For the upper bound we calculate $\left(\frac{\frac{1}{N_{coll}}\sum c_{coll}^{-\gamma}}{R\beta^t\left(\frac{1}{N_{postcoll}}\sum c_{postcoll}^{-\gamma}\right)}\right)-1$, where $\frac{1}{N_{coll}}\sum c_{coll}^{-\gamma}$ is the average marginal utility of consumption for the college population, $\frac{1}{N_{postcoll}}\sum c_{postcoll}^{-\gamma}$ is average marginal utility for the college-educated in the next age group (25-30 years old), and t is the difference in average age between the two groups (6 years). To calculate the lower bound, we separate both the student and post-college samples into centiles of consumption, calculate the same statistic for each centile (effectively assuming no mobility or uncertainty), and average over centiles.

We present welfare calculations for multiple values of the CRRA parameter γ, centered around $\gamma = 2$, the baseline chosen by Carroll (1997), Chetty (2006b), and Card et al. (2007). Welfare gains are increasing in the degree of risk aversion; if an individual's utility function is highly curved, then marginal utility will be much greater when consumption is held at a below-optimal value. We also allow the net discount rate $R\beta$ to vary. With $R\beta = 1$, we would expect a constant level of consumption over time, which is consistent with the behavior of the college-educated population in the CEX between the ages of 46 and 65 (Table 1). When $R\beta > 1$, individuals are patient and prefer to consume more in the future, which reduces the value of additional consumption while in college. The converse applies when $R\beta < 1$.

Table 3 presents estimated upper and lower bounds for the direct effect of grant aid on welfare for $\gamma \in \{1,2,3\}$ and $R\beta \in \{0.97, 1, 1.03\}$. We estimate the direct welfare gains for students from low- and high-income families to account for variation in the targeting of grant aid.[11] For low-income students like those in our empirical setting, direct welfare gains are positive and sizable for most parameter values, ranging from \$0.40 to \$1.94 per dollar increase in grant aid when $\gamma = 2$. For most parameter values, average and high-income students also receive fairly substantial, direct welfare gains from additional grant aid. With $\gamma = 2$ and $R\beta = 1$, the direct utility gain for the average college student exceeds \$0.50 per \$1 of grant aid, and effects are at least 30 percent larger for students with family income resembling that of the sample of Denning et al. (forthcoming).[12] Thus, direct effects of increased grant aid on welfare appear to be strongly positive. Since we also find positive indirect effects, we conclude that total welfare effects of increased grant aid for low-income students in Texas are positive.

[11] We adjust college-age consumption for low-income students to mimic the fact that those in our sample come from families with incomes around \$20,000. Specifically, we scale by the ratio of average consumption among students from families with AGIs between \$10,000 and \$30,000 to average consumption among all students (0.81). Likewise, to approximate the high-income college student population, we use the ratio of average consumption of students from families with AGIs between \$50,000 and \$85,000 to average consumption of all students as the adjustment factor (1.10).

[12] Jacob et al. (forthcoming) show that, in addition to academic spending, four-year institutions spend a considerable amount on what might be considered consumption amenities. To the extent that the consumption value of college is captured by the cost of on-campus room and board, it will be accounted for in our measure of consumption. However, institutional spending on student activities such as athletics will not be captured. As reported in Jacob et al. (forthcoming), the average public four-year institution charged \$5490 in tuition and provided \$3602 in consumption amenities in 2004, a ratio of 0.66. We impute the consumption value of college using this ratio and the expenditures on higher education reported in the CEX and report results in Table 4. Estimate direct welfare effects remain similar to those reported in Table 3.

4 Applications

In this section we start with general principles on applying the framework. Next, we discuss the welfare implications of estimated effects of a variety of changes in college pricing. Our back-of-the-envelope calculations should be viewed as illustrative. The relevant parameters have not all been estimated, and we must make assumptions about impacts on long-run income and tax revenue and, in the case of Bettinger et al. (2016), the resource cost of educating students at different schools. We ignore non-fiscal externalities, which would likely improve the welfare effects of the grants that increase educational attainment. These calculations serve as a rough example of the parameters that empirical researchers can estimate, and how they can connect the estimates of various outcomes to obtain estimates of the welfare effects of changes in grants and tuition rates.

4.1 Implementation guide

In this section, we lay out the steps to apply this framework to evaluate policy changes. Three things must be calculated: the direct welfare gains arising from a $1 change in price, the size of the transfer to students, and the costs and benefits caused by student behavioral responses to the change in price.

1. The first step is to calculate the direct gains to welfare for a $1 increase in grant aid. Table 4 presents estimates using the CEX, separately for all college students, college students from low-income families, and college students from high income families. These estimates should be applicable to a variety of settings, but authors may want to calculate direct effects themselves if consumption data are available in their setting or if the population is sufficiently different from those considered in Table 4.

2. Next, researchers should determine the amount of the transfer to students. Direct transfers would include grants or tuition that are a direct result of the change in price. As an example, consider a grant that only was available in a student's first year, did not affect enrollment in that first year, but that affected enrollment and grant receipt in the student's second year. In this case, the grant aid in the first year would be a direct transfer whereas the aid in a second year would be a fiscal externality arising from behavioral responses to grant aid. However, if a first-year grant induced more initial enrollment for some students, the costs associated with the increased enrollment would fall into the category of behavioral response to the grant outlined in the third step below, while inframarginal student's additional aid would be a transfer.

3. External costs and benefits arising from behavioral responses can then be calculated. These externalities include changes in government expenditures as a result of student and institutional responses to

the grant. For instance, if student enrollment increases, potential costs would include the additional grant aid and net-of-tuition instructional costs arising from increased enrollment. Potential benefits would include increased tax revenue, reduced student loan default, or shifts in enrollment to institutions that receive smaller public subsidies. External costs and benefits are calculated per dollar of transfer for comparability with the direct welfare effects.

4. Compare the sum of direct welfare effects and external benefits to the external costs. If the net of these effects is positive, then a marginal increase in the transfer used to fund the price change would increase welfare. The magnitude of the net effect can also be compared to the magnitude of the expected distortion of other funding options to determine whether the pricing change would be welfare-enhancing in a setting where the initial expenditures had to be funded through distortionary measures such as an increase in marginal tax rates.

4.2 Pell Grant aid provided to low-income recipients in Texas

Denning et al. (forthcoming) use a discontinuity in the generosity of Pell Grant aid to study its effect on the enrollment, attainment, and wages of Texans. We will focus on first-time-in-college students at four-year institutions, the group for which results are clearest. In this setting, the general welfare formula in equation (3) can be simplified. First, the amount of grant aid received is affected directly in only one year and does not depend on credits attempted as long as the student attempts at least 12 credits per semester. The vast majority of students in the sample attempt sufficient credits, and we find economically and statistically insignificant effects of the grant on the probability of attempting 12 credits per semester. Second, we consider current students at the automatic zero EFC eligibility threshold. Together, these assumptions imply that $\Delta_t^{km} = 1$ for the student's actual college and enrollment intensity, simplifying the expression for the direct welfare effect. Third, we assume away non-fiscal externalities, for which we do not have estimates. Assuming such externalities are positive on net, as prior literature would suggest (e.g., Lochner 2011; Oreopoulos and Salvanes 2011), this simplification works against finding that increasing grants would increase welfare. The resulting simplified condition for a welfare gain is:

$$\frac{dV(a_0|\boldsymbol{\eta})/dp}{R^T E\left[\frac{\partial}{\partial c_T} u_T\right]} = \left\{ \sum_{t=0}^{T} E\left[\frac{\frac{\partial}{\partial c_t} u_t}{R^T E\left[\frac{\partial}{\partial c_T} u_T\right]} - R^{-t}\right] + \sum_{t=0}^{T} R^{-t} E\left[\frac{d}{dp}\tau_t(\mathbf{s}, \mathbf{x}) - \sum_{k=1}^{K}\sum_{m=1}^{M^k} \left(\eta_t^{km} - \nu_t^{km}\right) \frac{d}{dp} \Pr\left(s_t^k \in \mu^{km}\right)\right]\right\} \quad (4)$$

This derivative measures the welfare gain or loss from reducing prices for current students. If we assume that $\frac{\partial}{\partial c_{t'}} u_t \geq R^{T-t'} E\left[\frac{\partial}{\partial c_T} u_T\right]$, as would be the case if only intertemporal budget constraints bind, then it is sufficient to show that net externalities of the increase in grant aid are positive. Showing that this holds for fiscal externalities alone will be sufficient if nonfiscal externalities are non-negative.

Since equation (4) shows that a revenue-neutral marginal increase in grant aid increases welfare if net externalities are positive and students do not over-consume in college, we assess the net fiscal externalities of the additional grant aid provided to students who qualify for an automatic zero EFC. The change in generosity for these students is not a marginal change but gives a linear approximation of the marginal effect, as is standard in the sufficient statistic literature (Chetty 2009). Estimating the marginal effect of increasing grant aid from any specific baseline level would require parametric assumptions. Our estimate is the slope of a line between the two points we observe on the social welfare function, a more relevant quantity than the slope of the tangent at either of these points, which would give the welfare effects of giving one dollar to compliers who are ineligible or who are eligible, respectively. Moreover, between the two observed levels of generosity there will necessarily be a level at which the marginal welfare effect is equal to the effect we estimate.

To measure program costs, we take into account total cash flows between students and the public sector, abstracting from issues related to transfers between the federal government, state government, and public educational institutions. An advantage of our setting is that we observe all grants that students receive, whether from the Pell Grant program or other sources. As such, we are able to directly estimate the effect of automatic zero eligibility on grant aid received over most students' full college careers. Effects on total grant aid represent one of the two largest fiscal externalities generated by behavioral responses to automatic zero EFC eligibility.

Denning et al. (forthcoming) show the effect of eligibility for an automatic zero EFC on total financial aid flows over seven years, a proxy that likely captures most of the lifetime effects on financial aid receipt. The $653 increase in grants received by eligible students at college entry generates a $1163 increase in total grant aid received over the duration of our panel, a period over which the majority of students have completed a degree or dropped out of college. Because automatic zero eligibility only mechanically affects grant aid in a student's first year, the increase in cumulative grant aid beyond the initial $653 is likely generated by increased persistence and the increase in the probability of qualifying for a TEXAS Grant in later years. Impacts on cumulative borrowing are small and statistically insignificant. The significant reduction in first-year borrowing among eligible students is offset by increased borrowing in later years. We also find no evidence of statistically significant effects on years of attendance or expenditures on direct subsidies to public institutions attended by eligible students; point estimates are small, negative, and statistically insignificant.[13]

Public revenue arising from the incremental grant aid exceeds the costs under relatively weak assump-

[13]Following Hoxby (forthcoming), we approximate the value of the direct subsidy provided to a given institution using data from the IPEDS finance survey and calculating average student-year expenditures on "core expenses" in excess of tuition payments. Specifically, the subsidy equals the difference between per-student core expenditures on instruction, student services, and academic support and per-student private tuition payments.

tions. Summing over the estimated effects of initial eligibility for an automatic zero EFC on federal income tax liabilities suggests that an additional $540 in federal tax revenue was generated in the seven years following college entry.[14] To recover the remaining cost of expenditures generated by initial eligibility requires $510. We cannot say whether the earnings effects (and resulting income tax gains) will continue to grow over the long-run, but if earnings gains remain at the level we observe at the end of our panel, the additional grant will be fully recouped in nine years and will continue to produce additional revenue for many years to come. The effect on subsequent years' earnings could be two-thirds as large, and the grant would pay for itself within ten years. Earnings gains need not even persist if we include the $565 increase in FICA taxes collected.[15]

According to the sufficient condition in equation (4), increasing grant aid generosity would be welfare improving in our setting. Of the $1163 increase in public expenditures, $653 is due to the initial difference in grant aid, which represents a transfer and does not enter directly into equation (4). The behavioral effect on subsidies received by the student is $0.78 per dollar of initial aid.[16] The behavioral effect on income taxes paid by the student within seven years is $0.83, giving a net externality of $0.05 over the first seven years. If students work an additional 30 years and pay an additional $540 in income taxes every 3 years then the net externality per dollar of initial aid rises to $8.32. Thus, even if we ignore the private return on the educational investment (which appears to be large) and any nonfiscal externalities (which we expect to be positive on net), our results indicate that such transfers raise welfare if direct effects are positive or reasonably small.

4.3 Pell Grant aid provided to marginal recipients in New York

Marx and Turner (2018) study the effect of additional grant aid provided to City University of New York (CUNY) students at the Pell Grant program's eligibility threshold and find no evidence that the additional Pell Grant aid affects college entry, choice, or attainment. However, additional Pell Grant aid generated significant reductions in borrowing. In expectation, borrowers will default on some portion of their federal student loan debt. As a result, the behavioral response to Pell Grant eligibility should increase welfare by reducing social expenditures via reductions in unpaid student loans. The total effect on welfare is positive even using the lowest estimate of direct benefits.

[14] Estimated tax liabilities are measured in real terms. No additional discounting is applied.

[15] FICA taxes increase current revenue but also may increase future liabilities, as they are tied to workers' future retirement and health insurance benefits.

[16] Ideally, we would also treat the portion of the increase in TEXAS Grant aid in later years that was due to awarding more TEXAS grants as part of the policy and only include expenditures induced by enrollment responses of these new recipients in the behavioral externality. Automatic zero eligibility leads to a marginally significant ($p<0.10$) 2 percentage point increase in the probability of receiving a TEXAS Grant in a student's first year. Because assignment of the TEXAS Grant for students near the automatic zero EFC threshold does not follow a simple formula, we take the conservative approach of treating all expenses after the first year as externalities.

Marx and Turner (2018) study the effect of additional grant aid provided to students at the Pell Grant Program's eligibility threshold within the City University of New York (CUNY) system. Identification comes from a discontinuity in Pell Grant aid as a function of students' expected family contribution (EFC), the federal government's measure of ability to pay for college. Students at this threshold have higher family income – with an average AGI of approximately $48,000 – than students at the automatic zero EFC threshold. The approximately $400 increase in Pell Grant aid received by eligible students with EFCs below the eligibility threshold at entry led to a $33 increase in other grant aid ($p < 0.05$), a $224 decrease in borrowing through federal loan programs ($p < 0.01$), and no significant effects on college entry, choice of institution, or attainment (including persistence, credits attempted, credits earned, or GPA). These estimates are available in Table 3, Online Appendix Table B.8, Table 5, Table 4, and Table 8 of Marx and Turner (2018).

For the purpose of welfare evaluation, the initial increase in Pell Grant aid is a transfer. The additional grant aid that is crowded-in represents an increase in social costs of $0.08 per dollar of Pell Grant aid. Accounting for the welfare implications of reduced borrowing requires additional assumptions, specifically, the fraction of the foregone loan dollars that would not have been repaid to the federal government. On average, 26 percent of Pell Grant recipients who attended a CUNY institution had either defaulted on their loans or had failed to make a payment of at least $1 towards their loan debt five years after leaving college.[17] Under the assumption that this average also applies to the students studied by Marx and Turner (2018) and that such borrowers fail to make further payments on their federal loans, we estimate that Pell Grant eligibility generated a $58 reduction in loan debt that would not have been repaid, representing a $0.15 reduction in social costs per $1 of Pell Grant aid. Thus, at least in the short-run, increases in Pell Grant generosity for students on the margin of eligibility would improve welfare by reducing social expenditures.

Taking into account the consumption-smoothing benefits from providing additional grant aid to middle-income students would generate larger net welfare benefits, in the range of $0.52 to $0.61 per $1 increase in Pell Grant aid (Table 8, Panel A with $\gamma = 2$ and $R\beta = 1$). Even using the lowest estimated direct effect of $0.03 in direct benefits per $1 increase in Pell Grant generosity, the reduction in borrowing would only have to generate a $0.05 reduction in social expenditures (corresponding to a loan repayment rate of more than 90 percent) for additional grant aid to improve welfare even without effects on educational attainment.

[17] The loan (non)repayment rate of 26 percent for Pell Grant recipients comes from the 2014-15 College Scorecard institution-level data (available at: https://collegescorecard.ed.gov/data/) and represents a loan repayment rates for federal borrowers who entered repayment in FY 2009 or FY 2010.

4.4 Cal Grant aid provided to marginal recipients in California

In our third example, Bettinger et al. (2016) examine the short- and long-run effects of the Cal Grant Program on college choice, degree receipt, and earnings. The program covers tuition and fees at four-year public institutions and heavily subsidizes tuition at four-year nonprofit schools. Cal Grant eligibility requirements generate two discontinuities based on income and high school GPA. At the income eligibility threshold, students have relatively high income and GPAs (approximately $60,000 and 3.55), while at the GPA threshold, students come from relatively low-income families and have lower GPAs (approximately $35,000 and 3.08).[18] We treat each threshold as a separate policy for the purpose of welfare analysis because estimated local average treatment effects and characteristics of grant aid recipients differ between thresholds.

At the income threshold, eligibility did not affect college enrollment (Table 2) or years of college attendance (Figure A6). Eligibility did have significant effects on choice of institution, leading students to select out of public institutions and into private institutions (Table 2). Impacts on earnings and AGI 10 to 14 years after college entry are small, negative, and statistically insignificant (Table 3). Thus, indirect welfare effects will be limited to changes in the social cost of educating students who were induced to switch between higher education sectors. Switches from public into nonprofit schools generate two fiscal externalities: changes in the public subsidy to the institution attended, and increases in the amount of Cal Grant payments relative to what would have been paid if students did not switch, as the grant is larger for students in private four-year institutions. The second externality arises from changes to public subsidies that are provided directly to institutions.

For simplicity, we assume that grants provided to four-year public school students equaled average tuition ($2500) and that average grant aid received by private-school attendees equaled the reported maximum amount available at these schools ($9388). To approximate the average Cal Grant received by eligible students at the income threshold, we take the average of tuition at the California State University and University of California school systems for students attending public four-year schools and the average grant available at private schools (see page 7 of Bettinger et al. (2016)). Assuming that marginal Cal Grant recipients are evenly split between public and private schools and that the average student obtains three years of schooling generates an estimated average total Cal Grant aid received by marginal students equal to $9129, matching the reported results. Shifting the shares of public- and private-attending students by the reported effect sizes suggests that of the $8129 change in grants at the threshold, $1218 was a negative externality due to endogenous responses.

[18] Table 1 of Bettinger et al. (2016) displays these characteristics.

From the IPEDS, we estimate that the net per-student-year subsidy at four-year institutions in California is nearly the same in the public and private sectors and substantially lower for community colleges. The externality due to shifting students away from the two-year to the four-year sector using the average difference in the per-student subsidy of $9769. Multiplied by the share of students induced to leave community colleges (0.035) and an average of three years of schooling gives a fiscal externality of -$1026. The sum of the two fiscal externalities is -$3244 or -$0.47 per $1 increase in grant generosity.

For the direct welfare gains, we use the estimate for high-income students (Table 3, Panel C, $\gamma = 2$, $R\beta = 1$), which suggests a benefit of $0.16 to $0.33 per $1 increase in grant aid generosity. For this value of the direct effect and our back-of-the-envelope calculations of net fiscal externalities, we conclude that the welfare effects of increasing grant aid at this margin are negative, on the order of -$0.14 to -$0.31 per $1 increase in grant generosity.

In the case of the Cal Grant GPA eligibility threshold, the authors find insignificant effects of eligibility on college attendance or choice of institution (Table 2), increased years of enrollment (discussed on page 17), and increases in log labor income and AGI 10 to 14 years after application (Table 2). Thus, at the GPA threshold, indirect welfare effects come from changes in social costs due to additional years of college attendance and increases in tax revenue paid by eligible students who experience earnings gains.

The average per-student subsidy to California four-year institutions (weighted by the enrollment proportions of 0.57 in public and 0.12 in private in this population at entry) is $13,172 per year. With eligible students obtaining an additional 0.08 years of education, this amounts to a $1054 increase in social costs. The additional Cal Grant aid received by eligible students is displayed in Table 2. Scaled by the average per-student subsidy suggests a $0.24 increase in social costs per $1 increase in Cal Grant generosity.

The increase in log AGI at the GPA eligibility threshold equals 0.01 (Table 3) or $469 more than the exponentiated control group mean ($46,630). To estimate the increased tax revenue from eligible students' earnings gains, we assume the annual AGI increase of $469 accrues in each year of a 35-year career and is taxed at the 8 percent rate that we obtain for our low-income Texas sample. Under these assumptions, we estimate that the positive fiscal externality is $0.30 per $1 of Cal Grant aid. Thus, even if students perfectly smooth consumption, these calculations suggest that increases in grant generosity for students at the GPA threshold for Cal Grant eligibility would increase welfare. This calculation should be viewed with extra caution, however, as it relies on a statistically-insignificant effect on AGI.

Even with negative net externalities, direct benefits to students at the GPA threshold would likely ensure a welfare gain. Mean family income at the time of application was $35,100. The lower bound for our middle estimate of the direct effect for low-income college students in Table 8 is 0.67. For net externalities in the range of -0.67, the effect on log AGI would need to be lower than the reported estimate by nearly two times its standard error.

5 Conclusion

Economists have studied a variety of grant programs for higher education and estimated a range of attainment effects. We present a general model that generates sufficient statistics for evaluating the welfare effects of changes in the price of schooling. These statistics include a direct consumption smoothing effect, which can be estimated from marginal utilities without knowledge about potential underlying frictions, and an indirect effect of externalities generated by behavioral responses to aid. We apply our framework and estimated direct effects to multiple settings and find that while welfare effects cannot be inferred from examining attainment outcomes in isolation, grants that target low-income students are the most likely to increase welfare. The benefits to students at the automatic zero threshold for Pell Grant aid are substantial, and increasing support for these students pays for itself through financial gains for the public.

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Figures and Tables

Table 1: Annual Consumption, Expenditures, and Adjusted Gross Income for Current and Former College Students

	Consumption		Total expenditures		AGI		Observations
	Mean	Median	Mean	Median	Mean	Median	
A. Attending college, age 18-24							
Full sample	$19,610	$16,119	$24,586	$19,399	$51,115	$31,939	11,397
All with AGI	$19,343	$15,911	$24,301	$19,280	$51,115	$31,939	5,579
AGI $10k-$30k	$15,695	$13,489	$18,953	$15,984	$19,198	$18,427	1,271
AGI $30k-$50k	$17,255	$15,014	$21,005	$17,700	$39,692	$39,319	912
B. College educated							
Age 25-30	$23,811	$19,616	$29,387	$24,679	$52,739	$45,000	7,178
Age 31-35	$23,391	$19,004	$29,553	$24,558	$65,772	$55,774	6,814
Age 36-40	$24,296	$20,431	$30,478	$25,978	$73,683	$61,740	6,367
Age 41-45	$25,565	$21,006	$32,161	$26,324	$78,736	$64,680	6,755
Age 46-50	$26,944	$22,453	$34,554	$28,353	$78,065	$64,190	7,335
Age 50-55	$28,794	$23,538	$36,484	$29,288	$80,052	$64,622	8,317
Age 56-60	$28,514	$23,637	$35,059	$28,352	$69,698	$53,018	7,640
Age 61-65	$28,451	$23,132	$33,279	$26,920	$51,864	$38,400	6,745
Age 66+	$27,670	$22,976	$31,075	$24,297	$27,627	$7,840	13,703

*Note*s: Data from the 2011 through 2016 public-use microdata Consumer Expenditures Survey (CEX) interview panel. Panel A includes CEX consumption units (CUs) with a college student between the ages of 18 and 24, Panel B includes CEX CUs in which either the reference person or their spouse had attended college but not received a bachelor's degree (48 percent of CUs) or had attended college and received a bachelor's degree (52% of CUs) and fell within the specified age range. Consumption is equal to total expenditures minus expenditures on education, household production, pensions, retirement accounts, and personal insurance, gifts, transfers, and contributions to charities, medical expenses, and health insurance, and expenditures on owned housing (mortgage, mortgage interest, maintenance and repairs) plus the rental value of owned housing. Consumption and total expenditures are adjusted based on CU size, where the adjustment factor equals $(adults + 0.7 * children)^{0.7}$. All dollar amounts are adjusted for inflation (2013$). Means and medians are calculated using CEX weights.

Table 2: Mean Marginal Utility of Consumption for Current and Former Students by Risk Aversion

	Mean marginal utility*100,000			Observations
Gamma =	*1*	*2*	*3*	
A. Attending college, age 18-24				
Full sample	70.73	0.0066	7.876E-07	11,397
All with AGI	71.10	0.0066	7.813E-07	5,579
AGI $10k-$30k	80.87	0.0079	9.110E-07	1,271
AGI $30k-$50k	70.47	0.0059	5.685E-07	912
B. College educated, age 25-30				
Nationally representative	56.61	0.0041	3.735E-07	7,178
Reweighted (TX sample attainment)	58.01	0.0043	3.976E-07	7,178

Notes: Data from the 2011 through 2016 public-use microdata Consumer Expenditures Survey (CEX) interview panel. Panel A includes CEX consumption units (CUs) with a college student between the ages of 18 and 24, Panel B includes CEX CUs in which either the reference person or their spouse had attended college but not received a bachelor's degree or had attended college and received a bachelor's degree and was between 25 and 30 years old. Nationally representative = based on attainment in CEX (52 percent with BA, 48 percent with some college). Reweighted to represent attainment in the Texas sample uses weights calculated by raking to fit the share of the Texas analysis sample that has a bachelor's degree 7 years after college entry (44 percent). Marginal utility = consumption$^{-\gamma}$ where the value of gamma (coefficient of relative risk aversion) is specified in column headings. See Table 3 for definition of consumption.

Table 3: Direct Utility Gain from $1 Increase in Grant Aid

	Risk aversion parameter (γ) =		
	1	2	3
A. All college students			
Net discount rate ($R\beta$) =			
1.03	[0.03, 0.05]	[0.27, 0.35]	[0.57, 0.77]
1	[0.23, 0.25]	[0.52, 0.61]	[0.88, 1.11]
0.97	[0.48, 0.50]	[0.82, 0.94]	[1.25, 1.53]
B. Low AGI college students			
Net discount rate ($R\beta$) =			
1.03	[0.07, 0.29]	[0.40, 1.05]	[0.84, 2.31]
1	[0.28, 0.54]	[0.67, 1.45]	[1.19, 2.95]
0.97	[0.54, 0.85]	[1.00, 1.94]	[1.63, 3.74]
C. High AGI college students			
Net discount rate ($R\beta$) =			
1.03	[-0.10, -0.05]	[-0.03, 0.11]	[0.07, 0.32]
1	[0.07, 0.13]	[0.16, 0.33]	[0.27, 0.58]
0.97	[0.28, 0.36]	[0.39, 0.59]	[0.53, 0.89]

Notes: Lower and upper bounds for the normalized present value of the direct welfare effect in equation 4 as a function of the risk aversion parameter (γ), college student sample, and $R\beta$. See Section 3 for details. All dollar amounts adjusted for inflation (2013$).

Table 4: Direct Utility Gain from $1 Increase in Grant Aid, Allowing for Consumption Value of College

	Risk aversion parameter (γ) =		
	1	2	3
A. All college students			
Net discount rate ($R\beta$) =			
1.03	[-0.02, -0.01]	[0.17, 0.21]	[0.41, 0.52]
1	[0.17, 0.18]	[0.40, 0.45]	[0.69, 0.81]
0.97	[0.409, 0.413]	[0.68, 0.74]	[1.02, 1.18]
B. Low AGI college students			
Net discount rate ($R\beta$) =			
1.03	[0.05, 0.12]	[0.34, 0.56]	[0.74, 1.22]
1	[0.25, 0.34]	[0.60, 0.86]	[1.08, 1.65]
0.97	[0.51, 0.60]	[0.93, 1.24]	[1.50, 2.18]
C. High AGI college students			
Net discount rate ($R\beta$) =			
1.03	[-0.15, -0.13]	[-0.09, -0.08]	[-0.014, -0.010]
1	[0.02, 0.04]	[0.09, 0.10]	[0.177, 0.182]
0.97	[0.22, 0.25]	[0.30, 0.32]	[0.41, 0.42]

*Note*s: See Table 8 notes for sample and estimation details.