Supplementary Materials for

Realizing the potential of digital development: The case of agricultural advice

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Details of the estimation for Figure 3

We focus our review on experimental studies of agricultural extension programs delivered by mobile technologies in developing countries (low-income or middle-income as classified by the World Bank), that collected information on yields or harvest value and were written in English. We employed Proquest, JSTOR, Google, and Google Scholar and used the following keywords: "digital agriculture," "phone agriculture," "ICT agriculture" combined with "yields" or "output." We identified six studies that met the criteria. Figure 3 shows estimates using Stata's *metan* command (*83*). On average, yields increased by 4% (95% CI: 0.00 to 0.08). To obtain an estimate of the overall effect across seasons for Cole and Fernando (*46*), we follow Borenstein *et al*. (*84*) and conduct a meta-analysis with multiple outcomes per program. For each season, we calculate the average effect size (AO vs. control) as the average of both season impacts (midline and endline) and derive its standard errors by assuming a 0.5 correlation across season effects. The results are virtually unchanged with different assumptions (ranging from 0 to 1) on this correlation. For the study by Van Campenhout *et al*. (*50*) with maize farmers, we take the point estimates and standard errors from the "video only" treatment arm. For the study by Van Campenhout *et al*. (*49*) with rice farmers, we take the effects of the "technical information" treatment arm.

We also perform a meta-analysis using a Bayesian random-effects model was implemented using R's *baggr's* (*85*) Rubin (1981) model (*86*) with specific normal (0, 0.1) priors on the hyper-standard deviation for the first steps. Under this model, the average yield increase is 3.8% (95% CI: −0.02 to 0.09).

References and Notes

1. World Bank, "World Development Report 2016: Digital Dividends" (World Bank, 2016); doi:10.1596/978-1-4648-0671-1.

2. J. C. Aker, J. E. Blumenstock, "The economic impacts of new technologies in Africa" in *The Oxford Handbook of Africa and Economics: Volume 2: Policies and Practices*, C. Monga, J. Y. Lin, Eds. (Oxford Univ. Press, 2015), pp. 354–371.

3. J. C. Aker, I. M. Mbiti, Mobile Phones and Economic Development in Africa. *J. Econ. Perspect.* **24**, 207–232 (2010). doi:10.1257/jep.24.3.207

4. J. C. Aker, "Using digital technology for public service provision in developing countries" in *Digital Revolutions in Public Finance*, S. Gupta, M. Keen, A. Shah, G. Verdier, Eds. (International Monetary Fund, 2017), pp. 201–224.

5. T. Suri, W. Jack, The long-run poverty and gender impacts of mobile money. *Science* **354**, 1288–1292 (2016). doi:10.1126/science.aah5309 Medline

6. J. H. Pierskalla, F. M. Hollenbach, Technology and Collective Action: The Effect of Cell Phone Coverage on Political Violence in Africa. *Am. Polit. Sci. Rev.* **107**, 207–224 (2013). doi:10.1017/S0003055413000075

7. B. Qin, D. Strömberg, Y. Wu, Why Does China Allow Freer Social Media? Protests versus Surveillance and Propaganda. *J. Econ. Perspect.* **31**, 117–140 (2017). doi:10.1257/jep.31.1.117

8. J. James, Digital Divide Complacency: Misconceptions and Dangers. *Inf. Soc.* **24**, 54–61 (2008). doi:10.1080/01972240701774790

9. J. Blumenstock, N. Eagle, "Mobile divides: Gender, socioeconomic status, and mobile phone use in Rwanda" in *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development - ICTD '10* (Association for Computing Machinery, 2010), article no. 6; doi:10.1145/2369220.2369225.

10. Food and Agriculture Organization of the United Nations (FAO), "The economic lives of smallholder farmers: An analysis based on household data from nine countries" (FAO, 2015); www.fao.org/3/a-i5251e.pdf.

11. Z. Cui, H. Zhang, X. Chen, C. Zhang, W. Ma, C. Huang, W. Zhang, G. Mi, Y. Miao, X. Li, Q. Gao, J. Yang, Z. Wang, Y. Ye, S. Guo, J. Lu, J. Huang, S. Lv, Y. Sun, Y. Liu, X. Peng, J. Ren, S. Li, X. Deng, X. Shi, Q. Zhang, Z. Yang, L. Tang, C. Wei, L. Jia, J. Zhang, M. He, Y. Tong, Q. Tang, X. Zhong, Z. Liu, N. Cao, C. Kou, H. Ying, Y. Yin, X. Jiao, Q. Zhang, M. Fan, R. Jiang, F. Zhang, Z. Dou, Pursuing sustainable productivity with millions of smallholder farmers. *Nature* **555**, 363–366 (2018). doi:10.1038/nature25785 Medline

12. B. K. Jack, "Market inefficiencies and the adoption of agricultural technologies in developing countries," [White paper, Agricultural Technology Adoption Initiative, JPAL (MIT)/CEGA (Berkeley), 2011]; https://escholarship.org/content/qt6m25r19c/qt6m25r19c.pdf.

13. J. Anderson, G. Feder, in *Agricultural Development: Farmers, Farm Production and Farm Markets*, vol. 3 of *Handbook of Agricultural Economics*, R. Evenson, P. Pingali, Eds. (Elsevier, 2007), pp. 2343–2378.

14. K. Davis, B. Swanson, D. Amudavi, D. A. Mekonnen, A. Flohrs, J. Riese, C. Lamb, E. Zerfu, "In-depth assessment of the public agricultural extension system of Ethiopia and recommendations for improvement" [International Food Policy Research Institute (IFPRI) Discussion Paper, IFPRI, 2010]; www.ifpri.org/publication/depth-assessment-public-agricultural-extension-system-ethiopia-and-recommendations.

15. S. Cole, G. Sharma, "The Promise and Challenges in Implementing ICT for Agriculture," Working paper (2017); https://precisionag.org/uploads/cole-sharma-july1-2017.pdf.

16. M. Gautam, "Agricultural extension: The Kenya experience: An impact evaluation" (World Bank Publications, 2000).

17. O. Bandiera, R. Burgess, E. Deserranno, R. Morel, I. Rasul, M. Sulaiman, "Social Ties and the Delivery of Development Programs," Working paper (2018); https://drive.google.com/file/d/1uESM-AfGaiY-7eZ7Zq1WBzyP1IKE4fuS/view.

18. J. R. Alwang, P. B. Siegel, "Rural poverty in Zambia: An analysis of causes and policy recommendations" (World Bank, 1994).

19. B. Cunguara, K. Moder, Is Agricultural Extension Helping the Poor? Evidence from Rural Mozambique. *J. Afr. Econ.* **20**, 562–595 (2011). doi:10.1093/jae/ejr015

20. F. Kondylis, V. Mueller, G. Sheriff, S. Zhu, Do Female Instructors Reduce Gender Bias in Diffusion of Sustainable Land Management Techniques? Experimental Evidence From Mozambique. *World Dev.* **78**, 436–449 (2016). doi:10.1016/j.worlddev.2015.10.036

21. K. A. Saito, H. Mekonnen, D. Spurling, "Raising the Productivity of Women Farmers in Sub-Saharan Africa" (Discussion paper, World Bank, 1994); doi:10.1596/0-8213-2749-6.

22. R. A. Viscarra Rossel, T. Behrens, E. Ben-Dor, D. J. Brown, J. A. M. Demattê, K. D. Shepherd, Z. Shi, B. Stenberg, A. Stevens, V. Adamchuk, H. Aïchi, B. G. Barthès, H. M. Bartholomeus, A. D. Bayer, M. Bernoux, K. Böttcher, L. Brodský, C. W. Du, A. Chappell, Y. Fouad, V. Genot, C. Gomez, S. Grunwald, A. Gubler, C. Guerrero, C. B. Hedley, M. Knadel, H. J. M. Morrás, M. Nocita, L. Ramirez-Lopez, P. Roudier, E. M. R. Campos, P. Sanborn, V. M. Sellitto, K. A. Sudduth, B. G. Rawlins, C. Walter, L. A. Winowiecki, S. Y. Hong, W. Ji, A global spectral library to characterize the world's soil. *Earth Sci. Rev.* **155**, 198–230 (2016). doi:10.1016/j.earscirev.2016.01.012

23. D. Arrouays, P. Lagacherie, A. E. Hartemink, Digital soil mapping across the globe. *Geoderma Reg.* **9**, 1–4 (2017). doi:10.1016/j.geodrs.2017.03.002

24. P. A. Sanchez, S. Ahamed, F. Carré, A. E. Hartemink, J. Hempel, J. Huising, P. Lagacherie, A. B. McBratney, N. J. McKenzie, Mde. L. Mendonça-Santos, B. Minasny, L. Montanarella, P. Okoth, C. A. Palm, J. D. Sachs, K. D. Shepherd, T.-G. Vågen, B. Vanlauwe, M. G. Walsh, L. A. Winowiecki, G.-L. Zhang, Digital soil map of the world. *Science* **325**, 680–681 (2009). doi:10.1126/science.1175084 Medline.

25. M. Rosenzweig, C. R. Udry, "Forecasting Profitability," Working paper 19334 [National Bureau of Economic Research (NBER) Working Paper Series, 2013]; doi:10.3386/w19334.

26. R. B. Alley, K. A. Emanuel, F. Zhang, Advances in weather prediction. *Science* **363**, 342–344 (2019). doi:10.1126/science.aav7274 Medline

27. M. Kremer, G. Rao, F. Schilbach, "Behavioral development economics" in *Handbook of Behavioral Economics - Foundations and Applications 2*, B. D. Bernheim, S. DellaVigna, D. Laibson, Eds. (North Holland, 2019), pp. 345–458.

28. M. Burke, D. B. Lobell, Satellite-based assessment of yield variation and its determinants in smallholder African systems. *Proc. Natl. Acad. Sci. U.S.A.* **114**, 2189–2194 (2017). doi:10.1073/pnas.1616919114 Medline

29. D. Donaldson, A. Storeygard, The View from Above: Applications of Satellite Data in Economics. *J. Econ. Perspect.* **30**, 171–198 (2016). doi:10.1257/jep.30.4.171

30. K. Vasilaky, K. Toyama, T. Baul, M. Mangal, U. Bhattacharya, "Learning Digitally: Evaluating the Impact of Farmer Training via Mediated Videos" presented at the Northeast Universities Development Consortium Conference, Providence, RI, 7 and 8 November 2015; https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=NEUDC2015&paper_id=519.

31. M. Ridley, G. Rao, P. Vikram, F. Schilbach, "Poverty and Mental Illness: Causal Evidence" (2019); https://economics.mit.edu/files/18694.

32. S. Alan, T. Boneva, S. Ertac, Ever Failed, Try Again, Succeed Better: Results from a Randomized Educational Intervention on Grit. *Q. J. Econ.* **134**, 1121–1162 (2019). doi:10.1093/qje/qjz006

33. E. La Ferrara, Aspirations, Social Norms, and Development. *J. Eur. Econ. Assoc.* 10.1093/jeea/jvz057 (2019). doi:10.1093/jeea/jvz057

34. T. Bernard, S. Dercon, K. Orkin, A. S. Taffesse, "The future in mind: short and long-run impact of an aspirations intervention in rural Ethiopia," Working paper (Univ. of Oxford, 2018); http://ibread.org/bread/system/files/bread_wpapers/429.pdf.

35. G. Murthy, M. Fernandez-Vidal, X. Faz, R. Barreto, "Fintechs and Financial Inclusion: Looking past the hype and exploring their potential" (Consultative Group to Assist the Poor, 2019); www.cgap.org/sites/default/files/publications/2019_05_Focus_Note_Fintech_and_Financial_Inclusion_1_0.pdf.

36. M. T. Damgaard, C. Gravert, The hidden costs of nudging: Experimental evidence from reminders in fundraising. *J. Public Econ.* **157**, 15–26 (2018). doi:10.1016/j.jpubeco.2017.11.005

37. U. P. Union, "Addressing the World–An Address for Everyone" (White paper, Universal Postal Union, 2012); www.upu.int/fileadmin/documentsFiles/activities/addressingAssistance/whitePaperAddressingTheWorldEn.pdf.

38. A. Erlich, D. F. Jung, J. D. Long, C. McIntosh, The double-edged sword of mobilizing citizens via mobile phone in developing countries. *Dev. Eng.* **3**, 34–46 (2018). doi:10.1016/j.deveng.2017.11.001

39. J. C. Aker, Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agric. Econ.* **42**, 631–647 (2011). doi:10.1111/j.1574-0862.2011.00545.x

40. E. Nakasone, M. Torero, B. Minten, The power of information: The ICT revolution in agricultural development. *Annu. Rev. Resour. Econ.* **6**, 533–550 (2014). doi:10.1146/annurev-resource-100913-012714

41. J. C. Aker, I. Ghosh, J. Burrell, The promise (and pitfalls) of ICT for agriculture initiatives. *Agric. Econ.* **47**, 35–48 (2016). doi:10.1111/agec.12301

42. H. Baumüller, The Little We Know: An Exploratory Literature Review on the Utility of Mobile Phone-Enabled Services for Smallholder Farmers. *J. Int. Dev.* **30**, 134–154 (2018). doi:10.1002/jid.3314

43. U. Deichmann, A. Goyal, D. Mishra, Will digital technologies transform agriculture in developing countries? *Agric. Econ.* **47**, 21–33 (2016). doi:10.1111/agec.12300

44. C. Larochelle, J. Alwang, E. Travis, V. H. Barrera, J. M. D. Andrade, Did You Really Get the Message? Using Text Reminders to Stimulate Adoption of Agricultural Technologies. *J. Dev. Stud.* **55**, 548–564 (2019). doi:10.1080/00220388.2017.1393522

45. X. Fu, S. Akter, The Impact of Mobile Phone Technology on Agricultural Extension Services Delivery: Evidence from India. *J. Dev. Stud.* **52**, 1561–1576 (2016). doi:10.1080/00220388.2016.1146700

46. S. A. Cole, A. N. Fernando, "'Mobile'izing Agricultural Advice: Technology Adoption, Diffusion and Sustainability," Working paper (2018); www.dropbox.com/s/0rewpp8oeost0o5/ao_final_v24_tables.pdf?dl=0.

47. R. Fabregas, M. Kremer, M. Lowes, R. On, G. Zane, "SMS-extension and Farmer Behavior: Lessons from Six RCTs in East Africa," Working paper (2019); www.dropbox.com/s/guiog3ief0hnwl7/textfarmers.pdf?dl=0.

48. L. Casaburi, M. Kremer, S. Mullainathan, R. Ramrattan, "Harnessing ICT to increase agricultural production: Evidence from Kenya," Working paper (2019); www.econ.uzh.ch/dam/jcr:873845ce-de4d-4366-ba9a-d60accda577d/SMS_paper_with_tables_20190923_merged.pdf.

49. B. Van Campenhout, W. Walukano, F. Nattembo, L. Nazziwa-Nviiri, J. Blom, "The Role of Information in Agricultural Technology Adoption: Experimental Evidence from Rice Farmers in Uganda" (IFPRI Discussion Paper, IFPRI, 2017); https://core.ac.uk/download/pdf/153429888.pdf.

50. B. Van Campenhout, D. J. Spielman, E. Lecoutere, "Information and Communication Technologies (ICTs) to Provide Agricultural Advice to Smallholder Farmers: Experimental Evidence from Uganda" (IFPRI Discussion Paper, IFPRI, 2018); www.ifpri.org/publication/information-and-communication-technologies-icts-provide-agricultural-advice-smallholder.

51. A. Arouna, J. D. Michler, W. G. Yergo, K. Saito, "One Size Does Not Fit All: Experimental Evidence on the Digital Delivery of Personalized Extension Advice in Nigeria" (2019); www.researchgate.net/publication/336927609_One_Size_Does_Not_Fit_All_Experimental_Evidence_on_the_Digital_Delivery_of_Personalized_Extension_Advice_in_Nigeria.

52. C. Udry, "Information, Market Access and Risk: Addressing Constraints to Agricultural Transformation in Northern Ghana" (2019); https://sites.northwestern.edu/christopherudry/files/2019/03/DIRTS-Final-report-1362c0g.pdf.

53. R. Gandhi, R. Veeraraghavan, K. Toyama, V. Ramprasad, “Digital Green: Participatory video for agricultural extension,” in *2007 International Conference on Information and Communication Technologies and Development* (IEEE, 2007); doi:10.1109/ictd.2007.4937388.

54. E. Tjernström, T. J. Lybbert, R. Frattarola Hernández, J. S. Correa, “Learning by (virtually) doing: experimentation and belief updating in smallholder agriculture” (2019); www.lafollette.wisc.edu/sites/tjernstrom/Learning_by_virtually_doing.pdf.

55. R. Jensen, The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector. *Q. J. Econ.* **122**, 879–924 (2007). doi:10.1162/qjec.122.3.879

56. J. C. Aker, Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger. *Am. Econ. J. Appl. Econ.* **2**, 46–59 (2010). doi:10.1257/app.2.3.46

57. J. C. Aker, M. Fafchamps, Mobile Phone Coverage and Producer Markets: Evidence from West Africa. *World Bank Econ. Rev.* **29**, 262–292 (2015). doi:10.1093/wber/lhu006

58. J. Svensson, D. Yanagizawa, Getting Prices Right: The Impact of the Market Information Service in Uganda. *J. Eur. Econ. Assoc.* **7**, 435–445 (2009). doi:10.1162/JEEA.2009.7.2-3.435

59. P. Courtois, J. Subervie, Farmer Bargaining Power and Market Information Services. *Am. J. Agric. Econ.* **97**, 953–977 (2015). doi:10.1093/ajae/aau051

60. E. Nakasone, “The Role of Price Information in Agricultural Markets: Experimental Evidence from Rural Peru,” Working paper (2014); https://fc317c2d-a-62cb3a1a-s-sites.googlegroups.com/site/eduardonakasone/Nakasone%20-%20Price%20Info%20and%20Ag%20Markets%20-%20OCT2014.pdf?attachauth=ANoY7crbtOVyu8ZK0saI6LjZFX5YTjR1uGo1cHVxIjGqIIwCGBxMJ_IlNbLwB9TYQn6vfZSW7ol2aX2JLozIxPvAWqbjvGZDtpdAtqLTQTQyWHFL4OMZ2294iGS4VN2afdYzi-rbC5gUKq8ADwq0aKtPVCX0iAMynd5Q3QK2oljTngQPoyLOYuNdJrQtyFxJV3pnkb9kLrEE8X6_oO2JBZJiF2snZppL-Edb5LwSVErpxNJJa4DARTJXcQPIsm7suHAaddvPwWGSiX75x7mE--gG9osAlVdVGg%3D%3D&attredirects=0&d=1.

61. M. Fafchamps, B. Minten, Impact of SMS-Based Agricultural Information on Indian Farmers. *World Bank Econ. Rev.* **26**, 383–414 (2012). doi:10.1093/wber/lhr056

62. A. Camacho, E. Conover, “The Impact of Receiving Price and Climate Information in the Agricultural Sector,” Working paper no. IDB-WP-220 [Inter-American Development Bank (IDB) Working Paper Series, 2011]; doi:10.2139/ssrn.1755057.

63. S. Mitra, D. Mookherjee, M. Torero, S. Visaria, Asymmetric Information and Middleman Margins: An Experiment with Indian Potato Farmers. *Rev. Econ. Stat.* **100**, 1–13 (2018). doi:10.1162/REST_a_00699

64. L. Casaburi, M. Kremer, R. Ramrattan, “Crony Capitalism, Collective Action, and ICT: Evidence from Kenyan Contract Farming,” Working paper (2019); http://econ.uzh.ch/dam/jcr:e2ffc4e5-ab32-4405-bfa4-70b0e962aa81/hotline_paper_20191015_MERGED.pdf.

65. R. J. Sexton, Imperfect Competition in Agricultural Markets and the Role of Cooperatives: A Spatial Analysis. *Am. J. Agric. Econ.* **72**, 709–720 (1990). doi:10.2307/1243041

66. T. Bold, K. C. Kaizzi, J. Svensson, D. Yanagizawa-Drott, Lemon Technologies and Adoption: Measurement, Theory and Evidence from Agricultural Markets in Uganda. *Q. J. Econ.* **132**, 1055–1100 (2017). doi:10.1093/qje/qjx009

67. S. Cole, T. L. He, "Farmers Business Network: Putting Farmers First," Harvard Business School Case 217-025 (2018); www.hbs.edu/faculty/Pages/item.aspx?num=51649.

68. B. Dillon, Using mobile phones to collect panel data in developing countries. *J. Int. Dev.* **24**, 518–527 (2012). doi:10.1002/jid.1771

69. M. Jones, F. Kondylis, Does feedback matter? Evidence from agricultural services. *J. Dev. Econ.* **131**, 28–41 (2018). doi:10.1016/j.jdeveco.2017.10.013

70. M. Tsan, S. Totapally, M. Hailu, B. K. Addom, "The digitalization of African agriculture report 2018-2019: Executive summary" (CTA/Dalberg Advisers, 2019); https://cgspace.cgiar.org/bitstream/handle/10568/103198/Executive%20Summary%20V4.5%20ONLINE.pdf.

71. K. J. Arrow, "Economic welfare and the allocation of resources for invention" in *The Rate and Direction of Inventive Activity: Economic and Social Factors* (Princeton Univ. Press, 1962), pp. 609–626.

72. P. M. Romer, Increasing Returns and Long-Run Growth. *J. Polit. Econ.* **94**, 1002–1037 (1986). doi:10.1086/261420

73. A. D. Foster, M. R. Rosenzweig, Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *J. Polit. Econ.* **103**, 1176–1209 (1995). doi:10.1086/601447

74. T. G. Conley, C. R. Udry, Learning about a new technology: Pineapple in Ghana. *Am. Econ. Rev.* **100**, 35–69 (2010). doi:10.1257/aer.100.1.35

75. L. Beaman, A. BenYishay, J. Magruder, A. M. Mobarak, "Can Network Theory-based Targeting Increase Technology Adoption?" Working paper 24912 (NBER Working Paper Series, 2018); doi:10.3386/w24912.

76. R. Fabregas, M. Kremer, J. Robinson, F. Schilbach, "The Value of Local Agricultural Information: Evidence from Kenya," Working paper (2019); www.dropbox.com/s/bumw8uj5dyhnt9n/valueinformation.pdf?dl=0.

77. G. A. Akerlof, The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *Q. J. Econ.* **84**, 488 (1970). doi:10.2307/1879431

78. S. Anagol, S. Cole, S. Sarkar, Understanding the Advice of Commissions-Motivated Agents: Evidence from the Indian Life Insurance Market. *Rev. Econ. Stat.* **99**, 1–15 (2017). doi:10.1162/REST_a_00625

79. R. Fishman, A. Kishore, Y. Rothler, P. S. Ward, S. Jha, R. K. P. Singh, "Can information help reduce imbalanced application of fertilizers in India?: Experimental evidence from Bihar" (IFPRI Discussion Paper, IFPRI, 2016); http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130249/filename/130460.pdf

80. Precision Agriculture for Development, "Mid-term evaluation of IVR/SMS project: Findings and recommendations" (Ethiopian Agricultural Transformation Agency, 2018);

https://precisionag.org/uploads/January-ATA-PAD-Report-FINAL-FOR-VALIDATION-WORKSHOP-compressed.pdf.

81. G. Loewenstein, S. Sah, D. M. Cain, The unintended consequences of conflict of interest disclosure. *JAMA* **307**, 669–670 (2012). doi:10.1001/jama.2012.154 Medline

82. H. Allcott, J. B. Kessler, The Welfare Effects of Nudges: A Case Study of Energy Use Social Comparisons. *Am. Econ. J. Appl. Econ.* **11**, 236–276 (2019). doi:10.1257/app.20170328

83. R. J. Harris, J. J. Deeks, D. G. Altman, M. J. Bradburn, R. M. Harbord, J. A. C. Sterne, Metan: Fixed- and Random-Effects Meta-Analysis. *Stata J.* **8**, 3–28 (2008). doi:10.1177/1536867X0800800102

84. M. Borenstein, L. V. Hedges, J. P. T. Higgins, H. R. Rothstein, *Introduction to Meta-Analysis* (Wiley, 2011).

85. R. Meager, W. Wiecek, baggr: Bayesian Aggregate Treatment Effects (2019); https://cran.r-project.org/web/packages/baggr/index.html.

86. D. B. Rubin, Estimation in Parallel Randomized Experiments. *J. Educ. Behav. Stat.* **6**, 377–401 (1981). doi:10.2307/1164617