Modeling the Economic Effects of Increased Drop-out Rates from High School

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Modeling the economic effects of increased drop-out rates from high school

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Abstract

With Covid, high-school students are having difficulty staying in school. We present a dynamic model of the effects of increased drop-out rates. The model accounts for labor productivity, crime costs and high-school savings. We simulate a 25 per cent increase in drop-out rates occurring in the two years starting September 2019, with a gradual return to pre-Covid rates in 2025. Our results show a loss of 597,000 high-school graduations from cohorts entering high-school in 2016-2024. The present-value cost is between $42 and $137 billion, depending on discount rates. These results support investment in high-school retention policies through the Covid crisis.

Key words: Covid and high-school drop-out rates; dynamic model of student numbers; educational attainment of workforce; cost of reduced high-school graduation rates

Jel codes: I26; J08; J24

Contents

1. Introduction

One of the effects of Covid is to increase drop-out rates in U.S. high schools. While no exact figures are yet available there is copious anecdotal evidence. As explained by McMorris-Santoro (2021), drop-out rates have increased because many students:

- have found home schooling to be extremely difficult causing them to fall behind in their studies and lose motivation;
- have needed to take jobs to supplement diminished family earnings; and
- have needed to help out in looking after younger children during school shutdowns.

Higher drop-out rates reduce individual productivity and income causing long-lasting negative effects on the economy by reducing effective labor supply. There are other negative effects. It is well established that high-school drop-outs commit considerably more crimes throughout their lifetimes than high-school graduates, see for example Lochner and Moretti (2004). Another possible negative effect is reduced health outcomes. However, this is more controversial. Grossman (2015) comments that:

> *"Many studies suggest that years of formal schooling completed is the most important correlate of good health. There is much less consensus as to whether this correlation reflects causality from more schooling to better health. The relationship may be traced in part to reverse causality and may also reflect "omitted third variables" that cause health and schooling to vary in the same direction."*

Offsets to the negative effects of increased drop-out rates are a saving of public expenditures on high-school education and a short-run increase in teenage labor supply.

We have created a dynamic model for calculating the macro economic effects of changes in high-school drop-out rates. The model takes in numbers of people entering high school in the fall of 2014, 2015, 2016, etc . It then uses drop-out rates for each high-school class level (HSL1 to HSL4) to calculate for each year the number of high-school graduates and the number of drop-outs. These numbers are translated into implications for effective labor supply, costs of crime and savings in high-school education expenditures.

Section 2 sets out the model. Section 3 describes an application showing the effects of an increase in high-school drop-out rates that could arise from Covid. Conclusions are summarized in section 4.

2. The Model

We specify the number of high-school students, N(k,t), at level k in year t (starting September) by

$$N(k,t) = N(k-1,t-1)*[1-DR(k-1,t-1)] \quad \text{for } k = 2, ..., 5; \text{ and } t = 1, 2, ..., \quad (2.1)$$

where DR(k,t) is the drop-out rate applying to students at level k in year t, that is the proportion of students who do not progress to the next level. By N(5,t) we refer to students who graduate from high school in year t.

The number of students undertaking level 1 (freshman) in year t is exogenous in our model.

The number of students, D(k,t), who drop out of high school in year t with k years of completed high-school education is given by

$$D(k,t) = N(k+1,t) * DR(k+1,t) \quad \text{for } k = 0, 1, 2, 3; \text{ and } t = 1, 2, ..., \tag{2.2}$$

The number of people, Q(k,t), in the workforce in year t whose educational qualification is k completed years at high school is given by

$$Q(k,t) = Q(k,t-1) * S(k,t-1) + D(k,t) \quad \text{for } k = 0, 1, 2, 3; \text{ and } t = 1, 2, ..., \tag{2.3}$$

where S(k,t-1) is the survival rate in year t-1 of people in the workforce who have k years of high-school education, that is the fraction of these people who stay in the workforce from year t-1 to the next year.

The number of people, Q(HSG,t), in the workforce in year t whose educational qualification is high school graduate (HSG) is given by

$$Q(HSG,t) = Q(HSG,t-1) * S(HSG,t-1) + N(5,t) - HS2PHS(t) \quad \text{for } t = 1, 2, ..., \tag{2.4}$$

where S(HSG,t-1) is the survival rate in year t-1 of people in the workforce with high-school education and HS2PHS(t) is the number of people in year t who enter a post-high-school educational program.

Finally, the number of people, Q(PHS,t), in the workforce in year t who have a post-high-school (PHS) qualification is given by

$$Q(PHS,t) = Q(PHS,t-1) * S(PHS,t-1) + HS2PHS(t-4) \quad \text{for } t = 1, 2, ..., \tag{2.5}$$

where S(PHS,t-1) is the survival rate in year t-1 of people in the workforce with post-high-school education. We assume that people joining the workforce in year t with post-high-school qualifications are those who entered PHS programs four years earlier. While we assume that on average people who undertake post-high-school programs are out of the workforce for four years, their PHS qualification need not necessarily be a completed program.

To implement the model we require a set of initial conditions and a scenario. Initial conditions are values for:

N(k,0) for k = 1 to 4, number of high-school students at each level in year 0;

Q(k,0) for k = 0 to 3, workers in year 0 with k years of completed high-school;

Q(HSG,0), workers in year 0 with completed high-school, but not higher;

Q(PHS,0), workers in year 0 with a post-high-school qualification;

HS2PHS(t-4) for t = 1 to 4, number of people entering post-high-school programs.

A scenario is a set of values for the model's exogenous variables which are:

N(1,t), t = 1, 2, …, number of people entering high school in future years;

DR(k,t), k = 1 to 4 and t = 1, 2, …, high-school drop-out rates in future years;

HS2PHS(t), t = 1, 2, …, number of people entering post-high-school education programs in future years; and

S(ℓ,t) for ℓ = 0 , 1, 2, 3, HSG and PHS, and t = 1, 2, …, workforce survival rates.

Given initial conditions and a scenario, (2.1) to (2.5) can be used to project for future years: the number of students at levels 2, 3 and 4 in high school; the number of drop-outs with completion of 0, 1, 2 and 3 years of high-school education; and the number of people in the workforce with education levels ℓ = 0, 1, 2, 3, HSG & PHS. By considering scenarios with different drop-out rates, we can use projections from (2.1) to (2.5) as inputs to calculations of the effects of increased drop-out rates on future paths of effective labor supply, costs of crime and costs of high-school education.

In the simulations reported in section 3, we set the initial conditions and the baseline scenario so that the model generates a no-growth steady-state baseline. This was achieved with values that are realistic for 2019.[2] For all years t, we set

- the high-school freshman class, N(1,t), at 4.16 million; and
- flows to post high-school education, HS2PHS(t), at 2.58 million.

With the workforce survival rate, S(k,t), set at 0.026 for all k and t, the total workforce remains steady at 160 million (= 4.16/0.026) and the number of PHS workers remains steady at 99.4 million (= 2.58/0.026). Given the baseline high-school drop-out rates that we adopt in section 3, the steady state number of HSG workers is 36 million, and the steady-state numbers of workers with 0, 1, 2, and 3 years of high-school are 5.1m, 5.6m, 5.8m and 8.1m. No growth is not intended as a forecast. Computing the effects of changes in drop-out rates from a no-growth baseline simplifies the interpretation of results without distorting them.

3. The effects of a 25 per cent increase in high-school drop-out rates

Using the model we calculate the effects of a 25 per cent increase in U.S. high-school drop-out rates. In subsection 3.1 we describe the inputs to the calculations. Subsection 3.2 gives results.

3.1. Inputs

(a) Drop-out rates

Our assumption of a 25 per cent increase in drop-out rates means that the percentage of high-school students dropping out each year increases from about 4 to 5. This is simply a guess of the possible effect of Covid. Results can be scaled when information becomes available. For example, if the true figure turns out to be 50 per cent then results reported later in this paper can be doubled. Our 25 per cent scenario seems quite moderate: Dorn *et al.* (2020) investigate scenarios in which the Covid-related increases in drop-out rates are between 40 and 150 per cent.

We assume that the 25 per cent increase applies to all high-school students in the years starting fall 2019 and fall 2020. In subsequent years we assume that drop-out rates gradually return to normal levels.

[2] In setting these numbers we were guided by BLS (2021). This source gives data for 2019 on educational attainment. However it leaves out agricultural workers, military personnel and the self- employed. We assumed that these people predominantly have low educational attainment.

Our specific drop-out assumptions are set out in Table 1.

No-covid baseline

As shown in the top half of the table, we assume in the baseline (no Covid) for all years that 3.195 per cent of students in the freshman class of high school (high school level 1, HSL1) drop out without completing the year. Higher drop-out rates apply to students in later classes of high school. The drop-out rate for students in the senior class of high school is 5.680 per cent. The baseline drop-out rates in Table 1 imply a constant graduation rate of 84.6 per cent. This is consistent with the rate reported for 2017 by Hanson (2021). The increase in the baseline drop-out rates from HSL1 to HSL4 is consistent with data in the NCES (2019)

Table 1. High-school drop-out rates (%) for years starting in fall

	2018	2019	2020	2021	2022	2023	2024	Y2025+
Baseline								
HSL1	3.195	3.195	3.195	3.195	3.195	3.195	3.195	3.195
HSL2	3.593	3.593	3.593	3.593	3.593	3.593	3.593	3.593
HSL3	3.891	3.891	3.891	3.891	3.891	3.891	3.891	3.891
HSL4	5.680	5.680	5.680	5.680	5.680	5.680	5.680	5.680
Covid-affected								
HSL1	3.195	3.994	3.994	3.835	3.675	3.515	3.355	3.195
HSL2	3.593	4.491	4.491	4.312	4.132	3.952	3.773	3.593
HSL3	3.891	4.864	4.864	4.669	4.475	4.280	4.086	3.891
HSL4	5.680	7.100	7.100	6.816	6.532	6.248	5.964	5.680

Covid drop-out scenario

The bottom half of the table shows our assumed Covid-affected drop-out rates: 25 per cent higher than baseline in the years starting fall 2019 and fall 2020, gradually returning to baseline levels by fall 2025.

(b) Relative earnings of people with different levels of education

We calculate changes in effective labor input by making a weighted average of changes in employment of people with different educational qualifications. Our weighting scheme gives high-school graduates a weight of 1, people with post-high-school qualifications (PHS) a weight of 1.68, and people without a high-school diploma a weight of 0.72. Thus, a shock that causes one person to be a high school drop-out rather than a high-school graduate reduces effective labor input by 0.28 units (=1 – 0.72). We based our choice of weights on wage data published by the BLS (2018).

A simplifying assumption that we make in the calculation of effective labor input is that the 25 per cent increase in drop-out rates does not affect the number of people with post-high-school qualifications. We assume that the extra drop-outs are people who would not have undertaken post-high-school education. Thus our results refer to a deterioration in the educational attainment of people without post-high-school qualifications, but not to a change in the number of such people.

(c) Costs of crime

Numerous authors[3] have found that public expenditures on the criminal-justice system and private damage from crime are reduced by extra high-school education. In our model, we

[3] See, for example, Haveman and Wolfe (2002), Lochner and Moretti (2004) and Machin *et al.* (2011).

introduce this effect by allowing for an annual saving per person per extra year of high-school education. This is the annual reduction in the costs to society of crime that occurs if a person leaves school with x+1 years of high school education instead of x years. The number we use in the simulation reported below is $912. This means that if a shock to the U.S. education system such as Covid-19 causes a person to experience one less year in high school, then crime will cost the U.S. an extra $912 every year in the future throughout this person's lifetime.

We based our estimate of $912 on work by Lochner and Moretti (2004). They find that:

> "A 1-percent increase in the high-school completion rate of all men ages 20-60 would save the United States as much as $1.4 billion per year in reduced costs of crime incurred by victims and society at large."

The $1.4 billion above refers to 1993. Updating for increases in prices (63 per cent between 1993 and 2019) and the number of high-school students (27 per cent), we find that $2.90b is the appropriate number for 2019. To translate $2.90b into an annual benefit of an extra year of schooling for one person, we ran a steady-state zero-growth simulation in which there was a permanent uniform percentage increase in high-school drop-out rates across the 4 high-school levels sufficient to produce a permanent one per cent reduction in the high-school graduation rate. With the annual benefit from crime reduction generated by having one person experience an extra year of schooling set at $912, our model produced a permanent annual society benefit of $2.90b.[4]

(d) Education expenditures per student per year

U.S. Census data for 2019 indicate that education expenses for each school student averaged $13,187.[5] This figure includes both elementary and high-school students. We did not find any direct estimates that distinguish between elementary and high-school students. Nelson (2015) implies that high-school students are only a little more expensive than elementary students. On this basis we assumed that the cost per year for a high-school student is $15,000. Although $15,000 is an estimate of average cost per student, we apply it to marginal changes in the number of high-school students. This will overestimate cost savings from reduced numbers associated with higher drop-out rates if fixed costs in the provision of high-school education are high. On the other hand, it will underestimate cost savings if the drop-out students are expensive to educate.

3.2. Results

As mentioned earlier, in every year of the no-Covid baseline, the high-school graduation rate is 84.6 per cent. Chart 1 shows the effect on the graduation rate over time of our assumed Covid-related increases in drop-out rates. Higher drop-out rates in the year starting fall 2019 reduce graduation rates for students that entered high school in fall 2016. For these students the graduation rate is reduced by the higher drop-out rate assumed for their HSL4 class in the year starting fall 2019. The graduation rate for students that entered high school in fall 2017

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[4] Lochner and Moretti refer to high-school completion rates for males. Females account for only a small fraction of crime. On this basis, we could calibrate our model to the updated Lochner and Moretti number, $2.9 billion, by setting the annual cost saving per extra year at high school for males at $1,824 (= 2*912) and for females at zero. But our model does not distinguish between males and females. Thus, in our simulations, we assume implicitly that increased drop-out rates apply equally to males and females. Under this assumption it is appropriate to adopt $912 per person.

[5] See Census (2021).

is reduced by the higher drop-out rate assumed for their HSL3 class in the year starting fall 2019 and for their HSL4 class in the year starting fall 2020. The reduction in the graduation rate is greatest for students entering high school in fall 2019. For this cohort, the Covid-affected graduation rate is 81.7. Added over all freshman cohorts from 2016 to 2024, our drop-out scenario causes 0.597 million students to miss out on high-school graduation.

Chart 1. Graduation rates (per cent) by year of entry to high school with 25 per cent Covid-related increase in drop-out rates

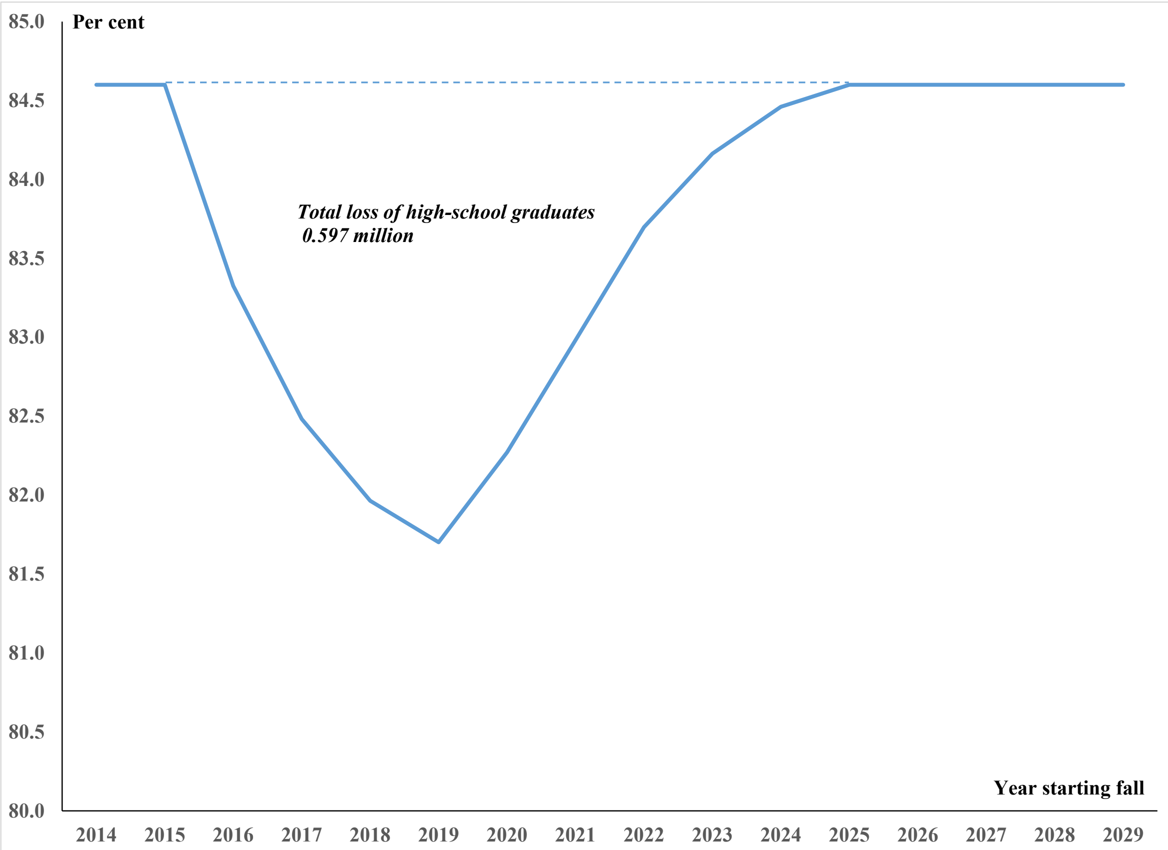


Chart 2 shows the percentage effect of the loss of high-school graduates on effective labor input. In the short-run, there is an increase in effective labor input caused by an increase in the supply of teenage labor. After 2023, effective labor input is reduced, reflecting the Covid-conversion of high-school graduates into non-graduates. This loss of labor input gradually dissipates over many years as the affected cohorts of high-school students retire. With annual labor input worth about $13 trillion, the present value of the loss of effective labor input is $128.0 billion if we use a discount rate of 3 per cent and $41.8 billion if we use a discount rate of 7 per cent.[6]

[6] These rates are recommended in US government guidelines for benefit-cost and regulatory analysis, see US Office of Management and Budget (2003).

Chart 2. Percentage deviations in effective labor input caused by the assumed 25 per cent Covid-related increases in high-school drop-out rates

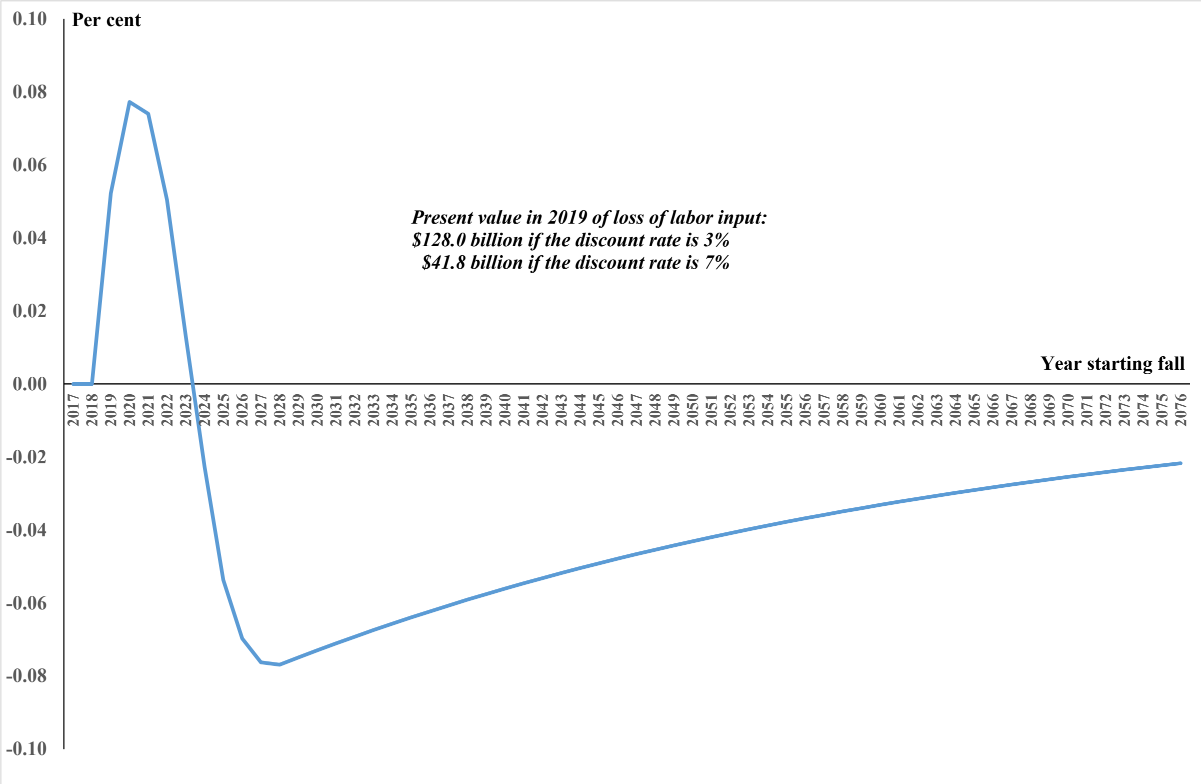
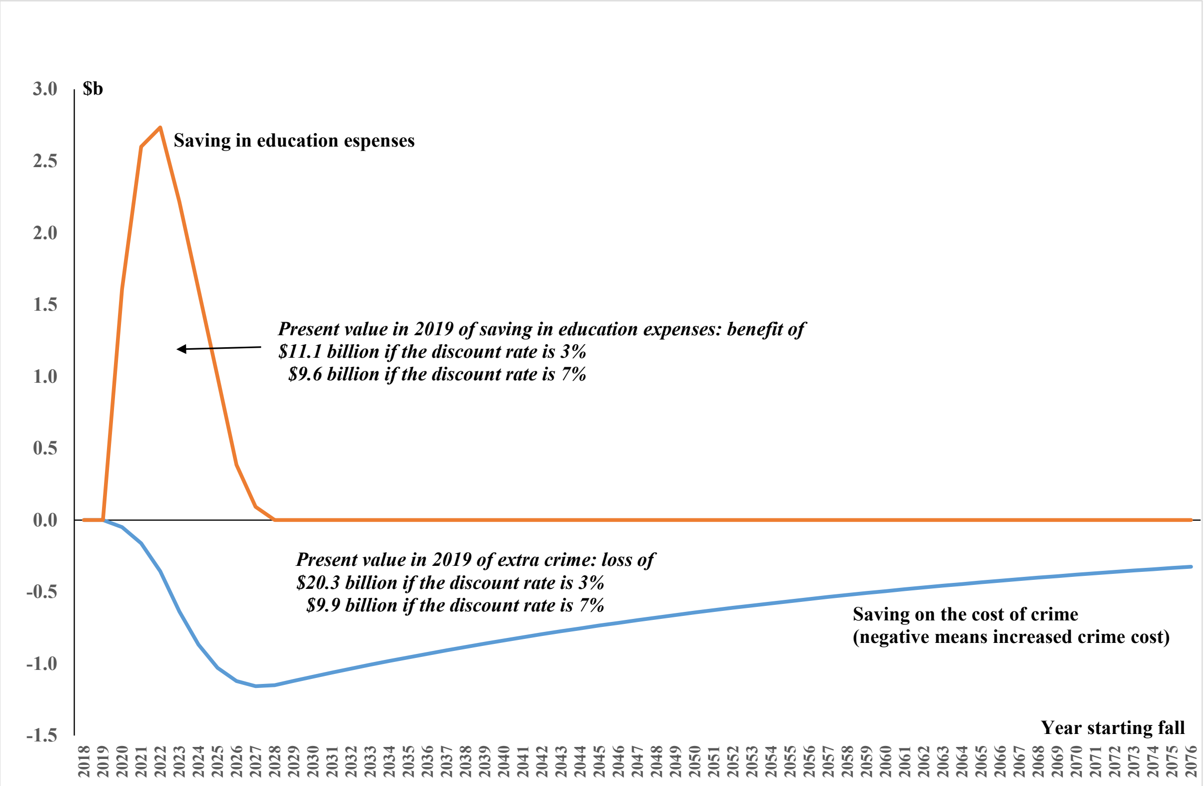


Chart 3 shows the extra costs of crime and the savings of education expenses associated with increased drop-out rates. As with the loss of effective labor input, the extra crime costs occur over many years. However, this effect may be exaggerated in our model because we do not allow for reductions in crime rates as people age. Subject to this proviso, our calculations show that the present value in 2019 of extra crime costs is $20.3 billion if the discount rate is 3 per cent and $9.9 billion if the discount rate is 7 per cent.

Cost savings associated with having less students in high school are substantial but short lived. With a discount rate of 3 per cent, the cost saving has a present value of $11.1 billion in 2019. With a discount rate of 7 per cent, the cost saving has a present value of $9.6 billion. Because the cost savings are concentrated over a relatively short period, the present value calculation does not depend strongly on the discount rate.

Chart 3. Education savings and crime costs ($billion, 2019 prices) associated with the assumed 25 per cent Covid-related increases in high-school drop-out rates



4. Summing up

We investigated the effects of a Covid-related increase in high-school drop-out rates. Specifically, we assumed a 25 per cent increase in the years starting fall 2019 and fall 2020 with a gradual recovery back to baseline (no Covid) rates in 2025. Our modeling indicated that these increases in drop-out rates would

- cause 597 thousand students who otherwise would have graduated to leave school without a diploma. These are students from the cohorts entering high school in the years starting fall 2016 to fall 2024.

This loss of high-school graduates would inflict long-term costs on the U.S. economy by

- reducing effective labor input. In present value terms, the cost would be between $41.8 billion and $128.0 billion depending on the discount rate (7 per cent or 3 per cent).
- increasing the number of crimes. In present value terms, the cost would be between $9.9 billion and $20.3 billion depending on the discount rate (7 per cent or 3 per cent).

With a higher drop-out rate there are less students in high school. In our 25 per cent scenario, this would

- reduce public expenditures on education. In present value terms, the savings would be between $9.6 billion and $11.1 billion depending on the discount rate (7 per cent or 3 per cent).

As can be seen in Table 2, the net cost in present value terms of having 597 thousand potential high-school graduates turn into high-school drop-outs is between $42.1b and $137.2b. On a per student basis, this cost ranges from $71,000 to $230,000. Taking account of "productivity and education costs" and using discount rates of 7 per cent and 3 per cent,

Table 2. Present value ($billion in 2019 prices) of a temporary 25 per cent increase in high-school drop-out rates

	Discount rates	
	3%	7%
Loss of effective labour input	128.0	41.8
Loss from extra crime	20.3	9.9
Total negative effects	148.3	51.7
Saving on high-school expenditures	11.1	9.6
Net cost	137.2	42.1

Vining and Weimer (2019, Table 3) give the per student cost of a missed high-school graduation as $75,000 and $228,000. The comparable numbers for us, excluding crime effects, are $54,000 and $196,000. Vining and Weimer obtain considerably larger numbers ($121,000 and $332,000) when they include externalities that cover crime and "improved consumption and fertility choices, and enhanced intra-family productivity". Distributional considerations also suggest that the net costs in Table 2 may understate implications for social welfare. It is likely that the costs of higher drop-out rates are borne disproportionately by socially disadvantaged groups.[7]

To us, the findings set out in Table 2 have two main implications: one for future research and one for policy.

For future research, effort should be put into fine tuning the calculation of effective labor input, including the wage-related weighting scheme used to add up the contributions made to the economy by people with different educational attainments. The costs of crime and the saving of educational expenses are small relative to the value of lost labor input.

For policy, given the cost per lost high-school graduate, our calculations support large scale efforts designed to help children stay in school through the Covid crisis. If effective programs such as provision of technology support, one-on-one online tutoring and family financial support can be implemented, then costs in 10s of billions of dollars should not be considered prohibitive.

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