Decisions in Economics and Finance (2025) 48:1641–1667
https://doi.org/10.1007/s10203-025-00526-9

The long term implications of co-creation in economics education

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Received: 8 August 2024 / Accepted: 16 April 2025 / Published online: 21 May 2025

Abstract

In this paper, we discuss how co-creation in designing and releasing teaching resources could directly contribute to the development of student co-creators' soft skills and enhance the intrinsic motivation of the students exposed to the co-created activities. In particular, we highlight how carefully employing co-created outputs in teaching new classes of students can have long-term intertemporal peer effects that would establish a sense of reciprocity among students and the formation of a long-lasting learning community. We discuss these insights with a particular focus on economics education; we develop a simple model to study the dynamic effects of co-creation and, finally, we provide some considerations on the initial experimental evidence generated by co-creation activities undertaken in an intermediate microeconomics module.

Keywords Co-creation · Soft skills · Behavioral economics · Intertemporal peer effects · Experimental evidence

JEL Classification 46B42 · 46B04

We are grateful to Karol Tolpa for his research assistance, and to Ela Tarcalova and Zeta Chai for supporting the collection of the experimental data. We are also grateful to Sonya Krutikova for helpful comments and suggestions. We acknowledge the feedback offered by the participants to the 2021 Developments in Economics Education Conference. The design of the experiment has been approved by the University of Manchester Research Ethics Committee application 2022-15463-26330. Fabio Lamantia has been funded by the PRIN 2022 under the Italian Ministry of University and Research (MUR) Prot. 2022YMLS4T - TEC - Tax Evasion and Corruption: theoretical models and empirical studies. A quantitative-based approach for the Italian case.

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1 Introduction

Over the years, regulatory reforms, together with societal and cultural changes, have favored the development of forms of marketization of Higher Education (HE) sectors around the world, with students increasingly seen and treated as consumers. Some aspects of this evolution of the sector do not have to be necessarily a source of concern. In countries where students are asked to pay significant tuition fees, it would be natural and appropriate to treat higher education as a critical investment for a student, with significantly high opportunity costs and impact on their future employability and welfare. However, it is also unfortunately evident that extreme forms of marketization may have produced programmes tailored around the needs of representative "consumers", whose educational investment may be predominantly driven by the desire to acquire hard skills and professional qualifications. A side effect of this is that these students may become increasingly detached from principles like *respect*, *reciprocity* and *responsibility*, potentially with significant negative effects on the outputs of their education. Indeed, recent contributions in economic and scholarship literature have highlighted how the development of soft skills and a sense of reciprocity may play essential roles in defining students' motivation and the way they engage with peers, teachers, programmes, institutions and, ultimately, their own discipline and learning experience.

Recent research from the fields of psychology, sociology and (behavioral) economics highlights the importance of the development of soft skills (socio-emotional/meta-cognitive skills) to define the economic outcome of education.[1] These contributions review the insights of experimental evidence and behavioral theories that show how peer effects, self control, patience and (intrinsic) motivation can play major roles in the academic and professional success of students. Koch et al. (2015), for example, discuss how the development of soft skills can be associated to concepts studied in behavioral economics: willingness to compete and gender differences, self-control and time-inconsistent decision making, extrinsic and intrinsic motivation. Contributions to the scholarship of teaching literature, in addition, describe in detail how principles such as responsibility, respect and reciprocity may influence student engagement and active learning. These principles, this literature argues, can be enhanced by introducing forms of student/staff partnership and co-creation.[2] Co-creation in teaching are those activities where students directly work with academics on the design, creation, delivery and evaluation of teaching resources and practices. The literature has identified in student partnership and co-creation typical features of *threshold concepts*; crossing a threshold is a transformative, troublesome, irreversible and integrative experience.[3] For example, Cook-Sather (2014) describes partnership as a space where the participants have to rethink their roles: from students/consumers to co-producers, and from teachers/producers to facilitators/co-creators.[4] She points out that not only intellectual reconceptualization occurs during that process, but also *emotional*. Crossing the

[1] See, for example, Koch et al. (2015) and Damgaard and Nielsen (2020).

[2] See Cook-Sather (2014).

[3] See Meyer and Land (2005) and Land (2011).

[4] See also Marquis et al. (2016).

threshold allows students and staff to review and reassess previous concepts. Students become active participants, they stop being just consumers and turn into active learners (Marquis et al. (2016)). Various contributions in the literature have already highlighted the advantages and challenges connected to co-creation.[5]. Ultimately, the advantages of co-creation are connected to the emotional transformation of students and consequent development of soft skills. At the very stage of entering and building a meaningful relationship between students and staff, both parties embrace a commitment for *shared responsibility* (Bovill et al. (2011)). This commitment is there to establish a shared approach to teaching and learning which allows for increased awareness and more active engagement (Cook-Sather (2011b)). Students may realize that the new nature of their participation indeed requires taking more responsibility, but, as Bovill et al. (2011) notice, that realization may help renewing their commitment to learning. Students, while taking greater responsibility for their learning, increasingly become active learners, which in turn supports the development of their soft skills (Cook-Sather (2011a)). When they start taking responsibility for their learning, students evolve from passive recipients of knowledge to more active participants, co-creators. Students become aware of the material they are being taught which makes them more responsible for their learning (Cook-Sather (2011b)), while academic staff facilitates learning and shared inquiry. When students are able to co-create a part of their teaching and learning experience, both students and staff are exposed to *mutual respect* as they feel heard and understood (Werder et al. (2010)). Within this newly created environment of partnership and co-creation, one party now is able to understand the other as they work together and see each other's view (Cook-Sather (2014) and Schlesinger et al. (2017)). The process of co-creation brings a new meaning based on *reciprocity* into producer-consumer relationship. Alongside with responsibility and respect, reciprocity re-positions partners/powers within current institutionalized higher education system (Mercer-Mapstone et al. (2017)).

Taken together, the broad integrative nature of partnership and the specific threshold features of co-creation can provide a critical contribution to the development of students' soft skills and reciprocity/intrinsic motivation. With the partnership of staff and co-creation, students evolve, acquire hard and, perhaps more importantly, soft skills; while they master threshold concepts, they become experts and feel part of a community of learning and knowledge.

The contributions in the literature discussed so far have focused on the benefits and impact that co-creation may have on the student co-creators that *directly* engage with it. Through partnership, co-creation and active learning, students can be given the opportunity to master threshold concepts and, this way, expand the output of their education. These are the *direct* benefits of co-creation. We believe that there are also additional *indirect* benefits of co-creation that have not yet been highlighted by the literature and that require careful consideration. If the co-created teaching resources and practices were meaningfully deployed in the future to teach threshold concepts to new classes of students, instructors could create an intertemporal connection between students in different years. New students exposed to co-created resources will see how previous cohorts have mastered threshold concepts (and soft skills) in partnership

[5] See Bovill et al. (2011); Bovill (2014); Bovill et al. (2016) and Dollinger et al. (2018).

with teaching staff; this could boost their confidence in the subject (especially if the resources also contain some reflective message from the co-creators as a channel for intertemporal peer communication) and could create a desire to engage in co-creation in the future. In other words, being exposed to the sense of reciprocity and intrinsic motivation of previous co-creators, students may be more inclined to engage themselves with co-creation/partnership and the related benefits that we have mentioned above. Effectively, the use of co-created resources could create the conditions for some form of intertemporal cultural transmission among students, potentially with long term effects on student engagement and experience.

For the behavioral traits considered in Koch et al. (2015), we include other dimensions, specifically related to the way individuals internalize and react to social stimuli, such as altruism, compassion, and emotions. Taken together, these traits contribute to the formation of something that we would like to name *education morale*.[6] Education morale in HE would describe the way students relate to their institution and to the HE sector more broadly, and their inclination to reciprocate and engage with forms of active learning. Students with a positive education morale would be those who see themselves as part of a learning community, they are intrinsically motivated to contribute to the learning experience of other students (for example engaging with schemes such as Peer Assisted Study Sessions, Peer Mentoring, student representation, student ambassadors duties during open days, etc) and, in some cases, to academic research (for example collaborating with academic staff via research internships). Essentially, co-creation could reduce the myopic behavior of those students who struggle to appropriately evaluate the future advantages of extracurricular activities, improve inclinations toward pro-social behavior (Bénabou and Tirole (2006)) and increase alignment of purposes between students and teaching staff (Besley and Ghatak (2005)). Ultimately, via co-creation, intertemporal peer effects could influence student behavior, improve intrinsic motivation and, this way, create a sense of education morale.

To describe the way co-creation of teaching resources and practices may affect directly the educational achievement of students and indirectly, through intertemporal peer effects, influence the education morale of new cohorts of students, we develop a simple dynamic model where, in each period, a junior cohort of students can benefit from accessing the resources co-created by senior students. Treating co-creation as a stock variable, we show how a long-run equilibrium level of engagement in co-creation could be reached and highlight how the extent and benefits of co-creation depend on the way intertemporal peer effects are transmitted via the adoption of co-created material and practices in the teaching of new students.

To shed additional light on the matter, we describe the insights of a pilot experiment run with a cohort of intermediate microeconomics students exposed to co-created resources and nudging by the senior students who co-created the material. The experimental evidence (accompanied by semistructured interviews with students) seems to corroborate the existence of direct and indirect (intertemporal) benefits of co-creation.

[6] We use this term, intentionally resembling the one of *tax morale*: broadly the attitude that taxpayers have toward institutions and tax compliance. Luttmer and Singhal (2014) describe various aspects of tax morale that are very closely related to the notion of education morale and the *respect*, *responsibility* and *reciprocity* principles mentioned above. See also De Giovanni et al. (2019) and Lamantia and Pezzino (2021).

The rest of the paper is organized as follows. In Section 2, we develop the stylized framework to model the behavioral and intertemporal benefits of co-creation. In Section 3, we focus our attention on economics teaching and discuss the insights of the pilot experiment run during an intermediate microeconomics module. Section 4 concludes.

2 A framework to study the long-term behavioral effect of co-creation

In this section, we propose a framework to model some of the insights that we have introduced in Section 1. The model highlights, in particular, the direct benefits that co-creation may produce on students who engage in it and the indirect intertemporal peer effects generated when new students are exposed to the co-created resources produced by previous cohorts. To do so, we build on the stylized set up and production function considered in Koch et al. (2015),[7] that describes the educational achievement of a representative student engaging with formal education in a two-period model.

To highlight the intertemporal nature of co-creation, let us treat it as a stock variable, CC_t, i.e. a collection of materials, resources, practices that have been co-created by an instructor and previous cohorts of students. To align to the example of practice that we shall describe in Section 3, let us consider an academic year divided into two semesters. Suppose that in the first semester, say time t, a *junior* class enrolls in a subject. The junior cohort's efforts are aimed at learning the concepts taught in the module; during the semester, they can also be exposed to the co-created resources produced by previous cohorts. In the second semester, time $t+1$, these students, whom we are now going to call *seniors*, while perhaps pursuing more advanced studies and progressing on their degree, may also engage, investing effort e^{CC}_{t+1} in extracurricular activities aimed at co-creating resources with the instructor who taught them at time t. The outcome of their efforts contributes to the stock of co-created resources. At the beginning of the new academic year, $t+2$, the stock of co-creation that an instructor can release to a new cohort is given by:

$$CC_{t+2} = \delta \ CC_t + e^{cc}_{t+1} \tag{1}$$

where $\delta \in (0, 1)$ represents the degree of obsolescence of the materials co-created in the previous year (e.g. examples, problems, analysis of data that may become outdated).

When taking the course in the first semester, time t, a representative junior student can decide how much effort to invest in learning the material; let us call e^s_t students' effort in learning the subject at time t. The output of education at time t for the representative junior student is given by an achievement production function of the form:

$$A_t = T \ (e^s_t)^{\alpha} \ (1 + CC_t)^{\beta} \tag{2}$$

[7] See also Todd and Wolpin (2003) and Hanushek (2020).

where $T = \mu F H E > 0$ is a coefficient that can describe (see Koch et al. (2015)) the contribution of family input (F), cognitive ability of students (μ) and educational input[8] (e.g. facilities and resources) invested by the higher education institution (HE). Two key inputs in the production function of educational output are the effort of students (e_t^s) and the stock of co-creation that has been produced by previous classes that previously took the same course (CC_t). $\alpha \in (0, 1]$ and $\beta \in [0, 1]$ are standard Cobb-Douglas coefficients. Notice that focusing on strictly positive values of α implies that, rather realistically, we are discarding the possibility that a student may experience strictly positive levels of educational achievement A_t engaging exclusively with co-created resources, regardless of the level of effort e_t^s. Students' effort can take several forms, e.g. attendance of timetabled sessions, private study, engagement with academic advising and co-curricular activities, etc.; in Section 3 we shall treat the time spent in accessing online resources (including the main textbook, videos, slide decks, etc.) provided in the virtual learning environment as a proxy of students' effort. Notice that $\beta = 0$ would describe the case in which students are not exposed to co-created resources produced by previous cohorts. The functional form of A_t describes an achievement production in which, if students invest no effort in their learning the production generates a level of achievement equal to zero; since co-creation enters in the form $(1 + CC_t)^{\beta}$, if no co-created resources are employed in the teaching of the module, a strictly positive level of achievement can still be generated as long as the student invests a strictly positive level of effort. It would be reasonable to assume a monotonically increasing relationship between A_t and students' attainment and performance in an assessment that tests their achievement of learning objectives. For simplicity, we do not introduce an additional argument to describe this relationship. In Section 3 we shall discuss, however, the insights of experimental evidence that refers also to assessment performance.

Each junior student will choose a level of effort e_t^s to maximize the following (indirect) utility of education:

$$E_t = A_t - \frac{\gamma}{2}(e_t^s)^2 \tag{3}$$

The utility of education E_t describes the objective function of junior students who attempt to maximize their educational achievements (A_t) choosing their engagement with the material (including the co-created one, CC_t), while incurring costs of effort.[9] In particular, the term $\frac{\gamma}{2}(e_t^s)^2$, where $\gamma > 0$, represents the cost of effort of junior students engaging with the learning of the subject.

[8] A discussion of the efficiency of the use of educational inputs is out of the scope of this work. See Ulkhaq et al. (2024) for a discussion of recent contributions in the literature that employ Data Envelopment Analysis to estimate efficiency in the provision of education.

[9] Note that we are implicitly imposing a certain degree of myopic behavior on the part of the junior students since, when choosing the optimal effort at time t they are not considering the possible repercussions on their academic achievement at time $t + 1$. This assumption, in addition to being rather realistic, is also inessential in our framework: the effort decisions are not affected if students were able to maximize their utility intertemporally.

Since $\alpha \in (0, 1]$, function (3) is concave and maximized by:

$$e_t^s = \left(\frac{\alpha(1 + CC_t)^{\beta} T}{\gamma} \right)^{\frac{1}{2-\alpha}} \tag{4}$$

Not surprisingly, the level of effort decreases with the cost of effort γ and, given the complementarity in production implied by the Cobb-Douglas functional form, when $\beta > 0$, i.e. the instructor meaningfully employs co-created resources in their teaching, students exposed to a higher level of co-creation may tend to engage more with their studies and, ultimately, generate a higher output of education. As we mentioned in Section 1, this *indirect* positive spillover of the co-creation produced by previous classes tends to be overlooked by the scholarship of teaching and learning literature, which focuses on the benefits to the students who directly engaged in the co-creation in the previous year. Being exposed to co-creation may also generate positive (intertemporal) peer effects to the junior class; they may develop a sense of, what we called, education morale: they discover and appreciate that there may be a community of learning that they can join and to which they can actively contribute in the future. These students, at time $t + 1$, will be senior and engaged in further studies, and will also have the possibility to co-create resources with the instructor who taught them at time t. For senior students the achievement production function will have as inputs the educational output produced at time t and the effort in co-creation from time $t + 1$ up to time $t + 2$ to produce:

$$B_{t+1} = A_t \ e_{t+1}^{cc} \tag{5}$$

B_{t+1} describes the *direct* benefits of engaging in co-creation in semester 2. Senior students can master advanced/threshold concepts, develop soft skills and generate additional output of education. This point has been often the focus of contributions that discussed the benefits of co-creation. At time $t+1$ the representative senior student will target the maximization of:

$$U_{t+1} = B_{t+1} - \frac{\eta}{(1 + \beta\, CC_t)} (e_{t+1}^{cc})^2 \tag{6}$$

where $\frac{\eta}{(1+\beta\, CC_t)} (e_{t+1}^{cc})^2$ represents the cost of effort of engaging in co-creation. If students were previously exposed to co-creation, i.e. $\beta > 0$, they may be in a better position to become co-creators. Being exposed to co-creation at time t had a positive effect on A_t (and this effect would also be stronger if those students faced a lower cost of effort γ) and, in turn, on B_{t+1}. At the same time, notice that, thanks to the development of education morale, the cost (often of an emotional/behavioral nature) of engaging in co-creation for a senior student is decreasing in the level of co-creation to which they have been previously exposed. In other words, due to intertemporal peer/spillover effects, students exposed to co-creation at time t may experience a form of education morale, be more easily integrated in a community of learning and, ultimately, become more effective co-creators. Parameter η could be interpreted as a standard efficiency coefficient describing the (inverse measure of the) innate predisposition of students

to become co-creators; however, it may be perhaps better interpreted as the result of the way co-creation was motivated and explained to students by the instructor at time t. Therefore, taken together, parameters β and η may describe how effective is the instructor's release of co-created material in establishing intertemporal peer effects[10] and their engagement with students co-creators. δ in (1) can also describe how effective is the instructor in keeping the co-created material up to date.

The optimal level of effort in co-creation of a senior student is given by:

$$e_{t+1}^{cc} = \frac{T(1+\beta CC_t)(1+CC_t)^{\beta}\left(\frac{\alpha(1+CC_t)^{\beta}T}{\gamma}\right)^{\frac{\alpha}{2-\alpha}}}{\eta} \tag{7}$$

Notice how the level of effort in co-creation depends on the costs of effort of both junior (γ) and senior (η) students; this is because students who faced lower costs of effort when junior would experience, ceteris paribus, a higher level of educational benefit in the following years and, therefore, a higher incentive to invest effort in co-creation. This interaction of the two cost parameters will determine the nature of the possible scenarios that could be generated in the long run. In addition, notice that, when $\beta = 0$, the co-creation effort of the senior students is strictly positive and given by:

$$e_{t+1}^{cc} = \frac{T}{2\eta}\left(\frac{T\alpha}{\gamma}\right)^{\frac{\alpha}{2-\alpha}} > 0 \tag{8}$$

This situation describes the *direct* positive effects of co-creation on the development of hard and soft skills; even if they may have not benefited from the co-creation of previous classes at time t, student co-creators can still approach and master threshold concepts and reach higher educational outcomes at time $t+1$. The case where $\beta = 0$ describes a story in which the benefits of co-creation are only partially unlocked, being limited only to the students who directly engage with it. Exposing junior students to the co-created outputs of previous classes (i.e. $\beta > 0$) would unlock the intertemporal benefits of peer influence and reinforce the dynamic advantages of student-staff collaboration.

Inserting the optimal co-creation effort (7) in (1), we have a dynamic pattern of co-creation described by a one-dimensional non-linear difference equation[11]

$$CC_{t+2} = f(CC_t) = \delta\ CC_t + \frac{T(1+\beta CC_t)(1+CC_t)^{\beta}\left(\frac{\alpha(1+CC_t)^{\beta}T}{\gamma}\right)^{\frac{\alpha}{2-\alpha}}}{\eta} \tag{9}$$

[10] In the next section we describe how asking student co-creators to accompany the resources with message delivered via videos or emails to new cohorts of students may be an effective practice to establish intertemporal peer effects.

[11] Note that we are assuming that there is no co-creation during the period when the student is in the first period (junior student). In a setup with overlapping generations it is possible to reformulate the model via a second-order (non-linear) difference equation. We leave this analysis to a possible future extension of the present work.

In what follows, in order to produce analytical results, we impose $\alpha = 1$ and consider two specific cases: $\beta = 0$, i.e. junior students are not exposed to resources co-created by previous classes, and $\beta = \frac{1}{2}$, i.e. students are exposed to co-created resources when studying a subject.

The stationary equilibrium condition is given by the solution of the equation:

$$CC = \frac{T(1+\beta CC)(1+CC)^{\beta}\left(\frac{\alpha(1+CC)^{\beta}T}{\gamma}\right)^{\frac{\alpha}{2-\alpha}}}{\eta(1-\delta)} \tag{10}$$

where CC describes the level of co-creation in steady state.

When $\beta = 0$, the co-creation effort of senior students is given by (8) and the difference equation simplifies to

$$CC_{t+2} = \delta CC_t + \frac{T^2}{2\gamma\eta} \tag{11}$$

and the unique equilibrium level of co-creation is:

$$CC^*_{\beta=0} = \frac{T^2}{2\gamma\eta(1-\delta)} \tag{12}$$

Being $CC^*_{\beta=0} > 0$, this equilibrium is also a stable attractor since $\delta \in (0, 1)$.

Intuitively, if the costs of effort for the two generations of students are sufficiently high, then the system converges to a positive level of co-creation, even if the outputs of co-creation are not used in the teaching of junior students. If, instead, the costs of effort of students are sufficiently low, then the contribution to the stock of co-creation of senior students is so high that the stock of co-creation in time will diverge to infinity, regardless of the initial value of co-creation at time $t = 0$.

When $\beta = 1/2$, the non-linear difference equation has two possible roots:

$$CC^*_{l,r} = \frac{4\gamma(1-\delta)\eta - 3T^2 \pm \sqrt{\left(4\gamma(\delta-1)\eta + 3T^2\right)^2 - 8T^4}}{2T^2}$$

Notice that the two roots are both real and positive if $\gamma\eta > \frac{\left(2\sqrt{2}-3\right)T^2}{4(1-\delta)}$. As we mentioned above, the interaction of the cost parameters of junior and senior students determines the nature of the steady state of the model. If costs are sufficiently high, the system has two positive stationary equilibria. This case is described graphically in Figure 1. Otherwise, the generic trajectory would diverge to an infinite level of co-creation.

When $\gamma\eta > \frac{\left(2\sqrt{2}-3\right)T^2}{4(1-\delta)}$ the smaller root, CC_l is a stable attractor, since the linearization of the difference equation at CC_l has a positive slope, smaller than 1. The larger root is, instead a repeller, since the linearization of the difference equation at

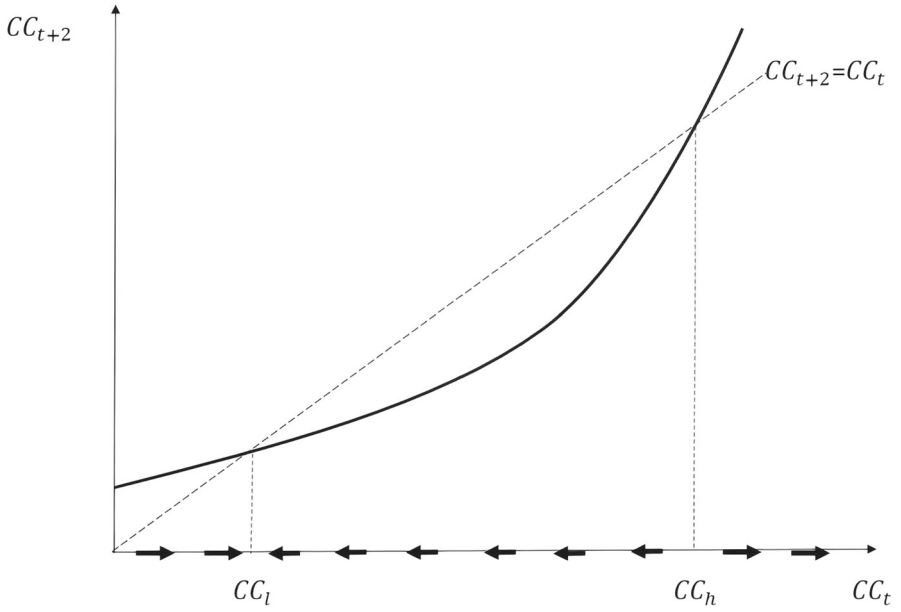

Fig. 1 Equilibria when $\beta = 1/2$ and $\gamma\eta > \frac{\left(2\sqrt{2}-3\right)T^2}{4(1-\delta)}$

CC_h has a positive slope, always greater than 1. This information, together with Figure 1, highlights how for $\beta = 1/2$ the level of initial co-creation at $t = 0$ may play an important role. For small or intermediate initial levels of co-creation, i.e. $CC_0 < CC_h$, the level of stock of co-creation will converge to a stable level in the long run. However, for sufficiently high levels of initial co-creation, i.e. $CC_0 > CC_h$, the stock level of co-creations will diverge to infinity in time.

Notice that, quite intuitively, an increase in T (i.e. an increase in cognitive abilities or investments from families and institutions) or in δ (i.e. co-created resources are not easily outdated) have a positive effect on CC_l. Instead, an increase in effort costs (γ and η) has a negative effect on the long-run equilibrium level of co-creation. Moreover, notice that the map reported in Figure 1 describes the co-creation growth pattern. This can be explained by the way co-creation in teaching CC_t influences, via the maximization of function (6), the optimal effort of students' co-creators, e_{t+1}^{CC}, and in turn this effort contributes to the expansion of the stock CC_{t+2}. Exposing students to co-created resources at time t, measured by CC_t, increases the educational achievement of junior students, A_t, and reduces the costs of co-creation efforts at time $t + 1$; taken together, these two positive effects interact and generate the convex nature of the map. These features explain how a sufficiently high ($CC_0 > CC_h$) initial level of co-creation would initiate a process that would see the stock of co-creation diverge to infinity. This is, of course, a rather exceptional scenario that may require considerable investments in pedagogical and technological innovation (e.g. the adoption of AI in developing learning material) to generate a drastic shock in the level of co-creation. However, this would not happen for intermediate levels of initial investment

in co-creation ($CC_l < CC_0 < CC_h$); the system would not be able to kick-start a self-sustaining growth pattern; instead, it would see a gradual reduction of the stock of co-creation that, in time, will converge to the lower interior equilibrium CC_l. In the pilot that we describe in the next section, our interest lies in the realistic scenario in which $0 < CC_0 < CC_h$; in other words, a situation in which a positive, but relatively small level of initial co-creation is introduced in the system.

3 Pilot study

The model discussed in the previous section predicts that students' effort may depend on both their exposure to existing co-created materials and the magnitude of the output elasticity of co-creation, denoted as β. Specifically, interventions capable of increasing β will result in larger amounts of effort given the level of exposure to co-created materials.

This section presents suggestive evidence on the effectiveness of a behavioral intervention aimed at increasing β. We manipulated the sender of an email encouraging students in a large microeconomics course to engage with co-created resources. In the treatment group, senior student co-creators were the senders of the email, whereas in the control group the sender was the lecturer in charge[12]. This intervention is, therefore, based on the creation of peer effects and it is connected to 'Social identity theory' (Tajfel and Turner, 1979), which states that a person's sense of self is perceived through various social categories to which they belong, and these perceptions can motivate preferential treatment of in-group peers.

In economics, Social Identity Theory was adopted by Akerlof and Kranton (2000, 2002) to show that individual choices are influenced by social identity. Subsequent experimental work has revealed that group memberships determine altruism, reciprocity or forgiveness (Chen and Chen, 2011) even when group membership is based on spurious characteristics, such as arbitrarily allocated colors. In-group favoritism based on real categories was demonstrated by Tanaka and Camerer (2009), who show strong in-group favoritism among Cambodian minorities (Khmer, Vietnamese and Chinese) in a series of laboratory experiments. Chen and Li (2009) show that just being identified with an arbitrary 'group' is sufficient to overcome self-interest in the lab. Similarly, players in dictator games transfer significantly more to in group recipients (Ockenfels and Werner, 2014), particularly when receiver's group membership is known. Bernhard et al. (2006) show that third parties show stronger altruism towards ingroup victims of unfair behavior (and punish less the deviations of in-group peers); individuals also cooperate more with ingroup members (Goette et al., 2006).

In view of this evidence, our hypothesis is that the peer effects established in the treatment facilitate the formation of some form of ingroup trust and education morale. Specifically, we conjecture that, by appealing to in-group characteristics, emails signed by students might elicit greater interest and trust in the online co-created materials and could, indirectly, contribute to better outcomes in academic settings.

[12] See Appendix A.

3.1 Background

Participants in the pilot experiment were students enrolled in a second-year intermediate Microeconomics unit at a large British research university. The module covers consumer theory, producer theory, competition and monopoly, and applied game theory. Each year, about 400 students take the course, including a significant proportion of international students. The unit is compulsory for all students enrolled in any Economics major degree, but it is also taken by students from other degrees such as Finance or Business. All students have completed introductory courses in Microeconomics and at least one course in mathematics, where they covered calculus and multivariate optimization techniques. All necessary resources (including textbooks, slide decks, videos and assessments) are available to students online on the virtual learning environment.

In December 2020, we issued a call to students enrolled in the module, seeking volunteers interested in engaging with the lecturer to co-create resources during the summer. These resources were intended for release to the new class of 2021/22. The principles and advantages of co-creation, as outlined in this paper, were also presented and explained to the class. We explicitly communicated that the co-created resources should include some form of direct message from the student co-creators to the junior students who would utilize the materials in the future. In the inaugural year of the project, two students committed to participating. One student agreed to co-teach a portion of a live lecture, while the other student produced a series of digital posters to aid the class in revision[13].

In September 2021, the module was taught in a hybrid format. Approximately half of the class was based on campus, while the rest of the cohort received remote instruction. Towards the end of the module, we released the co-created resources and co-taught a lecture on oligopoly theory and application.[14] Interestingly, despite not officially soliciting future co-creation activities, at the end of the module, about 8 students came forward inquiring about opportunities for co-creation during the following summer. Consequently, we initiated two projects: (i) co-creation of resources (videos and notebooks) to introduce students to the use of the software 'Mathematica'; (ii) co-creation of resources (videos and .tex files) to help students familiarize with the use of LaTeX, a software system for typesetting documents.

3.2 Experimental design

Against this background, in the 2022/23 academic year we undertook a pilot study to test our Social Identity Theory hypothesis, by having senior student co-creators directly motivating and promoting the resources released in the module. In terms of the set-up that we have developed in Section 2, this was akin to testing if, by appealing to in-group characteristics, direct communications from student co-creators could establish intertemporal peer effects and produce an increase in the parameter β (and consequently an increase in students' engagement with the material , e_t^s, and

[13] The posters were uploaded on the virtual learning environment and accompanied by a message from the student co-creator.

[14] We describe our experience in Pezzino and Riganti (2022).

an eventual improvement in educational attainment A_t). An increase in β may also increase students' engagement in co-creation for students in the future, thus kick-starting a virtuous process (similar to the one described in Figure 1), and increase the long-run level of co-creation as reported in equation 10.

In September 2022 we released to all students in the new cohort the co-created resources produced in the two previous academic years. The number of contact/teaching hours in the module was not affected by the release of the resources. The main cost for the instructors was in terms of the time dedicated, during the summer, to recruit, train, and support the student co-creators, and embed the resources in the digital learning environment of the module. During the semester, the resources were regularly promoted by the instructor and accompanied by videos in which the student co-creators introduced themselves to the new class and explained why they decided to engage in the project. It was explained to students that the use of the software 'Mathematica' or submission of assessment in LaTeX format were not part of the learning outcomes and, consequently, engagement with the co-created resources was not part of the formal assessment of the module. Students were also informed that, later in the term, they would be invited to express their interest in engaging in co-creating activities with the lecturer in charge of the course, during the summer.

Separately, students were told that, as part of the course, they would be invited to take part in '*an experiment*'. Specifically, an email was sent to students inviting them to take part in a research project to help the research team to '*better understand how students learn in an Economics setting*'. The email is reproduced in Appendix A.1. Students were explained that participation would not affect their marks. The invitation letter further specified that participants would be entered in a draw for cash prices. Specifically, the potential gains were as follows: three prizes of GBP100, ten prizes of GBP50 and thirty prizes of GBP25.

We ran the experiment in September-December 2022. Among the 473 students enrolled in the intermediate microeconomics module described above, a total of 111 students agreed to participate in the experiment. The experiment was divided into two phases. In phase 1, students completed an online survey and a personality questionnaire. The survey asked for students' gender, age, program of study, and place of birth.

In phase 2, participating students received an invitation to explore and engage with the co-created resources available to the class. Students received one among two possible e-mails. The type of email was randomly allocated to each participating student. Both emails were identical except for the sender. Students in the control group received email 'L' (Appendix A.2) sent by the Lecturer in charge of the module. Students in the treatment group received email 'S' (Appendix A.3) sent by two students who had been involved in co-creation of materials in the 2021/22 academic year[15]. Two sets of emails were sent. The first set of emails was sent on 26 October 2022. The same emails were subsequently sent again, without warning, on 10 November 2022.

[15] The allocation of students to treatment/control groups was based on a simple random sampling and operationalized using a random number generator in Excel (a uniform distribution on [0,1]). The survey was delivered online, via Heroku, a '*container-based cloud Platform as a Service (PaaS)*' commonly used to deploy apps.

Our goal was to evaluate if, conditional on the type of sender, students in the treatment and control groups exhibited different levels of engagement with online resources. Specifically, we wanted to evaluate if direct promotion of co-created resources by senior student co-creators may have produced positive inter-temporal peer effects and an increase in engagement for the control group.

The outcomes of the pilot were three. First, we wanted to study utilization of resources during the two days after the email was sent to students; this would provide a measure of the short-term effect of the intervention. Second, we studied mid/long term effects, by comparing utilization of online resources across treatment groups the two days *before* the second email was sent. Finally, we studied variation in utilization of resources during the two days *after* the second email was sent.

The causal parameter of interest is the difference in mean utilization of online resources across treatment groups,

$$\tau = \mathbb{E}(Y_i(1)) - \mathbb{E}(Y_i(0)) \tag{13}$$

where $Y_i(Z)$ are student i's potential outcomes and where Z is the indicator of the treatment ($Z = 1$) or control ($Z = 0$) group (and z is a realization of Z). We estimate τ via the empirical difference in means,

$$\hat{\tau} = \mathbb{E}_n(Y_{i1}|Z = 1) - \mathbb{E}_n(Y_{i1}|Z = 0) \tag{14}$$

where Y_{ij} is the observed outcome of student i before ($j = 0$) or after ($j = 1$) the intervention, and $\mathbb{E}_n()$ denotes the sample mean of the term in brackets. In addition to this, we calculate the difference in difference estimator of $ATE = E(Y_i(1) - Y_i(0))$,

$$\hat{\tau} = \mathbb{E}_n(Y_{i1} - Y_{i0}|Z_i = 1) - \mathbb{E}_n(Y_{i1} - Y_{i0}|Z_i = 0) \tag{15}$$

Under randomization, this parameter is a valid estimator of the Average Treatment Effect. Given that Z is randomly allocated, the exclusion of covariates does not affect their statistical properties. However, we will also evaluate the effect of pre-treatment covariates in small samples, in which case we replace the above unconditional expectations with conditional expectations, which can be estimated by least squares regressions. Finally, inference will be based on t-test associated with the treatment indicator in the regressions (with robust standard errors).

3.3 Results

Table 1 describes the characteristics of the students. The average student was 19 years of age. Of the 111 students, 45% were female, 38% were born in the UK, 29% were born in the P.R. China. Most of the students (41%) were enrolled in a mainstream degree in Economics (Program of study 'A'), 16% of the students were enrolled in a combined degree in Economics and Finance (Program of study 'B'), whereas the remaining students belonged to one among other 8 minority programs of study.

We evaluated the quality of the randomization by estimating a probit regression of the treatment indicator on the pre-treatment variables in Table 1. The results are

reported in Table 2 (robust standard errors are reported in parentheses). This table presents the results of a probit regression assessing whether the assignment to the treatment group was random with respect to observable pre-treatment characteristics. The dependent variable is an indicator for being in the treatment group ("Treated"). Each column represents a different specification of the model, with progressively more control variables included. Column (1) includes only gender (Female) and age as predictors. Column (2) adds indicators for whether the respondent was born in the UK or China, while column (3) replicates this specification as a robustness check. Column (4) further includes indicators for the program of study (Program A and Program B), and column (5) adds students' marks in an introductory microeconomics course and prior use of online resources. Each row in the table corresponds to a different predictor, with the first row displaying the estimated coefficient from the probit regression, the second row (in parentheses) showing the robust standard errors, and the third row (also in parentheses) reporting the p-values of the corresponding t-test. The results suggest that none of the variables show statistically significant differences across treatment groups, indicating that the randomization was successful. Since random assignment should lead to no systematic differences between groups, the large p-values (> 0.1) across all variables confirm that these covariates are not significantly different between treatment and control groups. Additionally, the intercept, which represents the baseline probability of being in the treatment group when all predictors are zero, is also not significant, reinforcing the conclusion that treatment assignment was not systematically related to these observable characteristics.

None of the pre-treatment variables predicted the treatment allocation so, overall, we believe that the random allocation worked as expected.

We next report the effect of the intervention on the amount of time engaged with online learning materials. The first column of Table 3 presents the difference in mean utilization of online resources across treatment groups the two days following the delivery of the first email. The second column in the table presents the difference in difference estimator of $ATE = E(Y_i(1) - Y_i(0))$. Overall, these methods suggest an increase in the time spent engaged with online materials in the treatment group of about 0.01-0.02 hours (or 36 to 72 seconds, or 0.6-1.2 minutes).

Next, we study if the intervention leads to some longer-term effects by estimating differences in total utilization the week before the second reinforcement email was sent. The results are provided in Table 5. On this occasion, Y_{i0} was usage of online resources before the first email. The results suggest that the treatment group spent more time engaging with the resources (0.171-0.159 hours or 9.54-10.26 minutes). Finally, in Table 4 we estimate the short-term effect of the second reinforcement email. We find a short-term increase in the utilization of online resources in the treatment group of 0.070-0.082 hours (or 4.2-4.92 minutes). The p-values associated with these estimates all exceed 0.1, and thus we conclude that the estimates are not statistically significant. These results do not reveal the dynamics in utilization observed in the data. Average utilization declined over time from 0.413 to 0.389, but while utilization in the control group dropped from 0.40 to 0.29, in the treatment group increased from 0.42 to 0.46. After sending the second email, utilization increased in both groups (0.46 to 0.61 in the treatment group and 0.29 to 0.53 in the control group). Note that, therefore, the estimates in Tables 4 and 5 capture different effects.

Table 6 evaluates the robustness of the difference-in-difference estimates to pre-treatment covariates. Specifically, we present estimates of the effects evaluated in Tables 3-5, but incorporating the pre-treatment variables in Table 1. The results change very little. Only the estimate of the effect of the first email is reduced (and becomes negative, at -0.012 hours), with some of the effect absorbed by the nationality indicators (in general non-Chinese and non-British students spent more time using online resources).

Overall, the statistical analysis presents suggestive evidence that the sender of the email determined utilization of online resources. This effect was small in the short run, but larger in mid-to-long run. However, the evidence presented here was not statistically significant, and therefore we cannot establish this causal effect with due confidence. The fact that the results, while positive, are not strongly statistically significant may be explained by the limited number of participants in the experiment; in addition, notice that the use of the software 'Mathematica' and the adoption of LaTeX as a format for submission of coursework were not formally assessed and, consequently, it is perhaps not surprising that, in general, the class did not prioritize engagement with them.

Ultimately, an important benefit of co-creation could be the improvement of students' academic performance. Our experiment was not designed to evaluate gains in academic performance, however it is interesting to explore if there were specific differences in tests scores across treatment groups. There were three graded assessments in the course, of which only two contributed to the final grade of the module. First, students had to complete a formative assessment.[16] This consisted of weekly online quizzes released in the virtual learning environment. Each quiz would contain a mix of multiple choice and true/false statements connected to the material covered during the specific week of release. Submission of the quiz would provide students with a score (that would not count towards the final mark of the course) and feedback on individual questions highlighting specific techniques and related sections in the textbook. Weekly quizzes had different number of questions and each question correct answer would provide 10 marks. The maximum combined mark on this assessment was 2,560. The second assessment was a mid-term requiring students to submit the description of an economic concept connected to the module and related policy discussion. Students received a mark out of 100 and this counted 30% towards the final mark. The third piece of assessment was a final (online open book) exam at the end of the term, consisting of three questions of which students were asked to choose two. As noted in Table 2, the treatment and control groups were comparable in terms of grades on an Introductory Microeconomics module that is as a pre-requisite for the course where the experiment took place. Table 7 presents the difference-in-difference estimates of the intervention on the scores in each of the assessments. The results all coincide in outlining a positive effect of the intervention on the scores. The effects on the mid-term test and the final exam correspond to 2.7% and 0.67% points respectively. These effects are, however,

[16] Following standard terminology, *formative* assessment does not formally contribute to the formation of a final grade but provides valuable feedback (including numerical marks) to students. *Summative* assessment provides feedback and grades that formally contribute to the final grade assigned to a student.

not statistically significant. The effect on the formative assessment was 166 points and the effect is significant at 10% level.[17]

These results constitute suggestive evidence that students in the treatment group performed better, on average, in the formative assessment, the coursework and the final exam than the control group. We cannot attribute this effect directly to the intervention. However, there are some channels through which the intervention could have driven these findings. Specifically, these results could be explained in part by the fact that the students in the treatment group may have engaged more on average with the material; however, the outcome of semi-structured interviews[18] with students in the treatment group also pointed toward some role for Social Identity and the establishment of *trust* toward the module and the instructor and, ultimately, the formation of some form of social identity and education morale. Here are some of the responses:

- Yes, I remember receiving emails from students. Being reminded of the co-created resources helped me knowing more about what the instructor thought was important for the module and the assessment. It did not change specifically my engagement (I was very committed to the module already), but it was *reassuring* to acquire a deeper knowledge of the skills connected to the module and the assessment.
- There are definitely peer effects, but for a student like me already engaged and committed to my studies, the main advantage was being reminded of the skills and knowledge required for the module and importance of the way to approach the assessment.
- It was a bit of shock to see co-created resources with students, at least initially. In general, they could help students understand what the instructor wants the class to do.
- I like more engagement from students, in particular in terms of communications. If I receive an email from a lecturer, my first thought is "what did I do wrong?", I feel the pressure of the authority of the role. With students [it] is different and it helps building *trust* with the teaching team.
- It made me thing that I could be like one of those students. Also, seeing that the instructor worked with students created a sense of *trust* toward the teacher and the module.

Notice that the messages sent to the students participating in the experiment, reported in the appendix, did not mention assessment nor exam preparation. In spite of this, it is interesting to observe how the students in the treatment group may have developed a sense of trust and connection with the course, including its structure, learning objectives and assessment format, that ultimately proved effective in improving their performance in the assessment.

[17] For a discussion and review of the literature on the benefits of formative assessment toward the enhancement of knowledge, skills and instructions acquisition, and the improvement of motivation toward learning see Shute (2008) and Lipnevich and Panadero (2021).

[18] Interviews took place in June 2023, week commencing the 19th. Questions asked followed the following sequence: Can you recollect seeing the emails reminding you of the co-created resources? What was your reaction to the reminder? Did you engage with any aspect of the module in response to those reminders? What do you think of the fact that students co-created some of the material of the course? Did this have any impact on your engagement with the module and your studies?

In December 2022, at the end of the semester, 13 (10 of which belonging to the treatment group) students expressed an interest in co-creating resources during summer 2023. The fact that, in December 2023, 23 students signed up for co-creation activities to take place in summer 2024 seems to be an indication of a clear positive trend[19] in co-creation over the multiple years, as depicted in the dynamics toward equilibrium CC_l in Figure 1 reported in Section 2.

3.4 Limitations

This section contextualizes the results of the pilot experiment and outlines avenues for future research.

First, while the pilot results were suggestive, they were not statistically significant. This could indicate that the intervention was ineffective, but it may also be due to the study being underpowered. A preliminary power analysis suggests that the sample size was insufficient to detect small effects. Although funding constraints played a role, the primary limitation was the "opt-in" design, which was necessary for ethical approval. A viable approach to increasing statistical power would be to accumulate data over multiple cohorts through repeated cross-sections.

Second, our analysis assumes that potential outcomes depend only on an individual's treatment status. However, in practice, interference between participants could have occurred, meaning that students' engagement may have been influenced by peers in different treatment groups. If, as suggested by the evidence, our intervention increased co-creation and resource utilization, then spillovers may have boosted engagement among control participants, leading to an underestimation of the intervention's true effect.

Beyond these statistical considerations, we identify several substantive directions for future research. The pilot experiment evaluated only a single form of intervention-enhancing peer effects through co-creation-to increase student engagement. However, as outlined in Section 2, additional mechanisms could amplify the benefits of co-creation. To foster the development of soft skills and promote active learning, future interventions should target subject threshold concepts, encouraging students to take intellectual risks. Incorporating creative elements such as videos, animations, or literary projects could further enhance cognitive and social development. Following the notation introduced in Section 2, such an approach could reduce γ and increase β.

To maximize the long-term impact of co-created materials, students could provide accompanying messages-such as recorded videos-explaining their motivations, key takeaways, and reflections on the process. This could strengthen intertemporal peer effects by reducing η and increasing β.

Overall, while the pilot results were statistically inconclusive, they are encouraging, particularly given the likelihood of spillover effects between treatment and control participants, which would have attenuated the estimated impact. Future research should address three key challenges: (1) increasing sample size through scalable study designs, (2) mitigating information spillovers, and (3) expanding intervention types to cultivate a broader set of skills.

[19] Remember that we started with 2 co-creators in 2020 and 8 in 2021.

4 Conclusions

The paper discussed the long term benefits of co-creation of teaching resources, explicitly distinguishing between direct effects on student co-creators and indirect (and intertemporal) benefits to those students who are taught via co-created resources. We stressed, in particular, that focusing exclusively on the direct benefits of co-creation would be a missed opportunity. To highlight the long terms benefits of co-creation, we developed a simple dynamic model and provided a discussion, supported by experimental evidence, on our current practice in establishing meaningful co-created initiatives in an intermediate microeconomics course.

We have not addressed here a few important aspects of co-creation, especially those related to the behavior of instructors. Engaging in co-creation can, of course, have an impact on the efforts and approach to teaching of instructors, influencing their motivation and inclination to innovate. The emotional connections (based on of the benefits of enhanced *respect*, *reciprocity* and *responsibility*) that co-creation activities can establish between academic staff and students can modify teaching staff's behavior in deeper ways than standard financial incentives or awards. A way to address these considerations would be to develop an evolutionary model in which a population of instructors, with different innate inclinations to innovate, may evolve depending on the benefits/costs of engaging in co-creation. The long-run level of co-creation will endogenously depend, not just on the efforts of students, but also on those of instructors and on the composition of their population. An insight born of our experience so far is that the benefits of co-creation can be feasible and sustainable only via a change in institutional culture. Individual instructors may have the innate vocation and determination to go above and beyond to maximize the benefits of co-creation; however, it is apparent to us that, if the costs and challenges of supporting students in becoming effective co-creators were not internalized and addressed at departmental or institutional level, it would not be sustainable in the long run to support the production and adoption of co-creation in teaching. This ultimately calls for agreed institutional principles and practices, administrative support and regular evaluation of the practices. We plan to explore some of these issues in the future. Finally, it is worth stressing that, while the case considered in this paper focus on economics teaching, most insights could be applied to the teaching on any other disciplines in which students would benefit from the development of soft skills, direct interaction with teaching staff and teaching practices, and exposure to materials created and delivered with the support of fellow (senior) students. Similarly, considerations on the feasibility and sustainability of expanding the use of co-created practices do not need to be discipline-specific.

A Appendix: Messages to participants

A.1 Invitation to take part in the project

Dear All,

Table 1 Descriptive statistics

Female	0.45
Age	19.66
Born in the U.K.	0.38
Born in P.R. China	0.29
Program of study "A"	0.41
Program of study "B"	0.16
Mark In Introductory Microeconomics	66.93
N	111

It was great to see you during the lesson on Friday. I am writing to you to invite you to participate in a research project that, together with a colleague based in Social Statistics, would like to run in our Microeconomics 3 module.

The research is to help us better understand how students learn in an Economics setting To participate in the project, you only need to fill in a small number of small questionnaires. Specifically, two questionnaires will be available for completion next Friday (DATE) and you will have exactly one week to submit your responses. Those of you who complete these two questionnaires will be entered in a draw for cash prizes. There will be:

- 3 prizes of £100
- 10 prizes of £50 and
- 30 prizes of £25

To enter the draw you only need to complete these two surveys and you will be automatically entered. The draw will be on Week 11. Whether you complete the survey or not will NOT affect your Microeconomics 3 marks but, with your participation in the project, you will be helping us to push the frontiers of science and improve how people learn. Your collaboration will be greatly appreciated. We will give you more information about this throughout next week.

A.2 Email to control group

Dear All,

I would like to remind you of the very helpful resources available to you in our Blackboard website.

In the Maths Refresh folder you can find a Mathematica Resources folder and a Overleaf&LaTex folder. These resources have been co-created with students (*co-creators' names here*) who took Microeconomics 3 last year. We worked together during the summer with the purpose to create some resources that would help you acquire helpful skills, that you can then report on your CV.

Engaging in co-creation also has been beneficial to the students co-creators: co-creating resources with me has given them the opportunity to learn new skills (for example using new software or producing videos), understand advanced aspects of Microeconomics and, ultimately, boost their CV. Co-creating is a great way to acquire experience (that you could discuss, say, during a job/master interview), engage with

Table 2 Evaluation of random allocation to treatment groups. Probit regression of the treatment indicator on pre-treatment variables. The robust standard errors are below the coefficients, whereas the p-values associated with the corresponding t-test appear below the standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (†) Average time use the two days before the first email (fraction of an hour)

	(1) Treated	(2) Treated	(3) Treated	(4) Treated	(5) Treated
Female	−0.031	−0.009	−0.009	−0.003	−0.002
	(0.097)	(0.099)	(0.099)	(0.101)	(0.103)
	(0.751)	(0.930)	(0.930)	(0.974)	(0.986)
Age	0.044	0.051	0.051	0.055	0.057
	(0.051)	(0.051)	(0.051)	(0.055)	(0.057)
	(0.386)	(0.323)	(0.323)	(0.321)	(0.319)
Born in U.K.		0.032	0.032	0.031	0.029
		(0.115)	(0.115)	(0.116)	(0.121)
		(0.782)	(0.782)	(0.790)	(0.808)
Born in P.R. China		−0.167	−0.167	−0.169	−0.174
		(0.121)	(0.121)	(0.123)	(0.126)
		(0.171)	(0.171)	(0.171)	(0.171)
Program of study 'A'				0.008	0.009
				(0.110)	(0.112)
				(0.940)	(0.933)
Program of study 'B'				0.062	0.063
				(0.148)	(0.150)
				(0.677)	(0.673)
Mark in Introductory Microeconomics					−0.001
					(0.005)
					(0.869)
Online resources (†)					−0.007
					(0.070)
					(0.924)
Intercept	−0.326	−0.433	−0.433	−0.529	−0.505
	(0.998)	(1.019)	(1.019)	(1.114)	(1.151)
	(0.745)	(0.672)	(0.672)	(0.636)	(0.662)
N	111	111	111	111	111

your studies and get a deeper understanding of teaching and learning in higher education. I had a great time working with *co-creators' names here*.

Mathematica is a very powerful mathematical software that makes calculating complex algebra and calculus very easy. It is also fantastic to draw diagrams, also 3D and parametric ones! Student [*co-creator's name here*] learnt how to use the software last summer with me and she created with my guidance the resources available to you online.

Table 3 Short-term effect of the first email; estimates of the Average Treatment Effect based on differences in means (column 1) and Difference in Differences (column 2) with robust standard errors below the estimates and p-values for the associated t-test below the standard errors. The outcome was utilization of resources in the 48 hour period following the delivery of the first e-mail

	(1) ATE	(2) Diff-in-Diffs
Treatment	0.019	0.007
	(0.131)	(0.155)
	(0.885)	(0.965)
N	111	111

Standard errors and p-values in parentheses
* $p < 0.1$, *** $p < 0.05$, *** $p < 0.01$

Table 4 Long/Mid-term effect of the first email; estimates of the Average Treatment Effect based on differences in means (column 1) and Difference in Differences (column 2) with robust standard errors below the estimates and p-values for the associated t-test below the standard errors. The outcome was utilization of resources in the 48 hour period before the delivery of the second e-mail

	(1) ATE	(2) Diff-in-Diffs
Treatment	0.171	0.159
	(0.138)	(0.180)
	(0.218)	(0.379)
N	111	111

Standard errors and p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Short-term effect of the second email; estimates of the Average Treatment Effect based on differences in means (column 1) and Difference in Differences (column 2) with robust standard errors below the estimates and p-values for the associated t-test below the standard errors.

	(1) ATE	(2) Diff-in-Diffs
Treatment	0.082	0.070
	(0.161)	(0.211)
	(0.611)	(0.742)
N	111	111

Standard errors and p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Overleaf and LaTex are respectively a website and language that allow you to create fantastic looking documents containing mathematical notation. In the academia we use LaTex to write dissertations, report and, of course, scientific papers. If you plan to do a master or PhD in the future, this is a very nice skill for you to acquire. Student [*co-creator's name here*] learnt how programme in LaTex and create files in Overleaf last summer with me and she created the resources available to you online.

I hope that you make the most of these resources.

Finally, if you would like to work with me during the summer to co-create more resources for future cohorts, please, let me know responding to this survey: *link to survey here*.

Feel free to get in touch if you would like more information.

Best, The instructor

Table 6 Robustness of the difference-in-difference estimator to pre-treatment covariates. The robust standard errors are below the coefficients, whereas the p-values associated with the corresponding t-test appear below the standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (†) Average time use the two days before the first email (fraction of an hour)

	(1) Email 1	(2) Long term	(3) Email 2
Treatment	−0.012	0.141	0.103
	(0.132)	(0.129)	(0.169)
	(0.927)	(0.275)	(0.542)
Female	−0.013	−0.023	0.091
	(0.124)	(0.163)	(0.146)
	(0.914)	(0.887)	(0.534)
Age	0.041	0.181**	0.004
	(0.069)	(0.083)	(0.076)
	(0.552)	(0.032)	(0.959)
Born in U.K.	−0.304*	−0.016	−0.074
	(0.174)	(0.166)	(0.227)
	(0.084)	(0.922)	(0.744)
Born in P.R. China	−0.343**	−0.019	0.072
	(0.165)	(0.199)	(0.234)
	(0.041)	(0.923)	(0.758)
Program of study 'A'	0.205	−0.143	−0.161
	(0.132)	(0.176)	(0.196)
	(0.124)	(0.418)	(0.412)
Program of study 'B'	0.051	−0.223	−0.291
	(0.168)	(0.145)	(0.263)
	(0.761)	(0.128)	(0.272)
Mark in Introductory Microeconomics	−0.004	0.012**	0.011
	(0.006)	(0.006)	(0.009)
	(0.488)	(0.037)	(0.221)
Online resources(†)	−0.683***	−0.883***	−1.037***
	(0.113)	(0.106)	(0.104)
	(0.000)	(0.000)	(0.000)
Intercept	−0.111	−3.989**	−0.199
	(1.552)	(1.794)	(1.354)
	(0.943)	(0.028)	(0.884)
N	111	111	111

A.3 Email to treatment group.

Dear All,

This is [*co-creators' names here*]. We are two final year students who took Microeconomics 3 last year.

Table 7 Robustness of the difference-in-difference estimator to pre-treatment covariates. The robust standard errors are below the coefficients, whereas the p-values associated with the corresponding t-test appear below the standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1) Formative	(2) Mid-term test	(3) Final exam
Treatment	166.364*	2.704	0.678
	(89.270)	(2.550)	(3.231)
	(0.065)	(0.291)	(0.834)
Female	17.535	4.191*	1.588
	(90.800)	(2.460)	(3.549)
	(0.847)	(0.091)	(0.656)
Age	−27.248	1.898	1.465
	(41.076)	(1.409)	(1.811)
	(0.509)	(0.181)	(0.421)
Born in U.K.	−80.199	2.265	−0.522
	(106.670)	(2.879)	(4.289)
	(0.454)	(0.433)	(0.903)
Born in P.R. China	118.960	0.334	1.882
	(115.004)	(3.301)	(4.339)
	(0.303)	(0.920)	(0.665)
Program of study 'A'	−24.606	4.593	6.928*
	(97.454)	(2.803)	(3.723)
	(0.801)	(0.104)	(0.066)
Program of study 'B'	−178.508	−2.053	4.074
	(145.138)	(3.408)	(4.644)
	(0.222)	(0.548)	(0.382)
Mark in Introductory Microeconomics	17.722***	0.514***	0.763***
	(3.798)	(0.133)	(0.150)
	(0.000)	(0.000)	(0.000)
Online resources	97.907**	−0.573	1.826
	(49.262)	(1.750)	(2.202)
	(0.050)	(0.744)	(0.409)
Intercept	230.917	−17.104	−19.689
	(800.291)	(28.790)	(38.480)
	(0.774)	(0.554)	(0.610)
N	111	111	111

[*co-creators' photos here*]

We would like to remind you of the very helpful resources available to you in your Microeconomics 3 Blackboard website that we co-created with [*instructor's name here*] during the summer. In the Maths Refresh folder you can find a Mathematica Resources folder and a Overleaf&LaTex folder. We co-created these resources working

with [*instructor's name here*] last summer with the purpose to provide some resources that would help you acquire helpful skills, that you can then report on your CV.

Engaging in co-creation has been very beneficial to us: co-creating resources with [*instructor's name here*] has given us the opportunity to learn new skills (for example using new software or producing videos), understand advanced aspects of Microeconomics and, ultimately, boost our CV. Co-creating is a great way to acquire experience (that you could discuss, say, during a job/master interview), engage with your studies and get a deeper understanding of teaching and learning in higher education. We had a great time working with [*instructor's name here*].

Mathematica is a very powerful mathematical software that makes calculating complex algebra and calculus very easy. It is also fantastic to draw diagrams, also 3D and parametric ones! [*co-creator's name here*] learnt how to use the software last summer with [*instructor's name here*]'s guidance and created the resources available to you online.

Overleaf and LaTex are respectively a website and language that allow you to create fantastic looking documents containing mathematical notation. In the academia we use LaTex to write dissertations, report and, of course, scientific papers. If you plan to do a master or PhD in the future, this is a very nice skill for you to acquire. [*co-creator's name here*] learnt how to programme in LaTex and create files in Overleaf last summer with [*instructor's name here*]'s guidance and she created the resources available to you online.

We hope that you make the most of these resources.

Finally, if you would like to work with [*instructor's name here*] during the summer, like we did, to co-create more resources for future cohorts, please, let him know responding to this survey: *link to survey here*.

Feel free to get in touch if you would like more information.

Best, [*co-creators' names here*]

Funding Fabio Lamantia has been funded by the PRIN 2022 under the Italian Ministry of University and Research (MUR) Prot. 2022YMLS4T - TEC - Tax Evasion and Corruption: theoretical models and empirical studies. A quantitative-based approach for the Italian case. Discrete time dynamic modelling in economics, finance and social sciences.

Data Availibility Experimental data is available at https://github.com/eduardo-fe/cocreation.

Declarations

Conflict of Interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethics Approval The design of the experiment has been approved by the University of Manchester Research Ethics Committee application 2022-15463-26330.

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