APPENDIX MATERIALS:

Limited Supply and Lagging Enrollment:
Production Technologies and Enrollment Changes at Community Colleges during the Pandemic

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Appendix Table 1. Mode of Course Instruction, Welding and Web Technologies, North Carolina Community Colleges

	Welding		Web technologies	
	Fall 2019	Fall 2020	Fall 2019	Fall 2020
	(1)	(2)	(3)	(4)
Panel A: Enrollment				
0% online	84%	37%	6%	1%
<=50% online	14%	50%	11%	7%
51-99% online	1%	9%	7%	4%
100% online	1%	4%	76%	88%
Total students	8859	7206	1569	1605
Panel B: Number of courses				
0% online	85%	36%	8%	1%
<=50% online	13%	51%	10%	10%
51-99% online	1%	9%	8%	6%
100% online	0.5%	3%	75%	83%
Total courses	882	869	173	155

Source: North Carolina Community College system administrative data.

Appendix Table 2: Characteristics of Fields, Community Colleges

	Percent Cred. Cert	Percent Cred. Online Total	Percent Cred. Men
Agriculture & Related Sci	0.485	0.041	0.618
Natural Resources & Conservation.	0.280	0.029	0.681
Architecture & Related Services.	0.385	0.039	0.647
Area, Ethnic, Cultural, & Gender Studies.	0.152	0.296	0.409
Communication, Journalism, & Related Programs.	0.191	0.038	0.457
Communications Tech & Support Services.	0.519	0.036	0.629
Computer & Info Sciences & Support Services.	0.549	0.298	0.780
Personal & Culinary Services.	0.779	0.010	0.255
Education.	0.351	0.278	0.100
Engineering.	0.077	0.012	0.839
* Engineering Technologies/Technicians.	0.580	0.056	0.864
Foreign Languages, Literatures, & Linguistics.	0.424	0.042	0.207
Family & Consumer Sciences/Human Sciences.	0.706	0.191	0.060
Legal Professions & Studies.	0.426	0.112	0.157
English Language & Literature/Letters.	0.143	0.217	0.334
Liberal Arts & Sci, Gen Studies & Humanities.	0.183	0.446	0.378
Library Science.	0.671	0.298	0.189
Biological & Biomedical Sciences.	0.051	0.052	0.323
Mathematics & Statistics.	0.047	0.068	0.698
* Military Technologies.	0.006	0.899	0.771
Multi/Interdisciplinary Studies.	0.084	0.101	0.429
Parks, Recreation, Leisure, & Fitness Studies.	0.194	0.051	0.512
Philosophy & Religious Studies.	0.016	0.022	0.653
Physical Sciences.	0.037	0.046	0.573
Science Technologies/Technicians.	0.435	0.012	0.668
Psychology.	0.014	0.128	0.237
Security & Protective Services.	0.506	0.190	0.633
Public Administration & Soc Service Professions.	0.268	0.123	0.174
Social Sciences.	0.023	0.192	0.354
* Construction Trades.	0.821	0.010	0.942
* Mechanic & Repair Technologies/Technicians.	0.796	0.009	0.940
* Precision Production.	0.901	0.003	0.933
* Transportation & Materials Moving.	0.925	0.007	0.886
Visual & Performing Arts.	0.518	0.153	0.415
Health Professions & Related Clinical Sciences.	0.558	0.078	0.177

Business, Mngt, Marketing, & Related Support Services.	0.435	0.392	0.384
History	0.005	0.083	0.637

Notes: * indicates ARM field. Authors' tabulations from 2018 IPEDS Degrees Conferred data.

Appendix Table 3. Community college enrollment changes 2018-2019

VARIABLES	(1) Overall	(2) Men	(3) Women	(4) Overall	(5) Men	(6) Women
% ARM	-0.031	-0.030	-0.028	-0.036	-0.034	-0.034
	(0.027)	(0.029)	(0.027)	(0.024)	(0.026)	(0.023)
Hybrid				0.003	-0.007	0.011
				(0.023)	(0.034)	(0.013)
Online				-0.007	-0.016	-0.001
				(0.019)	(0.027)	(0.012)
Unemp. Rate				-0.001	-0.001	-0.001
				(0.001)	(0.001)	(0.001)
Constant	-0.010	-0.015	-0.006	0.010	0.013	0.009
	(0.002)***	(0.002)***	(0.002)**	(0.019)	(0.025)	(0.016)
Observations	318	318	318	318	318	318
R-squared	0.185	0.151	0.175	0.193	0.159	0.183
Weights	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: Dependent variable is the ln difference in enrollment 2020-2019; "% ARM" indicates the share of certificates and AA degrees awarded in "Assembly, Repair and Maintenance" fields at the community college from IPEDS in the 2017-18 academic year. Designation as "Hybrid," "In-Person," "Online" indicates the overall institutional mode of delivery in fall 2020. See Data Appendix for additional details.

Appendix Table 4. Community college enrollment changes 2019-2020, Including Prior Online Exposure

| VARIABLES	(1) Overall	(2) Men	(3) Women	(4) Overall	(5) Men	(6) Women
% ARM	-0.408	-0.523	-0.296	-0.395	-0.531	-0.259
	(0.038)***	(0.050)***	(0.029)***	(0.064)***	(0.082)***	(0.035)***
Hybrid	-0.043	-0.042	-0.042	-0.042	-0.043	-0.040
	(0.016)**	(0.026)	(0.015)**	(0.017)**	(0.027)	(0.015)**
Online	-0.051	-0.068	-0.039	-0.051	-0.068	-0.038
	(0.007)***	(0.020)**	(0.010)***	(0.007)***	(0.021)**	(0.011)**
Unemp. Rate	0.002	0.004	-0.000	0.002	0.004	-0.000
	(0.003)	(0.005)	(0.002)	(0.003)	(0.005)	(0.002)
% Cert Deg Online	0.014	0.033	0.007	0.027	0.025	0.041
	(0.026)	(0.032)	(0.026)	(0.038)	(0.063)	(0.023)
% Online * % ARM				-0.130	0.085	-0.346
				(0.316)	(0.436)	(0.230)
Constant	-0.112	-0.184	-0.062	-0.113	-0.183	-0.066
	(0.027)***	(0.047)***	(0.023)**	(0.023)***	(0.045)***	(0.020)**
Observations	318	318	318	318	318	318
R-squared	0.237	0.243	0.172	0.238	0.243	0.174
Weights	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 5. Effects of Instruction Mode on Enrollment Changes, Automotive Service Excellence Data, 2020-2019

	(1)	(2)	(3)	(4)	(5)
Ch Asynchronous online	-0.387**	-0.345**	-0.358**		-0.397*
	(0.159)	(0.173)	(0.155)		(0.207)
Ch Synchronous online	-0.416***	-0.316**	-0.420***		-0.1400
	(0.133)	(0.139)	(0.130)		(0.177)
Ch Hybrid	-0.100***	-0.0817*	-0.106***		-0.154**
	(0.038)	(0.045)	(0.039)		(0.063)
Asynchronous online 2019				-0.7450	-0.9200
				(1.037)	(0.952)
Synchronous online 2019				0.453***	0.311**
				(0.125)	(0.140)
Hybrid 2019				0.0738	-0.0829
				(0.101)	(0.105)
Student/family had COVID			-0.0178	-0.0122	0.0272
			(0.117)	(0.127)	(0.119)
Had to care for child/sibling			0.0263	0.0245	0.0699
			(0.092)	(0.109)	(0.097)
Students uncertain a/b program changes			0.0214	0.0117	0.0681
			(0.100)	(0.105)	(0.103)
Unable to pay for courses b/c lost income			0.0361	0.0098	0.0984
			(0.130)	(0.148)	(0.131)
Constant	-0.122***	-0.560	-0.272***	-0.412***	-0.304***
	(0.024)	(0.000)	(0.102)	(0.109)	(0.110)
State FE	N	Y	Y	Y	Y
Observations	287	287	287	287	287
R-squared	0.110	0.293	0.127	0.249	0.291

Notes: Authors' tabulations from ASE Survey. See Data Appendix.

Appendix Figure 1: Pre-period (2019) Variation in Assembly, Repair & Maintenance (ARM) Enrollment, Full U.S. Universe of Community Colleges
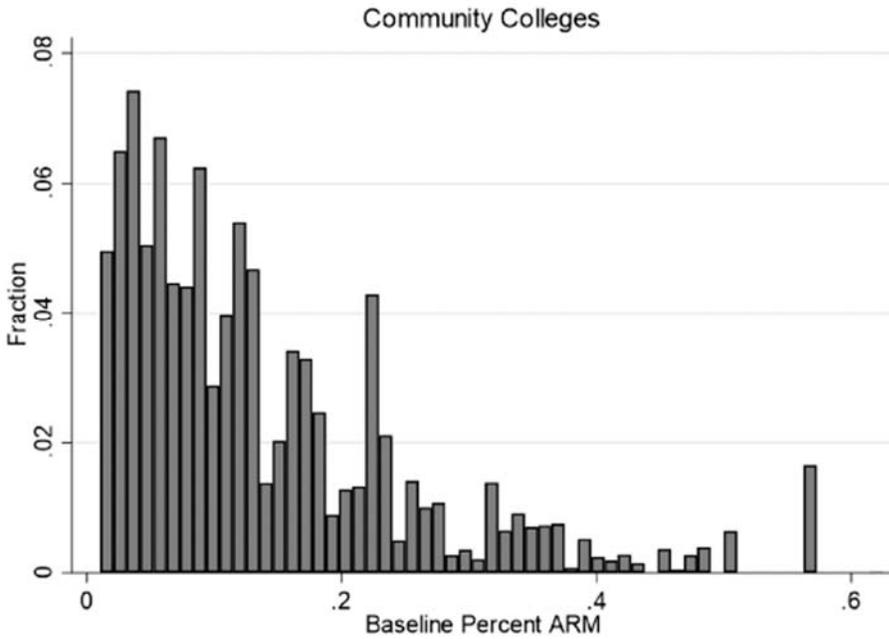
Appendix Figure 2: Pre-period (2019) Online Education Distribution, Community College Sample
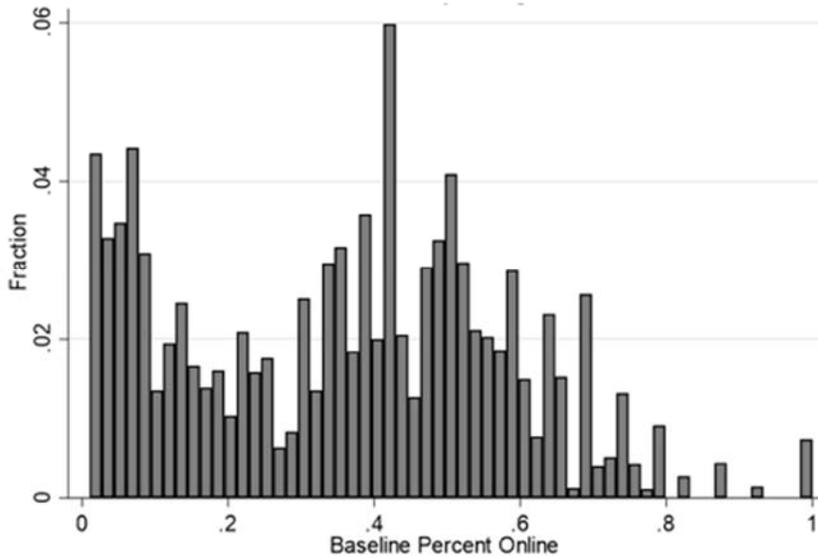
Source: Authors' tabulations from IPEDS (2018)

Supply Side Disruptions
Data Appendix

1   Community Colleges

1.1   Enrollment

We evaluate impacts on community college enrollment using annual fall headcounts for 19 states in which data for fall 2020 were available. We link these data to various institutional data files from the Integrated Postsecondary Education System (IPEDS). As state-level community college headcount files do not have unique identifying codes, we perform this link to IPEDS by manually attaching unique institutional numbers (UNITIDs) on institution names and location in the raw headcount data. Data Appendix Table 1 shows where these data were sourced, the level of enrollment disaggregation available (e.g., headcount by gender), and whether the set of institutions were included in our baseline specification.

1.2   Credentials Awarded

We measure the baseline awards/degrees conferred at each community college in our sample using the 2018 completion data from IPEDS. Specifically, we aggregate the count of awards over degree level (i.e., less-than-1-year certificate, 1-year certificate, 2-year certificate, associates) from July 1, 2017, to June 30, 2018, for each institution.

     We then identify the proportion of those degrees awarded in Assembly, Repair, and Maintenance (ARM) fields. To do so, we first define a job title to be an ARM job if any of the following elements is an important (i.e., importance rating 3 or higher) aspect of the job according to the Occupational Information Network (O*NET) classification system: repairing; equipment maintenance; equipment selection; operation and control. In sum, 229 job titles (out of 873 that map onto SOC codes) are coded as ARM jobs. Over 30 percent of the ARM-coded jobs include the word "operator" in their job title; another 15 percent each include "technicians" and "repairers." We then use a crosswalk between Standard Occupational Classification (SOC) job codes and Classification of Instructional Programs (CIP) education codes to identify CIP codes that lead to ARM jobs. Using this approach, we can code instructional programs by ARM status at the 2-, 4-, and 6-digit CIP level by linking courses of study to occupations using O*NET classifications. Finally, using IPEDS completion data, we identify the number of degrees awarded within each of these CIP ARM codes.

     It is relevant to note that many distinct SOC codes are linked to single CIP codes. For example, CIP 46.0101 (Mason/Masonry) is associated with 4 jobs: Brickmasons & Blockmasons; Stonemasons; First-line Supervisor of Construction Trades & Extraction Workers; Tile & Stone Setters. When the SOC codes linked to a single CIP code vary in ARM status, we define a CIP to be ARM if half or more SOC codes are ARM.

     We also assess the baseline proportion of community college degree programs that were offered online using the 2018 IPEDS completion data on the number of institutional programs that were offered via distance education. Following IPEDS classification, a distance education program is defined as a program for which all required coursework for program completion can be completed via distance education courses.

     The data used in our analysis are publicly available. Below is a list of the specific files described in this section which (at the time of publication) are readily accessible on each organization's respective website.

A. IPEDS
    a. C2018_A: Awards/degrees conferred by program (6-digit CIP code), award level, race/ethnicity, and gender: July 1, 2017 to June 30 2018, *(revised July 2020)*
    b. C2018DEP: Number of programs offered and number of programs offered via distance education, by award level: July 1, 2017 to June 30, 2018 *(revised July 2020)*
B. O*NET
    a. The O*NET Skills file, which provides a mapping of O*NET-SOC codes (occupations) to Skill ratings, from the U.S. Department of Labor.
C. CIP-SOC Crosswalk
    a. This file is produced jointly by the Bureau of Labor Statistics and the National Center for Education Statistics

1.3   Fall 2020 Reopening Plans

To account for enrollment responses driven by campus reopening plans we used data on U.S. postsecondary institution reopening models collected by Davidson College's College Crisis Initiative (C2i) team and published in *The Chronicle of Higher Education* in an article titled "Here's Our List of Colleges' Reopening Models" (last updated October 1, 2020.) Institutional reopening plans were categorized by C2i as follows – 1) Fully in person, 2) Primarily in person, 3) Hybrid, 4) Primarily online, 5) Fully online, 6) Other, and 7) Undetermined.

    In our analysis, we combine reopening plan categories such that "fully in person" and "primarily in person" are coded as "in-person" and "fully online" and "primarily online" are coded as "online." For a small set of institutions in our sample that were categorized as having a reopening plan that was "other" or "undetermined" we researched each institution's published communications on campus reopening structure and determined that these reopening models were best categorized as "hybrid."

1.4   North Carolina Automotive Curricula

We collected curricula from a selection of automotive credentials from ASE-affiliated North Carolina community colleges to measure changes in relevant degree course sections and headcounts. We then link these curricula details to our North Carolina enrollment data. We focus on automotive credentials to complement our ASE survey data. The North Carolina data are unique in that they are the only set of community college data we are aware of that publish enrollment at the college-term-course ID-course section level. To illustrate, we measure both changes in sections offered and student headcount of individual automotive courses (e.g., AUT116 - Engine Repair) from fall 2019 to fall 2020. Moreover, North Carolina details the delivery mode of each course section meaning we can measure how many sections of AUT116 were offered fully online versus in-person during a particular term. In contrast, the other community college data in our sample will publish, at best, enrollment at the college-term-CIP code level.

2   Unemployment Rate

To account for enrollment impacts driven by local labor market conditions we take an average of June, July, and August county unemployment rates for 2019 and 2020. We then link these data to the community college enrollment data by using the institution's county of establishment (from

IPEDS). As such, counties with multiple community colleges will have identical measures of the unemployment rate.

The unemployment data are from the BLS Local Area Unemployment Statistics County Data Tables. These data cover the previous 14 months of unemployment rates at the county level. We collect 2019 versions of these data using the Internet Archive's Wayback Machine, which has an archive of websites, including the county level unemployment data. Our 2019 data come from the April 10, 2020 archive of the local unemployment statistics. We downloaded the 2020 (unarchived version) of the data on June 7, 2021 directly from the BLS.

3   ASE Survey

The [Automotive Service Excellence Education Foundation](#) (ASE) accredits credential programs in preparation for ASE certifications in various specialties related to automotive and truck service and collision repair. According to ASE, accredited programs account for about 50% of the market with about 1268 programs serving secondary students and 770 serving post-secondary students. Our analysis focuses on the valid responses from 287 instructors in post-secondary programs, representing a 37.3 percent response rate. The survey collected information on program enrollment at various dates (April 1, July 1, and October 1, in 2019 and 2020), as well as mode of instruction (in-person only, online synchronous only, online asynchronous only, hybrid) in 2019 and 2020, and the instructor's perception of the importance of various barriers (having COVID, childcare, etc.) to changes in enrollment. Every instructor also provided an open-ended response to a question asking how COVID-19 affected instruction and learning in courses with a hands-on or lab component, which we coded using qualitative NVivo software.

Data Appendix Table 1. Community college enrollment data by state

State	Source Description	Headcount	Headcount by Age and Gender	Headcount by Age	Headcount by Gender	Baseline
California	California Community College Data Mart	Y	Y	Y	Y	Y
Connecticut	Connecticut State Colleges and Universities	Y	N	N	N	Y
Illinois	Illinois Community College Board	Y	N	Y	Y	Y
Massachusetts	Massachusetts Department of Higher Education	Y	N	N	Y	Y
North Carolina	North Carolina Community College System	Y	Y	Y	Y	Y
Tennessee	The College System of Tennessee	Y	N	Y	Y	Y
Texas	Texas Higher Education Accountability System	Y	Y	Y	Y	Y
Virginia	State Council of Higher Education for Virginia	Y	Y	Y	Y	Y
Washington	Washington State Board for Community and Technical Colleges	Y	N	Y	Y	Y