

## Volume 7



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#### Letter from our Editor-in-Chief

It is with great pride that I preside over Volume XII of the Print Publication of The Economics Review at New York University. It has become tradition for our publication to serve as a platform for promoting emerging scholarship in the field of economic sciences and this year we steadfastly continue with this mission. This year has been remarkable in that we experienced the reopening of our university and the return to the many practices that we missed greatly in the years prior. We regained a sense of community which has facilitated the development of some of highest quality writing this publication has had the pleasure of publishing. We likewise connected with leading experts in our field which allowed us to better navigate this challenging and at times confusing global economic environment.

Volume XII of the Print Publication is made possible by the tireless work of our staff. The Co-Editors of the Print Publication, Stuti Saria and Taran Agarwal, curated and edited the works that exemplify some of the most pressing themes in modern economic research. For this and all their other contributions to the operations of our publication I thank them. I also would like to thank and commend Eugene Seong and Anoushey Gajial for deftly serving as Managing Editors of our Online Publication. Your devotion to supporting our writers in the production of innovative and thought-provoking work for our readership was unwavering week in week out. Eugene, along with our Treasurer Joseph Kwon, will serve as Co-Presidents next academic year and I cannot think of two better candidates to guide this publication into the future. Thank you to the remainder of our E-board including Revan Aponso, Joseph Kwon, and Angel Cortes. You supported the operations of our publication well and we could not have done it without you. Lastly, I would like to thank Will Rojas, the Co-President who worked with me to manage and grow this publication that we both devoted so much to. I speak for the both of us when I say that The Economics Review is in great hands and that we cannot wait to see how you improve on our mission of providing outstanding student scholarship to the university community.

The papers in this year's Print Publication represent research techniques and topics at the forefront of economic inquiry. I hope that they inspire our readership to seek change and improvement in our world. In our view, this can be achieved by harnessing the power of economic research as exemplified by our works. The Economics Review is grateful for our readers that continue to support and inspire our research as well as our predecessors, including the former President Malvika Sriniwasan, for establishing a foundation on which we were able to build.

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Sincerely,	

Tomasz Jankowski

### Letter from the Managing Editors of the Print Publication

Our Print Publication is a means to cultivate research skills in our authors by providing them an au courant reading audience to their work. These authors are unique in their commitment to independent research, exploring crucial queries about our economic and societal realities. Their dedication, resilience, and desire to transcend traditional boundaries have brought them here. Their work reflects a deep passion to dig deeper and go further, traits that are commendable in a world that often values quick solutions over thorough understanding. We would like to present to you, with great pleasure, the Editorial of the Economics Review at New York University.

For the 2022-23 Academic Year issue, the print publication committee selected five papers to present to our readers. The researchers discuss a wide array of topics related to how different industries responded differently to COVID-19, the effects of school funding on test scores, the changes in economic output in response to investments in air transport infrastructure, explaining the U.S. stock market returns through a multi-factor model, and how economic development affects carbon dioxide emissions.

This publication would not have been possible without the comprehensive and thoughtful editing contributions of the Review Editors Minh Ta and Vyomini Kapse. We would also like to take this opportunity to thank our executive board members. Throughout this entire process, they have been diligent in their efforts to keep the Economics Review team centered and focused. Finally, we want to extend our thanks to Arvind Sriram and Jamie Simonson, our inspiring seniors at New York University, who have contributed their honors theses to this year's issue.

As a creative and ardent team of editors and writers, the Economics Review aims to provide New York University students with an informative, analytical, and inspirational source of articles and research papers that encourage students to think analytically and conduct original research. The subjects in this volume cover a wide range of interesting and thought-provoking topics that promote inquiry and critical thinking. We hope each piece in the publication provides you with a new perspective.

Sincerely,	
Stuti Saria	& Taran Agarwal

Happy Reading!

## **Academic Papers**

# The Effects of Spending on Standardized Test Scores: A Case Study in New York City Public Schools<sup>1</sup>

#### By Arvind Sriram

#### **New York University**

#### Abstract

This study uses data on standardized test scores from 2006 through 2018 at New York City public schools to determine the effects of spending on student performance. The years in the data set straddle 2008, when New York City dramatically changed the way that K-12 schools are funded, and moved toward equalization of spending across schools. Intuitively, this paper follows an Instrumental Variable framework, where I leverage the policy-induced funding variation, specifically, the implementation of the Fair Student Funding (FSF) policy in the 2007 - 2008 school year, as a natural instrument to use in addressing the possible endogeneity of spending. Focusing on standardized test scores for the English Language Arts ELA) and Mathematics exams (the most complete and consistent data available for New York City), I find that increases in spending have nontrivial, statistically significant effects on test scores.

#### 1. Introduction

The extent to which an increase in financial resources leads to an improvement in student outcomes is a topic of debate amongst education policy scholars as well as social scientists. Intuitively, one would expect that an increase in educational expenditure would lead to improvements in student outcomes such as test scores and graduation rates. To create greater equity among school districts, several states have shifted to centralizing K-12 school funding at the state level with the goal of providing equal resources per student (Papke, 2005). More recently, New York City centralized K-12 school finance to equalize spending through the Fair Student Funding (FSF), which utilizes a series of need-based weightings to determine the amount of funding for each public school. Proponents of a shift in educational funding argue that additional resources can lead to improved student outcomes, especially for lower-income families (Baker, 2017), while others argue that the link between state aid reform and student performance has been proven difficult to establish (Yinger, 2004).

This paper examines the causal impact of student spending on standardized test scores in the public education system in New York City from 2006-2018. To do so, I leverage the policy induced funding variation, specifically, the implementation of the Fair Student Funding policy in the 2007 - 2008 school year, as a natural instrument to use in addressing the possible endogeneity of spending.

A variety of econometric methods suggest a positive effect of spending on standardized test scores for the ELA and Mathematics standardized exams administered to New York City

<sup>&</sup>lt;sup>1</sup> This paper is adapted from the thesis that was submitted in partial fulfillment of the degree requirements for the honors degree of Bachelor of Arts in Economics.

3rd-8th graders with the most convincing estimates (the IV estimates) denoting the largest effects. A generalized rule would be that a \$10,000 increase in FSF per student tested increases the ELA exam by between 0.01 - 0.1 standard deviations and the Mathematics exam by 0.01 - 0.05 standard deviations.

The New York City public schools provide an interesting context for exploring the relationship between spending and standardized test scores. New York City has one of the largest and most diverse public school systems in the United States, with over 1.1 million students enrolled in over 1,800 schools (NYC DOE, n.d.). Research on the relationship between spending and standardized test scores in New York City public schools has produced mixed results. The method of measuring spending varies with some studies considering overall education expenditures and others focusing on specific areas like teacher salaries. Nevertheless, understanding the causal impact between these factors is crucial for efficient resource allocation and improving student outcomes.

#### 2. Background

Prior to 2007, New York City allocated public school funding through a series of financing formulas that were tied to the number of teachers the school had and the salary levels of those teachers. As a result, schools that performed better on standardized test scores received a greater amount of funding since they attracted and retained experienced teachers who earned higher salaries. (Disare, 2018). To address the funding equity problem that this policy contained, New York City passed the Fair Student Funding (FSF) formula, which promotes equity by funding students' needs (NYC DOE, n.d.). FSF is allocated to each school based on the following components:

- A formula that accounts for the number and instructional need attributes of students at the school, valued at the cost of providing these services at the citywide average salary, excluding collective bargaining-related increased costs
- Collective Bargaining related increases reflecting costs based on the number and salaries of current staff

One example of an NYC public school that experienced changes in funding before and after the introduction of the FSF is P.S. 110 The Florence Nightingale School in Manhattan. Before the FSF was introduced, P.S. 110 The Florence Nightingale School had an average total budget of \$3.2 million in school years 2005-2006 and 2006-2007, which came from a combination of state and city funding (SBER, n.d.).

After the introduction of the FSF in the 2007 - 2008 school year (FY 2008), P.S. 110 The Florence Nightingale School's budget increased by \$0.8 million, which allowed the school to make several significant improvements (SBER, n.d.). For example, the school was able to hire additional teachers and support staff, which helped to reduce class sizes and provide more individualized attention to students. Additionally, the school was able to invest in new technology which enhanced the learning experience for students.

Overall, the FSF had a positive impact on P.S. 110 The Florence Nightingale School, and many other NYC public schools, as it provided additional funding that allowed schools to invest in resources and programs. Suggestively, the school saw a significant increase in the ELA and

Mathematics exams, averaging 0.89 standard deviations above the mean ELA score post-FSF (2008 - 2018) compared to averaging 0.74 standard deviations above the mean Mathematics score pre-FSF (2006 - 2007) and averaging 1.10 standard deviations above the mean Mathematics score post-FSF (2008 - 2018) compared to an average of 0.77 standard deviations above the mean Mathematics score pre-FSF (2006 - 2007). Figure 1 shows the average mean scale score for the Mathematics exam pre-FSF (2006 - 2007) and post-FSF (2008) for schools with High FSF (schools above the average FSF) and Low FSF (schools below the average FSF).

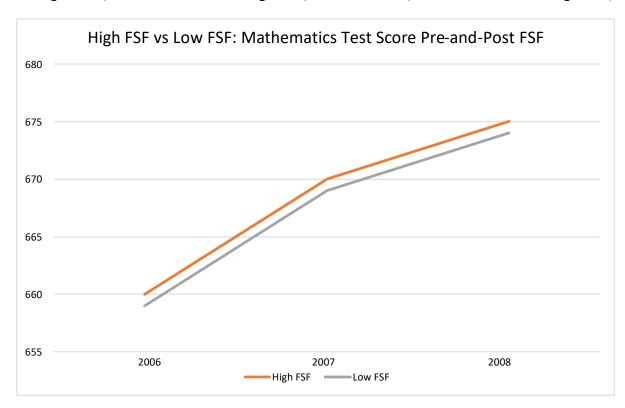


Figure 1: Mathematics Test Scores for High and Low FSF Schools

#### 3. Literature Review

(Papke, 2005) uses data on standardized test scores from 1992 to 1998 at Michigan schools to determine the effects of spending on student performances, defined as the pass rate on the math standardized test. Papke finds that 10% more real spending increases the pass rate by between one and two percentage points, and more for initially underperforming schools.

(Lee et. al., 2018) utilize a regression discontinuity design to examine how the change in school expenditures affect dropout rates in New York during the 2003-2004 to 2007-2008 school years. They find that increases in school expenditures reduce New York State dropout rates. (Dinerstein et. al., 2017) use a quasi-experimental design to examine the impact of public policies on the supply of private schools. Specifically, Dinerstein and Smith examine the impact of the Fair Student Funding (FSF) reform in NYC on student enrollment decisions and student outcomes. Dinerstein and Smith find that a \$1,000 projected increase in per-student funding

leads to an increase in a public elementary or middle school's enrollment increased by 32 students. Furthermore, Dinerstein and Smith argue that public schools spent a large fraction of the additional funding on teacher salaries and benefits, and this is reflected in an estimated increase in school value-added of 0.04 math standard deviations for a \$1,000 projected increase in funding per student, implying that the allocation of funding impacts student outcomes.

(Hong et. al., 2016) employ a regression discontinuity design to examine the causal impact of capital expenditures on school district proficiency rates in Michigan. They suggest that capital investments are unlikely to have short-term effects on achievement but could have longterm effects as the percentage of students reaching proficiency in reading increases by 2 to 6% (equivalent to 0.1 to 0.3 standard deviations). However Hong and Zimmer do not explain why they observe a positive effect in the long term, but not the short term.

(Martorell et.al., 2016) utilize a dynamic regression-discontinuity framework to examine the impact of school facility investments on student outcomes using the information on all tested students in the state of Texas over a 14-year time period. They conclude that typical recent capital investments made and financed by local school districts themselves did not generate appreciable improvements in student achievements. Although there may be intangible benefits to improvement in school facilities, they. conclude that improved test scores are not the main channel.

Based on the existing literature, an increase in operational expenditure and funding will lead to an increase in student outcomes such as test scores (Papke, 2005, Dinerstein et. al., 2017, Lee et. al., 2018). The impact of capital expenditure on student outcomes appears to be ambiguous; capital investments could have long-term effects as the percentage of students reaching proficiency in reading (Hong et. al., 2016) while an increase in capital expenditure could have no impact on student outcomes (Martorell et.al., 2016).

NYC's FSF reform created an excellent instrument for the performance-spending relationship since the change in school funding produced a natural experiment. By using the estimated FSF, I hope to exploit the extra variation in spending within schools that would not have been present without the implementation of the FSF reform.

In addition to utilizing the estimated FSF as an instrument, I aim to examine whether an increase in Direct Services to Schools per Student leads to an increase in standardized test scores. By using the Direct Services to Schools per Student as the variable of interest, I aim to examine the relationship between operational expenditure and student outcomes in a previously unexplored region, NYC. Additionally, I can examine the changes in spending directly on student performance by using data from state-wide tests that have a long history in the state. The next section discusses the data and summary statistics for key variables.

#### 4. Data and Summary Statistics

All the data for this paper comes from the New York City Department of Education (NYC DOE). This paper also focuses on 1,000+ New York City Public Schools that are eligible to take the standardized tests (grades 3-8) for the years 2006-2018.

As previously mentioned, the ELA and Mathematics standardized test results data comes from the NYC DOE which dates back to the 2006 school year. Every year, students in grades

three through eight participate in the ELA and Mathematics state assessments (NYC DOE). ELA and Mathematics test results are available at the city, borough, district, and school levels. Each file contains results for all students tested, as well as results by student characteristics including disability status, English Language Learner (ELL) status, race/ethnicity, and gender. The category in each file includes the school, grade (ranging from 3 – 8), year (ranging from 2006 – 2022), student category, number of students tested, mean scale score, and the number and percentage of students who achieve Level 1, 2, 3, and 4 statuses (NYC DOE, n.d.).

This paper in particular focuses on the mean scale score for both the ELA and Mathematics exam. However, since the New York State Department of Education re-scaled the ELA and Mathematics exam in 2018, I standardized the mean scale score by subtracting a school's mean scale score from the mean scale score for the examined year and dividing by the standard deviation of the mean scale score for the examined year. This standardized methodology can be summarized in the following equation:

$$z_{s,t} = \frac{x_{s,t} - \mu_t}{\sigma_t}$$

where  $x_{s,t}$  represents the mean scale score for a standardized test for school s in year t,  $\mu_t$  represents the average mean scale score for a standardized test in year t, and  $\sigma_t$  represents the standard deviation of the mean scale score for a standardized test in year t. Therefore,  $z_{s,t}$  represents the number of standard deviations away from the average mean scale score for school s in year t.

School revenue and expenditure data are sourced from NYC DOE's School Based Expenditure Reports (SBER) dating back to the 1999-2000 school year. The SBER categorizes annual expenditures at the DOE by purpose, district and system-wide levels, student service type, and source.

The SBER classifies the categories of spending based on direct services to schools, which are services provided directly to public school students which take place primarily in the school building during the school day and school year, central support costs, which are dollars spent to support system-wide support functions and obligations not directly associated with any specific district or school, system-wide obligations, which are non-administrative costs including debt service and pension contributions for DOE employees, and pass-throughs, which are funds administered by the DOE for children who are served in non-public schools, charter schools and the Fashion Institute of Technology (SBER, n.d.).

This paper particularly focuses on the direct services to schools per student at the school level from 2014 - 2018. The rationale behind this is that existing literature found that an increase in operational expenditure and funding will lead to an increase in student outcomes such as test scores (Papke, 2005). Furthermore, focusing on direct services to schools on a per-capita basis will allow for better comparison across different schools.

Fair Student Funding data, sourced from the NYC DOE, is calculated through five basic categories: FSF Foundation, FSF Grade weights, FSF Needs weights, Enhanced FSF weights for portfolio high schools, and collective bargaining-related increases.

For this paper, Fair Student Funding data is utilized as an instrument for school funding. Similar to previous literature, Fair Student Funding data is reported in terms of per-student tested, which can be summarized in the following equation:

$$FSF\ per\ Student\ Tested_{s,t} = \frac{FSF_{s,t}}{Students\ Tested_{e,s,t}}$$

where FSF represents the Fair Student Funding received by school s in year t and Students Tested represents the number of students tested in exam e (either mathematics or ELA) in school s in year t.

Table 1: Summary Statistics

	mean	Sd	min	max	N
Dependent variables					13,19
Normalized Mean Scale Score (ELA)	-0.02	0.98	-4.27	3.99	3
Normalized Mean Scale Score (Math)	-0.01	0.98	-3.12	3.66	13,19
T 1 1 4 11					3
Independent variables	20.2		11.2		5,16
Direct Services to School per Student (\$1,000s)	9	4.86	4	60.73	2
ELA: Estimated FSF per Student Tested (\$10,000s)	0.99	0.69	0.00	23.52	13,19 3
Math: Estimated FSF per Student Tested (\$10,000s)	0.97	0.71	0.00	25.09	13,19 3
Control variables	16.9			100.0	13,19
% Students Tested with Disabilities (ELA)	9	7.00	0.31	0	3
% Students Tested with Disabilities (Math)	17.2	6.93	0.31	100.0	13,19
	3			0	3
% Students Tested with Economic Disadvantage (ELA)	78.1	21.4	3.00	100.0	13,19
- , , ,	9	9		0	3
% Students Tested with Economic Disadvantage	78.2	21.4	2.99	100.0	13,19
(Math)	5	7		0	3
% Current ELL Students Tested (ELA)	11.7	10.5	0.10	97.96	13,19
	6	1			3
% Current ELL Students Tested (Math)	14.2	12.2	0.10	98.10	13,19
	1	8			3
Observations Count					
Years					12
Schools					1,10
					0

Table 1 presents summary statistics for ELA and Math test scores, covering 1,100 schools. The average normalized mean scale score for ELA is -0.02 standard deviations from the mean and for Math is -0.01 standard deviations from the mean.

Note, in Table 1, the minimum FSF received by a school was \$0. That is because the following schools in districts 1 - 32 are not funded via FSF due to their highly specialized needs: American Sign Language and English Secondary School, The American Sign Language & English Lower School, and The Children's School.

#### 5. Methodology

#### i. Ordinary Least Squares Model

I initially pool the data across schools and time to estimate the standard regression model by ordinary least squares (OLS). In this regression, I model the normalized mean scale score as a function of direct services to school per student and other observable controls. The equation can be written as:

$$Y_{s,t} = \beta_0 + \beta_1 S_{s,t} + \beta_2 X_{s,t} + \alpha_s + T_t + \varepsilon_{s,t}$$

$$\tag{4.1}$$

where Y represents the normalized mean scale score for ELA and Mathematics, S represents the direct services to schools per student, X includes my control variables — the percent of students tested with disabilities, the percent of students tested who are economically disadvantaged, and the percent of students tested who are current English Language Learners (ELL).  $\alpha_s$  represents school-level fixed effects, the vector  $T_t$  contains dummy variables for each year, and  $\varepsilon_{s,t}$  is the idiosyncratic error term that changes across year t for each school s. Estimating Eq. (1) with fixed effects allows for a correlation between unobserved heterogeneity in schools and spending. Essentially, the presence of  $a_i$  and  $T_t$  allows for differences in educational costs, geographical differences, and historical differences among schools. However, OLS model used has endogeneity issues due to factors like student and teacher characteristics, school quality, and local economic conditions, which can affect both school spending and test scores. These factors can bias the estimates of the direct effect of school spending.

#### Instrumental Variable Model

Furthermore, by estimating Eq. (1), it is still possible that spending is correlated with  $\epsilon_{s,t}$  since there are other factors such as parental motivation and parental income that are correlated with spending that are still in the error term. The nature of the NYC education finance reform beginning in the 2007-2008 school year provides a natural instrumental variable for school funding. In this paper, I use the estimated FSF per student tested calculated by the DOE as an instrument for funding. The equation can be written as

$$Y_{s,t} = \beta_0 + \beta_1 \widehat{FSF}_{s,t} + \beta_2 X_{s,t} + \alpha_s + T_t + \varepsilon_{s,t}$$

$$\widehat{FSF}_{s,t} = \gamma_0 + \gamma_1 Calculated \ FSF_{s,t} + \gamma_2 X_{s,t} + \alpha_s + T_t + v_{s,t} \ (4.3)$$

where  $Y_{s,t}$  represents the normalized mean scale score for ELA and Mathematics in school s for year t,  $\widehat{FSF}_{s,t}$  represents the estimated FSF per student tested calculated by the NYC DOE in school s for year t, and  $X_{s,t}$  includes my control variables for school s for year t.  $\alpha_s$  represents school-level fixed effects, the vector  $T_t$  contains dummy variables for each year, and  $\epsilon_{s,t}$  is the idiosyncratic error term that changes across year t for each school s.

Estimating Eq. (2) using school-level and year-fixed effects allows us to estimate the correlation between spending and unobserved school heterogeneity. However, it is still possible that spending is correlated with  $\epsilon_{s,t}$  since there are other factors such as parental motivation and parental income that are correlated with spending that is still in the error term.

#### 6. Results

In this section, I estimate equations relating the normalized mean scale score for the ELA and Mathematics exams to per-pupil spending and a few other controls using data at the individual school level. Columns (1) of Table 2 and Table 3 present pooled OLS estimates that do not remove an unobserved school effect. As I mentioned in Section 4, I normalized the mean scale score such that the point-slope estimate is in terms of standard deviations.

Table 2: ELA Results

	(1) Pooled OLS	(2) Fixed Effects	(3) IV	(4) FE - IV
Direct Services to School Per Student (in \$1,000s)	-0.030***	0.014***		
	(0.002)	(0.002)		
Estimated FSF per Student Tested (in \$10,000s)			0.098***	0.013
			(0.001)	(0.012)
% Economic Disadvantaged Tested	-2.345***	-0.135**	-2.427***	-0.087**
	(0.042)	(0.049)	(0.047)	(0.008)
% Students with Disabilities Tested	-3.403***	-1.763***	-4.334***	-2.159***
	(0.129)	(0.120)	(0.098)	(0.079)
% Current ELL Tested	-1.835***	-2.585***	-2.672***	-1.225***

	(0.083)	(0.130)	(0.068)	(0.066)
Intercept	3.249***	0.223	2.849***	0.110
	(0.039)	(0.129)	(0.038)	(0.095)
				V
Fixed Effects	No	Year, School	No	Year, School
Multiple R-Squared	0.6580	0.9585	0.3879	0.9003
Observations	5,162	5,162	13,193	13,193
Adj. R-Squared	0.6577	0.9474	0.3877	0.8903

Note: \* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001

Table 3: Mathematics Results

	(1) Pooled OLS (	(2) Fixed Effects	(3) IV	(4) FE - IV
Direct Services to School Per Student (in \$1,000s)	-0.031***	0.023***		
	(0.002)	(0.002)		
Estimated FSF per Student Tested (in \$10,000s)			0.048***	0.011
			(0.010)	(0.008)
% Economic Disadvantaged Tested	-2.327***	-0.095	-2.438***	-0.345***
	(0.049)	(0.049)	(0.051)	(0.028)
% Students with Disabilities Tested	-3.653***	-1.720***	-4.226***	-1.745***
	(0.153)	(0.123)	(0.108)	(0.083)
% Current ELL Tested	-0.591***	-1.851***	-1.112***	-0.360***
	(0.090)	(0.126)	(0.064)	(0.062)
Intercept	3.194***	-0.307*	2.732***	0.217*
	(0.046)	(0.002)	(0.042)	(0.100)

Fixed Effects	No	Year, School	No	Year, School
Multiple R-Squared	0.5445	0.9579	0.2866	0.8930
Observations	5,162	5,162	13,193	13,193
Adj. R-Squared	0.5442	0.9466	0.2864	0.8822

Note: \* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001

The estimated effect of a \$1,000 increase in Direct Services to School Per Student leads to a 0.030 decrease in standard deviations on the ELA exam and a 0.032 decrease in standard deviations on the Mathematics exam. Based on existing literature, it does not seem plausible that more resources devoted to the students lead to a decrease in standardized test scores.

Column (2) of Table 2 and Table 3 contains the school and year fixed effects estimates for the Pooled OLS model. The estimated spending effect appears to be similar to existing literature, a \$1,000 increase in Direct Services to School Per Student is estimated to increase the ELA test score by about 0.014 standard deviations and the Mathematics test score by 0.023 standard deviations.

As mentioned in Section 4, the OLS Model consists of endogeneity problems — specifically, spending is correlated with time-varying and idiosyncratic school-specific variables that affect standardized test scores. That is,  $S_{s,t}$  is correlated to  $\epsilon_{s,t}$  in Eq. (1). As explained earlier, NYC shifted to the FSF policy in the 2007-2008 school year, allowing for a natural instrumental variable for spending.

Instead of examining the spending and standardized test score relationship from 2014 - 2018, I increase the sample from 2006 - 2018 for the 2SLS model (equations 4.2 and 4.3). Remember, NYC shifted to the FSF reform in the 2007 - 2008 school year (FY 2008). In the 2SLS model, the pre-treatment group represents data from 2006 - 2007 while the post-treatment group represents data from 2008 2018. The pooled 2SLS estimates of the effects of spending are reported in column (3) of Table 2 and Table 3. The estimated effect of spending is much larger than the pooled OLS or fixed effects estimates. Now, a \$10,000 increase in spending is predicted to increase the ELA and Mathematics standardized test scores by 0.098 and 0.048 standard deviations.

In addition to controlling for spending in the 2007-2008 school year (the year in which NYC shifted to the FSF policy) to make spending exogenous to standardized test scores, I included the year and school fixed effects from Column (2) with the instrumental variable model in Column (3). The presence of year and school-fixed effects allows for initial spending to affect current performance, and it allows for other school-level heterogeneity that might be correlated with spending. The fixed effects—instrumental variables results are given in column (4) of Table 2 and Table 3. The estimated effect of spending is surprisingly smaller: a \$10,000 increase in spending is estimated to increase the ELA and Mathematics exams by 0.013 and 0.011 standard deviations.

The econometric results using the full set of NYC public schools that are eligible to take the ELA and Mathematics exams are broadly consistent with the notion that increased spending can improve student performance.

#### 7. Conclusion and Discussion

A variety of econometric methods suggest a positive effect of spending on standardized test scores for the ELA and Mathematics standardized exams administered to New York City 3rd-8th graders, with the most convincing estimates (the IV estimates) denoting the largest effects. A generalized rule would be that a \$10,000 increase in FSF per student tested increases the ELA exam by between 0.01 - 0.1 standard deviations and the Mathematics exam by 0.01 - 0.05 standard deviations.

This paper addresses a key limitation of earlier literature; previous literature utilizes district-level data that does not control for school-level characteristics. The study uses school-level data from 2006 - 2018, including standardized test scores. It controls for school-level characteristics and uses the Fair Student Funding as an instrumental variable to address changes in school spending. However, the study has limitations due to yearly changes in student composition and the inability to fully control for unobserved differences. Ideally, student-level data would be used to control for these differences. While the study considers the percentage of economically disadvantaged students, it doesn't capture other factors like parent involvement. Furthermore, this study was conducted in New York City, which may limit the generalizability to other states or regions given that different states have different education policies, funding levels, and student characteristics, which may lead to different results in other regions.

Finally, this study includes a limited set of control variables, such as students with disabilities, students who are economically disadvantaged, and students who are current English Language Learners. Other important variables, such as teacher salaries, student-teacher ratios, and curriculum quality, may also affect standardized test scores but are not included in the analysis.

There are several ways in which this study can be extended to further understand the relationship between spending and student outcomes. For example, this paper could analyze the effects of spending on other outcomes. I focused on the impact of spending on standardized test scores, but there are other outcomes that could be examined, such as graduation rates, college enrollment, or future earnings. Examining these outcomes could provide a more complete picture of the impact of spending on education.

Furthermore, this paper could examine the effects of spending on different subgroups. I only focused on the impact of spending on the entire student population. However, it is possible that the impact of spending varies across different subgroups of students, such as those from different socioeconomic backgrounds or those with different levels of academic ability. Examining these subgroups could provide more targeted information about the impact of spending.

Finally, this paper could analyze the impact of different types of spending. I only focused on total spending (Direct Services to School per Student and Estimated FSF per Student Tested), but it is possible that the impact of spending varies across different types of expenditures, such as

spending on teacher salaries, classroom supplies, or technology. Examining the impact of different types of spending could provide insight into which types of expenditures are most effective in improving student outcomes.

Based on the findings of this study, there are many policy implications that could be made in other regions:

- NYC shifted to FSF with the purpose of addressing the funding equity problem that previously existed. School districts in other regions should allocate resources based on student needs and consider providing additional support to low-income and minority students who may be more likely to attend schools with lower funding levels.
- When implementing FSF, NYC also had the goal of full transparency of funds. There should be greater transparency and accountability in how education funding is distributed to ensure that all students have access to the resources they need to succeed.
- Given the generalizability problem, policymakers need to conduct more research in other regions to identify the specific mechanisms through which education spending affects student outcomes, which could inform more targeted and effective policy interventions.

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## Analyzing and Constructing Behavioral Factors in the U.S. Equity Market

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#### **Abstract**

In this paper, we propose a multi-factor model based on investor behaviors and assess its capacity to explain the U.S. market stock returns. Our factor model is based on the behavioral factors which capture investors' reactions (overreaction and underreaction) to the equity price changes. We represent the factors with several quantitative anomalies adapted from Lian, Liu, and Shi (2021), who constructed a four-factor model in the Chinese market with the additional two-size factors. Inspired by Kent, Hirshleifer, and Sun's two-factor behavioral model (2020), we discard the size factors and obtain better performance than the market in explaining the expected equity returns in the U.S.

#### 1. Introduction

The multi-factor model in finance refers to the model utilizing several financial factors to price the return of the security. The model has evolved from the classic CAPM model, which is based on the beta factor for each stock. It has progressed to the French-Fama Three-Factor Model (FFTFM), incorporating firm size, book-to-market values, and market excess returns. Subsequent variations have integrated diverse financial aspects, reflecting extensive research." One variation of the FFTFM is the Carhart four-factor model in which Mark Carhart introduces an additional momentum factor. Specifically, the Monthly Momentum Factor (MOM) can be calculated by subtracting the equal-weighted average of the lowest-performing firms from the equal-weighted average of the highest-performing firms in each month (Carhart, 1997).

From there, more and more researchers have developed different multi-factor models to obtain better predictions of stock prices. Behavioral factors have also become a significant aspect of the model in recent years. However, the relevant papers have focused on a combination of the factors or on analyses of stock companies. We choose a different way in order to examine the investors' behavioral impact on the U.S. equity through overreaction and underreaction. The study suggests behavioral finance could play a major role in the field of quantitative analysis.

#### The Motivation of Behavioral Factors

While the Carhart four-factor model typically demonstrates positive excess returns, it is worth noting that momentum investment strategies can occasionally experience persistent strings of negative returns (Kent & Moskowitz, 2016). One factor influencing the cross-sectional performance is investor behavior. This focuses on the impact of systematic bias, which leads to anomalous excess returns. Such bias is fundamentally driven by individual investor psychology and their reactions to market dynamics. Several pieces of research have confirmed that

overreaction and underreaction can explain the market's anomalies (He, Wang & Yu, 2020). All these models aim to deliver more precise pricing, enhancing the explanation of stock returns. They illustrate the potential superior accuracy that behavioral factors can contribute to predicting such returns.

According to Lian, Liu, and Shi's research on the Chinese stock market, several existing factors have the potential to quantitatively represent the investor's overreaction (BM, short-term reversal, MAX, ABVOL, etc.) and underreaction (SUE, ROA, liquidity shock, etc.) in the U.S. market. We can build scores according to the anomalies, referred from Stambaugh and Yuan (2017), and obtain the correlation between return and reactions. From there, a model containing only the behavioral factors can be formed, and we tested the model's performance based on the historical and current data of the U.S. equity. According to our model which consists of reaction factors, we built a portfolio and ran the test on the portfolio with out-of-sample data. We expected to obtain a portfolio with high annualized returns and a relatively good Sharpe ratio.

### 2. Analysis of Behavioral Factors in Market Returns

We selected the stocks of large and mega market caps classified by Nasdaq. It is worth noting that Nasdaq is heavily skewed toward tech stocks. The reason for choosing Nasdaq's tickers was that tech stocks are more volatile and are supposed to be impacted by investors' reactions to a larger extent. Therefore, behavioral factors should affect the performance of the portfolio more significantly. The regression time range was from 2012-02-28 to 2020-03-30. The testing time range was from 2020-03-31 to 2022-03-30. Then we extracted the relevant field of each stock from Bloomberg Virtual Machine. The field data were chosen to construct the behavioral factors adapted from Lian, Liu, and Shi (2021) as shown in Table 1.

Anomaly	Definition
	Overreaction Factor
Short-term Reversal (STR)	The cumulative return of the past 21 trading days
MAX	The largest daily return of the past 21 trading days
Book-to-Market	Book Value Per Share
Idiosyncratic Volatility	The ratio between the variance of the stock return and the market return
Abnormal Turnover (ABTO)	The ratio between the turnover of the past 21 trading days to the turnover of the past 252 trading days
	Underreaction Factor
Momentum (MOM)	The cumulative return of the past 252 trading days excluding the most recent 21 trading days
MIN	The smallest daily return of the past 21 trading days
Standardized Unexpected Earning (SUE)	The ratio between the difference of the Earnings per Share minus the estimated Earnings per Share and the standard deviation of the estimated Earnings per Share

 Table 1. Factors' Anomalies and Definitions

After the construction of the anomalies, we ran multi-linear regression on stocks on the regression dataset to get the coefficient of the anomalies through Equation (1), which is the CAPM model with one additional behavioral factor:

$$R_s - R_f = \beta_1 * (R_m - R_f) + \beta_2 * Anomaly + e$$
 (1)

where  $R_s$  is the stock return,  $R_f$  is the risk-free return,  $R_m$  is the market return, and Anomaly is one of the behavioral anomaly factors listed in Table 1.

Theoretically, the overreaction factors should be negatively correlated with the stock returns, and the underreaction factors should be positively correlated with the stock returns. However, after obtaining each anomaly's coefficient, it turns out that for several anomalies, there is no such pattern for the division of overreaction and underreaction. From Table 2, we can see that Book-to-Market, Idiosyncratic Volatility, ABTO, MIN, SUE all have several stocks with positive and negative correlations to the return. MAX, STR, and Momentum are significantly positively correlated with the stock returns — only Momentum fits the definition of Underreaction, whereas MAX and STR demonstrate the opposite effects of Overreaction. So, the two behavioral factors from Lian, Liu, and Shi (2021) don't suit the U.S. stock market, and we can see that MAX, STR, and Momentum all underreact in the context of U.S. stock.

Anomaly	Number of stocks with positive correlation	Number of stocks with negative correlation
MAX	617	7
STR	624	0
Book-to-Market	208	416
Idiosyncratic Volatility	388	236
ABTO	318	306
Momentum	623	1
MIN	470	154
SUE	269	355

Table 2. Number of Stocks with Positive/Negative Correlations

Moreover, by testing our multi-linear regression using the above formula, we got the p-value for each stock based on different potential anomalies. By setting the critical value of 0.05, We were able to get rid of the anomalies whose p-values are not statistically significant over the whole set of selected stocks.

Anomaly	Number of stocks with p-value < 0.05	Average p-value
MAX	563	0.0342

STR	622	0.0003
Book-to-Market	111	0.363
Idiosyncratic Volatility	73	0.416
ABTO	19	0.533
Momentum	454	0.0567
MIN	105	0.403
SUE	55	0.386

**Table 3.** Number of Stocks with p-values less than 0.05 and the Average p-values

We observed that for different anomalies, the p-values of stock returns were very different and the number of stocks with p-values less than 0.05 also varied significantly. Specifically, we obtained the average p-values of the stocks for the eight anomalies. We found extremely low p-values for three anomalies: MAX, STR, and Momentum, which, not surprisingly, were the anomalies that were positively correlated with stock returns. As the p-values demonstrate the factors' statistical significance with the stocks' returns, we selected MAX, STR, and Momentum to construct our one reaction behavioral factor and calculated the expected returns of the stocks.

#### Construction of Reaction Factor

We weighted the three anomalies based on their average p-values. Particularly, we found out that STR is most statistically significant to the stock return (p-value 0.0003), whereas MAX (p-value 0.0342) and Momentum (p-value 0.0567) shared less significance. Based on the p-values and the relative value sizes of the anomalies, we weighted the three anomalies by 0.984, 0.01, and 0.006 corresponding to STR, MAX, and Momentum, and obtained the behavioral factor in Equation 2 by adding the weighted anomalies together.

Reaction = weighted STR + weighted MAX + weighted Momentum

(2)

Note that in Equation 2, we wrote "weighted" instead of the actual weights of the three anomalies due to the possibility of the weights changing with the observed data used to construct the factors in different periods. Then, we obtained the coefficients of the Reaction factor for each stock by performing multi-linear regressions on the regression dataset using Equation 1. After obtaining the behavioral factor's coefficients, we had our model to compute the expected return of the stocks by Equation 3:

$$R_s - R_f = \beta_1 * (R_m - R_f) + \beta_2 * Reaction + e$$
(3)

#### Portfolio Performance

On each week of the testing dataset from 2020-03-31 to 2022-03-31, We employed the coefficients from the previous regression to the behavioral factor to get the expected return of the stocks. We computed the expected cumulative return every week and extracted the last-day expected cumulative return for each stock, which was the stocks' expected cumulative return of the week. We sorted the expected cumulative return and selected the top 8 stocks with the largest expected cumulative return to construct the portfolio for the next week. We chose the weight of each stock in the portfolio based on their ranks of expected cumulative return. The higher the rank, the higher was the weight the stock got in the portfolio. Then we obtained the actual cumulative return of the portfolio each week from the weighted cumulative return of the stocks.

Since this was a weekly portfolio with many transactions, trading costs could impact the portfolio performance in some extent. To address this, we subtracted the trading cost from the PnL by counting the number of transactions in each week and times that number with 5 basis points, which was the assumed cost for every trade. Combining each week's cumulative return of the portfolio, we got a total of 92.2% cumulative return (the market's annualized return was 55.5%), with an annualized return of 41.3%, and a Sharpe ratio of 0.46 from 2020-03-31 to 2022-03-30.



Fig 1. Portfolio cumulative performance

As the above suggests, we obtained a relatively higher return compared to the market. However, due to the high annualized standard deviation of 0.895, we were not able to get a good Sharpe Ratio. We decided to set a stop-loss boundary for each stock in the weekly portfolio in order to lower the portfolio volatility. For each stock, we compared today's return with yesterday's return: if today's return was less than yesterday's return and was less than zero i.e., if we incurred a more significant loss today, we calculated the difference — if the difference was bigger than 0.1, we sold the stock in the remaining time of the week. The result demonstrated a

decreased annualized standard deviation of 0.74, with an increased annualized cumulative return of 59.5% and a Sharpe ratio of 0.8.



Fig 2. Portfolio cumulative performance with stop-loss

#### 3. Conclusion

As the results suggest, the proposed multi-factor model from Liu, Lian, and Shi can be reduced to only one "Reaction" Behavioral factor with the combination of STR, Max, and Momentum. By testing the correlations and p-values for the potential anomalies, we found out that STR, Max, and Momentum were positively correlated with the stock returns in a statistically significant way. By constructing weekly portfolios containing the Nasdaq stocks with the highest expected returns predicted by the model, we obtained an annualized Sharpe Ratio of 0.8 from 2020-03-31 to 2022-03-30. Despite the necessity to compare performance with other existing models in the same time range, this behavioral-factor model demonstrates to a certain extent how investors' reactions can impact the U.S. market and contribute to the return of the portfolio. However, it must be noted that we only tested the model on large and mega capital stocks which skewed to tech stocks between 2012 to 2022. Further analysis is required on other kinds of stocks with various caps and a more extensive time range. Also, the "Reaction" factor can be constructed in different ways. For example, other factors besides the selected three anomalies that were discarded might be due to the reason that we only tested the factors' relationship with the stocks' returns, and other factors were not statistically significant to the returns because their definitions not being related to the returns. Further research is needed to show how to pick the anomalies to represent the investor's reaction behaviors, which can potentially lead to a more accurate prediction of stock returns.

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## The Impact of Different Phases of COVID-19 on the Airline, Financial Services, and Healthcare Industry

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#### **Abstract**

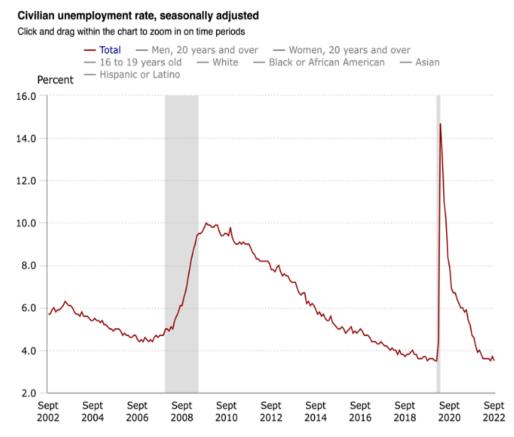
COVID-19, a global health crisis, has led to a severe economic fallout, but the detailed impacts of the pandemic on the United States airline, financial services, and healthcare industry remain unclear. The Capital Asset Pricing Model (CAPM) has been extensively adapted because it accounts for systematic risk and describes the relationship between the risk and the rate of return. In this paper, the impact of the pandemic on the industries will be measured to a numerical value by observing the change in beta from the CAPM model. The timeframe will be separated into pre-pandemic, peri-pandemic, and post-pandemic. The results indicate that the airline industry is the most volatile of the three with an increasing beta. Moreover, the financial services industry's beta rises but returns to the pre-pandemic level. Nevertheless, the healthcare industry is the most stable of all by having similar beta throughout the outbreak. This paper showcases the response of industries during a global pandemic with CAPM. For future studies, an improved method can be derived and applied to measure the robustness of other industries during various crises. These results shed light on guiding further exploration of beta variation of different industries.

#### 1. Introduction

The COVID-19 pandemic has had a significantly degenerative impact on the global economy. Capital Asset Pricing Model (CAPM) will be utilized as an efficient and standardized measurement of industries' response to the different phases of COVID-19. The financial markets and economies respond to the quick-spread virus simultaneously when governments mandate closures of non-essential businesses, lockdowns that limit the activity of people, and travel bans to suppress the death toll (Chen, H., Yeh, C., 2021). The mandates were not only aimed at constraining the virus. Reduced consumer spending induces a decline in sales affecting industries from raw materials to food services, hospitality, and entertainment businesses. With some exceptions, companies start to cut spending by firing and furloughing workers. The chain reaction eventually led to bankruptcies and an all-time high unemployment rate of 14.70% in April 2020 seen in Fig. 1.

The Bureau of Economic Analysis accounted for a 3.5% decrease in the gross domestic product (GDP) from 2019 to 2020. COVID-19 is unlike other disasters (e.g., global nuclear war). It is not survivable and relevantly costless, or climate change, which is slower moving and localized. The fast-paced worldwide pandemic resulted in a destructive economic impact (John, W. G., 2021). The CAPM is an efficient tool to measure the risk level and expected return of

financial assets during the COVID-19 era. CAPM provides a systematic approach to evaluate the relationship between an asset's expected return and its systematic risk. CAPM proposed by William Sharpe is well-established and widely used to this date (Sharpe, W. F., 1964). The Sharpe-Lintner CAPM has proven effective with empirical tests (Fama, E., French, F., Kenneth, R., 2004). With years of data from the New York Stock Exchange and evidence from the time series of returns, Jensen, Black, and Scholes state that the beta, the measure of volatility, is significant in explaining security returns (Black, F., Jensen, M., and Scholes, M. S., 1972). Throughout the years, there have also been studies challenging the validity of CAPM, and there have been studies that counter those challenges. Summarizing these articles, Jagannathan has concluded that the CAPM is still valid in the long run (Jagannathan, R., Ellen, R. M., 1995). Furthermore, Jagannathan strengthens his argument with quantitative research on the return and beta relationship for four types of assets over a period as long as 66 years.



**Fig. 1.** Civilian unemployment rate with seasonally adjusted (US Bureau of Labor Statistics, 2022)

CAPM has demonstrated its global implementation for industrial analysis on various stock exchanges during pre-pandemic, peri-pandemic, and post-pandemic periods. Studies that utilize the CAPM in the Indonesia Stock Exchange have suggested that the change in risk and return can be explained by COVID-19. A positive correlation between systematic risk and stock returns in the non-financial sector is found by the sample t-test being significant for 629 public firms (Budiarso, N. S., et al., 2020). The consistency between the investors' behaviors and the COVID-19 pandemic has proven the effectiveness of CAPM. The impact of COVID-19 on the

forest industries is also found prominent in North America, demonstrated by the capital asset pricing model (Størdal, S., Gudbrand, L., Erik, T., 2021). Both the declaration of the pandemic by the World Health Organization and the outbreak have increased the systematic risk for the forestry sector. So, the CAPM is utilized to investigate changes in the beta values. According to Ramelli, S., and Alexander's paper, the CAPM has a good explanatory power for pharmaceutical stocks traded on India's National Stock Exchange (Ramelli, S., Alexander, F. W., 2020). The finding is based on separating the COVID-19 era into pre-pandemic and peri-pandemic, which has shown CAPM to be statistically significant in explaining some effects, even with some limitations. The correspondence between the volatility of the global equity market and mass vaccination is also assessed with CAPM (Susanti, E., Ernest, G., and Nelly, E., 2020). Data from 66 countries report a volatility decrease as vaccination stabilizes the market. CAPM has revealed the intimate relationship between public health and the financial market. The importance of applying the proper beta for different periods is also highlighted in a study done for Mexican stocks from 2019 to 2020 (Rouatbi, W., et al., 2021). CAPM with a time-varying beta outperforms the one with a constant beta, because the financial risk level can fluctuate especially during periods of market turbulence, such as the COVID-19 era. The study demonstrates the application of CAPM in the Mexican stock market and indicates a change in systemic risk because of COVID-19.

Nevertheless, financial analysts and economists have closely monitored the directly impacted airline, healthcare, and financial services industries for a silver lining. Because of a COVID-19-induced plunge in passengers, global airlines have strived to adopt governmental policies and counter health risks with innovations (Joseph, A. A., 2021). However, whether the innovation is efficient and do they bring profit remains to be discovered. Hospitals worldwide have achieved one hundred percent capacity during the spike of COVID-19—despite this, whether the healthcare industry still profits with the shortage of supplies and high mortality rate remained unknown. Commercial banking has historically exhibited stability, but the pandemic led to a notable economic downturn and the effects on the banking industry remain uncertain. While the pandemic has generally impacted the economy negatively, the specific performance of each industry and investor reactions are complex and warrant detailed analysis. The influence of COVID-19 on the airline, healthcare, and financial services industries is two-sided.

In this study, the airline, healthcare, and financial services industries in the United States will be explicitly analyzed for their responses to the pandemic. CAPM will be utilized as a standard measurement, and beta will be observed pre-pandemic, peri-pandemic, and post-pandemic wise and demonstrate investors' behavior. To measure the impact of COVID-19, this paper investigates the beta change before, during, and after the pandemic based on the CAPM model. Specifically, the airline, financial services, and healthcare industries will be analyzed. The rest of the paper is organized as follows: Section 2 will define the date range, explain the research method, and indicate the chosen companies, section 3 will analyze each industry in depth and compare the results. Section 4 will interpret the limitation and prospects. The conclusion will be in section 5.

#### 2. Data and Methodology

The Standard and Poor's 500, which tracks the performance of 500 publicly traded companies on the U.S. stock exchanges, is chosen to be the representing market for CAPM analysis. The airline industry includes five representative airline companies in the United States.

The healthcare industry consists of 64 companies in the S&P 500, categorized into diagnostics and research, drug manufacturers, medical care facilities, medical devices and instruments, and pharmaceutical industries. The financial services industry consists of 17 companies and is separated into three categories: capital market, banking, and asset management. Pre-pandemic is defined as the period from December 31, 2019, to March 11, 2020. The start date is when the World Health Organization first discovered COVID-19 in China. Since the World Health Organization announced a pandemic on March 11, 2020, peri-pandemic is defined as May 3, 2022, when the mask requirement is no longer enforced. The post-pandemic period is defined from May 3, 2022, to September 30, 2022, when the research is conducted.

In the CAPM formula, the market beta of an asset is calculated as the covariance of the asset's return and the market return, divided by the variance of the market return.

$$\beta_{iM} = \frac{cov(R_i, R_M)}{\sigma^2(R_M)} \tag{1}$$

The term risk premium is the expected market return  $E(R_M)$ , minus the risk-free rate  $R_f$ . A risk-free rate, or a risk-free asset, guarantees a return with zero risks. A U.S. government bond is an example. The final equation is shown as follows:

$$E(R_i) = R_f + \beta_{iM}(E(R_m) - R_f)$$
 (2)

The market beta is the slope of the asset's return and market return. It measures the correlation, or the sensitivity, between the return on investment and the return on the market. It can also be interpreted that beta is the portfolio's risk as high  $\beta_{iM}$  (greater than one) indicates greater sensitivity to the market risk or the systematic risk.

To illustrate the data processing procedure, we will use a study of the airline industry as an example. Firstly, this study selects the stocks in the S&P 500 from the airline sectors, and Python will gather the closing price for each stock from Yahoo Finance. In this case, Alaska Airlines, American Airlines, Delta Airlines, Southwest Airlines, and United Airlines are being analyzed for their correlation with the general market, S&P 500. Secondly, Python pandas.pct\_change() will calculate the return for each stock. Thirdly, Python for loop will plot the returns as a scatterplot with the market return on the x-axis, and the ployfit() method will calculate an ordinary least square function to fit the coordinate points. Finally, the slope of the best-fit line is the beta of the given stock. This process is replied to for each period for comparison.

#### 3. Results & Discussion

Airline Industry

The airline industry has developed various countermeasures for the plunge in travel during COVID-19, yet the result and effectiveness still need to be discovered. Hygiene is considered a top priority in controlling the spread of the virus for airlines. Ultraviolet light and sanitization devices are purchased and used to eradicate viruses and bacteria. Touchless technologies and software are developed for minimum contact. United Airlines has software that allows self-check-in, and purchases can be made on one's cellphone. Inflight social distancing is also enforced with an open-middle-seat policy. The questions become whether the innovations were completed in time, adequate, cost-efficient, and profitable. This paper investigates the airline industry's response to a crisis timewise and the airline industry's ability to acclimate to a different environment.

The beta analysis results are presented in Fig. 2. An average beta of 1.185 before the pandemic is collected from CAPM analysis and marked as a comparison point. Beta analysis of the airline industry during COVID-19 has indicated a change in beta to 1.359, a 14.68% increase. Airline stocks have been more volatile than the overall market after the COVID-19 outburst. Yet, the volatility escalates and remains at a higher beta of 1.428 for the post-pandemic period, i.e., a total 21% increase. Although air travel is essential transportation, the counter-measurements for COVID-19 are shown not to be efficient and adequate for a global crisis. Investors and analysts signaled that the airline industry is riskier than pre-pandemic as COVID-19 has demonstrated potential risks for the industry that previously was not factored in. Moreover, disruptive technologies have evolved under the pressure of the pandemic. Online meetings and remote working have significantly reduced the demand for travel in addition to in-home entertainment and social media. Therefore, the rising beta is explanatory. Air travel is still time efficient and essential for long-distance travel. It is expected to recover with time, but certainly not in the current economy with the Russia-Ukraine war, oil production and import, and inflation.

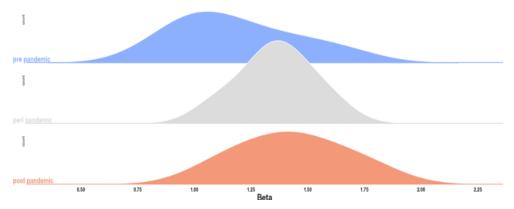


Fig. 2. Airline industry beta analysis.

#### Financial Services

The financial service industry has a historically low beta because of its consistent and stable returns that are favorable for the long run. Thus, the financial services industry will be examined for its response to the global pandemic. The capital market, banking services, and asset management services have established a healthy financial structure after the most recent 2008 financial crisis and the "Black Swan" events like the 9/11 terrorist attack. Strategies like hedging, risk control, portfolio diversification, and exit plans are all developed and prepared for similar events and recessions. At the same time, the financial industry is also sensitive. The "spillover effect" of terrorist attacks, natural disasters, etc., has contributed to market risks by increasing the level of unpredictability and instability within the market (Karolyi, G. A., 2006). Moreover, the spread of the COVID-19 pandemic is considerably a never-seen-before event, and most companies have not accounted for the risk of such an event. The impact of COVID-19 on the financial industry's market volatility will be examined and measured using CAPM beta.

The analysis results shown in Fig. 3 show that an average beta of 1.223 is collected before the virus outbreak. The beta increased 7.6% during the pandemic. Undoubtedly, COVID-19 has trembled the market. Yet, the beta has fallen lower during the post-pandemic period to 1.186, which is 3% further down than the beginning, indicating that the general market is more volatile than the industry. While the market is trading volatility, investors remain confident in

financial services. This industry is well prepared for these events, whether it is its financial structure, risk management, sensitivity to the market, or rapid response. From an investor point of view, the financial services industry has proven its robustness during a global crisis. It is reasonable to predict that the future beta of the industry will not spike outside of the normal range when facing similar events, but the industry will move with the market as the beta is in the range of 1.1 to 1.35.

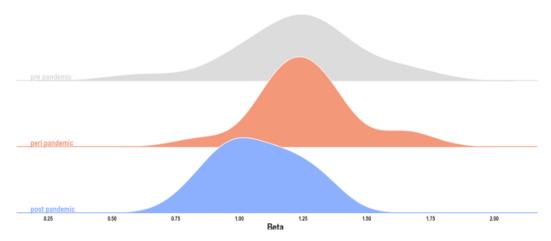


Fig. 3. Financial service industry beta analysis.

#### Healthcare

With hospitals reaching maximum capacity, a shortage of nurses and medical supplies, and pharmaceutical companies developing vaccines for COVID-19, the healthcare industry is in turmoil. CAPM beta analysis will provide a numerical measurement of the impact of these events on the healthcare industry. COVID-19 has put extreme stress on the healthcare workforce (e.g., burnout and trauma), in addition to the staff shortage. Yet, healthcare workers not directly caring for COVID-19 face being furloughed and work hours reduced. Not only were the hospitals full, but the high mortality rate of COVID-19 also left dead bodies in refrigerated trucks. The U. S. Food and Drug Administration has also posted a medical supply shortage list that includes surgical respirators and ventilators. On the bright side, Pfizer, Johnson & Johnson, and Moderna developed COVID-19 vaccines that alter the situation. Beta from the quantitative analysis will be examined to monitor the stock market's response to the series of events.

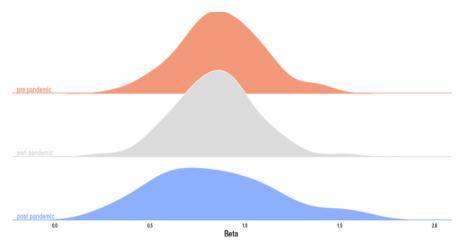


Fig. 4. Health care industry beta analysis.

The results of the beta analysis are exhibited in Fig. 4. The healthcare industry starts with an average beta of 0.874 pre-pandemic, demonstrating that this industry is less volatile than the market, i.e., the beta drops during the pandemic to 0.862. A 1.37% drop signals that the market is riskier than the healthcare industry when the virus hits globally. During the post-pandemic period, the average beta promptly returns to 0.872, which is close to the number of pre-pandemic periods. The trend signifies that the healthcare industry remains stable despite the series of events. The investors' and traders' behavior indicates that the healthcare industry is less risky than the market when the pandemic outbreaks. In addition, the beta below one shows that the healthcare industry does not move with the market. Although there have been shortages and high mortality rates, the healthcare industry is still an essential part of human life, unlike the tourism and hospitality industry. Hence, the healthcare industry will always exist when it comes to crises unless humans become immortal. Based on the analysis, it can be reasonably predicted that the beta of the healthcare industry will remain stable and below 1 in future crises.

#### 4. Comparison

The summary of the beta analysis for three industries is given in Table. 1. While they all endured the same economic fallout and financial pressure from COVID-19, the airline, financial services, and healthcare industries responded differently to the crisis. CAPM model analysis demonstrates beta for each industry advance in various directions in the pre-pandemic, peripandemic, and post-pandemic periods. Being more volatile than the market, the airline industry is the most affected, with a total of 21% increase in beta value before and after the outbreak. Despite the airline industry being riskier after COVID-19, the financial services industry returned 3% lower than the beta compared with the beta in the pre-pandemic period, inferring the stableness of financial services during a non-financial crisis. The most riskless of the three is the healthcare industry. Not only did it not move with the market, but the healthcare industry also maintained its beta at the same level.

Average Beta	Airlines	Change	Financial Services	Change	Healthcare	Change
Pre-	1.18495		1.22321		0.87434	
pandemic						

Peri-	1.35884	14.675%	1.31639	7.618%	0.86225	-1.383%
pandemic						
Post-	1.42807	5.095%	1.18623	-9.888%	0.87169	1.095%
pandemic						
Total	20.52%		-3.02%		-0.30%	
Change						

**Table 1.** Summary of the beta analysis.

#### 5. Discussion

However, this paper contains limitations that can be refined in further studies. Firstly, this paper utilizes a basic CAPM model. Meanwhile, there are arguments that the *Fama-French Three Factor Model* provides more accurate data with two additional factors that adjust for the outperformance tendency. Although the CAPM model has been widely used for centuries, other more comprehensive asset pricing models have been derivate that account for other specific determinants, such as the recent *Fama-French Five Factor Model* (Fama, E. F., French, K. R., 2015). While the CAPM model is adequate for a macro view in this study, it cannot be denied that quantitative easing, OPEC, the Russian-Ukraine War, inflation, and the Fed's adjustment of the interest rate also affect the market during the pandemic. Identifying each variance will produce a more precise numerical analysis of the impact of COVID-19 on the industries. Secondly, the study can be further detailed in terms of subsectors. Although the airline and financial industries have only some subsectors, the healthcare industry has subsectors from pharmaceutical manufacturers, medication and vaccination for pets and livestock, hospitals, and medical equipment manufacturers. The subsectors can differ during the outbreak even though they are in the same industry.

This paper can be extended for future studies. The beta and results are constructive for analyzing the airlines, financial services, and healthcare industry and predicting future trends. An improved and appropriate asset pricing model can be applied to other industries for other impacts of COVID-19, and the studies can be utilized globally. The time length of the research can be extended as the pandemic is still ongoing.

#### 6. Conclusion

In summary, this paper investigates the impact of COVID-19 based on measuring the change in the beta of the CAPM. To be specific, the airline industry, the financial services industry, and the healthcare industry of the United States are analyzed. According to the analysis, the airline industry experienced the most changes. A 20.52% increase in beta from pre-pandemic to post-pandemic indicates the riskiness of the airline industry after COVID-19. The post-pandemic beta of 1.428 demonstrates that the industry is more volatile than the market. Moreover, the beta financial services industry raises then fell to a beta 3.02% lower than pre-pandemic. Even though COVID-19 created an economic fallout, the financial services industry adapted and survived the crisis. Nevertheless, the healthcare industry remains the most stable of all during the virus outbreak. Not only does the industry beta stay at the level of 0.86 to 0.87, but the beta below one shows it's less volatile than the overall market. In the future, a more advanced and suitable asset pricing model that accounts for all the factors can be utilized for a precise

numerical measurement of the impact of COVID-19. Overall, these results offer a macro view of the performance and riskiness of the airline industry, financial services industry, and healthcare industry during the pandemic.

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# Testing the Environmental Kuznets Curve Relationship for Australia in the early 2000s<sup>2</sup>

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#### Abstract

Economic growth in developing nations often leads to a rise in Carbon Dioxide emissions. It is hypothesized that as these nations become wealthier, they invest more in abatement technologies that reduce these emissions. The Environmental Kuznets Curve (EKC) relationship, although widely debated, can help explain this. I construct a synthetic control group and employ a difference-in-difference technique to test this relationship for Australia during a period of rapid economic growth following the discovery of the Jansz-Io gas reserves in order to study how the country's per capita Carbon Dioxide emissions responded to the discovery. Finally, I assess whether Australia has reached the EKC turning point.

#### 1. Introduction

The Environmental Kuznets Curve (EKC) relationship hypothesizes that as countries grow richer, pollution emissions increase, but after a point (the EKC turning point), the trend reverses, i.e. higher income leads to lower emissions and better environmental quality. It is, therefore, an inverted U-shaped relationship between per capita income and emissions (Grossman and Krueger, 1995). Simply put, the transition towards any sustainable growth path involves environmental quality first worsening with economic growth and then improving as countries approach this balanced growth path. This is because economic growth primarily involves a shift towards industrialization, which requires the exploitation of natural resources and the methods of production that degrade the environment. However, as a country's income rises and people become more aware of the negative externalities created by pollution, environmental protection may become a higher priority. As a result, the country may begin to invest in cleaner technologies and environmental policies, which can lead to a decline in emissions. So, there is a threshold level of economic development at which a country begins to prioritize environmental protection over economic growth. This relationship can be observed in Fig. 1 below.

<sup>&</sup>lt;sup>2</sup> This paper was written to fulfill the requirements for Economic Development (ECON-UA 323) at New York University. The author acknowledges Martin Rotemberg for his valuable feedback.

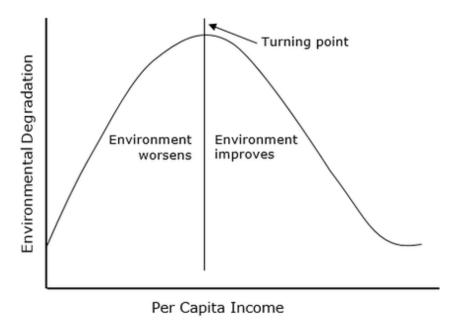


Fig1. Environment Kuznets Curve (EKC) relationship

Environment conservation has emerged as a global priority, especially since the Kyoto Protocol was agreed to in 1997 in order to shield nature from exploitation. Nonetheless, it is observed that Carbon Dioxide emissions have rapidly leveled up in developing countries like India and China. It is therefore very important to investigate the relationship between economic growth and emissions as the results from studying the EKC relationship and how countries achieve the turning point could be useful in motivating environmental policy worldwide. For instance, by focusing on achieving specific levels of economic development, countries can create the necessary conditions to eventually invest in environmental protection and abatement. Nonetheless, the EKC hypothesis is subject to a number of loopholes and criticisms, some of which are noted as follows:

- i) The inverted U shape correlation between per capita income and environmental degradation may not be a causal one.
- ii) Carbon Dioxide emissions alone do not represent the whole picture of environmental degradation, so the EKC relationship might be incomplete. Also, the curve's shape may be different for different pollutants (Andreoni & Levinson, 2001).
- iii) There could be omitted variable bias from factors such as population growth, technological progress, and policy interventions.
- iv) Holding constant the emissions, exogenous income shocks that do not increase per capita GDP through direct improvements in production can shift the EKC rightward, thereby shifting the threshold level or turning point to an even higher GDP level.
- v) Multiple turning points could result in an N-shaped curve. For example, efficiency in resource usage may not go along with the same level alongside economic growth, so emissions may start to increase again in the future levels of economic growth. (Özden and Beşe, 2020)

Lastly, on one side, scholars assure that once a certain level of development (or income per capita) is reached, the negative effect of economic activity on nature is reversed. On the other extreme, others warn that human demand has already led to environmental degradation that surpasses the Earth's ecological capacity to regenerate. (Aşıcı, 2013)

In this paper, I analyze the EKC relationship for Australia by testing if the growth experienced by Australia in the period following the discovery of the Jansz-Io gas reserves was environmentally sustainable. To study the relationship, I conducted an empirical analysis of the Australian economy to test if its Carbon Dioxide emissions changed after it experienced an exogenous positive income shock in the early 2000s. It is hypothesized that if, as Australia achieves higher levels of income following the exploitation of the reserves, its emissions fall, then it has surpassed its EKC turning point.

## 2. Background

The Western Australian Jansz field was discovered in April 2000 by drilling the Jansz-1 discovery well in the WA-18-R permit area and was appraised by drilling three wells post its discovery. The Io field was discovered in January 2001 by drilling the Io-1 discovery well in the adjacent permit area WA-25-R, which was appraised in 2006 by drilling the Io-2 well. The two fields were agreed to be unitized by 2009 through the Gorgon Project (Jenkins, et al., 2008), whose constructruction commenced in December 2009. Moreover, the Pluto Gas Project, an \$11-billion liquid natural gas transportation project, was approved in 2007 (Smith, 2021).

Keeping this timeline in consideration, 2007 serves as an appropriate choice for the intervention year since most exploitation activities had begun then or were scheduled to commence soon after. Most important is the fact that the exploration and appraisal program for the Jansz-Io fields was conducted from 2000 to 2006 (Jenkins, et al., 2008). As a result, there is no evidence of their economic exploitation pre-2007 except for the drilling of some wells.

## 3. Theory

The validity of the EKC hypothesis depends on the relative strengths of scale, composition, and technique effects and/or which effect dominates over time. The scale effect suggests that as the scale of economic activity increases, Carbon Dioxide emissions will rise. Once income exceeds a certain point, emissions will fall due to the composition and technique effects. The composition effect states that as income increases, consumer preferences for cleaner goods increase and there will be a gradual shift in the composition of national output towards services and light manufacturing industries, both of which will improve environmental quality. The technique effect states that at higher income levels, there is greater investment in research and development (R&D), which generates innovation in newer and cleaner technologies, which reduce pollution (Brock and Taylor, 2010; Grossman and Krueger, 1995).

It is possible that when Australia faced the massive income increase from the discovery of the Jansz-Io gas reserves, its economic patterns changed which, in turn, led to lower emissions through the composition and/or technique effects. Consequently, an increase in Carbon Dioxide emissions would point towards evidence of the scale effect, suggesting that Australia has not yet reached its EKC turning point. However, it must be taken into account that emissions take time to fall and in the specific case of Australia, since the exploitation of the gas reserves involved

undertaking potentially environmentally harmful projects such as drilling wells, building pipelines, etc., emissions could have risen in the early stages of exploitation and an underlying sustainable growth may instead be captured by a decreasing trend in the long run.

## 4. Data and Methodology

For my analysis, I have used time series data from the World Development Indicators about GDP per capita (current US \$) and Carbon Dioxide emissions (metric tons per capita) between 1990 and 2021. A difference in difference type analysis is conducted using synthetic controls. The treatment group is Australia, the pre and post-periods are 1990-2007 and 2007-2021, respectively as the intervention occurs in 2007. The synthetic control difference in differences method accounts for the effects of the confounders changing over time because the control group consists of countries weighted in a manner that minimizes the outcome difference between pre-treatment Australia and the synthetic control. It is appropriate in this case because we use a combination of countries that ex-ante resemble Australia as a measure of what would have happened to Australia if it had not discovered the Jansz-Io gas reserves. The difference in outcomes then gives the actual treatment effect for Australia and we can calculate appropriate p-values to test their statistical significance.

The first step is to measure the effect of the discovery on Australia's per capita GDP. For this, I plotted the WDI data for per capita GDP for Australia and the synthetic control between 1990 and 2021 against time. Some countries had missing data and others had stopped reporting their GDP around 2015, so they are dropped from the dataset and are therefore not considered while constructing the synthetic control group. The DiD plot is generated and the exact pre and post-treatment GDP values for both Australia and the synthetic control are reported in Table A. I estimated the treatment effect by measuring the difference between the treatment and control groups between 2008 and 2006, which is also reported in the table. Furthermore, the p-value is estimated by calculating the placebo effect for each country in the synthetic control group and finding the probability of the synthetic control having a larger average effect than Australia. Next, the same analysis is done for Carbon Dioxide emissions measured in metric tons per capita. The DiD plot is as in Fig 3 and the exact pre and post-treatment Carbon Dioxide emissions values for both groups are reported in Table B.

## 5. Inference

It was found that Australia's per capita GDP increased substantially following the exploitation of the gas reserves in 2007. The following graph measures the per capita GDP against time for Australia and the synthetic control. We can observe a clear divergence in patterns at the onset of 2007 when Australia's per capita GDP begins to increase rapidly. The exact values for the pre-treatment (2006) and post-treatment (2008) periods are reported in Table A and the treatment effect is estimated to be an increase of \$6363 in GDP per capita for Australia. The p-value for the one-sided test that the GDP effect on Australia is higher than the average effect on the synthetic control is 0.02843, so the results are statistically significant at the 5% level.

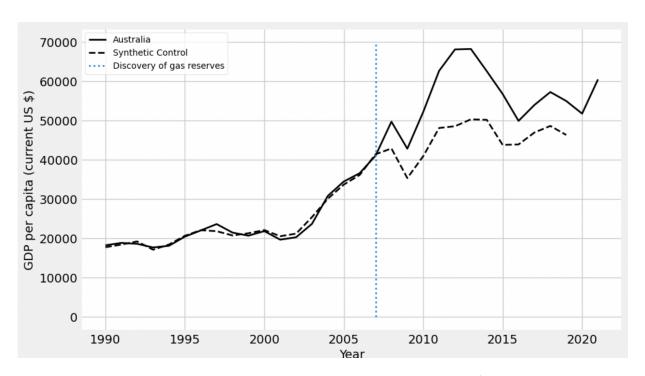


Fig. A DiD plot for GDP per capita (current US \$)

Period/ Group	Pre-treatment (2006) per capita GDP	Post-treatment (2008) per capita GDP	Difference
Synthetic Control	36123.30716	42868.72326	6745.416095
Australia	36570.720368	49679.180528	13108.46016
Difference	447.47922	6810.2488	6363.04406

**Table A** Pre and post-treatment values for per capita GDP

Additionally, it was found that Australia's Carbon Dioxide emissions increased as a result of the discovery of the Jansz-Io reserves, so we can conclude that Australia has not yet reached its EKC turning point as an increase in income led to more environmental degradation. The difference in differences analysis estimates the effect as an increase of 0.70718 metric tons (approximately 71 kilograms) of emissions per capita for Australia. The p-value for the one-sided test that the effect on Australia's emissions is higher than the average effect in the synthetic control group is 0.0365, so the results are statistically significant at the 5% level.

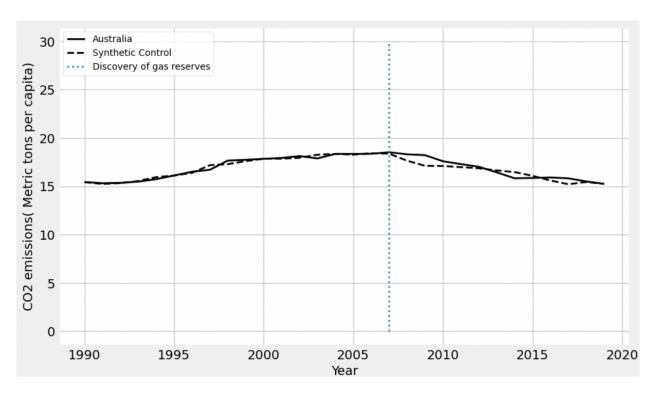


Fig. B DiD plot for Carbon Dioxide emissions (metric tons per capita)

Period/ Group	Pre-treatment (2006) CO <sub>2</sub> emissions	Post-treatment (2008) CO <sub>2</sub> emissions	Difference
Synthetic Control	18.41298	17.64905	-0.76393
Australia	18.36050	18.30375	-0.05675
Difference	-0.05248	0.65470	0.70718

Table B Pre and post-treatment values for Carbon Dioxide emissions

#### 6. Conclusion

The empirical analysis performed for the Australian economy shows that Carbon Dioxide emissions in the country rose after the Jansz-Io gas reserves discovery, at least in the short run. This suggests that the increase in income generated by the discovery was not used for moving towards cleaner consumption and/or production in a manner that would show a statistically significant decline in Carbon Dioxide emissions, so the EKC hypothesis for that period is not confirmed for Australia. Emissions went up by approximately 71 kilograms per capita in response to a \$6363 increase in GDP per capita — this is an approximate increase of 11 grams of emissions per dollar, which is substantial. Although Australia's emissions., by itself, seem to remain quite stable before and after the discovery, the positive difference between Australia's and the synthetic control group's Carbon Dioxide emissions points towards the fact that Australia's emissions rose while they fell in other countries that were similar to Australia pre-2007. However, we must also account for the fact that Carbon Dioxide emissions for Australia do converge to the synthetic control average in the long run. Consequently, the pattern observed in this paper could also be because the income shock merely shifted the EKC curve rightward without causing any movement along it.

Overall, these findings entail that a GDP boost due to the discovery of a natural resource, even in a time of high research and development of abatement and extreme awareness about the socio-economic consequences of a hotter planet, corresponded to an increase in Carbon Dioxide emissions. This implies that there is still a broad scope for governments to take action and implement policies that bring emissions down, reduce energy intensities, and increase efficiencies. It is, however, important to better understand the structure and causes of the EKC relationship before incorporating it into environmental policy (Andreoni & Levinson, 2001).

There is a large breadth of research that can be put into refining the EKC relationship to include more variables that impact the relationship between economic growth and environmental degradation, some of which are institutional quality, technological innovation, and resource endowments. Existing EKC studies have important implications for environmental policy, but more investigation is needed to better understand the specific policy interventions that are most effective at promoting sustainability — future analysis could study the effectiveness of different policy instruments such as taxes, regulations, and incentives in promoting environmental sustainability and how these may vary across different stages of economic development. It is worth exploring how international collaborations and treaties, such as the Paris Agreement, play a role in dictating national environmental policies and their effectiveness in promoting sustainability. It may also be useful to focus future EKC studies on developing countries such as India and China, given the significant amount of pollution that they emit. It would be interesting to see whether these countries also face an emissions-GDP trade-off and how policy interventions may help to maintain or enhance environmental quality. Further exploration of a possible Kuznets Curvetype relationship between GDP and other development indicators such as education, employment, mortality, and population growth could be of interest.

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## Air Transport Investment and Economic Output in Brazil, Chile, and Peru: A Leontief Simulation Analysis<sup>3</sup>

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#### Abstract

This paper evaluates the hypothetical effects of an increase in Air Transport infrastructure investment in Peru, Chile, and Brazil by estimating the expected change in total output, which is calculated using a Leontief input-output model. By constructing a general equilibrium model for each country's economy, the effects of the theoretical investment endowment can be simulated by manipulating the final demand for air transport and related industries within each economy. Based on the existing body of literature, it was predicted that an increase in air transport infrastructure investment would lead to an increase in final demand for air transport, which would in turn lead to an increase in the final demand for complimentary goods as well as a decrease in substitute goods, including road and water transportation. In all three countries the results of the input-output simulations indicated a validation of these predictions, suggesting that the investment endowment would likely lead to a significant increase in total economic output.

#### 1. Introduction

This paper is motivated by the goal of devising pragmatic and feasible policy recommendations to enhance economic prosperity in underdeveloped nations. With this broad goal in mind, the following principal research questions are defined: what investments can governments make to have the largest impact on economic growth and how can the successes of these investments be predicted with the highest accuracy?

These questions are very broad and impossible to answer in one paper. Thus, choices were made of the region of study, the investment type that the government will pursue, and the modeling technique to analyze its potential impacts. Many investment types were considered and this paper chose to focus on infrastructural investments since research seems to indicate that these have the highest payouts in both inducing demand and increasing total output (Guo et al., 2023). Specifically, the impact of an investment in air transport infrastructure was selected to study since, when compared to road and water transport, air transport generally seems to have higher multiplier effects.

The potential region of the study was restricted to and chosen largely based on data availability. With the criterion that the region had to contain a large number of developing nations, the South American region was chosen – three countries were selected using a comprehensive selection process, which included determining feasibility, the relative level of economic development in each country, and the size/development of the air transport industry. Generally, the countries selected had to have varying economic and aviation profiles to create a

<sup>&</sup>lt;sup>3</sup> This paper is adapted from the Thesis that was submitted on the day of April 17, 2023, in partial fulfillment of the degree requirements for the NYU Global Liberal Studies Bachelor of Arts degree.

more complete picture of potential investment effects. Given these criteria, Brazil, Chile, and Peru were chosen to be the target countries of study.

Consideration was then given to which modeling technique was to be used to conduct our analysis. The traditional econometric approach was considered, however, while the technique is useful, it is not as useful for answering questions posed by the broad motivations of this paper, which are focused on the inter-relationships between industries throughout the economy. Doing such an analysis requires a general equilibrium model which can demonstrate and predict capital flows throughout the economy. For this reason, the Leontief Input-Output approach was chosen as the best technique to model our simulations (Leontief, 1986).

To use this technique, one important assumption has to be made. That is, a strong relationship between infrastructure investment and final demand must be assumed.<sup>4</sup> This assumption is crucial because the study will simulate economic responses to investment in the air transport industry through changes in associated levels of final demand. Fortunately, there is strong evidence to suggest such a link exists and therefore changes in final demand can be used as a valid proxy for infrastructure investments in our model (Zhang & Graham, 2020). With the region of study, investment type, and modeling technique chosen, the following specific research questions for this paper, can be defined: how large is the economic multiplier effect of the air transport industry and considering all effects of a hypothetical investment in the industry and what is the expected increase in total economic output?

While there are a several possible strategies for economic growth and development, it is worth justifying why air transport development was chosen over the growth of other industries for this analysis. Governments typically prefer investments that yield the highest gross returnsthey aim to distribute resources in the most efficient manner to optimize the multiplier effects of investment expenditure. A multiplier effect is defined as the total output increase in the economy as a result of an increase in 1 unit of final demand in a particular industry. A larger multiplier can be viewed as more beneficial to an economy because this implies that an increase in final demand will lead to a larger increase in economic output across all industries.

It is generally contended that air transport has significant economic multiplier effects, with both direct and indirect stimulation effects. Econometric analysis has repeatedly found statistically significant correlations between GDP and air transport activity (Higgoda & Madurapperuma, 2019). However, there exists strong bi-directional effects associated with air transport activity and GDP (Zhang & Graham, 2020). These bi-directional effects exist due to the reciprocal mechanisms which exist in the feedback relationship between air transport and the economy (Graham et al., 2020). Air transportation provides direct economic benefits through employment and capital purchases, as well as indirect effects through its potential to stimulate other parts of the local economy by increasing access to the country (Graham et al., 2020). This can lead to higher levels of business activity, tourism, manufacturing, etc. However, it is also easy to argue for the existence of the inverse relationship. That is, as a country's GDP rises, so does the propensity to spend on air transport activities (Higgoda & Madurapperuma, 2019). If the stimulation effects are the dominant causal force in driving the correlation, then this implies that investment spending in air transport development will lead to significant GDP growth. However, if the latter effects are dominant, and the correlation is derived from higher demand for air

<sup>&</sup>lt;sup>4</sup> Final demand is defined as the demand for finished goods and services in a particular industry from consumers in the market, which can include domestic and/or international buyers.

transport as countries become wealthier, then investment money is probably better spent elsewhere.

## 2. Methodologies: Input-Output Modeling Framework

## A. Stylized General Equilibrium Model With 3 Industries

This section proposes how a generalized equilibrium model of a hypothetical simplified economy with only 3 industries can be constructed. Let three industries or sectors be defined as industries A, B, and C. It is known that each industry produces some good or service, which will simply be called "output". It is also known that to make this finished good or service, each industry must use outputs from the other two industries, as well as outputs from its own industry, in its production process. Another way to view these inputs is as internal demand, that is each industry demands a certain number of inputs from each industry to make their finished good. In addition to the internal demand, industries of course have a certain amount of final demand from consumers, which is the number of units (or value) of the goods and services that they sell. When internal demand is added to final demand, it equates to total demand, which in the general equilibrium model must be equal to total output. In more specific terms, industry A demands a certain number of inputs from industries A, B, and C, as well as faces its own final demand for its finished goods and services. Likewise, industry B demands goods from industries A, B, and C, as well as faces its own demand for its goods and services. The same applies to industry C. Mathematically:

$$\begin{cases} Total\ Demand\ (Industry\ A) = A_{AA} + A_{AB} + A_{AC} + Final\ Demand_A \\ Total\ Demand\ (Industry\ B) = A_{BA} + A_{BB} + A_{BC} + Final\ Demand_B \\ Total\ Demand\ (Industry\ B) = A_{CA} + A_{CB} + A_{CC} + Final\ Demand_C \end{cases}$$

where  $A_{ij}$  represents the inputs used in the production process (or internal demand) for industry i coming from industry j, and where Total Demand= Total Output.

It is noted that within our general equilibrium model, it must hold that the total demand is equal to the total production or output. Although this equivalence is not necessarily important for the calculations, it does allow the sum of a given industry's intermediate demands and final demand to be viewed as the same as the total outputs.<sup>5</sup> Mathematically:

```
\{Total\ Demand\ (Industry\ X) = Intermediate\ Deamnd + Final\ Deamnd\ Total\ Output\ (Industry\ X) = Intermediate\ Payments + Value\ Added\ where\ Total\ Demand\ (Industry\ X) = Total\ Output\ (Industry\ X)
```

## B. General Equilibrium Model of An Interconnected Economy

With the stylized 3-industry model constructed, it is simple to expand this model to create a complete general equilibrium model of the inter-connected economy. Before the mathematical representation of this model can be constructed, the following parameters must be defined:

<sup>&</sup>lt;sup>5</sup> In economics, GDP calculations face a similar accounting identity equivalence. It is said that GDP should be equal whether calculating output as total demand or total supply.

 $k = total \ number \ of \ industries \ , x_i = total \ output \ of \ industry \ i \ , A_{i,j} = intra$ industry payment from industry i to j,  $y_i = final demand of industry i$ 

A general equilibrium model of the inter-connected economy can now be created and used for the input-output analysis. In general, following the 3-industry model, the total output for a given industry can be summarized as follows:

Total Output Industry 
$$i = x_i = \sum_{j=0}^{k} A_{ij} + y_i$$
 (1)

Broadly speaking, the aggregate output of all sectors in the economy can be simply represented

Total Output 
$$(X) = \sum_{i=0}^{k} x_i$$
 (2)

With this general model now articulated, the input-output model that will be used for simulation analysis is nearly ready to be constructed. However, before this is possible, one part of the industry-level total output calculation must be changed. That is, in its current form, intermediate demand is inflexible and simply represented by a numerical value. While this representation is sufficient and accurate for demonstrating a static instance of an economy, it becomes insufficient when attempting to make the model dynamic. That is, if the final demand parameter is changed in this model, intermediate demand should change as well.

Returning to the three-industry example, if consumers suddenly demanded more from industry A, then it follows that industry A would need a proportionately larger number of inputs from industries A, B, and C to increase production and match demand accordingly. Therefore, in the dynamic model, it is no longer sufficient to represent  $A_{ij}$  as a numerical value, and rather it must be converted it into something else. Given the assumption that  $A_{ij}$  is directly proportional to total output,  $A_{ij}$  can be rewritten as the product of a certain coefficient,  $a_{ij}$  and total output of the sector,  $x_i$ . Mathematically:

$$A_{ij} = (a_{ij} * x_i) \tag{3}$$

This can now be substituted into the original summation equation for  $x_i$ :

Total Output Industry 
$$i = x_i = \sum_{i=0}^{k} (x_i * a_{ij}) + y_i$$
 (4)

Note that the  $a_{ij}$  can be represented as the following ratio (equation 5, below), which can be substituted into equation (4) and it can show that if the initial value of  $x_i$  is used, then equation (4) is the same as equation (1):

$$a_{ij} = \frac{A_{ij}}{x_i} \tag{5}$$

 $a_{ij} = \frac{A_{ij}}{x_i}$  (5) Substituting this ratio into the newly derived  $x_i$  summation equation gives:

$$x_i = \sum_{j=0}^{k} \left( x_i * \frac{A_{ij}}{x_i} \right) + y_i = \sum_{j=0}^{k} A_{ij} + y_i$$
 (6), which is the originally derived equation.

## C. Leontief Input-Output Model

Now that a general equilibrium model has been created which can be applied to an economy with any number of industries, the final step before any simulations can be run will be to transform this model into a useable form.

Let us begin by transforming equation (4) that was derived above into matrix form. By breaking the equation into two parts, equation (4) can be rewritten as:

$$x_i = \sum_{j=0}^k (x_i * a_{ij}) + y_i \tag{7}$$

 $x_i = \sum_{j=0}^k (x_i * a_{ij}) + y_i \tag{7}$  All part of this equation can be represented in matrix form in the following ways:

$$\begin{cases}
[X] = (x_1 x_2 \dots x_k) \\
[Y] = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_k \end{pmatrix} \\
[A] = \begin{pmatrix} a_{11} & \cdots & a_{1k} \\ \vdots & \ddots & \vdots \\ a_{k1} & \cdots & a_{kk} \end{pmatrix}
\end{cases} (8)$$

Putting these matrices together into the form of equation (4) yields:

$$[X] = [A][X] + [Y]$$
 (9)

Ultimately, the final demand of certain industries within the economy should be able to be manipulated in order to see the resulting change in total output. Therefore, a matrix equation should be formulated in which final demand is on one side of the equation and total output on the other. Referencing equation (9) that was derived above, it is clear that total output appears on both sides of the equation. After some algebraic transformations, the resulting equation can be used to run the desired simulations. This equation is referred to as the Leontief Inverse matrix equation for input output (Leontief, 1986), and can be represented as:

$$X = Y * (I - A)^{-1}$$
 (10)

where I represents the identity matrix with the dimensions of matrix A.

The  $(I - A)^{-1}$  is why the equation gets the "inverse matrix" name from and through this inversion, accounts for both direct and indirect effects of a change in final demand. By increasing final demand, there is an initial response to total output which is equal to the final demand increase. This in turn leads to higher demand for intermediate industries and leads to a further increase in total output. Consequently, final demand is again increased for all industries and total output is again increased. This process is continued for an infinite number of times. If and only if the (I - A) matrix is invertible, then there exists a convergence value for this infinite process and can be obtained through the Leontief inversion. With this model, the real-world data can be applied and used to run the desired simulations.

It should be noted that the matrix A is derived using data on intermediate demands as a ratio of total output. For all countries, data reported by the Organization for Economic Cooperation and Development (OECD) for 2018, in millions of USD, was used to make these calculations and build this model. These values were transformed using the Excel Software to produce a matrix of coefficient values, [A]. The matrix inversion was then able to be run using Excel and create the final demand vector, [Y], which was manipulated for each of the scenarios.<sup>6</sup>

### 3. Simulations

<sup>&</sup>lt;sup>6</sup> The Excel models for each country along with the data used can be accessed by using this link: https://bit.ly/Simonson GLS Thesis Data Note that you must have Excel Software that is macroenabled to view and manipulate these models and data. These models will not function properly with any other software, such as Google Sheets.

#### A. Simulation 1: Air Transport Economic Multiplier

The first simulation that will run using the Leontief input-output model will be a simple increase in final demand of the air transport sector. As defined by the OECD<sup>7</sup> to include all air transport related activities, final demand for air transport will be increased by one million USD for each of the three countries. The increase in final demand of one million dollars is not to suggest that an investment in air transport infrastructure would necessarily induce a final demand increase of one million dollars. Rather, it provides a continent unit measurement which can be easily scaled up depending on the estimated final demand increase of an investment project. The exact final demand stimulation value was chosen to not be defined since this would depend on the investment amount and is outside the scope of this paper.

The result of this simulation can be viewed as the "economic multiplier" of the air transport industry. As shown in Equation 10, this effect will be a function of the Leontief Inverse Matrix and will consider direct and indirect effects of the simulation on total economic output. The higher this value, the greater the effect on the economy it will have, since a higher multiplier suggests a higher increase to total output, which is a well-regarded indicator of economic wellbeing (Graham et al., 2020). The results of this summation will be used to test H1: Hypothesis 1 (H1): It is predicted that due to the complexity and resource-intensive nature of air transport, a one-unit increase in the final demand for Air Transport will increase total output in Chile, Brazil, and Peru by >2 units.<sup>8</sup>

## B. Simulation 2: Substitution Effect Between Transportation Choices

The second simulation will also consider possible substitution effects from increasing the final demand for air transport related activities. Generally, when demand for one industry rises, it is expected that there will be a decrease in the final demand for industries that produce substitute goods as consumers switch their consumption patterns (Weinhagen, 2020). In this context, if consumers demand more air transport related goods, then it is likely that consumers will demand less of other forms of transportation, such as land and water transportation.

By considering substitution effects, a more realistic model of the economy following the hypothetical investment in air transport infrastructure can be built. For simplicity, a one-to-one trade off in air transport to other modes of transportation will be assumed. Although this may not necessarily be the case in the real world, it is needed for both simplicity and the sake of comparison between countries.

It will be assumed that if demand for air transport increases by one unit (one million USD), then the demand for land transportation will decrease by 0.9 units, and water transport will decrease by 0.1 units in all three countries. This simplification is based on transportation patterns of consumers as well as shipped cargo (Gould & Segall, 1969). This will be used to test H2:

Hypothesis 2 (H2): If H1 holds, then it is expected to see that due to the relatively high multiplier effects of air transport demand, when final demand for air transport increases by one

<sup>&</sup>lt;sup>7</sup> This includes passenger air transport and air cargo actives.

<sup>&</sup>lt;sup>8</sup> In other words, this is suggesting that air transport investment will lead to increase in final demand, which will then lead to a significant impact in economic performance. For the purposes of this thesis, a significant impact is defined as a >2 unit increase in total economic output

unit and demand for its substitute goods simultaneously decreases by one unit, the change in total output will be positive.

## C. Simulations 3 and 4: Demand Increase Effect of Complementary Goods

In addition to substitution effects, it is also expected that there will be an increase in the demand for complementary goods following the increase in air transport demand. In the real world, there is a high correlation between air transport demand and the demand for both the tourism industry and industries related to high value manufacturing (Zhang & Graham, 2020). This correlation indicates a complementary relationship between air transport and these other industries, such that as demand for air transport rises, there is also a rise in demand for these industries. Generally, the causal relationship between the final demand for these industries is multidirectional, meaning that is an increase in the availability of air transport generally leads to higher tourism and high value manufacturing demands. However, an increase in these industries can also lead to a subsequent rise in demand for air transport (Baker et al., 2015). In the case of this simulation analysis, it will be assumed that an increase in air transport availability due to the investment endowment will lead to an increase in tourism and high value manufacturing.

To simulate this causal relationship, or what this paper refers to as the complimentary goods effect, a one unit increase for both high-value manufacturing and tourism will be assumed. These two effects are separated into two simulations to decompose the effects and see their separate multipliers.

Tourism was defined using the OECD categories of "Accommodations/Food Service Activities" and "Arts, Entertainment, and Recreation". A 0.8 weight was applied to the first category, that is a 0.8 unit rise in final demand, and a 0.2 weight to the second was used to obtain the desired 1.0 final demand increase. Although these exact figures are somewhat arbitrary, there is evidence that tourists spend most of their tourism dollars on accommodations and food services, and a less amount on entertainment (Neffke et al., 2018). Tourists are likely to spend on other categories as well; however, this spending is negligible and is therefore omitted for the purpose of our analysis (Neffke et al., 2018).

High-value manufacturing was defined using the sectors which rely most heavily on air-transport for their cargo logistics. Real-world evidence suggests that the manufacturing industries which rely most heavily on air-transport are Pharmaceuticals and High Value Electronics (Button, 1998). This is due to the fact the goods produced by these industries are both light-weight and high in value, making the marginal transportation cost via air transport low enough such that it is a viable means of shipping (Gould & Segall, 1969). Additionally, pharmaceuticals tend to be perishable, and must be shipped quickly or risk going bad. This also increases the industry's propensity to use air transport for shipping. A 0.5 weight was applied to both industries to obtain the target 1.0 increase in final demand, since there is no reason to predict demand for one will increase more heavily for either industry. The third hypothesis can be tested using this simulation:

<sup>&</sup>lt;sup>9</sup> It should be noted that agriculture also tends to be perishable, and therefore also occasionally uses air transport for shipping. However, their propensity for air transport depends heavily on location, and type of agriculture being shipped. Due to the OECD data not breaking down agriculture into specific enough categories, it was chosen to omit this from this analysis.

Hypothesis 3 (H3): Enhancing access to air transport will not only boost its demand but also stimulate demand for high-value manufacturing and tourism sectors, given their synergistic relationship with air transport. Significant total output increases are expected to be seen when final demand in these sectors to increase in all three countries, however high-value manufacturing will likely increase total output more due to its complexity.

## D. Simulation 5: The Simultaneous Effects of All Scenarios Impacting the Economy

In the final simulation, all effects from simulations 2-4 will be combined to see the complete picture of our model economy after a hypothetical investment in air transport infrastructure in each of our countries of interest. Simulation 1 is omitted in our calculation here since the multiplier effects of air transport are already accounted for in simulation 2. By adding together, the total output increase values of simulations 2-4, the total estimated unit increase in total output is obtained. It should be noted that this is not necessarily an exact unit value, since certain variables were omitted for simplicity. Additionally, this calculation is in unit value, and is therefore dependent on the amount of investment and the way in which final demand responds to this investment. Nonetheless, this model gives a reasonable baseline to guide policy makers on the estimated economic impact of an air transport investment and is therefore significant. With this in mind, our final hypothesis can be tested:

Hypothesis 4 (H4): If H2-H3 holds, then it can be reasonably expected that a hypothetical investment in air transport will induce a significant increase in total economic output.

#### 4. Results

_	Isolated Scenarios							
	Simulation 1	Simulation 2	Simulation 3	Simulation 4	FULL SCENARIO			
Air Transport Final Deamnd Change (Millions, USD)	1.00	1.00	-	-	1.00			
Road Transport Final Deamnd Change (Millions, USD)	-	-0.75	-	-	-0.75			
Water Transport Final Deamnd Change (Millions, USD)	-	-0.25	-	-	-0.25			
Tourism Related Industries* Final Deamnd Change (Millions, USD)	-	-	1.00	-	1.00			
High-Value Manuf.** Industries Final Deamnd Change (Millions, USD)	-	-	-	1.00	1.00			
Total Output Change (Millions, USD)	Chile: 2.23	Chile: 0.04	Chile: 1.80	Chile: 1.96	Chile: 3.80			
	Brazil: 2.44	Brazil: 0.35	Brazil: 1.88	Brazil: 2.28	Brazil: 4.51			
	Peru: 2.25	Peru: 0.42	Peru: 1.68	Peru: 1.96	Peru: 4.06			

Figure 1. Results for All Countries and Scenarios Consolidated<sup>10</sup>

For Peru, simulation 1, where air transport final demand was stimulated, produced the highest economic output increase among the 4 scenarios. Simulations 3 and 4 produced relatively equivalent output increases. However, simulation 4, which stimulated high value manufacturing final demand, was higher. It is also demonstrated that the effect of increasing air transport final demand does outweigh the substitution effects of decreasing final demand for other modes of transportation, since the result form simulation 2 is positive and well above zero.

For Brazil, similar to the results found in Peru, it is apparent that simulation 1 produces the highest total output increase. Simulation 4 produced a much higher total output increase than in

 $<sup>^{10}</sup>$  \* Tourism Related Industries: 0.8 weight on Accommodations/Food Service Activities, 0.2 Weight on Arts, Entertainment, and Recreation

<sup>\*\*</sup> High Value Manuf. Industries: 0.5 Weight on Pharmaceuticals, 0.5 Wight on Computers and High Value Electronics

Peru, whereas simulation 3 produced a similar value in both countries. It can also be concluded, as was the case for Peru, that the output increase for air transport outweighs substitution effects for water and road transport, as the result for simulation 2 is positive and significantly above zero.

The results from Chile differ the most from Brazil and Peru, with simulation 2 producing a positive, but near zero value. This suggests that in Chile, the total output change from substitution effects is almost as strong as the output increase form air transport demand stimulation. Additionally, simulation 4 does produce a higher output increase over simulation 3 but the difference is notably smaller than in Peru and Brazil. Despite these differences, simulation 1 did produce the highest output increase, and was roughly the same as that in Peru, but less than in Brazil.

#### 5. Conclusion & Discussion

The key takeaway from the results is that all the hypotheses are corroborated by the input-output simulations conducted for the three countries under study. In Peru, H1 was supported with an output increase of 2.25 for simulation 1 (S1), H2 was validated with an output increase of 0.42 for S2, H3 was supported with an output increase of 1.68 for tourism (S3) and 1.96 for high value manufacturing (S4), and H4 was supported with a total output increase of 4.06 in S4. Brazil had similar results, with H1-H4 being supported with an output increase of 2.44 for S1, 0.35 for S2, 1.88 for S3, 2.28 for S4, and a total output increase of 4.51 in S4. In Chile, there were similar results for S1, S3, and S4, supporting H1, H3, and H4, with output increases of 2.23 for S1, 1.8 for S2, 1.96 for S3, and a 3.8 increase in total output. However, S2 produced an increase of only 0.04, making it difficult to support H2 for Chile.

The majority of these results are unsurprising and consistent with both expectations as well as IATA's and other supporting research that was discussed in the introduction. Simulation 1 produced expected results in all 3 countries, which is not surprising since the primary motivation for this study was based on the assumption that the air transport industry is incredibly complex and connected to many parts of the economy, thus suggesting that it should have a high multiplier effect. In simulation 2, a high multiplier was expected in all three countries given the complicated nature of air transport compared to road or water transport. However, this only occurred in Brazil and Peru, therefore, it was surprising to see a value of 0.04 in Chile.

Although it is difficult to determine exactly why Chile produced such a small multiplier compared to the other countries for simulation 2 without further research, it can be suggested that it is due to Chile's relatively underdeveloped aviation market compared to Peru and Brazil (*The importance of air transport to chile*, 2018). This underdevelopment is represented in IATA's very low historic passenger facilitation scores in Chile, which is a good representation for aviation market development (*The importance of air transport to chile*, 2018). This underdevelopment has likely caused the country to rely more heavily on water and land transport compared to Peru and Brazil, which creates more substantial substation effects. That is, the simulated reduction of final demand for land and water transport caused a larger negative shock in Chile compared to Brazil and Peru. Nonetheless, this underdevelopment was surprising due to Chile's large tourism sector, which is usually correlated with higher aviation market development (Brida & Risso, 2009). Therefore, it is likely that this underdevelopment is caused not by passenger air travel motivation but rather by air cargo underdevelopment, since Chile's main manufacturing industry is mining, which is unsuitable for air transport (Fernandez, 2021).

Looking at simulations 3 and 4, which dealt with complimentary goods effects on final demand, there were mostly unsurprising but some surprising results. In simulation 3, which looked at simulated rises in final demand for tourism, although they were significant in all countries, there were higher multipliers for Brazil and Chile than for Peru. On the surface, this may seem unsurprising, given Peru's relatively lower level of development compared to Brazil and Chile by GDP per capita. One might think that due to this lower level of development, the tourism sector in Peru is simply less developed and more rudimentary, meaning the complexity of the industry is lower and does not rely on many inputs from other parts of the economy.

However, in reality, this is not the case. In fact, Peru has invested heavily over the past decade to improve hotel and tourism infrastructure (*Tourism growth driven by hotel investment and new air routes in Peru*, 2019). A possible explanation for this may simply be that the effects of these investments have not yet been realized in the Input-Output data available due to the fact that it takes time for these small investment projects to make meaningful differences in intermediate consumption. Possibly, in the future, the accommodation/food service multiplier in Peru, which is a proxy for tourism, will be larger.

Simulation 4 was very high in all countries, which is unsurprising since there is no reason to believe the multiplier effects of high-value manufacturing is significantly dependent to relative GDP per capita. Brazil's output increase was slightly higher, which is likely due in part to the larger high-value manufacturing industry in Brazil, which stems in part from the presence of an aircraft manufacturing sector in the country (Maculan, 2013).

The final simulation of the entire economy also produced results that were consistent with expectations, with Brazil having the highest overall simulated total output increase. This is not surprising, given Brazil's highly developed aviation market and industry compared to Peru and Chile. According to IATA, Brazil's air transport industry contributed \$18.8 Billion to national GDP in 2018 (*The importance of air transport to brazil*, 2018), whereas Peru's (*The importance of air transport to peru*, 2018) and Chile's (*The importance of air transport to chile*, 2018) air transport industry only contributed \$5 billion and \$7 billion in 2018, respectively.

Additionally, Brazil is the only country out of the three to have an established commercial aircraft manufacturing company, Embraer. This heavy aviation presence likely contributes to a higher reliance on the industry throughout the broader country compared to Peru and Chile, and is reflected through the high multiplier effects demonstrated in the simulations. Based on the simulations and the analysis of their results, three major takeaways were found:

(1) An investment that is able to increase demand for air transport related activities will likely stimulate an increase in total economic output that is higher than investments that stimulate demand for other modes of transportation, in most countries.

This conclusion was reached based on the simulation results and the fact that H1 and H2 were verified in each country with the exception of H2 in Chile. Even in Chile, where the result from S2 was not as significant as in Brazil and Peru, the result was positive, indicating a larger multiplier effect from air transport over land and water transport. Although in the analysis, S2 was used to demonstrate substitution effects from increased air transport demand, S2 can also be regarded as final demand stimulations for water and land transport (like in simulation 1) by simply subtracting away the result from S1 and changing the sign from negative to positive. This is possible since S2 effectively took the result of S1 and added a combined 1-unit final demand decrease for water/air transport, which is the negative inverse of a final demand increase. When this value is compared to the 1 unit increase in final

- demand for air transport, it is demonstrated that total output increase is higher when final demand in air transport is stimulated by an equivalent amount to water/land transport, leading to this takeaway.
- (2) Nations with a well-developed aviation market/industry can benefit from investment in air transport infrastructure more than countries without a pre-developed industry.

  This conclusion was reached based on the comparison between countries for total output increases in our complete model of a simulated investment in air transport. The results showed that Brazil's total estimated output increase was 0.45 units higher than Peru and 0.71 units higher than Chile. It might be suggested that there could be a variety of reasons for this, especially considering the fact that substitution/complimentary goods effects were taken into account, which means these higher multipliers could be driven from the underlying structure of those industries and not air transport. However, in simulation 1, which considers only an air transport final demand increase, Brazil is again 0.19 units higher in output increased compared to Peru and 0.21 units higher than Chile. Pairing this with the fact that Brazil is the only country out of these three with an established aircraft manufacturing sector as well as Brazil's relatively larger aviation market compared to these other countries, this second takeaway is reached.
- (3) GDP per capita alone is not a good predictor of how an air transport investment will affect the total output of a given economy.

This conclusion is the most surprising, due to the fact that the current body of literature usually suggests that demand for air transport is usually highly correlated with GDP per capita, and visa-versa. Although this may be the case, this correlation does not necessarily also apply to economic multiplier effects in a general equilibrium model. This is revealed in the example of Brazil, which sits in the middle of the GDP per capita range of the three countries studied, yet as indicated in S1 and S4, had the highest overall multiplier effects from increases in air transport final demand. This gave rise to takeaway 2, suggesting that Brazil's high multiplier effects form air transport would likely mean they would experience higher total economic output increases with an investment in air transport, compared to Brazil in Chile. Naturally, since Brazil has a lower GDP per capita than Chile (as of writing), then it can be concluded that GDP per capita is not necessarily a good indicator of the way in which an increase in final demand for air transport will affect total output.

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