

Income Disparity and Its Influence on Higher Education Affordability and Access*

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February 19, 2024

Throughout the years, we have seen how rising income inequality fuels college tuition hikes, casting a spotlight on the urgent need for policies that bridge the educational divide. This paper is a reproduction on the connection between rising income inequality and the surge in college tuition costs in the United States. Utilizing a detailed economic model, the increasing disparity in income has been a significant driver behind the growth in tuition fees since 1990, accounting for more than half of the observed increase and has also led to a decline in college attendance rates. Extending this analysis through secondary research to include Canadian universities reveals similar trends, indicating a broader North American pattern where income inequality impacts educational accessibility. This comparative approach underscores the global relevance of their findings, suggesting that addressing income disparities could play a crucial role in making higher education more accessible.

1 Introduction

In recent years, the escalating cost of college tuition in the United States has emerged as a critical issue, intertwining with the broader narrative of rising income inequality. The paper by Zhifeng Cai and Jonathan Heathcote addresses this pressing concern by examining the relationship between these two phenomena. Utilizing a competitive model of the college market, the study not only uncovers the mechanisms that link rising income inequality to increasing tuition costs but also sheds light on the consequent impacts on college attendance and social mobility (Cai and Heathcote 2022). Through this paper, we aim to illuminate the unique challenges and opportunities facing the Canadian higher education system in the context of

*Code and data are available at: <https://github.com/fanger2791/College-Tuition-and-Income-Inequality/tree/main>

rising tuition costs and income inequality. Incorporating a Canadian perspective into our reproduction study adds a crucial comparative dimension, allowing us to explore the dynamics of university tuition and income inequality within a different national context. This extension acknowledges the distinct structure of the Canadian higher education system and its funding mechanisms, which differ from those in the United States in terms of government support, the magnitude of tuition fees, and the socio-economic landscape.

Central to the Zhifeng Cai and Jonathan Heathcote paper’s findings is the assertion that the surge in U.S. income inequality since the 1990s can account for more than half of the observed increase in average net tuition over the same period (Cai and Heathcote 2022). This relationship underscores a critical feedback loop where income disparities not only affect individual capacity to afford higher education but also drive institutional behaviors around tuition setting. Moreover, the paper highlights the detrimental effects of rising tuition on college attendance rates, particularly among lower-income segments, positing significant implications for social mobility and equity (Cai and Heathcote 2022).

To build upon the original work of Zhifeng Cai and Jonathan Heathcote, our project will undertake a reproduction of the study, focusing on two or three of its core aspects. This will involve:

1. Recreating Table 3: We will split the table into private college versus public college. In the original work, it was not clearly stated where the data came from or for private two year studies or public four year studies. With that, we will look at data sets from the paper and recreate Table 3 from the original work. The new tables will focus on the price change from the earliest data and most recent data. In addition, the two tables are separated by private four year non profit college versus public four year college. This step includes extensive data cleaning and edits due to excel file formats. All the steps can be found in the source code to increase the reproducibility of our analysis.
2. Recreating the Model: We will start by reproducing the competitive college market model used in the original study, ensuring our work is entirely reproducible. This step includes verifying the model’s assumptions, computational methods, and data inputs.
3. Expanding the Study with a Canadian Lens: Specifically examine how income inequality within Canada affects university tuition, comparing these dynamics with the findings from the U.S. context. This will provide insights into how different policy environments and socio-economic conditions influence the relationship between income inequality and higher education costs.

Our project involves crafting a concise paper that encapsulates the entire reproduction study. This paper will meticulously outline our source and methodology, ensuring clarity on how we’ve mirrored the original study’s model while integrating steps for high reproducibility. It will also present a comparative analysis of our findings against the original study’s conclusions, pinpointing any variances and their potential causes. Additionally, the paper will delve into the implications of our policy simulations, offering insights into how income inequality

influences college tuition and attendance. Lastly, it will propose directions for future research, highlighting areas within the college tuition-income inequality that remain unexplored, setting the stage for subsequent scholarly inquiry.

2 Data

2.1 Source

This paper reproduces several areas of the original paper by Zhifeng Cai and Jonathan Heathcote (Cai and Heathcote 2022) which is originally from the American Economic Association. This reproduction utilizes the same data sets in the process. Please note that the datasets used are unfortunately not publicly accessible.

2.2 Methodology

In replicating the original model by Zhifeng Cai and Jonathan Heathcote, our methodology was crafted to mirror their approach with precision, ensuring the highest degree of reproducibility. This entailed a thorough analysis of the original study’s model, including its assumptions, variables, and computational methods. We closely followed the procedural steps outlined in their research, from data collection through to the analytical techniques employed to examine the relationship between income inequality and college tuition costs. To guarantee reproducibility, we documented each step of our process in detail, including the coding practices, statistical software used, and the sources of our data. This approach not only underscores our commitment to transparency and scientific integrity but also enhances the reliability of our replication efforts.

R (R Core Team 2023) was the language and environment used for this reproduction, with different packages such as tidyverse (Wickham et al. 2019), ggplot2 (Wickham 2016), readxl (Wickham and Bryan 2023), dplyr (Wickham et al. 2023), tidyr (Wickham et al. 2024), knitr (Xie 2023) packages.

2.3 Variables

Variables within the datasets have been constructed to reflect the nuances of income distribution across different socioeconomic groups and the corresponding tuition rates at a range of institutions, from community colleges to elite universities.

We have listed the different variables used below and how they correspond:

1. Net Prices Data:

public_college_netprice: Data on the net prices of public colleges.

private_college_netprice: Data on the net prices of private colleges.

2. Grants Data:

public_college_grants: Data on total grants by income and year for public four-year colleges.

private_college_grants: Similar data for private four-year colleges.

3. Funding and Revenue Data:

state_funding: average state and local funding for higher education per 1000\$ of personal income

public_rev_subs and private_rev_subs: detailing subsidies and revenues for public and private four-year institutions, with columns for institution type, year, net tuition revenue, subsidy, and education-related expenditures.

4. College Tuition and Fees Data:

Public Sticker: This is the advertised or sticker price for attending a public college or university. It includes tuition, fees, room and board, and other expenses before any financial aid, scholarships, or grants are applied. This price is typically higher than what most students will pay, especially after financial aid is taken into account.

Public Net: The net price for attending a public college or university. This is the amount that students and their families actually pay on average after subtracting scholarships, grants, and financial aid from the public sticker price. The net price provides a more accurate representation of the cost to students and families after accounting for available financial assistance.

Private Sticker: Similar to the public sticker price, this is the advertised price of attending a private college or university. It tends to be higher than the public sticker price, reflecting the total cost of tuition, fees, room and board, and other expenses at a private institution before any financial aid is applied.

Private Net: The net price for attending a private college or university. It's the actual cost to students and their families after deducting scholarships, grants, and financial aid from the private sticker price. Since private colleges often offer significant financial aid packages, the private net price can be considerably lower than the sticker price, though it generally remains higher on average than the public net price.

5. Income Distribution Data

Log Household Income: This refers to the log-transformed household income. In economic data analysis, income values are often log-transformed for several reasons such as to reduce skewness and helps linearize multiplicative relationships, making them easier to model and interpret

Density (EMG_ML_PDF): EMG_ML_PDF” stands for the Estimated Maximum Likelihood Probability Density Function. This term combines several concepts such as Estimated Maximum Likelihood (EML) which is a statistical method used to estimate the parameters of a probability distribution that make the observed data most probable. It’s a common approach in econometrics and statistics for fitting models to data and Probability Density Function (PDF) which describes the likelihood of a random variable to take on a given value. In practical terms, it shows how the values of the random variable are distributed across different outcomes. This density variable shows how the probability distribution of incomes (after log transformation) changes across different income levels for the years analyzed.

3 Results

3.1 Public Four Year College Data

Table 1: Public Four Year College Data

Type	Data_1	Data_2	PercentChange	TimeFrame
Net TFRB	8730	14210	62.77%	1996 to 2016
Grants by Income(1)	5847	9835	68.21%	1999 to 2011
Grants by Income(2)	3693	6667	80.53%	1999 to 2011
Grants by Income(3)	1748	2967	69.74%	1999 to 2011
Grants by Income(4)	1443	2576	78.52%	1999 to 2011
Funding for Higher Education per 1000\$ of Income	7.37	5.283	-28.31%	1984 to 2014
Tuition Revanue	6610	9740	47.35%	2003 to 2013
Subsidy	8350	7640	-8.5%	2003 to 2013

3.2 Private Four Year College Data

Table 2: Private Four Year College Data

Type	Data_1	Data_2	PercentChange	YearFrame
Net TFRB	20020	26080	30.27%	1996 to 2016
Grants by Income(1)	12155	22827	120%	1999 to 2011
Grants by Income(2)	11821	20355	80.84%	1999 to 2011
Grants by Income(3)	10333	15389	28.30%	1999 to 2011
Grants by Income(4)	6328	12489	97.36%	1999 to 2011
Funding for Higher Education per 1000\$ of Income	7.37	5.283	-28.31%	1984 to 2014
Tuition Revanue	19860	23360	17.62%	2003 to 2013
Subsidy	15560	20050	28.86%	2003 to 2013

In the two tables Table ?? and Table ??, the first column stands for tuition, fees, room and board. This is a summary data of the entire expense at that specific institution. The Grants by Income data then looks grants by year given to each income group. For example, the second row of the table looks at grants given out to people that has an annual income of less than 30,000. The sixth row looks at state funding according to an individual's income by per 1000. For example, if an individual were to make 50,000 a year, state funding for higher education to that individual should be 368.5\$. There was no private and public data, as a result the state funding data is the same for both private and public colleges. The last two row looks at the data of the institution's revenue and expenditure on subsidizing students. The year frame was different for each data sets, therefore, we decided to create a separate column for cleaner look for the table. This would prevent N/A cells and could be confusing for readers.

First, looking at Table ??, there is a big increase in the net fees at 62.77% increase in just 20 years. Then looking at the grants given out by the public institutions, even though we see a continuous increase of more funding for the two lower income groups, we are still seeing a big increase in percentage for higher income individuals. When looking at state funding, there is even a -28.31 % decrease in the funding for higher education. Lastly looking at the tuition revenue and subsidy, despite making steady profits, the institution on the other hand decreased subsitizing expenditures by 8.5% from 2003 to 2014.

Second, here are some key findings from Table ?? . There is a less increase of fees at 30.27%. However, the total expenditure is significant more compared to public institutions. Then looking at the grants given out by private institutions, with the lowest income group gaining a significant increase of 120%. Interestingly, the highest group also gained 97.36%. In the same situation, state funding, showed a -28.31 % decrease for higher education. Lastly looking at the tuition revenue and subsidy, 17.62% increase in tuition revenue, and also an increase of 28.86% subsidy expenditures.

Comparing the two data sets, we can see that even though the percentage increase of private institution fees. The net expenditure is still almost three times of public institutions. Overall by income group, private institutions are also a lot more generous in giving out grants, with large numbers compared to public institutions. Private institutions also have a positive percentage increase of subsidy expenditure compared to public institutions despite both having positive tuition revenue over the years. From the table, we can see that private institutions are much more generous in terms of grants and expenditure studies, however, they are also a lot more expensive to attend compared to public schools.

In attempts to uncover more about income disparity and the accesses of higher education, we will recreate two models from the paper.

3.3 College Tuition And Fees

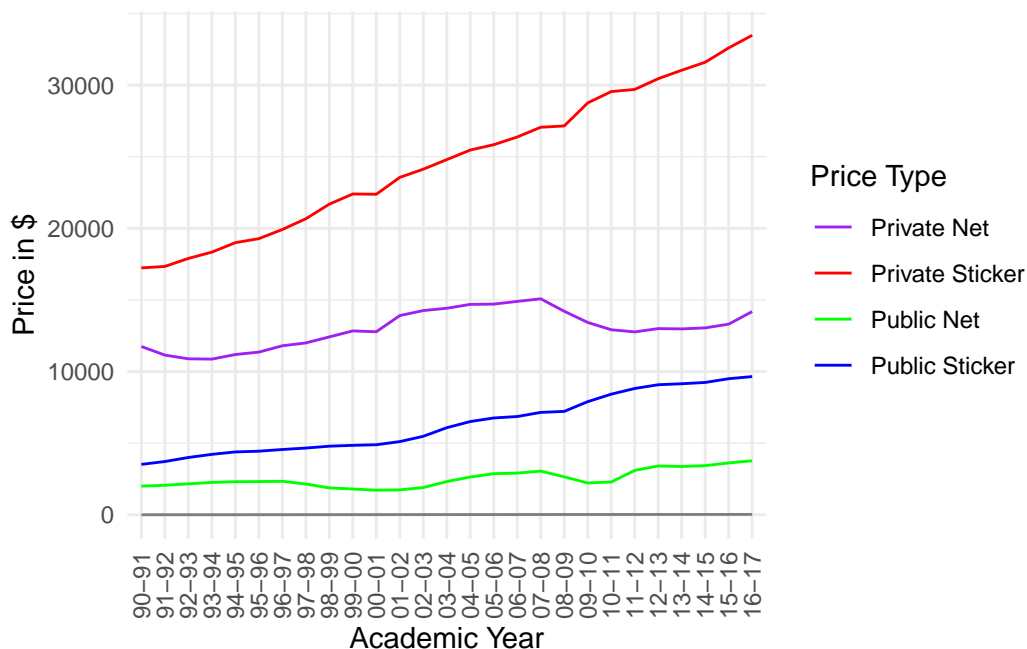


Figure 1: College Tuition And Fees, US\$(2016)

Figure ??, as presented, showcases a multi-decade overview of college tuition and fees in the United States, providing a clear visual representation of trends across both public and private institutions, accounting for inflation to 2016 dollars. The graph is particularly telling in its illustration of the divergent paths between sticker prices and net prices over time.

The private sticker prices, marked by the red line, demonstrate an unbroken ascent throughout the years, effectively doubling from the early 1990s to 2017. This relentless increase is indicative of a higher education market that is possibly responding to increased demand, or perhaps reflecting rising costs associated with providing education, such as faculty salaries, facilities, and resources.

In contrast, the private net prices, shown with the purple line, while following an upward trajectory, do so with a less pronounced slope. This implies that financial aid has absorbed some of the shock of rising sticker prices for students, although it's worth noting that the gap between sticker and net prices appears to widen over time, suggesting that financial aid may not be keeping pace with the increases in sticker prices.

For public institutions, the sticker prices, represented by blue line, show a significant increase but remain substantially lower than those of private institutions. This could reflect the impact of state funding and the different market pressures affecting public colleges and universities. The relatively gentle slope of the public net prices, depicted by the green line, indicates a measure of stability in what students actually pay, possibly due to a combination of state subsidies, federal aid, and institutional grants.

The stability of public net prices, despite the increase in public sticker prices, could be seen as a reflection of a commitment to maintaining access to higher education. However, the upward trend in both sticker and net prices, even if modest for public institutions, points to a broader trend of increasing financial burden on students and families, which may have significant implications for access to higher education, especially for those from lower-income backgrounds.

Analyzing Figure 1 also prompts consideration of the broader economic context, including changes in the funding models for higher education, the role of government policy, and the economic factors at play during this period, such as recessions and economic booms, which can influence both the supply and demand sides of higher education. The continuous rise in prices, especially in the private sector, may also reflect a competitive market where institutions vie for prestige, faculty, and facilities, which in turn, raises the question of the true value of higher education and the return on investment for students.

3.4 Comparison of Income Distribution for 1989 and 2016

Figure ?? is a comparison of estimated income distributions for two different years, 1989 and 2016, represented using a probability density function on a logarithmic scale for household income.



Figure 2: Comparison of Income Distribution for 1989 and 2016

The x-axis represents the logarithm of household income, indicating that the data is not raw income but transformed using a logarithmic function, likely to normalize the distribution and to handle the wide range of incomes more effectively. The use of logarithms in income distribution is common as it tends to make the distribution more symmetric and resemble a normal distribution, which is easier to work with statistically.

The y-axis represents the density, which is the probability per unit on the x-axis. In a probability density function, the area under the curve for a given interval represents the probability that a randomly selected household will have an income within that interval.

The increase in the variance of log income suggests that income inequality has widened from 1989 to 2016. This finding correlates with the hypothesis that growing income inequality might be one of the drivers behind the increase in college tuition. This could indicate that while the relative differences in income may have not shifted dramatically on a logarithmic scale, the actual incomes have grown, particularly at the higher end, contributing to the right skewness seen in the 2016 distribution.

4 Discussion

4.1 Findings

The paper by Zhifeng Cai and Jonathan Heathcote delves into the nuanced dynamics between escalating college tuition fees and the widening gap of income inequality in the United States. It posits a model showcasing how increased income disparities significantly drive up tuition costs, thereby impacting college accessibility. The study highlights the strategic role of financial aid and subsidies in counteracting tuition hikes, yet underscores their insufficiency in bridging the educational divide (Cai and Heathcote 2022). Through a detailed examination of higher education market dynamics, the paper sheds light on the competitive practices of colleges, such as differential pricing and the allocation of financial aid, aimed at attracting students. This analysis culminates in a discussion on the broader implications for policy, suggesting that reform in financial aid structures and a reevaluation of higher education funding models are imperative to address these challenges. The findings present a critical perspective on the economic forces shaping the higher education landscape, offering insights that could guide policy reforms aimed at ensuring equitable access to college education amidst growing income inequality (Cai and Heathcote 2022).

4.2 Dynamics of Canadian Universities using insights by Cai and Heathcote

To explore the dynamics of Canadian universities through the insights provided in the paper by Zhifeng Cai and Jonathan Heathcote and applying a Canadian lens, it's vital to delve into the nuances of tuition trends, income inequality, and access to higher education within Canada. Canadian universities have been experiencing a rise in tuition fees across various programs, with notable increases in professional degrees such as dentistry, medicine, law, and engineering, reflecting a potential barrier to access for students from lower-income backgrounds. The disparities in tuition fees are further exacerbated when considering the level of study, with graduate programs generally demanding higher fees than undergraduate ones, aligning with the expected returns in terms of future employment income (Longpré-Verret and Richards 2021).

The socioeconomic landscape in Canada, marked by growing income inequality, has profound implications for higher education access and outcomes. Trends in intergenerational income mobility and income inequality suggest that the economic background of a student's family plays a significant role in their educational opportunities and future earnings, thereby influencing their ability to afford higher education.

Moreover, the stratification of higher education institutions, observed both in the U.S. and Canada, indicates that access to elite institutions is highly influenced by social and economic factors. This stratification is perpetuated by the increasing concentration of resources and student selectivity at more prestigious universities, further challenging the meritocratic ideals of higher education.

Canadian higher education is also characterized by regional disparities in tuition fees and additional compulsory fees, with provinces like Alberta having higher fees compared to the national average. This regional variation adds another layer of complexity to the affordability and accessibility of higher education across the country. The increasing reliance on international students, who pay significantly higher tuition fees, further highlights the financial challenges faced by Canadian universities and the potential impact on domestic students' access to education.

Addressing these challenges requires a multifaceted approach that considers the role of public funding, financial aid, and policies aimed at reducing income inequality and improving access to higher education for all Canadians. Ensuring that higher education remains a pathway for social mobility and economic opportunity is crucial in the face of rising tuition costs and socioeconomic disparities.

4.3 Potential Weaknesses

There are several potential weaknesses in the findings that warrant consideration. Firstly, the model's assumptions, including a continuous distribution of college quality and linear relationships between variables, might oversimplify the complex, non-linear dynamics present in real-world scenarios. This simplification could introduce inaccuracies in predicting tuition trends and attendance patterns. Secondly, the study's reliance on observed data trends and specific calibrations may not fully encapsulate the intricacies of income distribution, tuition policies, and other socioeconomic factors, leading to potential biases or limitations in the dataset used for analysis.

Moreover, while the model accounts for a broad spectrum of college quality, it might not accurately represent specific types of educational institutions, such as community colleges, vocational schools, and online universities, which do not adhere to the traditional metrics of college quality. Additionally, the focus on income inequality as the primary driver overlooks other significant factors, such as changes in government funding for education, demographic shifts, and evolving labor market demands, which could also influence tuition costs and attendance rates.

Furthermore, the model may not sufficiently consider how policy changes or shifts in household behavior in response to rising tuition and income inequality could alter the college market dynamics. For instance, the increasing prevalence of online education and alternative credentialing pathways might disrupt traditional patterns of college attendance and tuition pricing strategies. Lastly, the study's conclusions are based on historical data up to a certain point, and the long-term applicability of these findings might be limited by emerging trends and changes in the landscape of higher education and economic inequality.

4.4 Limitations to our reproduction

From a reproducibility standpoint, the absence of provided code or detailed methodology for recreating the tables, graphs, and statistical analyses by Zhifeng Cai and Jonathan Heathcote introduces significant limitations. The ability to replicate study findings is foundational to the validation and advancement of scientific research. Without access to the exact computational procedures, data analysis scripts, or software used, other researchers are hindered in their ability to verify the results, explore the implications further, or apply the methodology to new datasets. This lack of transparency can impede the reproducing process as others may struggle to build directly on these findings without a clear understanding of the original analysis techniques.

Moreover, the reproducibility issue extends beyond just the recreation of visualizations to the very core of the study’s conclusions. The modeling assumptions, data transformations, and statistical methods employed are crucial for understanding the dynamics between income inequality and college tuition. Without clear documentation or code, it becomes challenging to assess the robustness of the model, the sensitivity of the results to different assumptions, or the potential for bias in the analysis. This gap not only affects the credibility of the findings but also limits the potential for educational policymakers, economists, and other stakeholders to apply these insights effectively.

4.5 Future Research

Future directions should focus on closing gaps in our understanding of the dynamics between income inequality and college tuition. This involves exploring the nuanced effects of policy interventions over the long term and across diverse socio-economic groups. Researchers should consider longitudinal studies that track the impact of tuition changes on generations of students, incorporating variables like technological advancement, labor market shifts, and changing demographics. Policy-wise, a multi-faceted approach is necessary, combining financial aid adjustments, tuition regulation, and innovative funding models for higher education. Engaging with broader societal issues, such as wage stagnation and economic mobility, is crucial for creating more equitable access to higher education.

Like mentioned in the paper, Cai and Heathcote acknowledges the limitations of using a perfectly competitive model to understand real-world educational markets, where competition among colleges is imperfect and how colleges might use financial aid information to offer less aid to students from wealthier families, particularly at more selective institutions, suggesting these colleges possess significant pricing power. To delve deeper into these complexities, the passage proposes several research extensions such as modeling colleges with unique attributes like location or brand name that could justify differential pricing and attract students with specific preferences. They also raise the idea of exploring how colleges’ limited information about applicants’ abilities affects students’ strategies in applying to multiple institutions. It advocates for broadening the scope of attributes considered in college admissions to include

the value of diversity, potentially altering the competitive landscape for colleges seeking to attract students from varied backgrounds. By examining how changes in the value placed on college quality could affect income inequality and intergenerational mobility over time. They hypothesizes that an increase in the financial returns from attending high-quality colleges could lead to greater investment in such education by wealthier families, thereby exacerbating income inequality and reducing social mobility across generations.

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