Large-scale Quantitative Evidence of Media Impact on Public Opinion toward China: Supplementary Information

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Methods

Topics

We use eight predefined topics to segment content from The New York Times: Ideology, Government & Administration, Democracy, Economic Development, Marketization, Welfare & Well-being, Globalization, and Culture.

Ideology includes topics and terms related political thought and political systems, such as socialism, communism, and Marxism and the thinking of major figures in Chinese politics.It also covers the many slogans of the Chinese Communist Party, such as "Socialism with Chinese

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Characteristics", "Three Represents (San Ge Dai Biao)", and "Scientific Concept of Development (Ke Xue Fa Zhan Guan)".

Government & Administration articles cover how the Chinese state performs public administration, including the measures, policies, laws, institutions, rules taken or made by State Council and Ministries. This includes, for example, Hukou registration, migrant management, family planning, and changes in the departmental leaders or other officials. Articles related to the military are also lumped into this topic.

Democracy covers voting, village elections, freedom of speech, behavioral controls, local government autonomy, and the centralization or decentralization of power. Democracy also includes any mention of the Chinese state's censorship apparatus, commonly referred to as the Great Firewall of China, and tensions in Taiwan, Xinjiang, or Tibet.

Economic Development relates to economic growth, infrastructure investment, business development, industrial structure, and changes in GDP.

Marketization reflects how much industrial decision making in China is guided by market forces instead of the Chinese state. State intervention in the Chinese market and government encouragement of private business or market competition are considered examples of marketization. We restrict this topic to articles that exclusively discuss China's domestic market and put all articles about international trade under Globalization.

Welfare & Well-being relates to the living standards of ordinary Chinese people and the Chinese state's actions to improve or otherwise change the material or mental conditions of its citizens. Discussions of China's poverty relief policy ("Jing Zhun Fu Pin"), protection of the

elderly, education-related investment, disease control, and daily life in China all fall under this topic.

Articles about *Globalization* discuss how China and the Chinese people are connected to or otherwise involved with the rest of the world. Positive articles on this topic mention, for example, Chinese students studying abroad, launching the Thousand Talents Program ("Qian Ren Ji Hua") to entice scientists to work in China, and the One Belt One Road Initiative. Negative articles on globalization discuss the spread of SARS and other diseases, copyright infringement, and restrictions on foreign business or foreigners living in China.

Culture includes sports, music, movies, literature, art, architecture, food, and museums about China.

Media sentiment annotation and extraction

Media sentiment is defined as perceived sentiment, i.e., asking if an article would make a typical American reader view China more or less favorably. For each of eight possible topics mentioned in an article, we assign a sentiment label: strongly positive, neutral, or strongly negative. Weak sentiments are considered neutral, and most articles typically cover 3 to 4 topics.

We extract media attitudes from our data with a three-stage procedure. Firstly, all authors read and labelled 42 representative articles to create a golden standard for our labeling criteria. We then used these articles to train two undergraduate students to read and annotate an additional 712 articles. Finally, we use Bidirectional Encoder Representations from Transformers (BERT) (Devlin et al., 2018), a natural language processing model, to learn from the tagged text and classify the

rest of the articles in our sample. We started with BERT's pre-trained 12-layer uncased neural network, fine-tuned it with 873 hand-labeled, and used the tuned model to predict the sentiments of the full sample of 267,907 articles.

We built two BERT classifiers for each topic, an "assignment" classifier to evaluate whether a sentence expresses positive or negative sentiment in terms of this topic, and a "sentiment" classifier to distinguish positive and negative sentiments. The two classifiers are evaluated by AUC (Area Under the Received Operating Characteristic Curve) because the both face data imbalance. The assignment classifier deals with much more articles labeled as neutral / irrelevant than those labeled as positive or negative. The sentiment classifier deals much more articles with the dominating tone (e.g., negative articles in democracy, positive articles in culture) than those with the dominated tone. The sentence assignment and sentiment accuracy ranges between 59% to 99% across topics.

The article prediction is based on sentence prediction results. Article sentiment identification accuracy is measured by the percentage of correctly labeled articles in each topic.

Public opinion

Survey data were obtained from three large public archives / centers, namely Roper Center for Public Opinion Research (ROPER), NORC at the University of Chicago, and Pew Research Center (Pew Research Center, 2019; Smith et al., 2018). We collected 101 cross-sectional surveys, administered by 10 organizations, by searching for questionnaires with three criteria: (1) The questionnaires measured general attitude toward

China, rather than specific attitude toward Chinese people and government etc; (2) The questionnaires targeted at the entire U.S. population, rather than regional polls; (3) The questionnaires were surveyed for at least two years. The last criterion came from the algorithmic requirement to align various surveys. The surveys asked a representative American population simple questions about how they felt about China, in binary options like positive and negative, or out of 1 of 4 or 10 scales.

The list of surveys obtained from NORC: General Social Surveys, 1972-2018 (Smith et al., 2018).

The list of surveys obtained from Pew Research Center: Global Attitudes & Trends, 2005-2019 (Pew Research Center, 2019).

The list of surveys obtained from ROPER (by question ID): USABCWP.89APR.R41G, USABCWP.89JAPN.R35E, USABC.379.R03B, USABC.060398.R04, USABCWP.011911.R31, USABCWP.021412.R01, USTNS.10TRANS.R08CA, USTNS.2011GMF.Q07C, USTNS.12TRANS.R05C, USMISC.2004GMF.Q08H, USTNS.2005GMF.Q10H, USTNS.2006GMF.Q12H, USTNS.2008GMF.Q03I, USCBSNYT.020179.R16C, USCBSNYT.051589.R08, USCBS.98MY23.R16, USCBSNYT.061098.R05, USCBS.051299.R09, USCBS.040601.R26, USGALLUP.954.Q004B, USGALLUP.1123.Q05B, USGALLUP.1147.Q005B, USGALLUP.1224.R09AC, USGALLUP.93NV15.Q20B, USGALLUP.96JAN.Q38, USGALLUP.960307.Q22I, USGALLUP.01FYR1.R28D, USGALLUP.7757GO.RA03, USGALLUP.79138G.R02D, USGALLUP.022615TR2.R01A, USGALLUP.TM09PR.R202G, USGALLUP.081689.R02A, USGALLUP.040689.R1D, USGALLUP.122021.Q02K, USGALLUP.422021.R20A, USGALLUP.422035.Q15C, USGALLUP.96MAR8.R21I, USGALLUP.97JE26.R21, USGALLUP.98JUL7.R12, USGALLUP.99MAR12.R34, USGALLUP.99FEB8.R02G, USGALLUP.99MM07.R23A, USGALLUP.00MC17.R17B, USGALLUP.00NMB13.R13C, USGALLUP.200005.Q06A, USGALLUP.01FYR1.R27D,

USGALLUP.02FBA04.R33C, USGALLUP.04FBY09.R23M, USGALLUP.05FUY007.R26L, USGALLUP.06FE006.R22C, USGALLUP.07FBR01.R26E, USGALLUP.08FUY011.R26C, USGALLUP.09FBRY9.R18C, USGALLUP.10FBR001.R17C, USGALLUP.11FB002.R16C, USGALLUP.12FB002.R16D, USGALLUP.13FBUY07.R14C, USGALLUP.031315TR.R01C, USGALLUP.022615TR1.R01A, USGALLUP.031315.R18C, USGALLUP.022017.R19C, USGALLUP.022818.R17C, 31116081, USHARRIS.02CCFRB.R0510N, USKN.04GLOBE.R330F, USKN.06GLOBEV.R333F, USKN.08GLOBAL.R0150F, USKN.08SOFT.R070C, USKN.10GLOBALV.R0045F, USKN.201304CCGA.Q01A, USKN.2014CCGA.Q19F, USORC.87DEC.R1C, USORC.040709A.R20D, USORC.053111.R11K, USORC.020514A.R30H, USPSRA.90TM2A.R200E, USPSRA.080798.R21A, USPSRA.120313.R12AF1, USZOGBY.05CHINA.R02, USZOGBY.07CHINA.R01 (ABC News/Washington Post, 1989; ABC News, 1990, 1998; Washington Post/ABC News, 2011; ABC News/Washington Post, 2012; Compagnia di San Paolo di Torino, Italy/The German Marshall Fund of the United States, 2010, 2011; German Marshall Fund of the US and the Compagnia di San Paolo, Italy, with additional support from other organizations shown below, 2012; Compagnia di San Paolo di Torino, Italy/The German Marshall Fund of the United States, 2004, 2005, 2006, 2008; CBS News/New York Times, 1979; CBS News/The New York Times, 1989; CBS News, 1998; CBS News/New York Times, 1998; CBS News, 1999, 2001; Gallup Organization, 1976, 1979, 1980, 1983; Cable News Network (CNN)/USA Today, 1993; USA Today/Cable News Network (CNN), 1996; Cable News Network (CNN)/USA Today, 1996; Gallup Organization, 2001; Potomac Associates, 1977, 1979; Gallup Organization, 1985; Times Mirror Center for the People & the Press, 1987; Gallup Organization, 1989a,b, 1991; Cable News Network (CNN)/USA Today, 1993, 1994, 1996, 1997, 1998; CNN/USA Today, 1999; Gallup Organization, 1999a,b; Cable News Net-

work (CNN)/USA Today, 2000; Gallup Organization, 2000a,b, 2001, 2002, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014b,a, 2015, 2017, 2018, 2019; The Chicago Council on Foreign Relations, 2002; Chicago Council on Foreign Relations, 2004; Lowry Institute for International Affairs/East Asia Institute/Chicago Council on Foreign Relations, 2006; The Chicago Council on Global Affairs, 2008a,b, 2010, 2013, 2014; Opinion Research Corporation, 1987; Cable News Network (CNN), 2009, 2011, 2014; Times Mirror Center for the People & the Press, 1990; Pew Research Center for the People & the Press, 1998; Pew Research Center for the People & the Press/The Council on Foreign Relations, 2013; Committee of 100, 2004, 2007)

We incorporate a probabilistic model to aggregate surveys with various scales (Wang et al., 2021). We ended up with a series of attitudes spanning between 1974 - 2019, with a single float number to represent the public attitude in every year.

Fitting public attitudes

We run a linear regression model to select the most important topic from media sentiment to predict the public opinion. The dependent variable is the yearly public opinion, with each year as an observation. The independent variables include the average yearly volume and fraction of positive and negative reports on each of eight topics, in the same year and each of the previous 5 years. We also list their first order derivatives as independent variables, e.g., the difference in the average yearly fraction of positive reports on one topic between the current year and the previous year. The goodness-of-fit is measured by the variance of the dependent variable explained by the independent variables. To find

out a core set of independent variables with the best explanatory ability, we search with a greedy strategy. First we run a bivariate linear regression that regresses the dependent variable on every single independent variable v, and choose an independent variable v_0 with a maximal explained variance of the dependent variable. Then we continue to select the second important independent variable by running a linear regression that regresses the dependent variable on two independent variables, i.e. a combination of v_0 and every other independent variable v. And we choose an independent variable v_1 that $\{v_0, v_1\}$ together provide a maximal explained variance of the dependent variable. Iteratively inserting independent variables to this selection results in a suboptimal solution of best predictors. In practice, we end up with two independent variables with the favor of simple models.

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