

Journal Pre-proof

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PII: S1477-3880(22)00019-6

DOI: <https://doi.org/10.1016/j.iree.2022.100252>

Reference: IREE100252

To appear in: *International Review of Economics Education*

Received date: 16 July 2021

Revised date: 7 September 2022

Accepted date: 15 September 2022

Please cite this article as: Paul Middleditch, Will Moindrot and Simon Rudkin, Teaching with Twitter: An Extension to the Traditional Learning Environment., *International Review of Economics Education*, (2021) doi:<https://doi.org/10.1016/j.iree.2022.100252>

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Teaching with Twitter: An Extension to the Traditional Learning Environment.

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Abstract

Recent global events have forced a reexamination of the teaching tools that we make use of in higher education. We present our findings from a pilot, using Twitter as an extension to the learning environment for economics students at the University of Manchester and draw lessons for the use of this platform as part of a taught course. We suggest that, whilst popular in terms of personal adoption with students, the use of the Twitter platform is not empirically important for learning outcomes, with the important exception of where students have a history of lower performance. As a result, we suggest that targeted use may prove more warranted where the range of abilities is wide.

Keywords: Twitter, Social Media, Informal Learning Environment, Attainment Distribution

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Dr Paul Middleditch is an Associate Professor of Macroeconomics at the University of Manchester, Director of the Centre for Innovation in Pedagogy and Author of *Introduction to Macroeconomics 4th Edition*, with Pearson Education. Paul has published his research in the Cambridge Journal of Economics, Scottish Journal of Political Economy, The Manchester School, Journal of Perspectives in Applied Academic Practice and in Cogent Economics and Finance.

Will Moindrot works as an Educational Developer for the Centre for Innovation in Education at the University of Liverpool, and has worked within the area of educational technology for over 15 years at other UK HEI. He has specialisms in the use of classroom engagement techniques, VLE migration, development of online, blended and flexible learning design. He received his masters at the University of Manchester in 2013 in Digital Technology, Communication and Education, and has several areas of his work published.

Dr Simon Rudkin is a Senior Lecturer in Economics at Swansea University where he is an active promoter of innovative and technology led learning. Simon's research explores opportunities to use innovative data approaches to understand more of the Economy and pedagogical environment. His work has appeared in Environment and Planning A, Food Policy, Tourism Management, Applied Energy and Expert Systems with Applications amongst others.

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Abstract

Recent global events have forced a reexamination of the teaching tools that we make use of in higher education. We present our findings from a pilot, using Twitter as an extension to the learning environment for economics students at the University of Manchester and draw lessons for the use of this platform as part of a taught course. We suggest that, whilst popular in terms of personal adoption with students, the use of the Twitter platform is not empirically important for learning outcomes, with the important exception of where students have a history of lower performance. As a result, we suggest that targeted use may prove more warranted where the range of abilities is wide.

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Introduction

This paper provides a discussion and empirical analysis of an action based research project undertaken to measure the learning outcome effects of the use of social media platform Twitter, introduced as part of the taught course learning environment. The platform was introduced with the intention of furthering the level of engagement with students in a large cohort setting; developing and connecting with course participants in a familiar external setting. The motivation aligns in part with Jones and Baltzersen (2017), who also make use of

the platform to address problems associated with large cohorts. Our main contribution to the debate surrounding the use of social media in teaching is both descriptive from our survey results and empirical; whilst our survey evidence is more consistent with the consensus view that the platform is popular and can widen student engagement, we find that positive learning outcome effects only feed through to those students with lower performance abilities.

It is perfectly possible that the usefulness of such a platform in teaching may manifest itself through a number of channels indirectly; though here we directly measure the learning outcome effect for students exposed to an end of term multiple choice revision test, given in class. Although, we do not find the use of Twitter positively significant across all students generally, it is interesting that this result reverses when we empirically measure the resulting learning outcomes. Our results suggest that the students most in need of support benefit the most from using this platform.

The UK education sector has witnessed a prolonged period of persistent change in operating environment over the last decade or so, brought about by the proliferation of digital technology and the commercialization of university education. This has led to or reinforced a growing view that higher education needs to add substantive value to the education of its students, (Barn, 2016). Metrics introduced to mitigate the risks presented include student interaction, student engagement and student involvement, (Naidoo & Williams, 2015). Approaches taken to bring improvement in these areas include active learning design, empowering students to take greater control of learning, and greater interactivity in traditional classroom settings; meaning the use of classroom voting systems, novel forms of assessment and collaborative platforms.

So called ‘Web 2.0’ social media platforms can be used as a space for collaboration and interactivity and can also act as a popular, informal and universally available connection between academic and student; a welcome tonic for an environment which has tended towards the impersonal, see Schroeder et al. (2010) who weigh the benefits and pitfalls of using social media as part of the course environment. Intuitively, we might imagine that a rise in the use of social media in teaching would coincide with some other more indirect benefits, such as the universality of smartphone ownership, the ease of linking content, and natural features such as palm to palm short text communication.

Institutions and individual instructors are in an era of exploration into the use of social media platforms, or other university substitutes that provide some of the same affordances, but with less risk; see Al-Bahrani and Darshak (2015) for a discussion on the benefits of introducing such platforms. The COVID-19 pandemic has brought an urgent drive to make undergraduate provision available, either completely online, or through an emergency form of blended education, (Murphy, 2020). Teaching staff will be thinking about tools that have already been proven to be successful in engaging students or ways to evaluate the tools that we are now using.

In this paper we present our findings from the sustained use of social media platform, Twitter as part of a taught course in macroeconomics at the University of Manchester between 2013 and 2017. We provide observation and measurement of student reaction to the intervention in terms of perception, engagement and impact on performance where it was used throughout the lifecycle of the course. We contribute to the literature surrounding the use of Twitter in higher education by providing a first measure of the distributional effects of using this platform as part of the suite of tools in a taught course. For our empirical analysis we ask

the question, as to whether or not the use of Twitter within the curriculum has the ability to raise individual student performance against intended learning outcomes. This is not the first study to analyze the use of Twitter as a teaching tool, see Welch and Bonnan-White (2012), Junco, Hieberger and Loken (2011), Junco, Elavsky and Heiberger (2013), and Graham (2014) for earlier examples. For our research, the application was introduced in an attempt to extend the learning environment from inside to outside of the classroom and to provide an informal channel of communication between students, a particular use case highlighted by Kassens-Noor (2012), and to carry out a formal function similar to that traditionally used within discussion board features, typically seen in many virtual learning environments.

One of the closest studies to our own research is that provided by Al-Bahrani, Patel and Sheridan (2017), who carry out a random control trial to measure learning outcomes from test results across three different institutions; they too find the empirical importance of Twitter on learning small for the class as a whole. We depart from this by allowing a less restricted experiment and by controlling for performance across time; rather than limiting the platform's use to communication of connecting material, we have also allowed students to find their own ways to utilize twitter as a learning tool. One instance of this, was the peer to peer interaction between students enjoyed during their period of revision; when students asked a question to the lecturer via the platform, others watching the discussion then opened their own conversations about the material; it is possible that this particular way of using the tool may have influenced the results that we obtain for students with lower capabilities.

From the survey results, we could see that the use of Twitter as an informal tool for course engagement was viewed overall positive by students; being a novel way to promote interconnection with a large cohort of students and consistent with the findings of Evans

(2014) and Jones and Baltzersen (2017). **The perception of the platform as an aid to engage increases markedly and consistently in the second year; the authors suggest that the most likely cause of this is the persistence in use and the experience gained from the previous year.** We also saw Twitter as an extension of the course environment to outside of the classroom, as suggested by Wood (2020), though not to the extent of replacing the traditional ‘single point of truths’ for important class announcements (where announcements within the Virtual Learning Environment are sacrosanct). In light of the recent drive towards online delivery driven by the most recent pandemic of 2020, we suggest that Twitter is at least a worthy consideration for inclusion within a suite of blended learning approaches. The platform was used in a variety of ways: firstly as an icebreaker for first year students where we held competitions using a classroom voting system, to collate suggestions and then vote for a course hashtag (in contrast to Novak & Cowling (2011) who set the hashtag a priori); secondly as a connective medium, relating the news of unfolding real world events to the taught material; and lastly as an easy to use and inclusive forum during the exam revision period, see Tang & Hew (2017) for an extensive review of the many other ways Twitter has been utilized in a higher education setting.

By including this platform as part of the ‘blend’ that made up the course, the convenor was able to connect real world events to the taught material in real time, aimed at reinforcing learning. Students were also encouraged to collaborate peer to peer and even request support from the teaching assistants. But alongside these pre-planned activities, the students themselves shaped how this tool was used and drove the innovation; for example, quickly discovering the ease and effectiveness of attaching photos of technical material to receive feedback. It is also important to highlight that, due to the openness with which the platform was used, the learning

outcome effects reported here may be influenced by vicarious user bias, whereby students who were able to view the course account Twitter feed embedded within the Virtual Learning Environment (VLE) may have also benefited although less participatively.

We did not mandate that students had to have a personal Twitter account, and students were shown how they could access tweets left by others and thereby benefit from the interactions that went on. Wood (2020) suggests that by allowing students who are not using Twitter to view the content of the course Twitter feed via the course VLE one can overcome the problem of inclusivity for non-users. One last thought, and in hindsight of our empirical approach, is that it would have been useful to collect further control variables beyond the scores and success rates achieved in the end of course test; we acknowledge this omission and respectfully leave this refinement of our design to future research.

This study takes a dual approach to measure the effectiveness of Twitter as a pedagogical enhancement. Firstly, we present survey evidence, taken immediately before the start of the 'end of course' revision lecture for each of the four academic years under consideration, to measure the student perspective of our use of Twitter as an engagement tool. Secondly, we carry out an empirical analysis to test the performance of Twitter against learning outcomes, comparing Twitter users versus non-users. The data for this comes from the anonymous multiple choice type revision test that took place at the end of the course. Our sample extends from the academic year 2014/15 after we began collecting richer data, including our control variable into the year 2016/17. Our project, like many others, was motivated by a keen desire to bring back a personal feel to the environment of a large cohort setting. Though the idea of using social media, in particular Twitter is not new; Junco, Hieberger and Loken (2011) provide some of the earliest evidence that the platform can be

used as a pedagogical tool. Through a control trial, they find that the tool improves student engagement and even provides better learning outcomes. Further to this and as we have also found in our own practice, Junco, Elavsky and Heiberger (2013) find that this virtual engagement tool can facilitate peer interaction, though this does require active engagement from faculty to maximize the beneficial impact.

Students report that the use of Twitter as majority positive in terms of the ability to raise student engagement during the active elements of a taught course, in a similar manner to George (2019), though this perception is intuitively more positive in those students with Twitter accounts, a condition also noted by Welch and Bonnan-White (2012). Repeated exposure to the technology may explain the proportion of students who value the use of Twitter as a course platform in the second year suggesting, that in our case at least, committed use may have increased following year adoption rates; we imagine that some nudging is required to fully realise the platform's potential as a form of communication between convenor and student, also noted by Graham (2014) who firmly suggest using incentives. Other benefits that came from the use of Twitter were a reduced reliance on traditional one-to-one communication channels such as emails, an increase in peer to peer interaction, course engagement from less confident student character types (also highlighted in Barn 2016), more focused questions with use of embedded images, and feedback from students on how the course was going.

Furthermore, and consistent with Tang and Hew (2017), we find no clear or significant impact of the use of Twitter on learning outcomes in our aggregate. What is interesting however, is that this result reverses for a sub-set of students with lower initial ability, suggesting that the tool could be used as part of a suite of approaches aimed at a more uniform distribution in levels of attainment. These mixed findings are reflected in other studies, for

instance, Kassens-Noor (2012) who compare the use of Twitter over more traditional methods of learning, caution that Twitter can be a powerful learning aid out of the classroom, but it can also hinder other types of learning, where students are required to reflect as part of the process.

The rest of this paper is laid out as follows: firstly, we present a descriptive analysis of the survey data that we have collected over time, to provide early evidence on student perceptions and saturations of using Twitter as part of the taught course environment. Following this we present our empirical exercise, that attempts a scientific measurement of the effects on student learning outcomes by connecting test results collected during the end of course in class multiple choice test. Lastly we conclude with recommendations from our experience of using this platform as an extension to the learning environment.

Survey Evidence

In this section we present evidence taken from the students using an anonymous classroom voting system (CRS) towards the end of each course during an end of semester revision session. **The courses in question are both core modules in Macroeconomics, referred to here as ECON100xx and ECON20xxx. ECON100xx is a first year introduction to Macroeconomics that covers an overview of the macroeconomic issues, an introduction to economic policy and analysis using basic macroeconomic models. The second year ECON20xxx follows ECON100xx with a more intermediate understanding provided using more complex model set ups. Student numbers on both courses might be considered as large, being in the range of 500-600 for the first year course and 250-350 for the second year. Consequently, it is worth highlighting that all students that sat ECON200xxx must also have taken ECON1000xx as a pre-requisite.**

The social media platform was introduced with the aim of alleviating some of the problems normally associated with large cohort teaching; especially for students who might normally feel inhibited from interacting in such a setting. For this project we made the choice to use the platform Twitter, based on its uptake by the UK media, though there is no reason why any other platform should not be used particularly, see Al-Bahrani et al. (2015) for a discussion on this choice. To begin with, we discussed the inclusion of the technology with the class as a whole and signposted to the course specific account. Students could use the platform in any way they saw fit, bar using it in such a way that might cause offence. Not providing ground rules at this stage was a deliberate decision to keep the project in the boundaries of action based research.

We were also reluctant to provide summative rewards or incentives for using the platform, though it is interesting to see other research providing more positive outcomes for the use of Twitter where this is the case, for instance Enz and Kassens (2016). What is interesting, is that the students did indeed find innovative ways of using the course account; learning to collaborate, asking with pictures and interacting with peers. At no point in the introduction of the technology was there any attempt to sell participation, the technology was introduced to facilitate rather than to influence behaviour. Early thoughts on this project and some further details surrounding the motivations are given in Middleditch and Moindrot (2015).

For this survey, students were asked whether or not they had Twitter accounts, and if they were planning to open an account in the future. Secondly, students were questioned on their perception of the tool as a vehicle to enhance engagement with the taught material at the end of the course. Carried out in this way, we were able to record a student's participation

status and measure performance against learning outcomes simultaneously and in a way that protected the anonymity of students.

We consider our work here to come under the classification of action-based research, meaning that the research design evolved through practice. Furthermore, we emphasize that the robustness of the results and interpretations put forward here are sensitive to that design, and as with any other estimation technology may contain biases from various sources. Possible bias from our estimation may present itself in the form of self-selection, spill-over from treatment, and missing variable. We have not disadvantaged or put at risk of harm, stigma or prosecution any students through our investigation. Data collected is either collected anonymously (surveys and polls for example) or anonymised at point of collection without the use of control groups. The paper is a secondary evaluation of refinements and reflection of our practice carried out as part of the normal license of practicing lectureships; accordingly, we do not consider that any of the work presented here to have raised ethical concerns.

From Table 1, we can see that Twitter adoption remains consistent for the new intake of first years across all years. However, there appears to be an increase in Twitter adoption as students pass into the second year in the next academic year, for example 63% of ECON100xx reported that they had a Twitter account in 2014/15, but by 2015/16 the same class would report 72%, so roughly a 9% increase; this result is consistent across all three cohorts. There could be a number of reasons for the increase in adoption for the second years; namely that second year students tend to be more likely to adopt new platforms in their second year in any case, or some other indirect factor; though it is also possible that students felt more familiar having experienced the tool embedded in their first year teaching.

We also asked students who had Twitter accounts whether they were regular or ‘irregular’ users of Twitter, and we observed that whilst the percentage of regular users was again a consistent split for each new intake of first years; notably there was an increase to this when students passed into second year. We might explain this as being due to a familiarity in the experience obtained in year 1, or other effects such as recognition of long term benefits to learning as discussed by Lowe et al. (2013).

Table 1. Twitter adoption/penetration

<i>Do you have a Twitter account?</i>				
		Yes	No	
2014/15	ECON100xx	62.68%	37.33%	100%
		89	53	142
	ECON20xxx	75.79%	24.21%	100%
		72	23	95
2015/16	ECON100xx	61.77%	38.23%	100%
		84	52	136
	ECON20xxx	72.41%	27.59%	100%
		63	24	87
2016/17	ECON100xx	60%	40%	100%
		_*	_*	_*

	ECON20xxx	71.21%	28.79%	100%
		47	19	66
Aggregate total across all modules and years		59.99%	40.08%	100%

* As highlighted within our outline of methodology, in 2016/17 our data was collected through a student response system used as a teaching tool, but this crashed during the lecture and we were left with only a PowerPoint containing populated charts showing percentages.

Furthermore when we examined the data we found a consistent picture of students moving from no accounts to those who used Twitter, but irregularly – a result consistent with the idea that the benefits from using Twitter were taken vicariously; where students did not feel the need to use the platform for personal. We asked students if they were intending to get Twitter accounts in the future and we observed that strong objection to using the platform fell markedly from year 1 into year 2. Even if the source of this result is difficult to pin down; the consistency of the result across all three years is notable, and might make an interesting channel for future research. Twitter penetration amongst incoming students has also remained pretty consistent during the project. Using this technology has brought on positive effects on learning including a greater responsiveness and voice from students, in a similar way to that reported by Barn (2016), and also an array of other indirect benefits such as preparedness for employment, connection to the wider field, increased digital literacy and social development.

As can be seen from the data student perception of using Twitter as a tool to enhance engagement is split, however tending to be in agreement with the statement ‘The use of Twitter on this module has made the course more engaging’. But by itself does not say much until we slice the results by user type, the results from which are presented in Table 3.

Table 2. Student perception of Twitter as a learning tool

The use of Twitter on this module has made the course more engaging						
		Agree	Mostly Agree	Neither Agree Nor Disagree	Mostly Disagree	Disagree
2014/15	ECON100xx	12.0%	16.8%	45.6%	8.8%	16.8%
		15	21	57	11	21
	ECON20xxx	16.19%	28.57%	46.67%	3.81%	4.76%
		17	30	49	4	5
2015/16	ECON100xx	16.67%	13.16%	43.86%	4.39%	21.93%
		19	15	50	5	25
	ECON20xxx	15.15%	26.26%	47.47%	4.04%	7.07%
		15	26	47	4	7

2016/17	ECON100xx	7%	19%	50%	5%	19%
		_*	_ *	_ *	_ *	_ *
	ECON20xxx	8.22%	19.18%	54.79%	5.48%	12.33%
		6	14	40	4	9
Aggregate total across all modules and years		14.98%	23.42%	45.15%	5.84%	10.62%

Measured over all years; student's perception of pedagogical benefits of using Twitter as an extension to the learning (Twitter used as a course medium). *Missing rows indicate data not taken or corruption of data file.

Table 3. Student perception by user type across all modules and years

		Do you have a Twitter account?	The use of Twitter on this module has made the course more engaging (<i>Results shown as number of responses</i>)				
			Agree	Mostly Agree	Neither Agree Nor Disagree	Mostly Disagree	Disagree
2014/15	ECON100xx	Yes	13	20	29	9	8
		No	2	1	27	0	11
	ECON20xxx	Yes	10	24	26	2	2
		No	1	2	12	2	0
2015/16	ECON100xx	Yes	14	12	33	5	7
		No	4	3	16	0	18
	ECON20xxx	Yes	9	18	28	3	1

		No	5	1	11	0	3
2016/17	ECON100xx (No data *)	Yes	-	-	-	-	-
		No	-	-	-	-	-
	ECON20xxx	Yes	4	7	26	3	5
		No	1	5	8	1	3

(Totals above are smaller than those found in Table 2 because only responses from students who answered both questions are included. * Missing rows reflect the system crash during data collection which meant that ‘slicing’ of data was not possible.)

Building on the observations of Table 2, we can see that when perceptions of engagement are broken down between those with and without Twitter accounts, we can explore the potential effect of this variable. We can see from this data, perhaps unsurprisingly, that those students who reported they had Twitter accounts tended towards a greater positive perception of the use of Twitter as an engagement enhancer. Representing the five engagement levels as a scale from 1 being agree to 5 being disagree, the average engagement amongst Twitter users is 2.686 and amongst non-Twitter users is 3.301, the difference is 0.615 with a two-sample t-test of equality of means being rejected at the 0.1% level ($p=0.000$ to 3.d.p). However, there are some students without Twitter accounts that also felt some benefit – these may be students who are viewing tweets without an account, such as through the course Twitter feed, or benefit vicariously in some other way. From the open comments on the course, it was also interesting to see a couple of cases where students, who did not make use of the platform, felt that it enhanced their experience more generally.

Students on module ECON100xx progress onto ECON20xxx in the following academic year; from Table 2 we can see a shift of opinion towards a positive view of Twitter as students progress in their studies. Here again, viewing 1 as agree and 5 as disagree produces an average of 2.703 amongst second years and exactly 3 for first years, the difference being 0.297 with the two-sample t-test of mean equality rejecting at the 5% level ($p=0.011$). **Although we have not been able to measure this directly, we suggest that the increase in the proportion of students who view Twitter positively as an aid to course engagement in year 2, is largely due to the experience gained from using the platform as part of the course in the previous year. If a student has seen value in using the platform in the previous year, they are more likely to report positively in the second year. This finding is reflected in the results reported earlier from Table 1, of a pick-up in adoption noted in year 2.** A change of perception by students toward Twitter may be due to its sustained use across one full assessment cycle and a recognition of the value of the platform as an extension of the learning environment.

Summary of Findings from Survey Data

Firstly, our findings suggest that the use of twitter has not declined over the timeframe of the project. This suggests a relative stability in its favorability compared to other platforms; an observation that may be reflecting the relative longevity of Twitter as a social media platform. Use actually picks up consistently over the academic year jumping from 63% in semester 1 of year 1 (Table 1: 2014/15 ECON100xx) to 72% by the time we meet the students again in semester 2 of following year (2015/16 ECON20xxx), and this pattern appears to be repeated in subsequent cohorts. This may suggest that students 'warm' to using the technology as part of

the course, after experiencing first-hand the benefits to their own enjoyment of the course, or through other forms of acceptance of using the technology, Edmunds et al. (2012).

As a whole, students are mostly indifferent when asked to report their perceptions of the tool as both an engagement and satisfaction enhancement. This finding might have a lot to do with the timing of the survey, especially in the first year before the exam period, when the usefulness of the tool may have become more pronounced. What is more interesting, is that when we splice the responses to the same question by user type; as reported by Welch and Bonnan-White (2012), when Twitter users are asked about the effectiveness of the platform in teaching, the distribution shifts away from mostly disagree and disagree to a majority of neutral and positive. The more positive result in terms of student perception is consistent with the findings of Wood (2020) who asked different questions: firstly whether Twitter ‘helped connect’ course material to real world events or case studies, secondly that Twitter was a ‘worthwhile addition’ to the course and lastly, that Twitter ‘helped stimulate’ interest in the subject.

Empirical Analysis

Our empirical analysis exploits the benefits of a quantile regression to unpack the contribution of Twitter across the outcome distribution taken from the in-class test for each cohort. The data that we use for this exercise was taken during an in-class revision session at the end of the course. Students were asked to complete a series of multiple choice questions using their mobile phones connected through a web application. Due to the fact that students could choose which individual questions to respond to, we construct two variables: exam result and exam success. For the exam result variable, where students did not answer a question they received a

zero as part on their individual average score; whereas for the success variable, where students did not complete or give a response to an individual question, the value was omitted from the average calculation.

By considering the distribution of performance, we are able to uncover not only the conditional average effect of social media engagement, but also the extent to which use of the module Twitter promotes improved attainment amongst the lowest, and highest, achievers. The original quantile regression approach of Koenker and Basset (1978) has been utilized in the study of student performance by many studies. Notable examples in which the variation of the impact from variables of interest include Brown and Bielinska-Kwapisz (2012), who explore the diversity of student backgrounds whilst Edwards (2012) review the impact of class start times. Arulampalam et al. (2012) study heterogeneity in attendance effects, Ng et al. (2011) analyse learning styles, and Deerfield (2019) study of co-operative learning. More recently, Harmon and Tolomolonis (2019) consider how observing the impact of Facebook use at different levels of attainment may inform robustness of past research in social media use. In each case there is power in looking beyond first order moments such as the mean.

Since the original development of quantile regression analysis, there has been significant advancements in the way that panel data and misspecification have been handled (Angrist et al., 2006; Canay, 2011). Wider movements into appreciating quantile treatment effects are reviewed in Powell (2020); an area from which many of the trials of new teaching approaches can take, thus these advancements offer further value to educational research. For the present study the critical advancement lies in Firpo et al. (2009) who develop the way in which the distributions of the independent variables impact upon the estimated coefficients. The resulting approach, termed unconditional quantile regression, offers a vital robustness to

the choice of control variables; especially relevant in areas like education research where not all variables are available and choices amongst the set for which we do have data are not clear cut.

Borah and Basu (2013) working in the context of health provide a detailed review of the supremacy of the Firpo et al. (2009) approach. In turn these advantages have seen use in Ding and Lehrer (2011) who explore class size effects and the Cebolla-Boado et al. (2018) exposition of the spread of Chinese students across UK universities. Unconditional quantile regression continues to hold greatest strength in the more common distributional analysis of inequality (Andreoli et al., 2019, Pereira and Galego, 2019) and in terms of health (Davillas and Jones, 2019; Freire and Rudkin, 2019). In this paper we take the benefits offered by unconditional quantile regression, in tandem with the motivations from the education literature, provided by those works employing the traditional Koenker and Basset (1978) approach.

UQR is a two-phase methodology in which the variable of interest is first scaled before being regressed on the explanatory variables at stage two. First in order to take account of the quantile τ we recenter the inference function of the outcome variable according to the quantile. This is done using equation (1). We have two outcome variables termed success and exam, these form our Y . Success is the proportion of questions attempted in the examination that the student got correct, whilst exam is the overall score in the examination. These two variables may then be interpreted as the students ability to succeed when they feel comfortable answering questions and then the overall impact on their academic performance respectively.

More specifically we regress two key explanatory variables described as follows; firstly the score obtained from the test as a whole where a missing answer is recorded as a zero in the

calculated total. Secondly we regress a measure of success from the same attempts, where missing answers are discounted from the calculated total. We consider that it is important to measure the effect of both measures separately, so that any bias that might exist from missing answers, that would have been answered correctly otherwise, are controlled for as part of our investigation. We also acknowledge that this particular design is influenced by the type of application used to carry out the test itself. Essentially it is important to note that there is no enforcing mechanism to prevent students from cherry picking, and accordingly make the decision to measure the empirical importance of both variables. To distinguish between each outcome in the later exposition a superscript S or E is used for success and examination performance respectively.

$$RIF(Y, q_\tau, F_Y) = q_\tau + \frac{\tau - I(Y \leq q_\tau)}{f_Y(q_\tau)} \quad (1)$$

Here Y represents the outcome, F_Y , is the cumulative distribution of the outcome variable Y , and f_Y is the marginal distribution. q_τ is the τ th quantile of the outcome distribution and $I()$ is an indicator function which takes the value 1 whenever the inequality within the brackets holds. As there are no covariates in (1) we are able to ensure that the choice of explanatory variables is not affecting the distributional insight given from the regressions.

Phase two is to then regress these recentered inference function values on the covariates that have been created for this study. We explain these outcomes as functions of the level of the module, d_{2i} being a dummy for the individual being in the second year module ECON20xxx. We also include an interaction between d_{2i} and t_i , $t2_i$, to capture any A dummy

variable for the first year of operation in 2014/15, A_{15i} , is included to capture any impact from the first use of Twitter within the teaching. Focus in this paper is on a dummy for Twitter use, t_i . The stage two regression takes the RIF from equation (1) to estimate the following:

$$RIF(Y, q_\tau, F_Y) = \alpha + \beta_1 t_i + \beta_2 d_{2i} + \beta_3 t2_i + \beta_4 A_{15i} + \varepsilon_i \quad (2)$$

Table 4. Results from the unconditional quantile regression (exam mark)

	OLS	Unconditional Quantile Regression				
		$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$
Constant	40.80***	12.28***	23.14***	42.49***	58.85***	74.81***
	(2.403)	(0.889)	(0.712)	(2.279)	(0.571)	(2.461)
Twitter User (t_i)	-2.534	2.490**	-0.195	-3.267***	-0.348	-6.438*
	(2.769)	(0.921)	(0.641)	(0.538)	(0.725)	(3.601)
ECON20xxx (d_2)	6.539	-0.819	2.657***	7.574***	12.76***	10.37***
	(3.684)	(1.121)	(0.584)	(2.051)	(2.813)	(1.363)
Twitter ECON20xxx ($t2_i$)	-0.833	-0.444	-0.757*	-0.287	-8.155*	4.333
	(4.321)	(1.453)	(0.388)	(2.510)	(2.813)	(3.422)
2014/15 (A_{15})	-6.841***	-3.380***	-1.109	-6.058**	-10.12***	-13.20***
	(1.999)	(0.472)	(1.358)	(2.510)	(0.833)	(1.778)
R Squared	0.084	0.003	0.029	0.052	0.074	0.071
Adj. R Squared	0.078	0.002	0.018	0.041	0.067	0.062

Notes: Values show estimated coefficients for ordinary least squares (OLS) and unconditional quantile regressions with dependent variable being the Exam mark. For the UQR case the exam score is first transformed using RIF_i^E at each stated quantile τ . Twitter user is a dummy which takes the value 1 if a student uses the Twitter platform at any time. ECON20xxx is a dummy for the module in second year macroeconomics capturing students using Twitter for the second time in their studies. Twitter EOCN20xxx is an interaction of the Twitter and ECON20xxx

dummies. 2014/15 is a dummy to capture the first run of the approach within the teaching. Figures in parentheses report associated standard errors. Significance denoted by * - 5%, ** - 1% and *** - 0.1%

Note as well that an iid error term, ϵ_i is added which has mean 0 and constant variance.

Estimation of (2) is via simple ordinary least squares (OLS) regression. For comparison we also estimate OLS coefficients for all outcomes using the same set of explanatory variables.

This simply involves replacing $RIF(Y, q_\tau, F_Y)$ with y_i^X in equation (2), where $X = S, E$ and y_i represents the realisation of the outcome for student i .

Results from the linear regressions in Tables 4 and 5 show that being a Twitter user may have a negative impact on performance under both the exam score and success measures. Coefficients can be interpreted as the number of percentage points increase which arises from a 1 unit increase in the independent variable. We note that neither coefficient on the Twitter dummy is significant meaning that, within our data and set of model specifications, the adoption of Twitter has neither a significant benefit, or significant cost, to student performance. From this we conclude that use of the platform is not empirically important for learning outcomes in the aggregate.

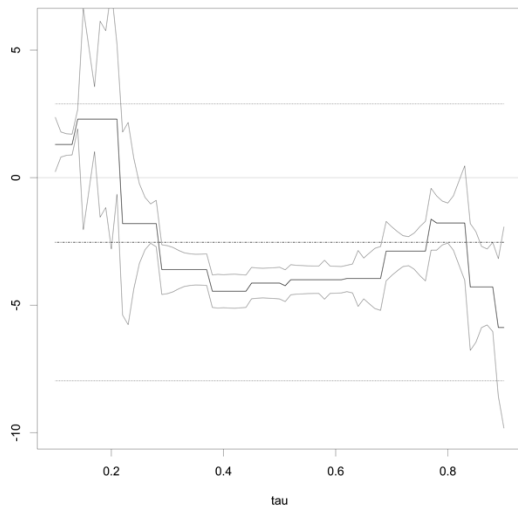
Table 5. Results from the unconditional quantile regression (success)

	OLS	Unconditional Quantile Regression				
		$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$
Constant	58.09***	33.87***	43.63***	55.62***	66.96***	80.35***

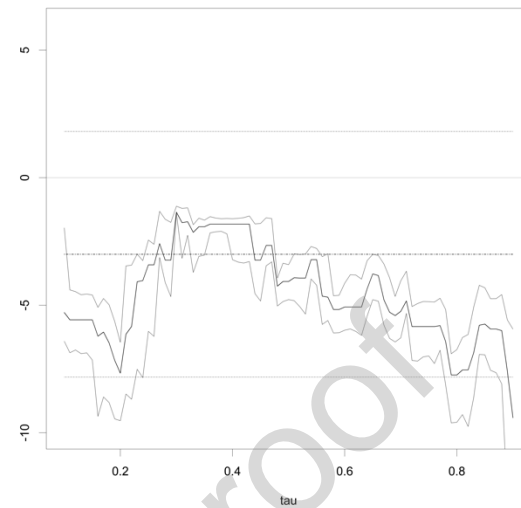
	(2.133)	(1.238)	(0.818)	(0.720)	(0.646)	(1.981)
Twitter User	-3.004	-1.999**	-1.158	-1.415*	-3.369***	-5.720***
	(2.257)	(0.653)	(0.601)	(0.333)	(0.622)	(0.882)
ECON20xxx	10.31***	7.614***	10.15***	7.941***	10.77***	20.68***
	(3.215)	(0.997)	(0.871)	(0.892)	(1.054)	(3.223)
Twitter ECON20xxx ($t2_i$)	-3.017	-5.728***	-5.197***	-2.919**	0.755	-7.484
	(3.834)	(1.290)	(0.616)	(1.087)	(0.473)	(4.153)
2014/15	-4.427*	-7.607***	-6.053***	-4.512***	0.295	-5.605*
	(1.773)	(0.849)	(0.507)	(0.400)	(0.398)	(2.621)
R Squared	0.051	0.026	0.037	0.029	0.036	0.028
Adj. R Squared	0.042	0.018	0.031	0.022	0.028	0.018

Notes: Values show estimated coefficients for ordinary least squares (OLS) and unconditional quantile regressions with dependent variable being the Success. For the UQR case the exam score is first transformed using RIF_i^S at each stated quantile τ . Twitter user is a dummy which takes the value 1 if a student uses the Twitter platform at any time. ECON20xxx is a dummy for the module in second year macroeconomics capturing students using Twitter for the second time in their studies. Twitter EOCN20xxx is an interaction of the Twitter and ECON20xxx dummies. 2014/15 is a dummy to capture the first run of the approach within the teaching. Figures in parentheses report associated standard errors. Significance denoted by * - 5%, ** - 1% and *** - 0.1%

Figure 1. Unconditional quantile regression coefficients



(a) Exam Scores



(b) Success

Notes: Figures show unconditional quantile regression coefficients in the range of 0.1 to 0.9 inclusive. Horizontal solid line is used for the OLS regression coefficient. Thinner lines above and below the coefficient represent 95% confidence intervals.

Looking into the results in more detail, we suggest that exposure to past use of the teaching approach is beneficial, this is captured by the ECON20xxx dummy. The interaction dummy produces negative significant coefficients, many of which are significant for Exam. Hence whilst past exposure is beneficial, that benefit is reduced for those who actually use Twitter. In the first year of operation, 2014/15, the coefficient is negative but not significant in both regressions. Tables 4 and 5 both inform that the fit of the model is poor and there are likely to be a large number of other factors which determine exam performance. Because we do not have demographics or past educational attainment it is then entirely reasonable for the constant to be so significant in both regressions.

In employing UQR we are able to say more about the impact of Twitter use on student attainment across the outcome distribution. Aiding the evaluation we present the coefficients on the Twitter dummy in Figure 1. Panel (a) illustrates the exam outcome, whilst panel (b) depicts the success outcome. In both cases the solid line is the estimated coefficient from the UQR, with dotted lines providing 95% confidence intervals around the estimates. We also show the OLS estimate as a solid horizontal line, again surrounding with dotted lines for the 95% confidence intervals. Immediately we note the significant positive effect of Twitter at the lower end of the Exam distribution, is in fact the only positive significant effect from the intervention.

This result is consistent with George (2019) who finds Twitter positive for knowledge retention on an aggregate level, though less so for knowledge creation. Higher up the exam performance distribution, and for all of the success measure levels, negative significant impacts are seen. Interestingly it is George (2019) who comments from conversations, that the students who seem less likely to engage that benefit the most. Within the specification controls are added for previous exposure to the Twitter intervention, the ECON 20xxx dummy, and for the first operation of the intervention in 2014/15. In the former case there is a strong positive impact on performance which increases as we move up the outcome distribution. For those at the top levels of performance the impact is much stronger than the OLS estimates would suggest. In the first year of operation we see relatively consistent effects across the distribution ranging from 0 to 3 percentage points lower. In the case of these two dummies, and particularly for the Twitter dummy it is clear that there are quantile variations and the adoption of UQR has offered additional insights.

Conclusion

The survey evidence that we have presented here tends to support the view that the use of Twitter as part of the taught course is received positively by students, consistent with studies such as Wood (2020); this is more marked when asked specifically about the ability of Twitter to promote engagement. Though students may not directly identify Twitter as a source of engagement, uptake and usage both increase across successive cohorts, suggesting a possible seepage of activity into the group of non-participants. Through practice we have found ways of using the technology that can benefit the course outcomes indirectly; student satisfaction outcomes are indirect and appear through metrics such as the end of semester online evaluation scores. Students were also forthcoming in praise in their open comments passed through the course Twitter account; for instance, connecting real life events in real time with the taught material, using retweets of policymakers media output and also connecting with regular policy events like the annual government budget.

Other indirect benefits identified by students included: giving the course a more approachable feel, getting feedback more quickly and having access to the Twitter feed on the course website. Our results provide an interesting contrast to other studies in this field that also find difficulty connecting twitter to high learning outcomes; a breaking down of the results by ability suggests that it can be beneficial to students with lower performance levels.

Students were more likely to ask questions in front of their peers on Twitter, meaning that these students were more likely to be included in regular course engagement, which tends to be dominated by more confident students. Of course, one might question the use of a distracting technology in the class altogether, and whilst we agree that this is a valid

consideration, our experience is consistent with Kuznekoff, Munz & Titsworth (2015) who find no evidence of such negative effects.

The results from our empirical investigation in terms of learning outcomes provide a message that is more mixed. The effect on the student body as a whole is neutral, as suggested by Tang & Hew (2017); but what is more interesting is the result for lower performing students, when we splice the results. In contrast to Junco et al (2011), who find that Twitter is positive for both engagement and learning outcomes, we find that this effect is more prevalent for students who had lower performance against learning outcomes in the previous year, meaning that we have evidence that the use of Twitter on the taught course has a levelling effect between students of different attainment.

Our advice to those considering using a platform such as Twitter as part of the learning environment, is that they may not see direct results in terms of student provided metrics. However, they may well witness an uplift in student satisfaction that presents itself indirectly, alongside important other pedagogical benefits that result, such as the ability to write concisely, as noted in studies such as Kassens (2014). In terms of inclusivity our data implies that less confident students and those with lower attainment are more likely to benefit. Convenors of large cohort classes are best placed to benefit from using a platform such as Twitter, given that these class sizes tend to come hand in hand with large spreads in student abilities. Our study is limited to the analysis of the particular social media platform Twitter, applied to the subject field of economics. It would be interesting, however, to see how this result compares across other platforms, a subject discussed in Al-Bahrani et al. (2015), or applied to other disciplines. With the benefit of hindsight, it would also be interesting to see the effects of controlling for more sophisticated demographics or the use of a richer set of

covariates from the outset. Whilst this extension of our analysis remains firmly on our agenda, we respectfully leave this to future research.

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