APPENDIX A: Additional Details on Robustness Checks

Alternate specifications

In addition to our main regressions, the entry model, and the graphical analysis, we evaluate the robustness of our specification to alternate modeling assumptions in Appendix Table B10. In the first model, we use a Poisson quasi-maximum likelihood specification for the count dependent variable—the number of contributions. Second, we estimate our regressions with region-specific time trends. Specifically, we classify countries depending on the World Bank Income Classification (high income or low/middle income) and then include separate quarterly time-trends for each of these two income categories. This specification allows us to control for the possibility that OpenStreetMap is evolving differently in richer and poorer countries. Finally, we implement a "placebo" regression to identify whether our results are driven purely by the structure of our setup or data rather than by the specific timing of Google Maps entry. In the spirit of Bertrand et al. (2004), we randomly assign each country to one of the five quarters in which Google Maps entered and use this entry time to estimate a new $Post\ Google\ Entry_{it}$ variable that we use in the regression testing the baseline specification.[1] For example, if a country experiences a Google Maps entry in the first quarter of 2009 (the first wave), we might randomly assign it to the fourth quarter of 2010 (the fifth wave), assign a country from the fifth wave to the second wave, and so on.

The results from the three tests for the pre-entry and newly-recruited contributions variables are presented in Appendix Table B10; the results are not sensitive to these alternate specifications. In particular, as Columns 3 and 6 show, the estimates from our baseline regression are not significantly different from zero, suggesting that our results are not driven by mechanical artifacts of our setup or by the definitions of variables, but are indeed driven by the specific timing of Google Maps entry. Further, our results for newly-recruited contributions are based on the number of contributors making their first contribution in a given quarter. This definition of a newly-recruited contributor is admittedly arbitrary and so, in Appendix Table

[1] We do not implement many permutations of the placebo inference, just one of the many possible combinations using a randomly chosen seed.

B9, we examine alternate definitions of newly-recruited-entry contributors (those who have been active in the previous two quarters or the previous six quarters) and find the negative effect on contributions robust. In other words, it does not matter if we measure newly-recruited contributors as those making their first contribution in a given quarter or those who are "relatively new" (having contributed in the last few quarters for the first time); the effect of competition on contributions from this group is still negative. Combined with the event study figures, these results are especially helpful in building confidence in the result that pre-entry and newly-recruited contributors have a differential response to competition.

DID Decomposition

In staggered Difference-in-Difference, the general estimator from the TWFE approach is actually a "weighted average of all possible two-group/two-period DiD estimators in the data." When the treatment effect varies across time, some of these 2x2 estimates enter the average with negative weights because already-treated units act as controls: more weights will be given to units treated towards the middle of the panel, so if the treatment effects during that period differ materially from other treatment effects, the coefficient could be biased (Goodman-Bacon 2021).

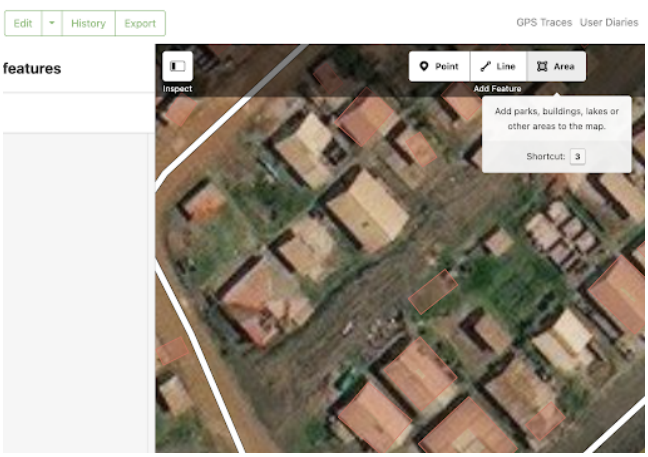
Appendix Figure B7 shows results based on DiD decomposition theorem from Goodman-Bacon (2021) for the total number of contributions. The plot shows each 2x2 DiD with its weight and calculates the average effect (shown by the red line). The weights are determined by the absolute size of the subsample, the relative size of the treatment and control groups in the subsample, and the timing of the treatment in the subsample (variance). We can see that the groups treated earlier in the period (light cross) and the groups treated later in the period (dark cross) distribute evenly and the majority of the TWFE estimates are negative. The few positive coefficients are lightly-weighted as the relative sample size is very small and the treatment is toward the beginning or ending of the sampling period.

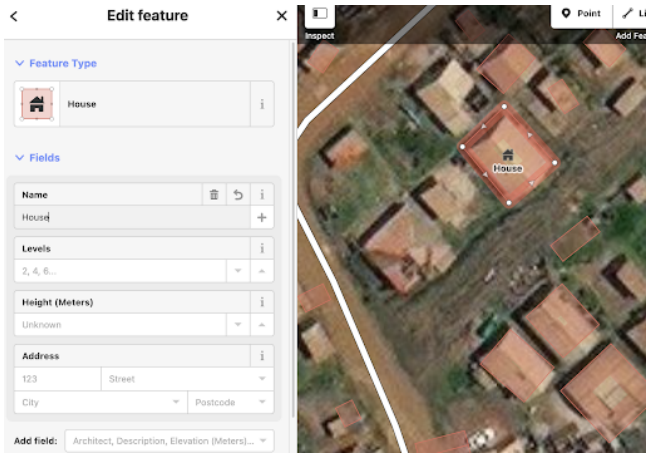
List of Appendix Figures

List of Appendix Tables

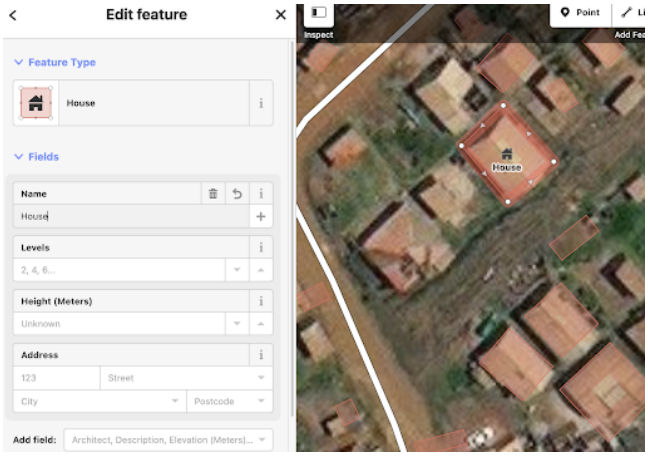
FIGURE B.1. Overview of Making a Contribution on OpenStreetMap

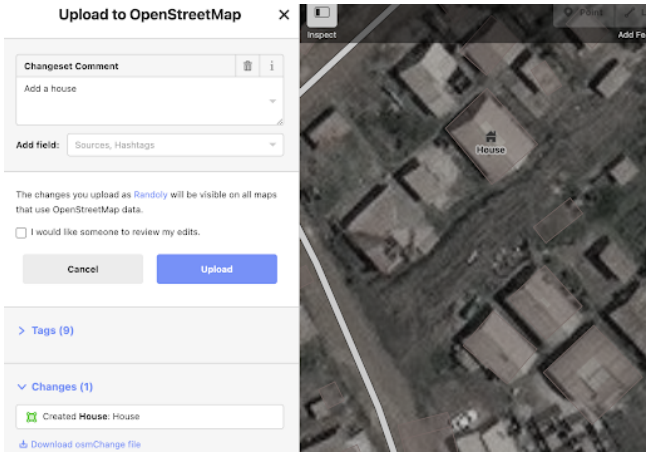
(i) Locate *(ii) Portray*





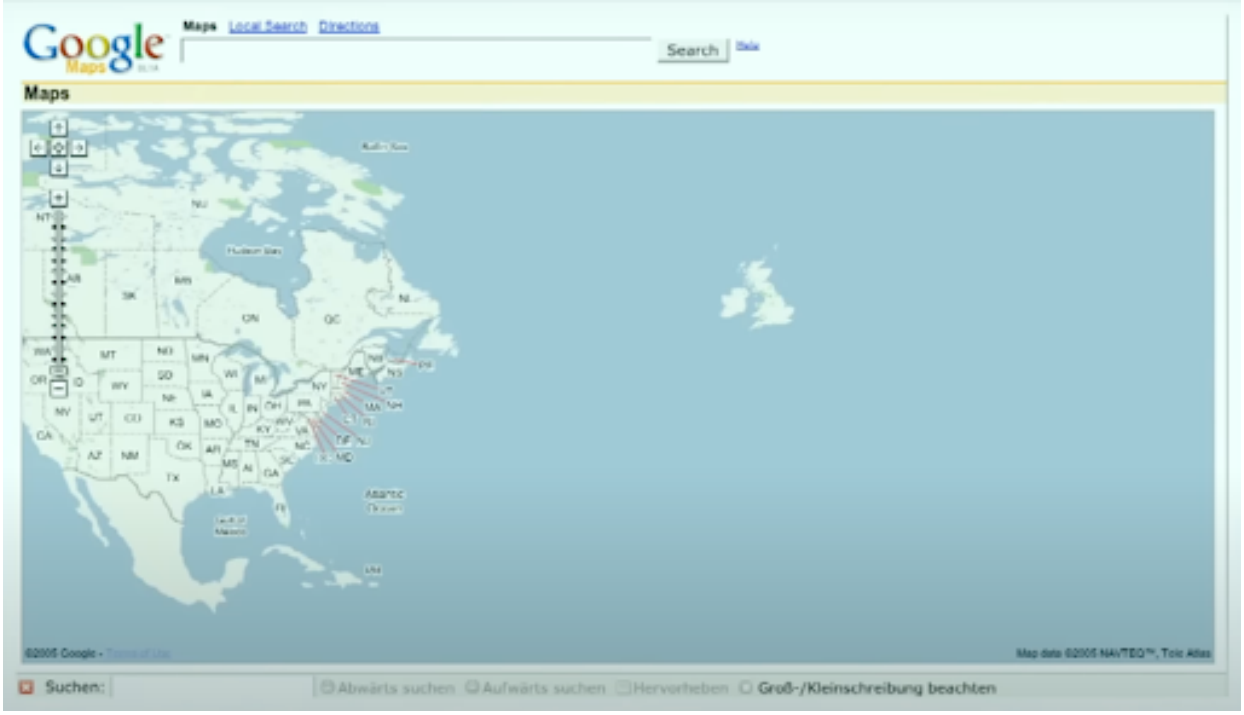
(iii) Describe *(iv) Save*





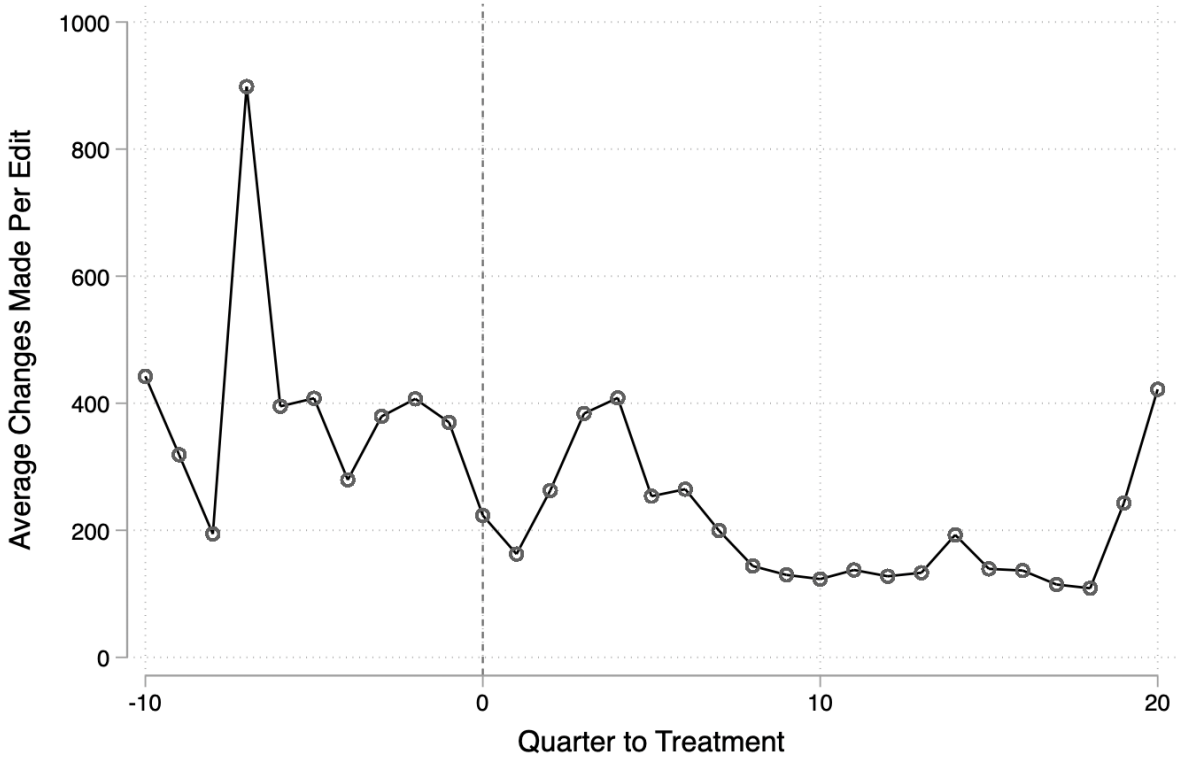
Note: This graph shows the steps for a member to make a contribution (adding a building) on OpenStreetMap.

FIGURE B.2. Google Map Launched Globally with a “Blank Map”



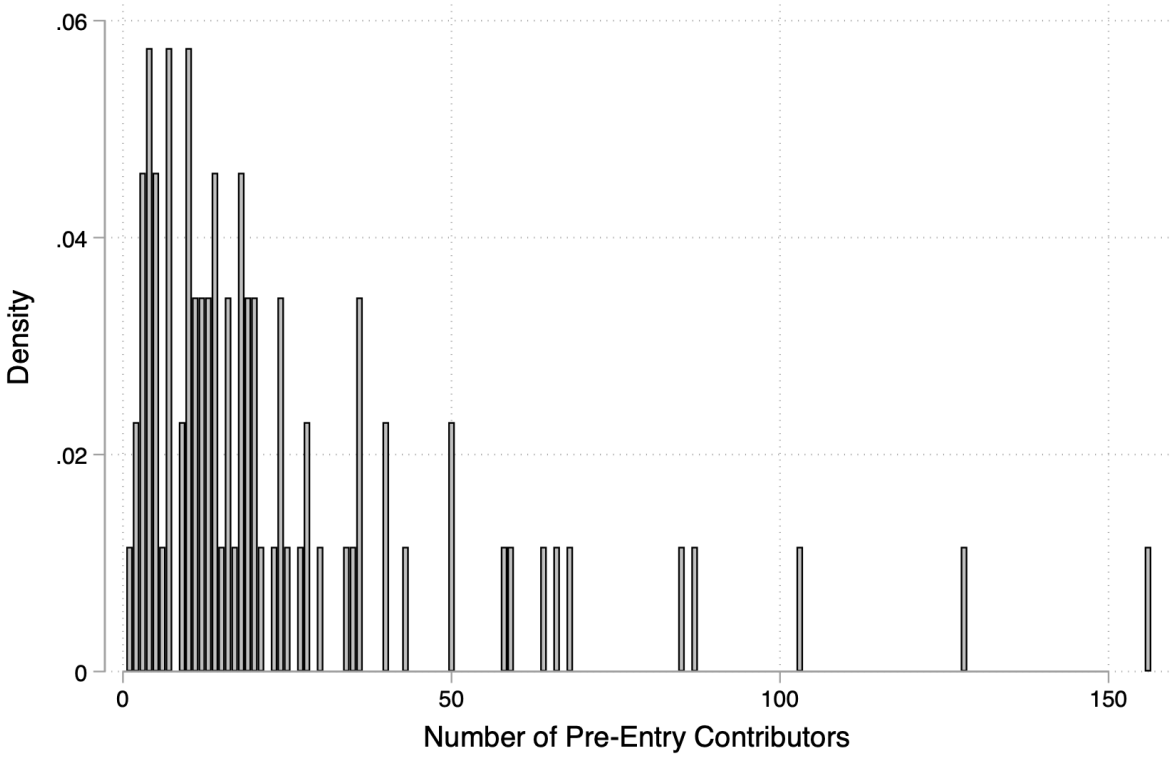
Note: This graph shows how Google Map launched globally with a “blank map”.

FIGURE B.3. Average Number of Changes Made Each Edit



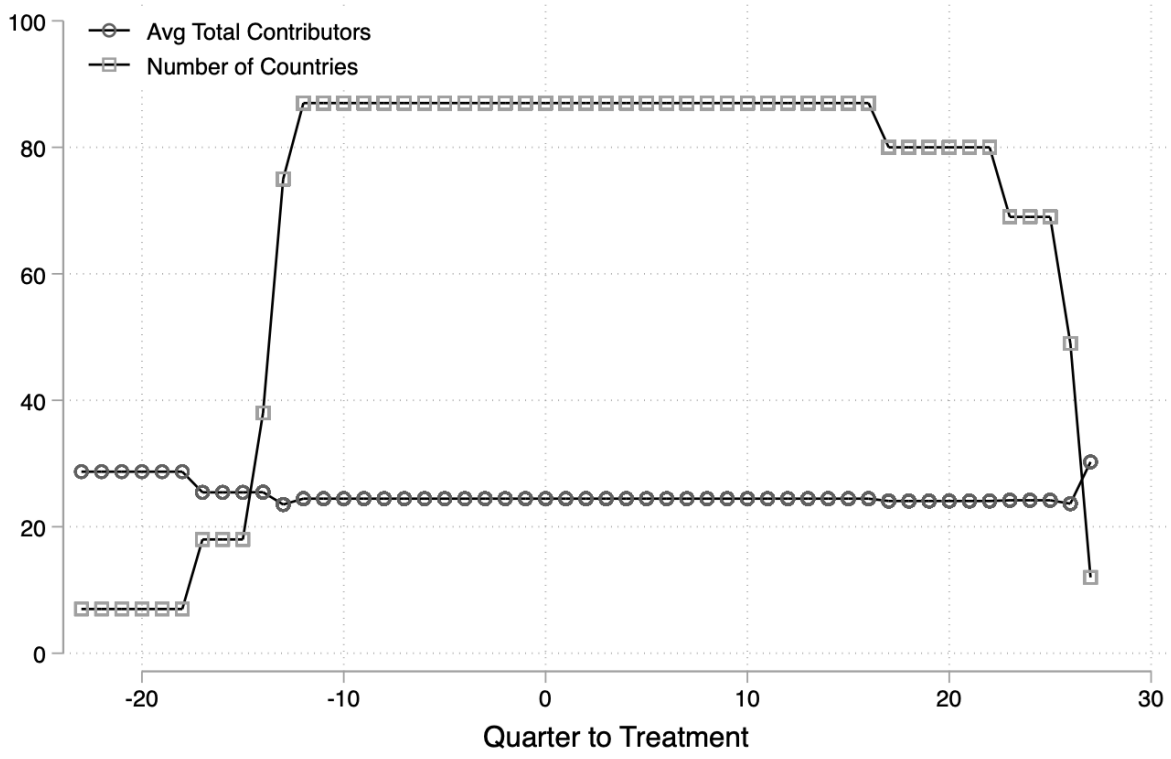
Note: This graph shows the trend in the average number of changes made in each edit over time.

FIGURE B.4. Distribution of the Number of Pre-Entry Contributors



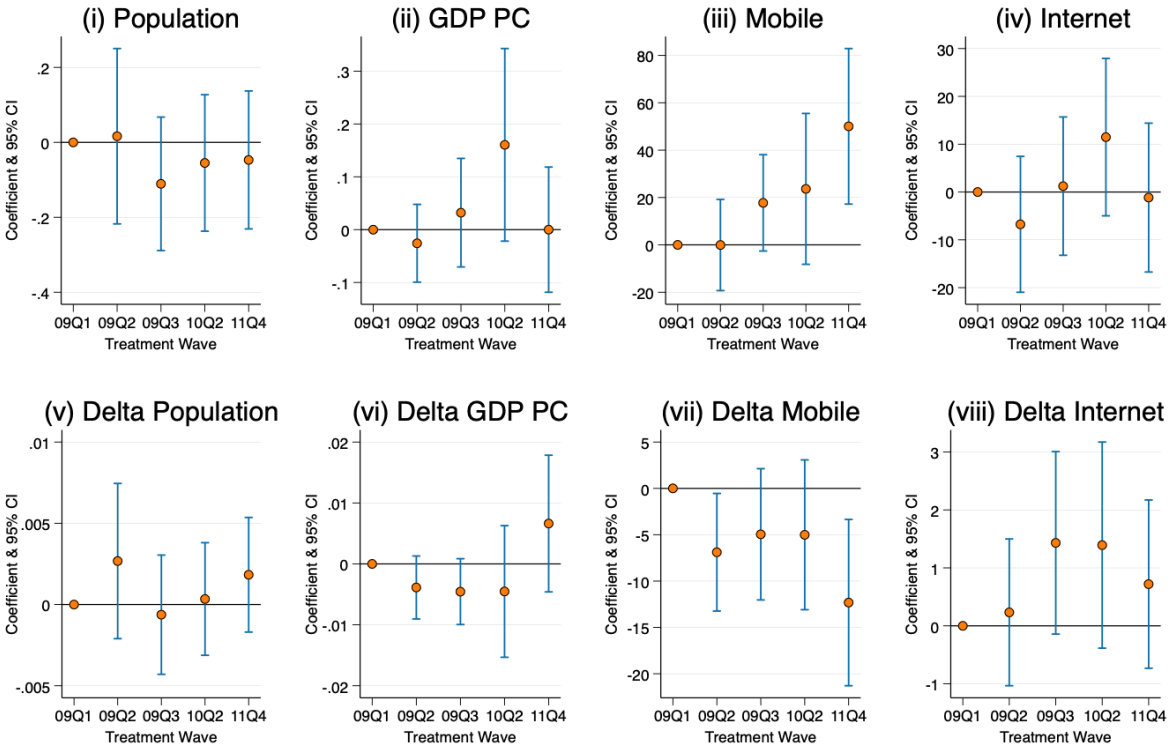
Note: This graph shows the distribution of the number of pre-entry contributors by country.

FIGURE B.5. Size of Pre-entry Sample



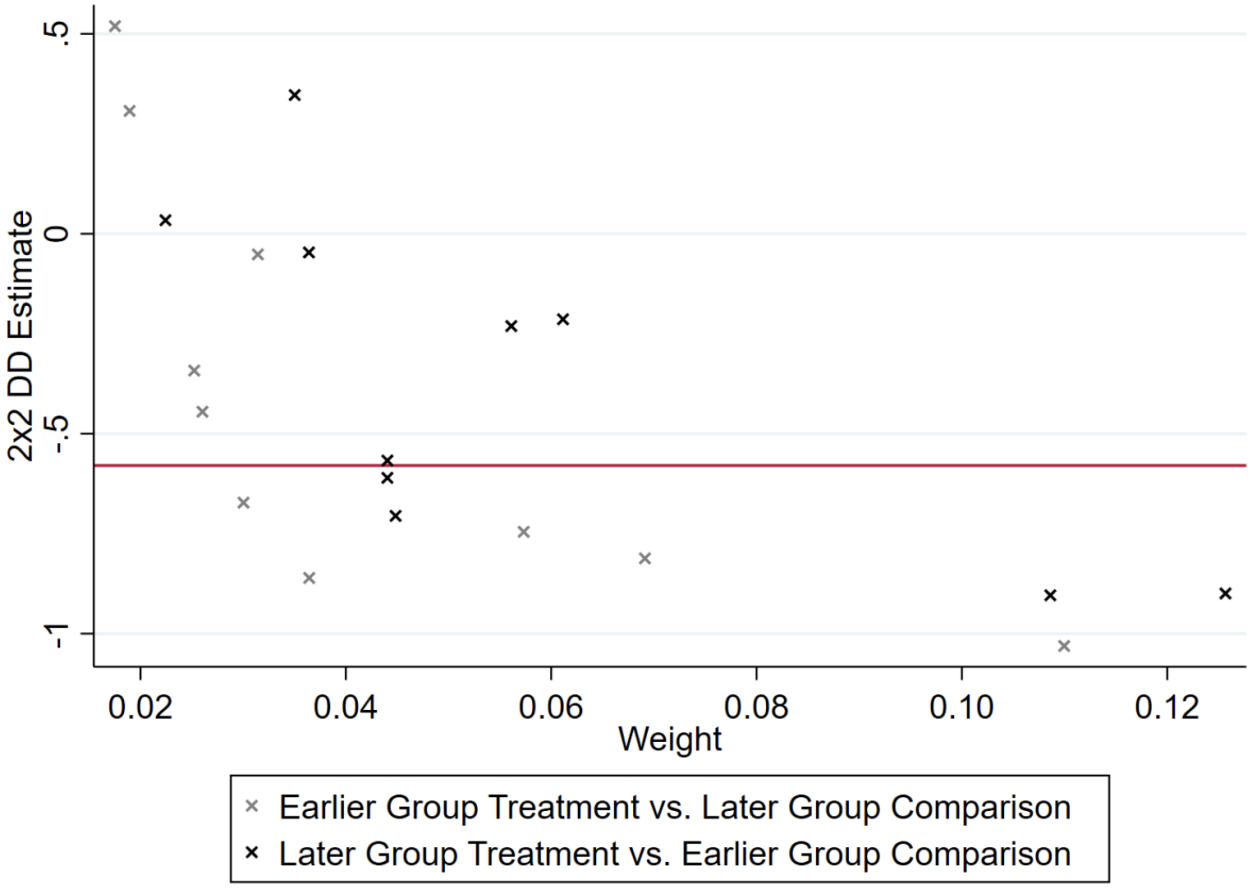
Note: This graph shows the number of countries and the average number of total contributors in the pre-entry sample.

FIGURE B.6. Compare Countries by Wave



Note: This figure compares all the countries depending on the year in which they were treated. Each panel presents coefficients on the years of treatment from cross-sectional regressions of different country-level covariates. The dependent variables in the first row are (i) population, (ii) GDP per capita, (iii) mobile penetration and (iv) internet penetration. Variables in the second row provide a measure of pre-treatment trends, which are (v) change in population, (vi) change in GDP per capita, (vii) change in mobile penetration, and (viii) change in internet penetration. We plot coefficients for each year of digitization, including 95% confidence intervals. The omitted category is the group of countries that were first treated (2009 Q1).

FIGURE B.7. DID Estimate Decomposition



Note: This figure provides the decomposition of DID estimates for the total number of contributions based on Goldman-Bacon (2021). See text for more details.

Table B.1. Examples of Competition between Traditional and Crowdsourced Knowledge Platforms

Category	**Traditional**	**Crowdsourced**
	Professionally sourced, closed	Volunteer, Open
Reference guides		
Online Maps	Google Maps	OpenStreetMap
Encyclopedic Reference	Encyclopaedia Brittanica	Wikipedia
Coding Guides	O'Reilly	Stackoverflow
Reviews/Evaluations		
Restaurant Reviews	Guide Michelin	Yelp
Product Reviews	Consumer Reports	Amazon Reviews
Book Reviews	NY Times	Goodreads
Theater/Arts	National Endowment for Arts	Kickstarter
Startups	TechCrunch, Venture Capital	Angellist
Software		
Mapping Software	ESRI Arc GIS	QGIS
Image Editing Software	Adobe Photoshop	GNU Image Manipulation Pro
Relational Databases	Oracle9i	MySQL
Desktop Publishing	Microsoft Word	OpenOffice
Media & Publishing		
News	Newspapers	Blogs
Financial Analysis	CNBC, Wall Street Journal	Reddit WallStreetBets
Classifieds	Newspapers	Craigslist
Stock Photography	Getty (pre 2005), Corbis	Flickr, iStockPhoto
Video Entertainment	Netflix / Traditional TV	YouTube

Note: This table illustrates a few examples where traditional and crowdsourced platforms compete with each other in different categories. These examples are only illustrative of the diversity in the type of competition we study and are not a comprehensive list of all such types of competition, or even of all the relevant platforms in any given category.

Table B.2. Summary Statistics (Contributor-Quarter Level)

	N	Mean	SD	Median	Min	Max
Outcomes						
Overall Contributions	85080	0.4	14.5	0	0	2649
Total Active Members	85080	0.1	0.2	0	0	1
Timing Variables						
Post	85080	0.6	0.5	1	0	1
Year	85080	2010.5	2.9	2010.5	2006	2015
Controls						
Population (100 millions)	85016	0.4	0.4	.207206	0	2
GDP per capita, PPP (in 100k USD)	80800	0.1	0.1	.0720666	0	1
Mobile Penetration (per 100)	85012	76.6	41.5	76.67284	0	232
Internet Penetration (per 100)	84808	22.6	22.1	14.33	0	98

Note: Observations at the user-quarter level. Data on controls is at the country-year level. GDP per capita is PPP adjusted.

Table B.3. Entry Model

Panel A. Cross-Sectional

	(1) Entry Quarter	(2) Entry Quarter	(3) Entry Quarter
Population (millions)		-0.54	-1.16
		(0.79)	(0.96)
GDP per capita		1.54	2.17
		(2.69)	(2.66)
Mobile Penetration	0.028	0.024	0.016
	(0.019)	(0.019)	(0.019)
Internet Penetration	-0.045	-0.056*	-0.048
	(0.030)	(0.031)	(0.032)
User Contribution Growth			0.019
			(0.014)
N	81	76	76
R2	0.21	0.21	0.24

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel B. Discrete Time Hazard Model

	(1) Entry Quarter	(2) Entry Quarter	(3) Entry Quarter	(4) Entry Quarter	(5) Entry Quarter
Population (millions)		0.10	0.10	0.10	0.10
		(0.087)	(0.086)	(0.089)	(0.088)
GDP per capita		-0.31	-0.30	-0.30	-0.31
		(0.28)	(0.26)	(0.29)	(0.29)
Mobile Penetration	-0.0023**	-0.0024**	-0.0023**	-0.0024**	-0.0024**
	(0.00093)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Internet Penetration	0.000070	0.0027	0.0027	0.0026	0.0026
	(0.0033)	(0.0038)	(0.0038)	(0.0039)	(0.0039)
Change Ratio (last quarter)			0.000015		
			(0.000032)		
Change Ratio (last 2 quarters)				-0.000022	
				(0.000044)	
Change Ratio (last 3 quarters)					-0.0000092
					(0.000037)
N	218	204	204	204	204
Quarter FE	Yes	Yes	Yes	Yes	Yes

*p<0.10; **p<0.05; ***p<0.01

Reported coefficients represent marginal effects with quarter fixed effects. Standard errors clustered at the country level.

Note: This table provides estimates of a model predicting the timing of Google Maps entry based on country and openstreet-map characteristics. The key dependent variable is the quarter in which Google Maps enters. Panel A uses a cross-sectional panel of countries, while Panel B presents results from a discrete time probit model.

Table B.4. Impact of Competition on Contributions Interacted with Google Popularity

	(1) Pre-Entry Contributions	(2) Newly Recruited Contributions
Post Google Entry	0.021**	-0.48***
	(0.0096)	(0.17)
Post Google × High Competition	-0.0020	-0.13
	(0.0096)	(0.14)
Population (millions)	0.081	4.00**
	(0.076)	(1.77)
GDP per capita	-0.13	0.44
	(0.089)	(2.61)
Mobile Penetration	0.00022	0.0063**
	(0.00016)	(0.0028)
Internet Penetration	-0.000035	-0.0037
	(0.00030)	(0.0081)
Community Member FE	Yes	Yes
Quarter FE	Yes	Yes
N	80524	3192
Adj. R2	0.056	0.78

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Estimates the impact of competition from Google Maps on the number of pre-entry and newly-recruited contributions in a differences-in-differences framework and interacts the Post dummy with an indicator of whether the country is of high competition.

Table B.5. Robustness Check: Comparing Pre-trends between Treatment and Control Communities in Log-Linear Models

	Pre-Entry		Newly-Recruited	
	(1)	(2)	(3)	(4)
Google-Entry(-6)	0.012	0.0094	0.72***	0.63***
	(0.021)	(0.021)	(0.23)	(0.23)
Google-Entry(-5)	-0.0072	-0.0085	0.54**	0.49**
	(0.020)	(0.020)	(0.23)	(0.23)
Google-Entry(-4)	-0.0067	-0.0078	0.49**	0.45**
	(0.018)	(0.019)	(0.19)	(0.19)
Google-Entry(-3)	-0.031	-0.032	0.17	0.14
	(0.020)	(0.020)	(0.19)	(0.19)
Google-Entry(-2)	-0.0067	-0.0073	0.24	0.22
	(0.018)	(0.018)	(0.20)	(0.20)
Google-Entry(-1)	0.010	0.010	0.42**	0.41**
	(0.011)	(0.011)	(0.17)	(0.17)
Google-Entry(1)	0.014	0.014	-0.10	-0.090
	(0.014)	(0.014)	(0.15)	(0.15)
Google-Entry(2)	0.027*	0.028*	-0.41**	-0.38**
	(0.015)	(0.015)	(0.17)	(0.18)
Google-Entry(3)	0.0078	0.0087	-0.54***	-0.51***
	(0.016)	(0.016)	(0.17)	(0.17)
Google-Entry(4)	0.0089	0.010	-0.52***	-0.49**
	(0.012)	(0.012)	(0.20)	(0.20)
Google-Entry(5)	0.013	0.014	-0.50**	-0.45*
	(0.013)	(0.013)	(0.22)	(0.23)
Google-Entry(6)	0.016	0.017	-0.52**	-0.46*
	(0.014)	(0.014)	(0.26)	(0.26)
Google-Entry(7)	0.0057	0.0070	-0.70***	-0.65**
	(0.015)	(0.015)	(0.26)	(0.27)
Google-Entry(8)	0.012	0.013	-0.62**	-0.57**
	(0.014)	(0.014)	(0.28)	(0.28)
Google-Entry(9)	0.015	0.017	-0.76**	-0.69**
	(0.014)	(0.014)	(0.30)	(0.31)
Google-Entry(10)	0.012	0.013	-0.83**	-0.77**
	(0.013)	(0.013)	(0.35)	(0.35)
Population (millions)	0.068	0.078	3.90**	4.07**
	(0.076)	(0.074)	(1.84)	(1.78)
GDP per capita	-0.080	-0.11	-0.24	0.21
	(0.064)	(0.091)	(2.02)	(2.46)
Mobile Penetration		0.00021		0.0061**
		(0.00015)		(0.0029)
Internet Penetration		-0.000041		-0.0047
		(0.00031)		(0.0081)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	80800	80524	3224	3192
Log-likelihood	-18773.1	-18825.5	-4535.8	-4482.8

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table provides estimates from Figure 2 Panel A and B. Columns 1 and 2 use the time-varying, log-linear specification $Ln(Y_{it}+1) = \alpha + \Sigma_z \beta_t \times 1(z) + \gamma_i + \delta_t + \varepsilon_{it}$ where γ_i and δ_t represent contributor and time fixed effects respectively for contributor i in quarter t. Columns 3 and 4 use an analogous specification defined for country c in quarter t. z represents the "lag", or the quarters relative to a "zero quarter", which marks the quarter when a country first faced competition from Google Maps except for $z > 10$ and $z < -6$ where z equals 10 and -6 respectively.

Table B.6. Heterogenous Effect of Competition on Pre-Entry Contributors without Control Community Size

	Ideology		Social		Standing		All
	(1) Github	(2) Firefox Share	(3) Maillist	(4) Events	(5) Rank	(6) Contribs	(7) —
Post Google Entry	0.013	0.0094	0.015	0.014	0.029***	0.028***	0.021*
	(0.0097)	(0.010)	(0.0094)	(0.0097)	(0.010)	(0.0092)	(0.011)
Post X High-Ideology	0.023**	0.015*					0.021**
	(0.011)	(0.0080)					(0.010)
Post X High-Social			0.016	0.016			0.0063
			(0.011)	(0.010)			(0.011)
Post X High-Standing					-0.039*	-0.079**	-0.039*
					(0.022)	(0.033)	(0.023)
N	80524	80524	80524	80524	80524	80524	80524
adj. R^2	0.056	0.056	0.056	0.056	0.057	0.057	0.057

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: We present estimates decomposing the positive effect of pre-entry users depending on different drivers of attachment for this group of contributors. In three different analyses, we evaluate the role of ideological environment, opportunities for social interaction and the standing of the contributor, along with a model that includes all three factors. For each analysis, we classify a contributor as belonging to a group that ranks highly on each dimension and provide a heterogenous response to the effect of competitive entry. High-Ideology equals one if the contributor belongs to a country with above-median github contributions or firefox market share, High-Social equals one if a contributor belongs to a community with a mailing-list or has hosted a mapping event and High-Standing equals one if a contributor ranks in the top 5 by contributions or has more than 10 contributions in her community. All models include interactions by community size as well as an additional control. Please see text for more details.

Table B.7. Impact of Competition of Contributions Controlling for Community Size

(a) Pre-Entry Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		0.018**	0.018**	0.019**
		(0.0085)	(0.0088)	(0.0089)
Population (millions)	0.12		0.11	0.12
	(0.075)		(0.077)	(0.076)
GDP per capita	-0.11		-0.057	-0.12
	(0.094)		(0.069)	(0.095)
Mobile Penetration	0.00012			0.00014
	(0.00015)			(0.00015)
Internet Penetration	0.00019			0.00018
	(0.00039)			(0.00040)
Lag Community Size	0.0039**	0.0039**	0.0039**	0.0039**
	(0.0016)	(0.0015)	(0.0015)	(0.0016)
Community Member FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	80448	84993	80718	80448
Adj. R2	0.058	0.058	0.059	0.058

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Newly Recruited Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.58***	-0.56***	-0.52***
		(0.14)	(0.14)	(0.15)
Population (millions)	1.76*		1.59	1.71
	(1.03)		(1.09)	(1.03)
GDP per capita	0.016		-0.67	0.18
	(1.89)		(1.56)	(1.86)
Mobile Penetration	0.0064***			0.0059**
	(0.0023)			(0.0023)
Internet Penetration	-0.0086			-0.0085
	(0.0070)			(0.0069)
Lag Community Size	0.0040***	0.0043***	0.0040***	0.0040***
	(0.0011)	(0.0012)	(0.0011)	(0.0011)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3116	3393	3142	3116
Adj. R2	0.78	0.78	0.78	0.78

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table replicates the baseline specification with an additional co-variate controlling for lagged community size.

Table B.8. Impact of Competition on Contributions Interacted with Community Size

(a) Pre-Entry Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		0.021**	0.024**	0.024**
		(0.0096)	(0.010)	(0.0100)
Post × Mid-Size		-0.0029	-0.0073	-0.0055
		(0.0086)	(0.0090)	(0.0089)
Post × High-Size		-0.0034	-0.0084	-0.0066
		(0.012)	(0.011)	(0.011)
Population (millions)	0.079		0.093	0.098
	(0.075)		(0.071)	(0.068)
GDP per capita	-0.12		-0.074	-0.12
	(0.090)		(0.069)	(0.091)
Mobile Penetration	0.00020			0.00021
	(0.00015)			(0.00014)
Internet Penetration	-0.000045			0.0000059
	(0.00031)			(0.00031)
Community Member FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	80524	85080	80800	80524
Adj. R2	0.056	0.056	0.056	0.056

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Newly Recruited Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.89***	-0.83***	-0.77***
		(0.17)	(0.17)	(0.18)
Post × Mid-Size		0.28***	0.24***	0.22***
		(0.077)	(0.080)	(0.077)
Post × High-Size		0.48***	0.41***	0.41***
		(0.11)	(0.11)	(0.11)
Population (millions)	4.23**		3.01*	3.23*
	(1.80)		(1.72)	(1.64)
GDP per capita	0.12		-0.29	0.27
	(2.57)		(1.90)	(2.36)
Mobile Penetration	0.0070**			0.0067**
	(0.0028)			(0.0028)
Internet Penetration	-0.0047			-0.0056
	(0.0082)			(0.0078)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3192	3480	3224	3192
Adj. R2	0.78	0.78	0.78	0.78

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.9. Alternate Definitions of Newly-Recruited Contributions

Panel A: 2 Quarters

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.56***	-0.54***	-0.50***
		(0.14)	(0.15)	(0.15)
Population (millions)	2.55		2.29	2.48
	(1.65)		(1.75)	(1.66)
GDP per capita	-1.30		-2.37	-1.04
	(2.64)		(2.23)	(2.56)
Mobile Penetration	0.0068**			0.0062*
	(0.0031)			(0.0031)
Internet Penetration	-0.012			-0.012
	(0.0094)			(0.0093)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	2692	2922	2700	2692
Adj. R2	0.66	0.66	0.66	0.67

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel B: 6 Quarters

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.54***	-0.53***	-0.48***
		(0.16)	(0.17)	(0.17)
Population (millions)	2.15		1.86	2.08
	(1.57)		(1.69)	(1.58)
GDP per capita	0.19		-1.08	0.43
	(2.78)		(2.33)	(2.70)
Mobile Penetration	0.0078**			0.0072**
	(0.0034)			(0.0034)
Internet Penetration	-0.014			-0.013
	(0.010)			(0.010)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	2692	2922	2700	2692
Adj. R2	0.69	0.68	0.69	0.69

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Contributors are considered "newly recruited" if they made their first contribution in the focal quarter of the quarter before (Panel A) or upto six quarters preceeding the focal quarter (Panel B).

Table B.10. Evaluating Robustness to Alternate Specifications

	Pre-Entry			Newly-Recruited		
	(1) Poisson	(2) Diff. Trends	(3) Placebo	(4) Poisson	(5) Diff. Trends	(6) Placebo
Post Google Entry	0.78***	0.021*	0.00053	-0.27***	-0.54***	-0.091
	(0.037)	(0.012)	(0.0090)	(0.0084)	(0.16)	(0.11)
Population (millions)	4.23***	0.069	0.079	3.66***	3.16*	4.24**
	(0.22)	(0.073)	(0.075)	(0.076)	(1.73)	(1.79)
GDP per capita	-2.43***	-0.11	-0.12	-6.94***	0.88	0.14
	(0.70)	(0.083)	(0.090)	(0.16)	(1.17)	(2.61)
Mobile Penetration	0.0067***	0.00019	0.00020	0.0074***	0.0051**	0.0070**
	(0.00055)	(0.00016)	(0.00015)	(0.00012)	(0.0021)	(0.0028)
Internet Penetration	0.044***	-0.000013	-0.000045	-0.017***	0.0040	-0.0048
	(0.0011)	(0.00032)	(0.00031)	(0.00031)	(0.0060)	(0.0082)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Quarter	Inc. X Quarter	Quarter	Quarter	Inc. X Quarter	Quarter
Age FE	No	No	No	No	No	No
N	80524	80524	80524	3192	3192	3192
Adj. R2		0.057	0.057		0.79	0.78

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table evaluates the robustness of the baseline results to alternate specifications for contributions by pre-entry and newly-recruited contributors in two sets of analyses. In each analysis, the first column estimates a specification similar to the baseline specification, using Poisson rather than Log-OLS models with the dependent variable being $Contributions_{it}$ and reports standard errors clustered at the country level. The second model estimates the log OLS models using the baseline specification, except these estimates include region-specific time-trends rather that common quarter fixed effects across regions. Specifically, this model includes, IncomeClass X Quarter fixed effects, where countries in the High income category (based on the World Bank Income Classification) have a spearate time trend as compared to the rest. Finally, the third model presents results from a placebo exercise where countries are randomly assigned to the five Google Maps entry cohorts, and the *Post Google Entry* variable represents the period after this randomly assigned date.

Table B.11. Impact of Competition of Contributions Removing Outliers

(a) Pre-Entry Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		0.017*	0.016	0.018*
		(0.0096)	(0.0098)	(0.010)
Population (millions)	0.031		0.028	0.033
	(0.049)		(0.051)	(0.050)
GDP per capita	-0.066		-0.077	-0.067
	(0.077)		(0.060)	(0.077)
Mobile Penetration	0.00026*			0.00028*
	(0.00015)			(0.00014)
Internet Penetration	-0.00033			-0.00036*
	(0.00021)			(0.00021)
Community Member FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	65456	69600	65732	65456
Adj. R2	0.058	0.058	0.058	0.058

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Newly Recruited Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.63***	-0.61***	-0.56***
		(0.14)	(0.15)	(0.16)
Population (millions)	3.84**		3.64**	3.78**
	(1.66)		(1.76)	(1.66)
GDP per capita	0.14		-0.26	0.29
	(2.53)		(2.06)	(2.51)
Mobile Penetration	0.0072**			0.0067**
	(0.0028)			(0.0028)
Internet Penetration	-0.0055			-0.0055
	(0.0085)			(0.0084)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3076	3360	3108	3076
Adj. R2	0.78	0.78	0.78	0.78

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table replicates the baseline specification. For contributors who contribute to multiple countries, only the country with the highest number of contributions counts.

Table B.12. The Impact of Competition on the number of Pre-Entry Contributors

	(1) Contributors	(2) Contributors	(3) Contributors	(4) Contributors
Post Google Entry		-0.032	-0.032	-0.027
		(0.053)	(0.056)	(0.057)
Population (millions)	-0.44		-0.38	-0.45
	(0.39)		(0.39)	(0.39)
GDP per capita	-0.11		-0.35	-0.098
	(0.64)		(0.55)	(0.64)
Mobile Penetration	0.00068			0.00065
	(0.00086)			(0.00086)
Internet Penetration	-0.0034*			-0.0034**
	(0.0017)			(0.0017)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3192	3480	3224	3192
Adj. R2	0.66	0.65	0.66	0.66

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Estimates the impact of competition from Google Maps on the number of pre-entry OpenStreetMap contributors in a differences-in-differences framework. The unit of analysis is country-quarter. The outcome variable is $Contributor_{it}$ and is measured as the total number of pre-entry contributors in country i in a given quarter t. $Post\ Google\ Entry_{it}$=1 after Google Maps has entered the country i in a given quarter. The control variables X_{it} include population, GDP, internet penetration, and mobile penetration, and they vary at the country-year level. γ_i and δ_t indicate fixed effects for country and quarter respectively. Clustered standard errors at the country level are reported.

Table B.13. CEM and Time-Varying Trends

	New Recruits Contributions	
	(1)	(2)
Post Google Entry	-0.42*	-0.42*
	(0.23)	(0.23)
Cntry-Pair FE	Yes	Yes
Time FE	Quarter	Income X Q
Sample	CEM	CEM
N	6400	6380
Adj. R2	0.75	0.76

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This model provides additional robustness checks on the baseline models with a larger sample of countries matched using CEM. Cols 2 and 4 using time-varying income-group times quarter fixed effects while Cols 1 and 3 include quarter fixed effects only

Table B.14. Testing Ideology Using 512 Matched Users

	(1) Github	(2) Firefox Share	(3) Combined
Post Google Entry	0.0079	0.0083	0.014
	(0.014)	(0.015)	(0.021)
Post X High-Ideology	0.034***	0.023*	0.027***
	(0.0100)	(0.013)	(0.0088)
Post X High-Standing			-0.036
			(0.041)
Post X High-Social			0.018
			(0.014)
N	37156	37156	37156
adj. R^2	0.055	0.054	0.055

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents robustness to the regression examining the mechanisms underlying the positive response of pre-entry contributors. We match 512 "high ideology" pre-entry users with a similar number of control users based on the quarter of Google Maps entry, income and region category and with a similar pattern of contributions prior to Google Maps entry. In the final column, high-ideology is measured based on Github contributions, standing based on rank in terms of contributions and social in terms of whether the community has a mailing list. See text for more details.

Table B.15. Impact of Competition of Contributions Dropping the 5^{th} Wave

(a) Pre-Entry Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		0.040***	0.043***	0.043***
		(0.012)	(0.013)	(0.013)
Population (millions)	0.079		0.074	0.085
	(0.076)		(0.081)	(0.078)
GDP per capita	-0.097		-0.061	-0.092
	(0.11)		(0.099)	(0.12)
Mobile Penetration	0.00025			0.00024
	(0.00016)			(0.00016)
Internet Penetration	-0.000089			-0.000081
	(0.00033)			(0.00035)
Community Member FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	72484	77040	72760	72484
Adj. R2	0.056	0.056	0.056	0.056

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Newly Recruited Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-0.57***	-0.49***	-0.48***
		(0.14)	(0.15)	(0.15)
Population (millions)	4.64**		4.34**	4.59**
	(1.91)		(1.99)	(1.90)
GDP per capita	0.61		-0.11	0.76
	(2.58)		(2.28)	(2.61)
Mobile Penetration	0.0074**			0.0074**
	(0.0029)			(0.0029)
Internet Penetration	-0.0072			-0.0074
	(0.0083)			(0.0083)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	2912	3200	2944	2912
Adj. R2	0.78	0.77	0.78	0.78

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table replicates the baseline specification with only the first 4 waves of treatment.

Table B.16. Country-level Heterogeneous Impact of Competition on Contributions

(a) Pre-Entry Contributors

	(1) Population	(2) GDP PC	(3) Mobile	(4) Internet
Post Google Entry	0.019	0.012	0.019*	0.010
	(0.013)	(0.011)	(0.011)	(0.010)
Post × High	0.0014	0.012	0.0017	0.016
	(0.0096)	(0.0096)	(0.011)	(0.0098)
Population (millions)	0.078	0.094	0.086	0.095
	(0.075)	(0.072)	(0.088)	(0.071)
GDP per capita	-0.12	-0.15	-0.12	-0.13
	(0.092)	(0.10)	(0.094)	(0.097)
Mobile Penetration	0.00023	0.00026	0.00023	0.00028*
	(0.00015)	(0.00016)	(0.00015)	(0.00016)
Internet Penetration	-0.000055	-0.00025	-0.000078	-0.00039
	(0.00032)	(0.00030)	(0.00030)	(0.00032)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	80524	80524	80524	80524
Adj. R2	0.056	0.056	0.056	0.056

Standard errors in parentheses

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

(b) Newly Recruited Contributors

	(1) Population	(2) GDP PC	(3) Mobile	(4) Internet
Post Google Entry	-0.85***	-0.36*	-0.48**	-0.64***
	(0.20)	(0.21)	(0.21)	(0.20)
Post × High	0.63***	-0.26	-0.052	0.22
	(0.16)	(0.19)	(0.20)	(0.19)
Population (millions)	-0.029	2.26	2.74*	3.06*
	(1.03)	(1.58)	(1.62)	(1.65)
GDP per capita	2.94	3.26	2.91	2.81
	(1.99)	(2.36)	(2.39)	(2.37)
Mobile Penetration	0.0082***	0.0080***	0.0083**	0.0086***
	(0.0028)	(0.0030)	(0.0032)	(0.0030)
Internet Penetration	-0.0024	0.0018	-0.0023	-0.0084
	(0.0078)	(0.0085)	(0.0086)	(0.0096)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3192	3192	3192	3192
Adj. R2	0.84	0.84	0.84	0.84

Standard errors in parentheses

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

Note: This table replicates the baseline specification and interacts the Post dummy with indicators of country-level heterogeneity. Column (1) interacts with an indicator of high population, column (2) interacts with an indicator of high GDP per capita, column (3) interacts with an indicator of high mobile penetration, and column (4) interacts with an indicator of high internet penetration.

Table B.17. Impact of Competition on Contributions Dropping Multi-country Contributors

(a) Pre-Entry Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		0.045**	0.044**	0.046**
		(0.019)	(0.019)	(0.019)
Population (millions)	0.14		0.13	0.15
	(0.14)		(0.14)	(0.15)
GDP per capita	-0.14		-0.31	-0.15
	(0.17)		(0.21)	(0.18)
Mobile Penetration	0.00056**			0.00060***
	(0.00023)			(0.00021)
Internet Penetration	-0.0014***			-0.0014***
	(0.00050)			(0.00051)
Community Member FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	108852	114720	109344	108852
Adj. R2	0.013	0.012	0.013	0.013

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Newly Recruited Contributors

	(1) Contributions	(2) Contributions	(3) Contributions	(4) Contributions
Post Google Entry		-1.14***	-1.10***	-1.04***
		(0.18)	(0.19)	(0.20)
Population (millions)	7.53***		7.02**	7.41***
	(2.80)		(2.72)	(2.79)
GDP per capita	0.95		1.73	1.25
	(3.77)		(3.05)	(3.75)
Mobile Penetration	0.0091**			0.0082*
	(0.0042)			(0.0042)
Internet Penetration	0.0047			0.0046
	(0.011)			(0.011)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	3192	3480	3224	3192
Adj. R2	0.63	0.61	0.63	0.63

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table replicates the baseline specification. For contributors who contribute to multiple countries, only the country with the highest number of contributions counts.