The Impact of Free Media on Regime Change: Evidence from Russia

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Abstract

Can free media become a powerful lever to make regime change possible? Are Western countries successful in exporting their values to other countries and triggering regime change abroad? I study these questions in the context of Russia in the early 90s when the Soviet Union was crumbling. In particular, I analyze the impact of Radio Liberty on the 1991 Russian presidential elections, which were the first democratic elections in the country. In order to study the effects of this American radio broadcasting from outside Russia, I use a novel empirical strategy exploiting ionospheric variation, which affects shortwave propagation over long distances, measured by NASA with the aim of obtaining a measure of radio availability in each Russian electoral district. The results show a significant effect of these broadcasts in favor of Yeltsin and a negative significant effect on communist support. Such results are robust and bolstered by a series of placebo exercises, and survey evidence. Thus, this paper documents that free media can play an important role in political processes of regime change.

Keywords: Regime change, free media, communism, ionosphere.

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1 Introduction

"In Russia we had only two channels. Channel One was propaganda. Channel Two consisted of a KGB officer telling you: Turn back at once to Channel One."

-Yakov Smirnoff, Russian comedian.

This paper investigates the impact of free media on political regime stability and change in tightly controlled countries with barriers established to curtail freedom of press. In particular, this paper puts the focus on the regime change, switching from communism to capitalism, which took place in the USSR (Soviet Union) at the end of the eighties and beginning of the nineties. During that period, the majority of the media within the USSR were still dominated by the Soviet hierarchy but free media were, notwithstanding, present in the country through shortwave radio broadcasts, mainly from Radio Free Europe/Radio Liberty (RFE/RL), the British Broadcasting Corporation (BBC), and Voice of America (VOA). This paper investigates what was the effect of these Western broadcasts on the fast demise of communism and its substitution by a new capitalist regime led by Boris Yeltsin. Therefore, the goal is to study the importance of free media to help changing the status quo in seemingly stable regimes, and their possible role as a catalyst for political change.

To shed light on these questions I focus on the impact of Radio Liberty, which was the most prominent foreign radio station (Parta 2007) in Russia in 1991, on the 1991 Russian presidential elections. I study the 1991 Russian presidential elections since they were a momentous landmark inasmuch as they legitimized Yeltsin to complete regime change. Radio Liberty was the Russian branch of Radio Free Europe and according to the Soviet Area Audience and Opinion Research (SAAOR), it was listened by 19 percent of the USSR citizens in 1990. This radio station became a critical source of information within the Soviet Union, broadcasting in Russian and a dozen other languages (Sosin 1999; Rearden 2001; Ross-Johnson 2010).

In those elections the main television channel, OTR, was still controlled by the Soviet authorities[1]and the same situation applied to the main Russian radios, spearheaded by Radio Moscow and Radio Peace and Progress (Allison and Lantz 1996; Beumers 2005; Beumers, Hutching and Rulyova 2008).

In this paper, I develop a novel empirical strategy in order to predict Radio Liberty reception before the elections celebrated on June 11, 1991. The key factor for identification is that shortwave radio propagation depends uniquely on ionization, and at night only on the electron density of the F layer of the ionosphere (Rawer 1993; Yene 1995). In particular, Radio Liberty waves were sent from the station in Platja de Pals[2], traveled through the ionosphere, and if ionization were high enough, the free electrons would reradiate the signal in the F layer at the midpoint between the transmitter and the receiver. In such a case, the ionosphere will behave as a mirror and the waves will be reflected back to Earth at the midpoint between Platja de Pals and the corresponding Russian district at altitudes between 200 and 300 km[3]. Using survey data on listener rates in Russian cities between 1991 and 1993, I find a significant positive relationship between listener rates and ionospheric variation.

I introduce this new methodology since standard empirical strategies used hitherto in this literature to predict radio strength signal, such as the Irregular Terrain Model (Hufford 2002; Olken 2009) exploiting topographic variation, cannot be applied in this setting. The reason for this is that Radio Liberty used the 6, 7, 9, 11, 15 and 17 MHz bands to reach Russia (Padula 2000) whereas the ITM model is only appropriate for frequencies between 20 MHz and 20 GHz (Hufford, Longley and Kissick 1982).

The ionospheric variation is plausibly exogenous and a crucial assumption for my identification strategy is that Radio Liberty signal reception was idiosyncratic conditional on observables. One concern could arise if the technicians of the Radio Liberty infrastructure in Platja de Pals aimed at sending the radio waves only to certain areas such as cities or urban areas. This possibility is, however, ruled out by historical evidence since there was a

[1]Ownership was transferred to the Russian Federation (RSFSR) after the August Coup (1991).

[2]Platja de Pals is a small beach town on the Costa Brava, in the Girona province of Catalonia, Spain.

[3]These altitudes correspond to the ionospheric region where we can find the F layer at night.

whole ray of radio waves sent in order to cover the Russian territory (Channel Effectiveness 1987 Annual Report). The output was targeted on azimuths [4]ranging from 41 degrees to 63 degrees, essentially in a north easterly direction from Pals, to cover the whole area (Padula 2000). My identification assumption cannot be tested directly, but I provide some evidence to support it. To do so, I test a stronger version of the assumption to ascertain whether the ionospheric variation is uncorrelated with the demographics I have in my analysis. Furthermore, I include these demographic variables in my specification to check the robustness of my results, and I also run my specification dropping Moscow and Leningrad from my sample to verify that these areas are not driving the results.

Results using ionospheric variation over 1991, uncover that Radio Liberty had a significant effect on the elections, increasing Yeltsin's vote share, and reducing the aggregate vote share for the communist candidates. In particular, I find that a one standard deviation increase in ionospheric variation increased Yeltsin's vote share by 8.59 percent and reduced aggregate communist vote share by 7.67 percent. Using ionospheric variation from 1988 until 1991, which were those years without jamming practices by the Soviet authorities, I obtain that a one standard deviation increase in ionospheric variation increased Yeltsin's vote share by 9.5 percent and reduced aggregate communist vote share by 8.5 percent. To recover the causal effect of listenership, I use a two-sample two-stage least squares procedure and I obtain that an increase in Radio Liberty listenership by 10 percent, would increase Yeltsin's vote share by 5.39 percentage points and would decrease the aggregate communist vote share by 6.25 percentage points. In addition, a counterfactual exercise, conducted to compare predicted vote shares with and without Radio Liberty, shows that Radio Liberty increased Yeltsin's vote share by 14 percentage points and decreased communists' vote share by 12 percentage points in 1991. I complement my work with survey data from the September 1991 Vox Populi survey, in order to estimate the causal effect of listening to Radio Liberty on Russian politi-

[4]An azimuth is an angular measurement in a spherical coordinate system. The vector from an observer (origin) to a point of interest is projected perpendicularly onto a reference plane; the angle between the projected area and a reference vector on the reference plane is called the azimuth.

cal views. Using listener rates on Russian economic regions and instrumenting with average quality reception of Radio Liberty, I obtain a positive relationship between listenership and both anti-communism and pro-Western attitudes.

I address an important tension of my paper involving the impact of Radio Liberty broadcasts in different years. This is important to resolve empirically because Radio Liberty had been broadcasting to Russia from Spain since 1960. To deal with this issue, I exploit fluctuations over time of jamming practices against Radio Liberty, extending my specification to include ionospheric variation for all years since 1960. My results show that the relevant period to explain regime change corresponds to the years ranging from 1988 until 1991, while I do not find significant effects for those years where Radio Liberty broadcasts were heavily jammed by the Soviet authorities.

I conduct a placebo exercise using ionospheric variation in the period ranging from 1992 until 1995, and I obtain that broadcasts during that period do not explain 1991 electoral outcomes. I also develop a quasi-placebo experiment analyzing the ionospheric effect in the 1996 Russian presidential elections. Yet in those elections I expect Radio Liberty propagation from Platja de Pals to have a smaller effect on the vote share of Yeltsin and the new communist candidate Gennadi Zyuganov, the main reason being that although Radio Liberty was still broadcasting using shortwave frequencies from Platja de Pals, this communication method became much less important since 1993 when Boris Yeltsin rewarded Radio Liberty with AM and OIRT licenses, allowing the station to operate within Russia (see, e.g., Zolotov 2002). Another reason to bear in mind is that in the 1996 elections the two main TV channels, ORT and RTR, were state-controlled and launched a very aggressive pro-Yeltsin campaign (Colton and McFaul 2003; White and Oates 2003). The hypothesis is born out by the regressions, which show that the ionospheric conditions between 1993 and 1996 were not significant in explaining voting behavior in 1996.

I also develop robustness tests to see whether the main results are affected when I include exposure to other Western broadcasts such as the BBC or VOA. My results do not substantially change when including these other Western media.

My paper contributes to the literature on political regime change (De Mesquita, Smith, Siverson, and Morrow 2003; Acemoglu and Robinson 2006), which is an essential part of modern theories of democratization. The paper is also related to the economics literature studying the role of media and information technologies in overthrowing autocratic regimes (Esfandiari 2010; Edmond 2011), and the political consequences of having an informed electorate (Besley and Burgess 2002). The paper is related to the economics literature focusing on the causal effect of mass media on electoral outcomes (DellaVigna and Kaplan 2004; Olken 2007; Enikolopov, Petrova and Zhuravskaya 2011; DellaVigna, Enikolopov, Petrova, Mironova and Zhuravskaya 2014; Adena, Enikolopov, Petrova, Santarosa and Zhuravskaya 2014; Yanagizawa-Drott 20014), and the impact of exposure to foreign media on the economic behavior of agents in totalitarian regimes (Bursztyn and Cantoni 2014). It also contributes to test quantitatively, with the help of econometric techniques, the Cold War Success Story, which posits that the spread of a new liberal regime in Russia and the demise of communism owes a debt to Radio Liberty (Kind-Kovacs 2013; Risso 2013). In addition, this paper can also be connected to the Political Economy literature which studies the success of institutions in winning hearts and minds in unstable countries (Berman, Shapiro, and Felter 2009; Beath, Christia, and Enikolopov 2012). Finally, my paper is also related to the literature which has analyzed, applying statistical methods, which factors were important to explain the radical shift occurred in Russia in the 1991 elections (Myagkov, Ordeshook and Sobyanin 1997; Gehlbach 2000).

The remainder of the paper is organized as follows: Section 2 provides background information on Radio Liberty and political landscape in Russia at the beginning of the nineties. In Section 3, I describe the data. Section 4 explains the empirical strategy and identification. Section 5 presents the main findings. Section 6 and 7 present, respectively, the placebo exercises, and some additional robustness checks. I conclude in Section 8.

2 Background

In this section, I start providing a brief historical overview of Russian politics in the 1991 elections, emphasizing the role and characteristics of each candidate. Then, I concisely explain the history and main events related to Radio Liberty, its relationship with Radio Free Europe, and the characteristics of the shortwave relay of the US Government in Platja de Pals used for Radio Liberty broadcasts.

2.1 Political Landscape

The first presidential elections in Russian history were held on 12 June, 1991. There were six candidates and Boris Yeltsin was the candidate put forward by the anti-communism opposition[5]. Yeltsin's platform included promises of more democracy, further decentralization of authority from the Soviet Union and economic reforms promoting free enterprise. Yet Yeltsin had a communist past since he had spent most of his career as a loyal party functionary in the Soviet regime until he broke away from the Communist Party and started challenging the communist rule in the 80s.

There also were four communist candidates with some notable differences among them: Nikolai Ryzhkov, a Gorbachev loyalist who was the candidate of the Soviet state apparatus, Vladimir Bakatin, who was a moderate communist candidate and the last Chairman of KGB in 1991, Aman Tuleyev, who was at that time a prominent member of the Communist Party of the Russian Federation, and Albert Makashov, who was a nationalist-communist politician. The last candidate was the populist and far-right nationalist Vladimir Zhirinovsky, who could not be classified as either capitalist or communist and whose unsuspected irruption was a large surprise in the elections.

Yeltsin won in a landslide with a vote share of 57.3 percentage points against Ryzhkov (17.2 percent), Zhirinovsky (8.0 percent), Tuleyev (7.0 percent), Makashov (3.8 percent) and

[5] The opposition was made up of a heterogeneous array of movements, including Democratic Russia, the Democratic Party of Russia and the Social Democrats.

Bakatin (3.5 percent). Having obtained more than 50 percent of the votes, Yeltsin did not need a second round. The aggregate of the four communist candidates added up to 31 percent of the votes and some 79 million Russians (74.7 percent of registered voters) went to the polls.

2.2 Radio Liberty Brief History and Political Role

Radio Free Europe (RFE) was created and grew in its early years through the efforts of the National Committee for a Free Europe (NCFE), an organization that was formed in New York City in 1949 and received widespread public support from Eisenhower's "Crusade for Freedom" campaign. RFE was developed out of the belief that the Cold War would eventually be fought by political rather than military means and to counter the appeal that Communism had in some parts of the Western world such as Western Europe. Radio Liberty was Radio Free Europe sister station and whereas Radio Free Europe targeted satellite countries, Radio Liberty targeted the Soviet Union. Radio Liberty was formed by the American Committee for the Liberation of the Peoples of Russia (Amcomlib) and it began broadcasting from Lampertheim (Germany) on March 1, 1953. Nevertheless, in 1959 it started broadcasting from Platja de Pals; this place was chosen because the open seaside vista and the perfect reflecting medium provided by the sea water qualified it as the best possible spot for sending a shortwave signal into the Soviet Union. Shortwave radio comprises all those waves with frequencies between 3 and 30 MHz, called high frequencies (HF). These waves are used by foreign broadcasters to propagate political messages and by radio amateurs, and they are capable of traveling, either with one or multiple hops, from a single broadcasting point to any location on the planet. Shortwaves go to the ionosphere and are reflected back from it to Earth. Hence shortwave is a medium capable of direct communication from one country to listeners in another country without intermediaries and it is primarily used for long-distance communications. Principally, the station's 540-foot towers holding antenna curtains at the sea's edge provided an optimal launching site for shortwave signals.

RFE and Radio Liberty received funds from the CIA until 1972, although Radio Liberty kept a relatively high degree of autonomy. In 1974 both stations came under the control of an organization called the Board for International Broadcasting (BIB). The BIB was designed to receive appropriations from Congress, give them to radio managements, and oversee the appropriation of funds. In 1976 the two radios merged to form Radio Free Europe/Radio Liberty (RFE/RL) and added the three Baltic language services to their repertoire.

The importance of the Radio Liberty shortwave emissions started its decay after the end of Communism in 1991 and the relay in Platja de Pals was eventually dismantled in 2006.

The relevance of the political contents of Radio Liberty and its objectives are reflected in the Moderator's Report contained in the SAAOR internal Radio Liberty report written in 1990, and which can be found in the Hoover Archives. In this report, it is written that "Soviet people need a totally independent radio station, which is not only free from communist propaganda, but also from all the myths engendered by Soviet life and Soviet imagination". This report also emphasizes the role of Radio Liberty as a "sympathetic outsider" expected to reveal information which is not revealed in the USSR.

The possibility that Radio Liberty did have an effect on the 1991 elections is supported qualitatively by different scholars who explain that if Yeltsin became a formidable Russian political figure, it was due in some part to Radio Liberty, which devoted considerable coverage to his pronouncements and political actions from the beginning (Puddington 2003). In fact, McFaul and Stoner-Weiss claim that the best investment the US government made in its efforts to destabilize the Soviet Union was in Radio Free Europe and Radio Liberty because these radios are credited by being one of the West's most effective tools in promoting, what they call, "psychological warfare" against the USSR (Stoner-Weiss and McFaul 2013). Furthermore, some authors have further elaborated on how Boris Yeltsin was hugely indebted to Radio Liberty for backing him in his rise to become the first Russian president of the post-Soviet area and to quell the 1991 August Coup (Dunlop 1995; Kelly 2005). As an example, on the occasion of Radio Liberty's fortieth anniversary in 1993, Yeltsin proclaimed

[6] :"It would be difficult to overestimate the importance of Radio Liberty contribution to the destruction of the totalitarian Soviet regime".

3 Data Sources

In this section I briefly refer to the data sources used in my paper. It is worth emphasizing that all variables are measured at the *raion* level. *Raions* are Russian districts and the smallest territorial unit at which electoral results are available.

Electoral Outcomes: The electoral data of the 1991 elections has been obtained from the web site Electoral Geography 2.0 which had collected the data from the Central Electoral Commission. I use electoral data at the district level. For the 1996 elections I obtain the data from the Central Election Commission of Russia.

Ionospheric Data: I get the ionospheric data from the online interface of the International Reference Ionosphere found at *omniweb.gsfc.nasa.gov/vitmo/iri2012_vitmo.html*. This interface is supported by NASA. I use the International Reference Ionosphere (IRI) model in its 2012 version[7](Bilitza, Rawer, Bossy and Gulyaeva 1993; Bilitza and Reinisch 2007), which was created by NASA Chief Scientist Dieter Bilitza, and it is considered the international standard and the most accurate model to predict ionization. The model uses all available data sources for the ionospheric plasma. This includes the worldwide network of ionosondes that have monitored ionospheric electron density for more than half a century, powerful incoherent scattered radars, and in situ and topside sounder satellites.

Geographic Variables: I pinpoint the coordinates for Russian districts and I compute the midpoint coordinates between each district and Platja de Pals.

Demographics: These variables have been retrieved using the data contained in the last Soviet Census released in 1989, two years before the 1991 elections.

[6]Boris Yeltsin, March 1993, at http://www.rferl.org/about/impact/yeltsin.asp.

[7]This is the most recent version. There are older versions like IRI 2007 and IRI 2001.

4 The Empirical Strategy

In this section, I first explain in detail the ionospheric properties and why they can be used in order to identify the effect of Radio Liberty on the 1991 Russian elections. Subsequently, I provide evidence of the relationship between listenership and ionospheric variation, and I describe the main econometric specification used in this paper.

4.1 Ionospheric Variation and Identification

The ionosphere is the region in the atmosphere where ions exist. In this layer, solar radiation through ultraviolet light is so powerful that when it strikes gas molecules, they split (i.e., they ionize) and an electron is set free. This process is illustrated in Figure 1. These free electrons affect radio waves and constitute the single factor which determines if the HF radio waves will be successfully reflected back to Earth. The interaction is complex but the net effect is to cause an effective decrease in the dielectric constant, which causes the waves to be bent toward Earth. Therefore, to first order, the ionospheric radio effect is proportional to electron density. The process is straightforward: radio waves are re-radiated by the electrons, provided that the ionization level is high enough. In such a case, the vibration of the electrons interact with the radio waves when the latter ones find themselves in a highly ionized region and as a result, the upper part of the radio waves will increase the velocity and the waves will be bent back to Earth.

During the day there are three layers in the ionosphere: the D layer which is the lowest, at altitudes between 50 and 80 km, the E layer found at altitudes between 100 and 125 km, and the F layer. The last is the most important layer for long-distance communications. During the day it splits into two sub-layers called F1 and F2. However, at night the F1 and F2 sub-layers merge into the F-layer which is between 200 and 300 km height. During the day the effect of ionization is not as crucial for various reasons; most importantly, during the day there is a lot of recombination among electrons depending on the sun radiation, while at night the ionization level has already been formed and remains stable. In addition, the D and E layers disappear at night but during the day they absorb radio waves between 8 and 12 MHz, specially if there are a lot of electrons, preventing them from reaching the F layer. This is the reason why shortwave radio can be listened at night much better than during the day. Another reason why we could expect to find larger effects of Radio Liberty at night comes from the September 1991 Vox Populi survey in which they ask all the regular Radio Liberty listeners at what time do they listen to Radio Liberty. Out of 241 listeners drawn from the entire country, 60 percent listen to Radio Liberty between 8 pm and 12 am at night, whereas solely the 8 percent tune in to Radio Liberty between 8 am and 5 pm.

The degree of ionization and electron density in each point of the ionosphere is caused by both seasonal factors and short-term random disturbances. The F layer has, unlike the lower layers, a very high variability due to its strong interactions with the plasmasphere (upper region of the ionosphere). Importantly, the ionospheric variation in this region does not depend on the angle of the Sun. Seasonal variations are the result of the Earth revolving around the Sun. In particular, electrons' formation in the ionosphere is influenced by the Solar radiation during he periodic 27-day Solar cycle. Examples of irregular disturbances during the day are electromagnetic storms, solar flares, and sudden ionospheric disturbances. Ionospheric variation at night depends on ionization during the day and also on other factors such as plasmasphere variation, chemical changes, diurnal heating and cooling, the wind, and electric fields.

Radio Liberty sent its radio waves to Russia in 1991 from its relay in Platja de Pals. During the day, it used the 11, 15 and 17 MHz bands, while at night it used the 6, 7 and 9 MHz bands. At night the waves went to the F layer and at the midpoint between the receiver and each Russian district they would be reflected at the midpoint back to Earth at altitudes between 200 and 300 km, if ionization were large enough. In figure 2, the typical trajectory of a HF radio wave from the transmitter to the receiver is depicted and we can see how the ionosphere behaves as a mirror reflecting the wave back to Earth.

I use Figure 3 to illustrate the ionospheric effect: we can see different radio waves, sent with the purpose of reaching different receivers locations. Radio wave C is in a poorly ionized region. The strategy of measuring the ionospheric conditions at the midpoint is supported and further explained in the books *Ionospheric Prediction and Forecasting* (2014) by Bruno Zolesi and Ljiljana R. Cander, and *Dictionary of Geophysics, Astrophysics, and Astronomy*(2001) edited by Richard A. Matzner. Importantly, small ionospheric changes could drive large effects in radio reception. Anecdotal evidence underscoring the importance of the ionosphere for these broadcasts is conveyed in the statements of the spokesman of Radio Liberty in 1989, Robert Redlich, claiming that similar effects of jamming could be caused by sudden changes in solar activity, which can hamper radio reception (Baltimore Sun, March 15,1989).

In order to measure the relative weight of seasonal and irregular factors, I regress Russian ionospheric variation in 1991 at noon and at 9 pm on fourth-order polynomials of latitude and longitude at the midpoint between the transmitter and the receiver. The R-squared is 0.9520 at noon and 0.7142 at night.

The ionospheric model predicts that for those Russian districts where the ionization level at the midpoint between the district and Platja de Pals is high at night, the Radio Liberty waves will be most likely reflected and will reach the corresponding district, while for those districts where ionization is low at the midpoint, the radio waves will not be, with a high probability, reflected and will not reach the corresponding district. This gives me a measure which proxies for the availability of receiving the radio broadcasts in each Russian district. The next step is to estimate whether in those places where ionization predicts good Radio Liberty reception, there will be an increase of Yeltsin's vote share vis-a-vis the districts with poor radio reception. Specifically, I pinpoint the midpoint between each Russian district and Platja de Pals and for each district I use the IRI 2012 model to find the predicted vertical electron density, also called total electron content (TEC), measured in TECUS[8]in the iono-

[8]One TECU are 10^{16} electrons per meter squared.

spheric region between 200 and 300 km, which is the region where the Radio Liberty HF radio waves were traveling at the midpoint. This variable measures the number of electrons integrated between 200 and 300 km along a tube of one meter squared cross section.

In my preferred specification I use ionospheric data at night. In particular, I calculate average electron density in 1991 at 9:00 pm local hour[9]. Given the different time zones, this means that the HF radio waves reached[10]the majority of Russian districts at 11:00 pm.

As ITM models, which exploit topographic variation to estimate the signal strength of radio waves, cannot be applied for HF waves, and there are technical difficulties in adapting the existing HF propagation models[11]to this particular setting due to the singular properties of the antenna system (Kershner 1968) of the relay station, my empirical strategy is seemingly the only feasible approach in this context to account for variation in Radio Liberty reception. Nevertheless, this ionospheric model only applies to single hop paths which are those going straight from the transmitter to the receiver. There are also multi-hop paths, for which those waves which have returned to Earth from the ionosphere are returned back to the ionosphere thanks to the Earth's surface acting as a reflector. My analysis does not apply to those more complicated cases. Since the maximum distance that these waves can travel in single paths is 4800 km, (Mann 2005; Magnani 2014) I drop observations which are at distances farther than 4800 km from the transmitter, corresponding mainly to regions located in Eastern Russia[12].

Radio Liberty reached Russia with single hop paths up to approximately that distance but we cannot discard the possibility that after a particular wave had reached Russia for the first time, it could be reflected again and reach farther regions on Russian soil subsequently. This is a limitation of my empirical strategy although the signal strength of the first hop is

[9]I check that results remain very similar if I use one or two hours before that time.

[10]The wave goes from the transmitter to the receiver in only a few seconds, almost instantaneously.

[11]Examples of HF models are VOACAP and IONCAP

[12]This does not constitute a major setback since the majority of the Russian population lived in Western and Central Russia. As a matter of fact, I initially had 1770 observations and after restricting my sample, I end up with 1279 observations.

always the largest and each subsequent hop results in a lower signal level[13]. This implies that even if the districts in Eastern Russia could receive the signal of Radio Liberty, the signal was attenuated[14]. Importantly, districts in my sample were reached by Russian broadcasts exclusively via single-hop paths because subsequent paths[15]travel similar distances to the first hop, implying that the Westernmost Russian district potentially reached via second hops would be at a distance farther than 5000 kilometers from the relay station, whereas my sample only covers distances up to 4800 kilometers.

Summarizing, my identification strategy relies on the assumption that Radio Liberty availability through the ionospheric effect was idiosyncratic conditional on observables.

In Figure 4, I plot the ionospheric data at night over the year before the elections matching it to the location of the corresponding Russian district and the plot displays that my sample covers all geographical areas in Western and Central Russia.

4.2 The Relationship Between Listenership and Ionospheric Variation

To ascertain whether there is a positive correlation between listening to Radio Liberty and ionization, I collect data on listener rates in Russian cities (I have 30 observations in total) from all the surveys[16]on Radio Liberty available in the Hoover Archives between 1991 and the start of 1993[17]. I only consider those cities[18]where the broadcasts could be reached from the relay station, and I gather listener rates for the days in which each sample was

[13]See this information in detail at www.blackcatsystems.com.

[14]As a matter of fact, Radio Liberty broadcasted from Taiwan between 1955 and 1973 in order to reach with a single hop eastern parts of Siberia and the Maritime Provinces of the Soviet Union. However, the agreement between Radio Liberty and the Broadcasting Corporation of China (BCC) was ended in 1973 and this made the reception of Radio Liberty in the USSR's Far East much more difficult from then on.

[15]There is a comprehensive analysis of multi-hop paths at http://www.ips.gov.au.

[16]These are the Vox Populi Surveys in August and September 1991, the BBC Central Russia Media Survey conducted in November 1991, and the RIOM surveys conducted in January 1992, and May 1993.

[17]Since for the Omnibus Surveys conducted in September 1991 and February 1992 there is only aggregated data by region, I back out for these two surveys estimates for each city using the average listener rates obtained for different city sizes and villages, and taking into account the demographic features of the different cities surveyed in each region. Hence, this data comes with some measurement error.

[18]The sample includes the majority of medium and large size cities in Western and Central Russia.

conducted. Then I compute the correlation between short-run listener rates and ionization at night in order to appraise how the first stage would fare. The Pearson coefficient is 0.225 and this positive correlation can be attested in Figure 5.

I also run an OLS regression of listener rates on electron density clustering the standard errors at the city level. I also include the coordinates of each city and distance to the transmitter logged. I get a strong positive effect of ionization on listenership: the coefficient is 1.17 and it is significant at 5 percent level, as we can observe in Column 1 of Table 1. In Column 2, I fully exploit the panel including city fixed effects[19], to take into account intra-city variation, and a variable measuring in which month each survey was conducted to take into account seasonal effects. The new coefficient is larger than in Column 1 and significant at 10 percent level, and the first stage is strong.

Finally, I do an additional exercise to measure the relationship between listener rates and Radio Liberty availability, using the first Russian survey conducted after the 1991 presidential elections[20], the RSFSR Vox Populi Survey, carried out between September 5 and September 19, 1991, just after the coup attempt which took place in Moscow in August. Two-thousand individuals were surveyed and the results are disaggregated at the region level. I have a sample of 12 observations corresponding to the 12 economic Russian regions[21]. These regions cover the entire Russian territory. Using the listener frequencies in the survey for each region, I collect listener rates for each region and I instrument this variable with the average quality of the broadcasts in each region, obtained in the same survey. This variable is measured as follows: in each region, they asked Radio Liberty listeners to assess the quality of Radio Liberty reception in a 1-5 scale. I also use as an additional instrument average distance

[19]Some cities appear more than once since they were studied in different surveys.

[20]The only existing survey on Radio Liberty listenerhip carried out at the Russian level before the June Presidential elections was the Vox Populi Survey conducted between 14 and 28 February, 1991 with a sample size of 1989 Russian citizens. Unfortunately, the tables for this survey on the Hoover Archives only display aggregated data but not data at the city level, which is not available. Furthermore, the questions for Radio Liberty in this survey have a 88.5 percent of respondents in the category "not available/error".

[21]These are Moscow Region, North-West RSFSR, North RSFSR, Central RSFSR, Volga Vyatka, Central Chernozem, Volga Region, North Caucasus, Ural Region, West Siberia, East Siberia and Far East. Unfortunately, the raw data has been untraceable thus far.

logged between each region and the Pals relay station, taking into account the distances from the relay station to the cities sampled in each economic region

The first stage is strong and the Radio Liberty reception instrument is significant at 5 percent level with a coefficient of 10.92, as we can see in Table 2. The distance instrument is also significant.

In conclusion, these exercises suggest that there is indeed a positive relationship between listenership and ionization, where the latter captures Radio Liberty availability.

4.3 The Econometric Specification

The baseline empirical specification is the following:

$$Vote\ Share_{d,1991} = \beta_1 Electron\ Density_{mdpt_d,1991} + X'_{d,1989}\beta_2 + \phi'_d\delta + \alpha_r + \epsilon_d \quad (1)$$

My dependent variable is the vote share for Yeltsin in district d in 1991, the vote share for the communist contenders, or the vote share for Zhirinovsky. I use the last one as my "placebo" candidate: nobody expected him to secure a good score in the elections and he was marginalized by the media, so I do not expect to find much of a sizable effect of Radio Liberty on his vote share.

My ionospheric variable is electron density at the midpoint between Platja de Pals and the district at altitudes between 200 and 300 km in 1991 until June 11, which is election day. Therefore I use cross-sectional ionospheric variation carrying both short-run and long-run variation. I expect β_1 to be negative when the dependent variable is the communist vote and positive when it is Yeltsin because the mechanism is:

Higher electron density→ Higher ionization→ Higher probability to receive Radio Liberty→ More votes for Yeltsin.

The vector $X_{d,1989}$ embeds the demographics of the 1989 Soviet Census for each district[22]. The only variables disclosed by the Census were total population[23], percentage of men,

[22]Unfortunately, there is no data on GDP or wages by raion in that Census.
[23]I use logged population, as it is customary in the literature.

and percentage of urban population. By including these additional control variables, I lose about 400 observations for which there is no data on demographics but I check that the remaining observations are still scattered throughout the entire country. In my complete specification, I also include fourth-order polynomials of the control variables in order to allow for more flexible functional forms.

The vector α_r embeds *oblast* (i.e., region) fixed effects[24]. This is particularly important to ensure that the ionospheric variation is not absorbing variation related to some kind of unobserved heterogeneity at the region level. In addition, I include in vector ϕ_d the coordinates for each district and logged distance to the transmitter, Moscow, Leningrad, and Kiev in order to further control for geographic variation.

Finally, I use robust standard errors clustered by region[25]to account for the geographic clustering of radio reception. In Appendix 1, I present results for the main specification using spatial standard errors as an alternative[26].

I use a second specification, averaging electron density over the period ranging from 1988 up to the 1991 elections. I focus on this period since 1988 was the first year where jamming practices were removed by Gorbachev in order to implement the timid reforms associated with *glastnost*[27]. Jamming practices[28]on Western broadcasts had been rife between 1950 and 1987, featuring a Soviet network of 200 large skyway jammers that bounced high-powered shortwave signals off the ionosphere, and tens of thousands of additional transmitters to interfere with radio signals (Schmemann 1988).

[24]In the data, I have 54 regions. They correspond to the territorial units in the former Soviet Union for Russian territory.

[25]If I just use robust standard errors, the standard errors are much more lower due to positive intra-cluster correlation. Hence, the estimates presented in this paper are fairly conservative.

[26]There might be a case for using those spatial standard errors throughout the paper. However, I use standard errors clustered at the region level since they are larger. Therefore, my criterion is to use the most conservative standard errors when showing the main results.

[27]In the former Soviet Union, glasnost was the policy or practice of more open consultative government and wider dissemination of information, initiated by leader Mikhail Gorbachev from 1985.

[28]Those practices were very expensive and it was estimated by Radio Liberty officials to cost more than $1 billion a year.

5 Results

In this section, I present the main results of the paper.

5.1 Initial Exogeneity Checks

My identification strategy relies on the premise that voters in the locations with good and bad exposure to Radio Liberty are similar in all unobserved characteristics that may account for voting behavior once I control for observable characteristics between these locations. Nevertheless, it could be worthwhile to explore whether the ionospheric variation satisfies a stronger version of the main identification assumption and it is uncorrelated with the observable demographic variables. To ascertain if this is the case, I regress in Table 3, the average midpoint electron density in 1991 at 9:00 pm local hour, on the socioeconomic variables of the 1989 Soviet census, which are logged population, percentage of urban population and percentage of men in each district. The regression includes region fixed effects and the geographic variables. The coefficients are not significant at 5 percent level. Furthermore, I do an F-test to elucidate if the control variables are jointly significant. I fail to reject the null that socioeconomic variables have a zero impact on ionization.

5.2 Benchmark Results

In this part of the paper, I summarize the findings obtained when I estimate the model described in equation (1) using my measure of electron density in the F layer at night, averaging over 1991 up to the elections. In Table 4, I report the results for Yeltsin. In Column 1, I regress his vote share on electron density including region fixed effects and geographic characteristics. I find a positive and significant effect of electron density on Yeltsin's vote share. The magnitude is difficult to gauge a priori[29]but a possible interpretation is that if there were a uniform increase in electron density of 0.1 TECUS along a tube of one meter

[29]Unfortunately, I do not have disaggregated data on turnout in 1991, preventing me from computing persuasion rates.

squared cross section between 200 and 300 km at the midpoint in the F layer at night, Yeltsin's vote share would increase, on average, by 14.28 percentage points. The reason for this increase would be an improvement in the reflection of the radio waves in the ionosphere and consequently, an increase in the availability of Radio Liberty in Russia.

In Column 2, I also include total logged population, the percentage of male population and the percentage of urban population to verify the robustness of the results. Note that as outlined in Section 4, the sample size is reduced by almost 400 observations due to the lack of comprehensive data on socioeconomic variables in Russia before 1996. In the new regression, the effect of electron density is positive, and significant at the 1 percent level. Interestingly, I find a positive and significant effect of the percentage of urban population and total population on Yeltsin's vote share. The importance of the urban-rural dichotomy in those elections and the chasm between these two types of productive structures in terms of political views, with urban areas in favor of Yeltsin and rural areas more reluctant to usher in a change in the status quo, has already been emphasized by some scholars (see, e.g., Myagkov, Ordeshook and Sobyanin 1997, who also use data at the district level, or Gehlbach 2000), so my findings further support this fact. Finally, in Column 3, I further probe the robustness of my results by including fourth-order polynomials of the control variables. The coefficient of electron density is again significant and its magnitude very similar to Column 2.

In Table 5, I perform the same exercise but using the aggregate communist vote share as my dependent variable. I obtain in the different specifications a negative and significant effect of electron density on communist support. In Column 1, with the whole sample, we can see that if there were a uniform increase of 0.1 TECUS along a tube of one meter squared cross section between 200 and 300 km at the midpoint in the F layer at night, the aggregate communist vote share vote would be reduced, on average, by 12.74 percentage points. In Columns 2 and 3, I run the same regression but including the socioeconomic variables. Results are significant, and we also see that communist candidates gleaned more votes in rural and less populated areas.

In Table 6, I perform the same exercise but analyzing Zhirinovsky's vote share. I use this politician as my placebo candidate to estimate the impact of Radio Liberty. In the three columns we see that the magnitudes of the electron density coefficient are almost negligible and the confidence intervals very wide. Finding no effects for this populist, and difficult to situate in the classical 0-1 line, candidate is consistent with what I initially surmised about the role of Radio Liberty in those elections dominated by a polarized debate whose focal point was the communist legacy.

In Table 7, I run the same regressions but using average ionospheric variation between 1988 and 1991 until election day, which comprises the entire post-jamming period until the elections[30]. I expect to obtain sizable effects due to the absence of jamming and because many important political events [31] involving Yeltsin and the balance of power between the advocates of a new regime and the authorities of the Soviet regime, occurred over those years. Results confirm this hypothesis showing a positive significant impact on Yeltsin and negative impact on communists' slates.

In the Appendix, I show the main regressions' estimates when using spatial standard errors. The new standard errors are, if anything, smaller, so the same conclusions apply.

5.3 Comparison of the Magnitudes

A more relevant comparison can be obtained when I scale the coefficient by the variation in Radio Liberty availability in the sample[32]. The estimates imply that for 1991, a one standard deviation increase in the ionospheric variation increased Yeltsin's vote share by

[30] I have also used a specification separating average electron density between 1988 and 1990, and electron density in 1991. These two variables are not significant due to large standard errors. My interpretation is that due to their strong correlation (Pearson coefficient is 0.81) this regression is not able to distinguish separate effects. Besides, these two variables carry short-run and long-run ionospheric variation, so it is not surprising that the two variables neutralize each other.

[31] Some of these events before 1990 include Yeltsin's demotion in the Communist Party in February, 1988, his constant attacks against Gorbachev for the slow pace of Soviet reforms, and the smear campaign against him led by Gorbachev lieutenant, Yegor Ligachev. In 1990, I highlight as major events the declaration of sovereignty of the RSFSR in June, and Yeltsin definitive resignation from the CPSU in July.

[32] This procedure has already been used in this literature, see for example Yanagizawa-Drott (2014).

8.59 percent and reduced the aggregate communist vote share by 7.67 percent. When I perform a similar exercise using average 1988-1991 variation, I obtain larger estimates than when I focus solely on 1991. In particular, I obtain that a one standard deviation increase in the ionospheric variation increased Yeltsin's vote share by 9.5 percent and reduced the aggregate communist vote share by 8.5 percent.

5.4 Interpretation: Two-Sample IV and Counterfactual Analysis

Interpreting the magnitude of the coefficients is not straightforward, but two additional exercises might help do so. The first one is to use a Two-Sample Instrumental Variables Procedure to directly retrieve the causal effect of listenership on regime change. In particular, my first sample is the one used for the reduced-form results presented in Section 5.2 for 1991, while my second sample, which is used for the first stage, was introduced in Section 4.2 and includes listenership data from the surveys. In Appendix 2, I explain step-by-step how this two-stage approach works. This exercise has many caveats but it might still be useful to obtain an estimate which approximates the causal effects of Radio Liberty listenership. One apparent limitation is that listenership data in the surveys is measured after the 1991 elections, so we must assume that those listener rates are correlated with listener rates in the relevant pre-elections period. Another important limitation is that the first sample uses cross-sectional ionization variation averaging over almost six months, while in the second sample ionization is measured over a short interval of time, corresponding to the days of the survey.

Using the two-sample two-stage least squares (Inoue and Solon 2010) estimator, which is a more efficient variant of Angrist and Krueger's Two-Sample IV estimator, I obtain that a 10 percent increase in Radio Liberty listenership, implies an increase of 5.39 percent in Yeltsin's vote share and a decrease of 6.25 percent in the aggregate communist vote share. For this exercise, I instrument Radio Liberty listenership with ionization and the geographic variables, as shown in the first column of Table 1.

The second exercise which might help interpret the magnitudes of the estimates is a counterfactual analysis in the absence of Radio Liberty broadcasts. To do so, I construct the predicted probability that Radio Liberty reaches each Russian district using the empirical cumulative distribution in my sample. Then, I predict voting results in the counterfactual scenario of zero Radio Liberty availability in all districts, by estimating the main specification with the full set of covariates set to their mean values in the sample, with the exception of Radio Liberty availability, which is set to zero. I compare this to the predicted vote at the mean value for all the covariates including Radio Liberty. This calculation implies that, as a result of Radio Liberty broadcasts, Yeltsin's vote share increased by 14 percentage points while the aggregate communists' vote share decreased by 12 percentage points. These findings are noteworthy because they suggest that in the absence of Radio Liberty broadcasts, Yeltsin, who got 58.6 percent of votes in the elections, would have scored below the 50 percent threshold required to avoid a second run. In other words, this counterfactual exercises indicates that without Radio Liberty broadcasts, a second round would have taken place, facing off Yeltsin and communist runner up Ryzhkov.

5.5 Survey Evidence: The Causal Effect of Radio Liberty Listenership on Russian Political Views

In this part of the paper, I evaluate the causal impact of Radio Liberty listenership on Russian political views with a standard Instrumental Variables procedure. Therefore, this exercise is a good complement to the two-sample two-stage approach explained in Section 5.4.

For this exercise, I use the first-stage between listener rates and Radio Liberty quality reception in the 12 Russian economic regions, which was introduced in Section 4.2 and presented in Table 2, to obtain the fitted listener rate values. These fitted values are used to evaluate the causal effect of listening to Radio Liberty on the percentage of respondents who support liberal anti-communist ideas. The predicted listenership coefficient is positive and in Figure

6 there is a figure showing the positive relationship between liberal anti-communism and fitted listenership. Since I only have 12 observations, these results are to be taken with caution but they suggest that listening to Radio Liberty had a positive impact on Russian views about the new political regime.

I also analyze the Radio Liberty listenership impact on a variable measuring how much the respondents like the West; this variable takes into account the answers to the question "The West wants us to fail", and captures the degree of likeability towards the West. The predicted listenership coefficient is positive and in Figure 7, we can see the positive relationship between Western support and fitted listenership. This figure suggests that Radio Liberty had a positive impact on the pro-Western attitudes of Russian citizens.

In Table 8, the estimates of the second stage are shown. In this table, we can see that the fitted coefficients are positive, and particularly large for liberal anti-communism.

6 Placebo Tests

In this section, I present different placebo tests conducted in order to check the validity of my findings. First, I extend my specification to study the impact of Radio Liberty broadcasts when broadcasts were jammed. I exploit fluctuations of jamming over time documented by the historical evidence. Then, I conduct a placebo test using ionospheric data after the 1991 elections. Finally, I run a quasi-placebo test focusing on shortwave Radio Liberty in the next Russian Presidential elections held in 1996.

6.1 Extended Specification and Jamming Before 1988

In this part of the paper, I look into pre-1988 effects to test whether in intense periods of jamming, Radio Liberty impact on the 1991 elections is mitigated. This is related to the existence of an inherent tension in the paper stemming from the fact that Radio Liberty had been broadcasting to the Soviet Union from Platja de Pals during more than thirty years, since 1960. This implies that it is possible that the perceptions of Russian citizens had already been changed before 1991 and previous broadcasts had already been successful in changing Russian beliefs. In order to resolve this tension empirically, I include in specification (1) average yearly ionospheric variation at night using all the years between 1990 and 1960, and also keeping variation for 1991 up to the elections. Therefore my extended specification is:

$$Vote\ Share_{d,1991} = \beta_1 Electron\ Density_{mdpt_d,1991} + \beta_2 Electron\ Density_{mdpt_d,1990} + ... + \beta_{31} Electron\ Density_{mdpt_d,1960} + \phi_d^{'}\delta + \alpha_r + \epsilon_d \quad (2)$$

Since seasonal factors are important for ionospheric variation, this extended specification is likely to be afflicted by collinearity problems due to high correlation between ionospheric variation for different years, rendering the magnitudes of the coefficients unreliable, but this is still a useful exercise to assess the importance of Radio Liberty exposure. In Table 9, I show the correlation matrix of electron density at night between 1985 and 1991, where I use for 1991 data between January and the June elections. As we can see, the correlation is strong, specially for adjacent years.

In Table 10, I perform four joint tests, using the aggregate communist vote share as the dependent variable[33]. The first one tests the null of no impact of Radio Liberty broadcasts on the 1991 elections, during the post-jamming period, which comprises years between 1988 and 1991 elections up to the elections. The F statistic is distributed under the null as an F(4,52), and I reject at the 5 percent level that these broadcasts have a zero effect on the elections. This is consistent with the results of the main specification presented in Section 5.

The second test analyzes the impact of broadcasts in 1962 and 1963. I choose this time span, since jamming was particularly intense over this period due to the Cuban Missile Crisis (Mikkonen 2010). I fail to reject the null of a zero impact. I conduct a similar test for years between 1968 and 1973. Those were years characterized also by very acute jamming

[33]Similar results get through with Yeltsin's vote share as the dependent variable.

following the outbreak of the Prague Spring in 1968. Jamming was reduced in 1973, when Henry Kissinger became secretary of state of the US. Again, I cannot reject the null of no impact of Radio Liberty during this period on 1991 electoral outcomes. Finally, I test the null of no effects of Radio Liberty between 1981 and 1987 on the 1991 elections. This period of time is interesting because it starts when Ronald Reagan became President of the US and ends the last year of jamming. The reason to focus on Reagan Administration is that Ronald Reagan urged Radio Liberty to be more critical of the communist regimes (Puddington 2003), plausibly triggering more severe jamming practices. I do not appreciate important effects of Radio Liberty for those years either.

In the bottom part of Table 10, I report the coefficient of average electron density between 1988 and 1991 when controlling for yearly ionospheric variation between 1960 and 1987 [34]using the communist aggregate vote share as the dependent variable. The new coefficient is larger than in Table 7 but still significant at 5 percent level.

6.2 Placebo Tests Post-1991 Elections

In this section I analyze the impact of Radio Liberty broadcasts after 1991 on the 1991 elections. This is a placebo test implemented to check that broadcasts targeting Russia after the celebration of the elections, do not matter to explain electoral outcomes in 1991. To this end, I modify my baseline specification, and I include ionospheric data for 1988, 1989, 1990, 1991[35], 1992, 1993, 1994 and 1995. In particular, I regress electoral outcomes in 1991 on two ionospheric variables. The first variable is average ionospheric variation between 1988 and 1991 up to the elections, while the second regressor is average ionospheric variation between 1992 and 1995. I include, as in all the regressions, oblast fixed effects and I control for geographic factors. Results are presented in Table 11. The variable related to Radio Liberty

[34]Due to the strong correlation of yearly variation between 1988 and 1991, the individual coefficients are not precisely estimated and not very meaningful. The estimates in specification (2) are -2.65 in 1991, -2.02 in 1990, 2.04 in 1989 and -10.02 in 1988. The only significant coefficient corresponds to year 1988 while the coefficient for 1991 has a p-value of 0.14.

[35]Variation in 1991 is measured only for those days before the elections.

availability for 1988-1991 is significant at 5 percent level with a similar magnitude as in the baseline regression shown in Table 7. In contrast, I do not find significant effects for the post-elections exposure measured between 1992 and 1995.

6.3 Quasi-Placebo Test Using 1996 Russian Elections

Here, I present the findings related to the 1996 Russian presidential elections, which were the second Russian presidential elections after 1991. In the first round of those elections there were several candidates: The most important ones were Yeltsin and his communist rival Gennadi Zyuganov, though there were other significant candidates such as General Alexander Lebed (centrist and nationalist), Grigory Yavlinsky (liberal), Vladimir Zhirinovsky (populist), and Mikhail Gorbachev (former communist). None of the two candidates who gathered more support in the first round, Yeltsin and Zyuganov, reached the 50 percent threshold, and a second round, in which Yeltsin soundly defeated Zyuganov, was held two weeks later. As explained in the introduction, I expect a more nuanced and less important effect of Radio Liberty on the 1996 elections, which were the second presidential elections in Russian history. There are two reasons for this. First, Russians could listen to Radio Liberty and enjoy a better reception by tuning both to the OIRT[36]and AM (i.e., medium wave) frequency bands, granted by Yeltsin in 1993 to Radio Liberty. This is a subtle point because this historical event does not tell us that Radio Liberty was irrelevant in those elections insofar as it could be listened within the country but it does suggest that the importance of the shortwave broadcasts from Platja de Pals will not be as salient as in 1991. This is shown in the April 1993 RISC survey in which 55 percent of the respondents listened to Radio Liberty via shortwave, while 20 percent listened through the OIRT bandplan, and 8 percent via medium wave. The other reason to be considered is that the two main TV channels in

[36]This is an FM broadcast covering the 87.5 to 108 MHz and it was used from 1993 onwards in all the former communist countries prompted by the expansion of broadcasting and the modernization of existing transmission networks, using new or second-hand transmitters from Western countries, together with a general desire for standardization with the West.

1996, OTR and RTR[37], launched a very aggressive campaign praising Yeltsin and smearing the Communist candidate Zyuganov, and this media effect could most likely overwhelm any other type of media such as radio broadcasts. This last point is consistent with empirical evidence showing a decay of shortwave radio in the former USSR after the communist regime demise (Parta 2011).

In Table 12, I regress the vote shares of Yeltsin and Zyuganov in each round of the elections on the average electron density at night in 1996 before the corresponding election day using the same procedure as in 1991. In all my regressions I use region fixed effects and I additionally control for the same geographic variables as in Section 5. As we see in the four columns, the effects of Radio Liberty on 1996 electoral outcomes are, as expected, smaller in magnitude and non-significant. However, the signs of the coefficients are still positive for Yeltsin and negative for Zyuganov in both rounds, consistent with the expected signs and the 1991 results. This quasi-placebo exercise suggests that the importance of the shortwave broadcasts from Platja de Pals had already faded away in 1996 and that other factors were possibly more important in explaining electoral results in those elections. In Table 13, I run the same specification but using average electron density between 1993 and 1996 up to the elections. The point estimates are not significant either.

I conclude that the 1991 elections were, for a wide array of reasons, quite unique and different from any other elections held later in Russia since they were key to consolidate the substitution of the former communist regime by a new political regime. This argument has already been developed by some scholars (e.g., Gehlbach 2000) who show the weak correlation of electoral results in 1991 and 1996.

I also run the same specification, including ionospheric variation in 1991. I find no effects[38]of this additional regressor on the 1996 elections, which is consistent with Russian citizens having updated their political beliefs in 1996.

[37]Anecdotal evidence suggests this was indeed the case, as the day before the Election Day in the first round, the three state TV channels broadcasted three anti-communist movies about the Stalin era repressions during prime time. *hemeroteca.lavanguardia.com/preview*/1996/06/17/*pagina* − 4/33958958/*pdf.html*.

[38]Tables omitted but available upon request

7 Robustness Tests

I present some additional results in this section in order to examine the robustness of my findings.

7.1 The Other Western Media: BBC and VOA

Radio Liberty was not the only foreign station which used shortwave radio in the Cold War and in 1991 to broadcast to Russia. The other two main radios broadcasting to Russia were the British Broadcasting Corporation (BBC) and Voice of America (VOA). An interesting question is whether the Radio Liberty impact on Russian regime change, highlighted thus far in this paper, is absorbing variation related to other Western broadcasts.
However, it is not clear a priori if those other broadcasts also played a role as important as Radio Liberty. One feature shared by both BBC and VOA is that they had less political content than Radio Liberty in their emissions. This is related to the fact that these stations are the official radio stations of the UK and US Governments respectively, so they had to be a bit more cautious in their analysis. Radio Liberty, instead, received funds from Congress but always maintained a strong sense of autonomy (Puddington 2003) to choose the contents and the general tone. These considerations are born out by the SAAOR surveys. In 1985 SAAOR carried out surveys among Soviet travelers to appraise their motivations for listening to Western radio broadcasts. Their primary reason was the desire to hear uncensored news, followed by the need to obtain information not available from sources within the USSR (Parta 2007; Parta 2011). Another important motive was to verify or disprove information already received from the Soviet media. Seeking entertainment was also a motivation for listening but only for 20 percent of the respondents versus the 77 percent concerned about information and news. In addition, respondents singled out Radio Liberty for its coverage of the USSR and for how it was also used as a way to verify domestic Soviet information. VOA was cited for its coverage of the West and its entertainment programs such as jazz music

shows while BBC was noted for its objectivity. However, hearing the official viewpoint, a category reserved for government-sponsored stations such as BBC and VOA, was important to only one in seven listeners. Finally, according to the 1990 Annual Reach of Western Broadcasters to the USSR developed by SAAOR, Radio Liberty was listened by 20 percent of population, VOA by 15 percent and BBC by 8 percent.

In order to incorporate these Western broadcasts into my analysis, I pinpoint the location from where BBC and VOA were broadcasting in 1991. The BBC transmitter site was located at Woofferton, south of Ludlow, Shropshire, England. The BBC's Russian Service broadcast from Woofferton since 1946 and emissions came to an end in 2011 after some budgetary cuts. Interestingly, the BBC leased some of its capacity at Woofferton to VOA during the Cold War and the 90s (Shacklady, and Ellen 2003; Cant 2006). Thanks to this lease, VOA enhanced its signal to the Eastern bloc. Thus, both BBC and VOA were broadcasting to Russia in 1991 from the transmitter station at Woofferton.

Then, I compute electron density in the F layer at the midpoint between Woofferton and each Russian district in 1991 before the presidential elections and I include this additional regressor in my baseline specification. Doing so adds robustness to the main results. Results are summarized in Table 14, in which I include electron density at the midpoint for both Radio Liberty and BBC&VOA broadcasts. In Columns 1 and 2, we can see that the estimated coefficient of Radio Liberty's electron density is significant at 1 percent level both for Yeltsin and the sum of the communist candidates, with the expected signs. We also see that electron density for BBC and VOA had a positive impact on Yeltsin's vote share and a negative one on communist slates, but the effect is not statistically significant at 10 percent level, albeit not far from it.

I conclude that shortwave radio broadcasts by Radio Liberty had a noteworthy impact on the 1991 Russian elections and regime change, even controlling for other Western broadcasts.

7.2 Leaving Out the Largest Urban Areas

In the years in which Soviet authorities used jamming practices to endeavor to prevent Radio Liberty from reaching the Soviet Union, the technicians in Platja de Pals combined sometimes, when those practices were more intensive, the six transmitters into a single one in order to send a very powerful signal to Moscow, Kiev, and Leningrad, which were the most important cities in the Soviet Union. This procedure was used to overcome jamming practices and still reach the Soviet Union. Jamming practices were ended with the *glasnost* in the 80s and since then, Radio Liberty launched radio waves in all directions to cover the largest possible amount of Russian areas via single hop paths[39]following its 1987 modernization plan. However, to test that this was indeed the case and that my results as of 1991 are not being driven by Moscow and Leningrad, I drop all the districts corresponding to Moscow and Leningrad as well as the surrounding districts located at distances less than 20 kilometers from those cities. In Table 15, I show the new results for Yeltsin and the communist electoral outcomes after removing those places from my sample in 1991. We can see in all the columns that results are significant and similar to the exercise including both Moscow and Leningrad. This rules out that the significance of the ionospheric variable is being driven by the two largest urban areas in the Russian Federation.

7.3 Additional Tests

In Table 16, I compute electron density at altitudes between 200 and 300 kilometers at 12:00 and 9:00 pm local hour using cross-sectional variation over the two months before the elections. I use short-run variation because electron density at noon depends heavily on solar radiation, so taking the average over the whole year would cancel out any possible effects as solar radiation is very different in the winter and spring. At noon, as explained in Section 4, most radio waves are absorbed in the first place by the D and E layers, which

[39]These waves could travel further and reach Eastern Russia on second and third bounces, as I explain in Section 4.

are not present at night. Moreover, during the day the electrons are constantly colliding and recombining, while at night ionization has already been formed and remains stable. In Columns 1 and 2, we see that the impact of electron density on 1991 electoral outcomes at night is significant. In Columns 3 and 4, we see that electron density at noon is not significant, despite having signs which are consistent with the theory. In Columns 5 and 6, I include both electron density at noon and at night. We see that while electron density at noon remains insignificant at 5 percent level, electron density at night is significant and much larger in magnitude. This finding is in line with the ionospheric model outlined in this paper and the better propagation of HF radio waves at night.

Finally, I plot in Figures 8 and 9 the residuals of my model against the fitted values when I regress respectively Yeltsin and the communist vote share on the baseline regressors. I do not observe any abnormal pattern such as any noteworthy outliers to take into account.

8 Conclusions

This paper uses econometric techniques to estimate the causal effects of Western radio on regime change in Russia in the beginning of the nineties, focusing mainly on Radio Liberty broadcasts, which reached Russia via shortwave. In particular, I document the effects of Radio Liberty on voting outcomes in the first democratic elections in Russia held in 1991. Since shortwave radio's main usage is precisely to export political messages and values of countries willing to spread their area of influence and become important beyond their borders, this seems a powerful tool through which free media can accelerate regime change and prevent the rulers of a given regime from perpetuating the political system they wish to keep. My empirical strategy is new and uses variation in the ionospheric parameters responsible for the propagation of Radio Liberty in order to construct a measure which proxies for Radio Liberty exposure. This strategy allows me to estimate the impact of Radio Liberty, circumventing both the paucity of high-quality geographic data on listener rates and the endogeneity biases inherent in survey-based studies.

My regressions show that Radio Liberty had a significant positive effect on Yeltsin's vote share, and a negative significant effect on the communist aggregate vote share. The interpretation is that in those places where Radio Liberty signal was received, thanks to good radio propagation through the ionosphere, Yeltsin vote share increased and the communist support declined. I interpret these results as Radio Liberty being an important catalyst for regime change. A counterfactual exercise suggests that Radio Liberty broadcasts were a key factor for Yeltsin's landslide victory which made unnecessary the celebration of a second round and accelerated regime change, culminating in the dissolution of the Soviet Union in December, 1991. I also use a two-sample two-stage least squares procedure to directly assess the causal effects of listening to Radio Liberty. In addition, I provide evidence from listenership surveys which show the importance of Radio Liberty to affect the perceptions of Russian citizens towards the Western world and liberalism.

I perform further exercises to probe the validity of the findings, mainly, a battery of placebo tests using ionospheric data for periods before 1988 in which Radio Liberty broadcasts were intensely jammed, and after the 1991 elections. I complement those tests with a quasi-placebo exercise using the 1996 presidential elections, where I do not expect to see such a large effect of shortwave broadcasts. Finally, I investigate the robustness of the results, including in the main specification exposure to the other Western broadcasts reaching Russia such as BBC and VOA.

Overall, the main message of this paper as to current public policy discussions is that free media can play a relevant role in regime change. In this paper, this is achieved against the backdrop of a powerful regime, the Soviet Union, which collapsed in a short period after having shown high levels of regime stability since its creation in 1917. A relevant tool at the disposal of free media to promote regime change is shortwave radio, which is an effective channel to trigger and accelerate significant changes in political regimes. A possible explanation of its success is that in tightly controlled regimes with little freedom of press, shortwave technology is in position of providing an independent source of information very difficult to control for the rulers, unless they resort to expensive jamming practices. My results provide support to the role that Radio Free Europe could play nowadays in Muslim countries and suggests that the new radio branches, such as Radio Farda in Iran or Radio Mashaal in Pakistan, might have some important effects in the medium run to unleash noteworthy changes in those countries. Interestingly, my results seem to suggest that soft power (Nye 1990), which encompasses all the communication tools using attraction rather than coercion, can also be a powerful level to win hearts and minds. Empirical evidence on this issue (Berman, Shapiro, and Felter 2009; Beath, Christia, and Enikolopov 2012) has thus far focused on how material incentives such as reconstruction programs and development projects have improved the citizens' attitudes towards the government in Iraq and Afghanistan. My paper indicates that political messages and ideas can also be an effective channel to win hearts and minds, and change perceptions and attitudes in foreign countries.

Consistent with previous work on media's power of persuasion, I find relevant effects of an important media outlet on voting outcomes. This finding could be rationalized with the weak institutions Russia had in those elections. In fact, the Soviet Union still existed at that point and the foundations of the new Russian state were still to be built. Hence Russia was in 1991 at a crucial turning point and the elections had to decide who would become the leader of a political transition inching towards a new status quo. This consideration coupled with the lack of prior information about the performance of the candidates and the scarcity of anticommunist media within Russia at that time, could also help explain the results. However, this paper only explains a part of the story because the general context and institutional details of Russia in 1991 do matter to get the full picture. It is important to study not only the causal effect of Radio Liberty on those elections, but also the whole political process leading to regime change and, specially, why the elections were finally held in 1991. The celebration of these elections was the consequence of a complex political process in which Gorbachev and Yeltsin finally agreed to pave the way for a new political regime and give more power to the Russian government vis-a-vis the coexisting Soviet Government in 1991. Thus, further research is needed to study what incentives had the different political agents in Russia in 1991 and why they considered that June 1991 was the right time to go to the polls. Some scholars (Stoner-Weiss and McFaul 2013) have suggested that Radio Liberty could have had a noteworthy impact on the views of the Soviet leaders at that time, exposing them to the regime's failing and influencing their decisions in the last days of the Soviet Union. This is an interesting theory which could complement my work but it is difficult to test empirically. Finally, further research is also needed in order to estimate the relative importance of these conditions and the magnitude of shortwave radio effects in other countries and settings.

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Ionization in the Ionosphere

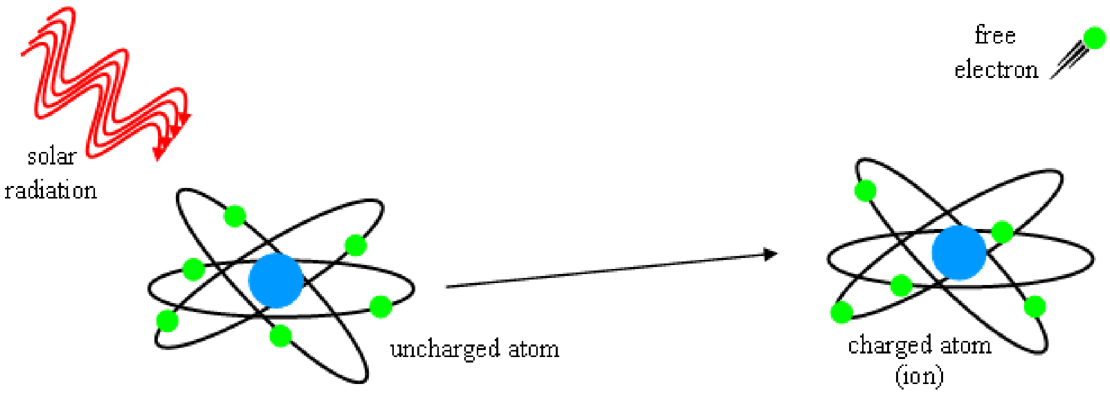

Figure 1: Obtained from IPS Radio and Space Services, Australian Government.

Reflection HF Radio Waves

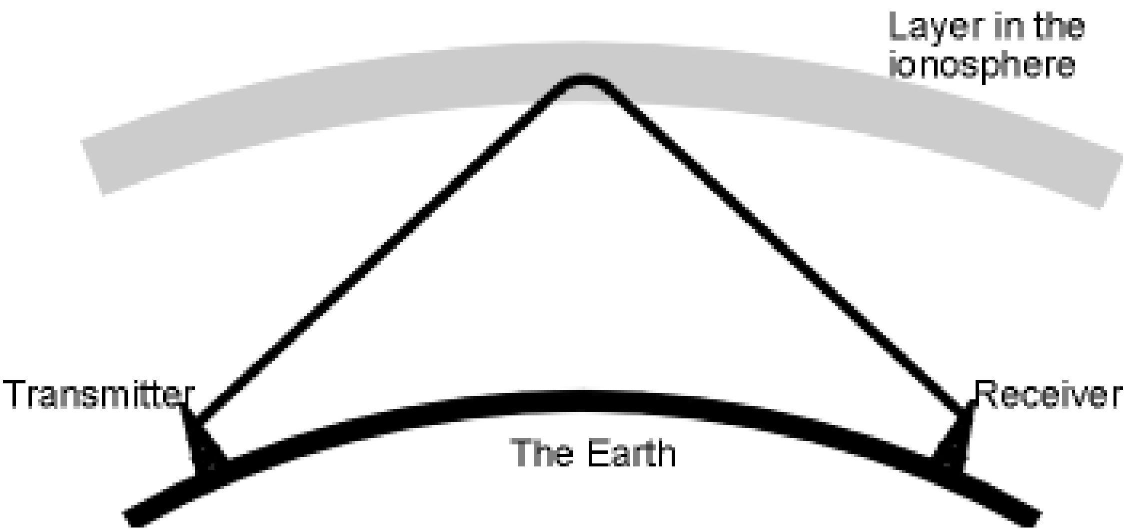

Figure 2: Obtained from IPS Radio and Space Services, Australian Government.

Ionization and Propagation

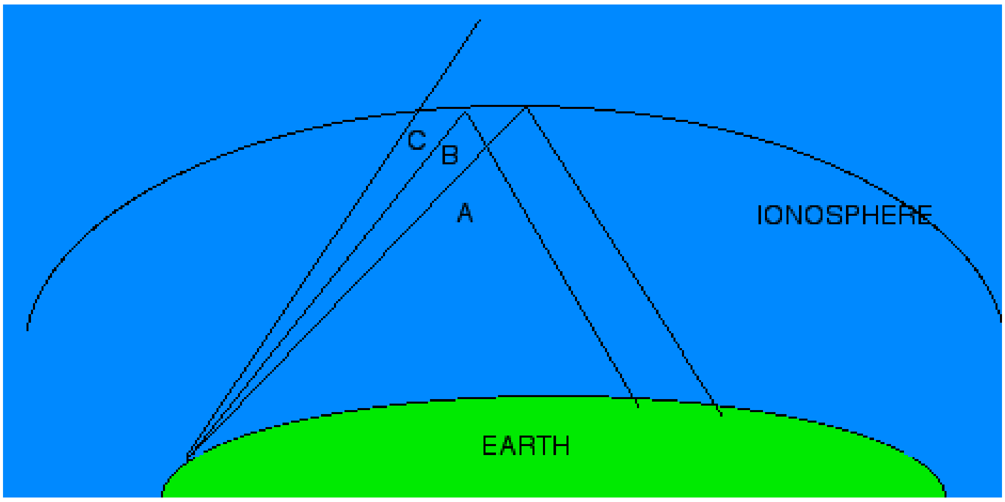

Figure 3: Radio Wave C passes into outer space while waves A and B are deflected downwards.

Average Electron Density Map Year Before Russian Elections

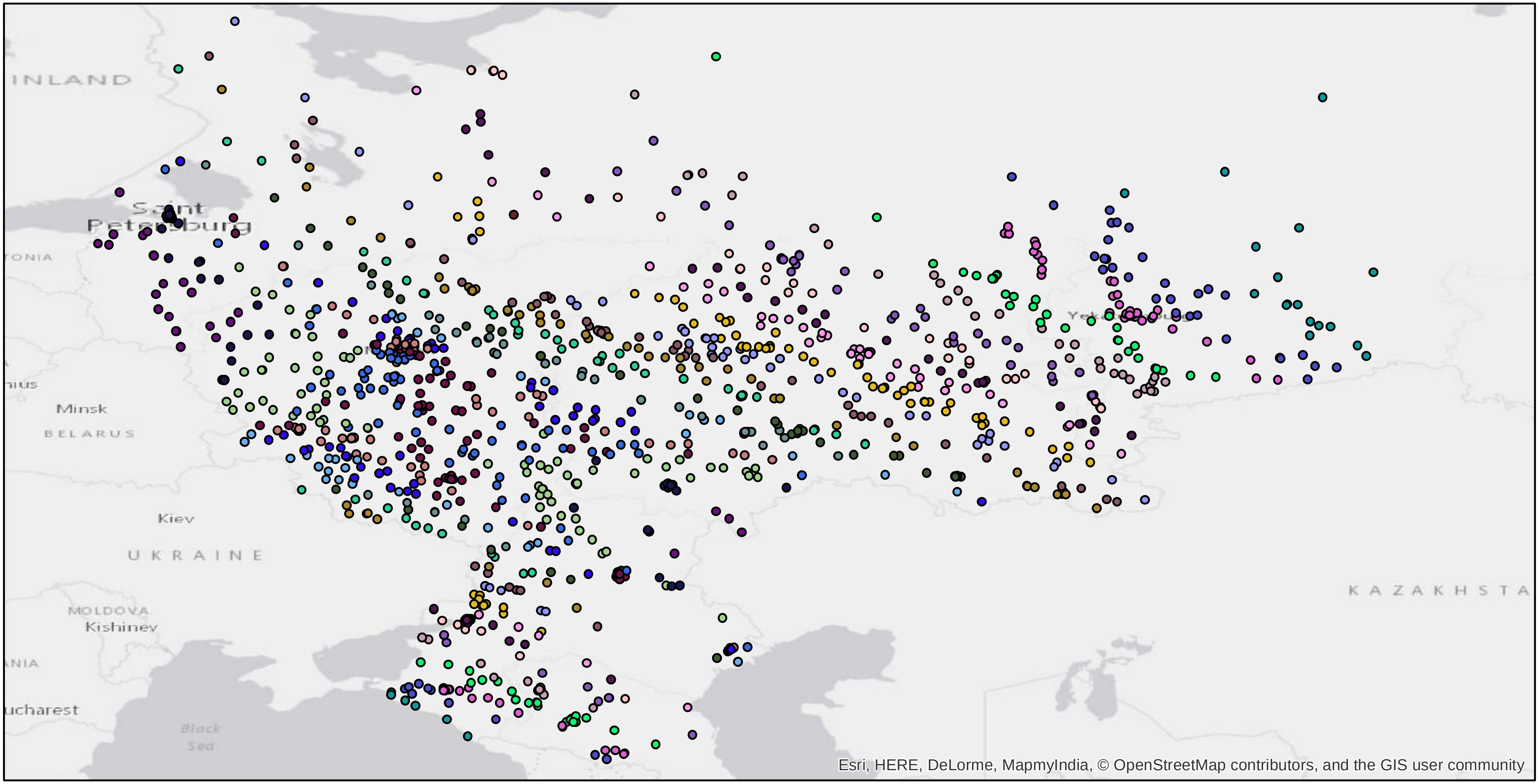

Figure 4: Map Ionospheric Variation

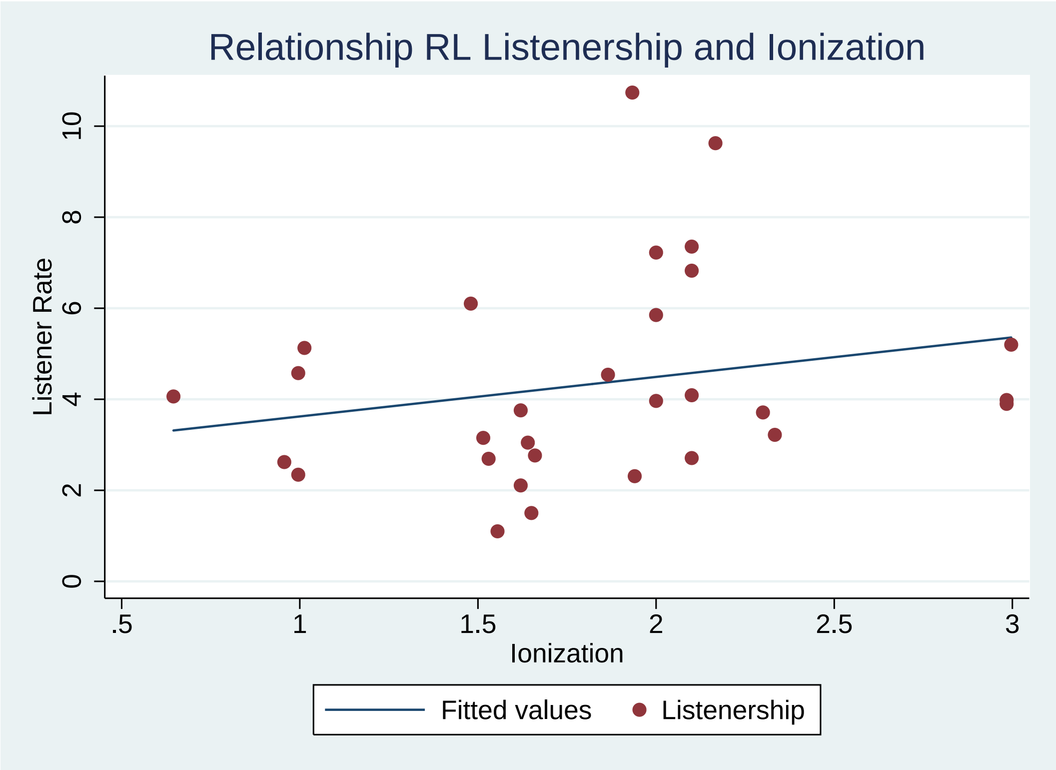

Figure 5: Correlation Listenership and Ionization.

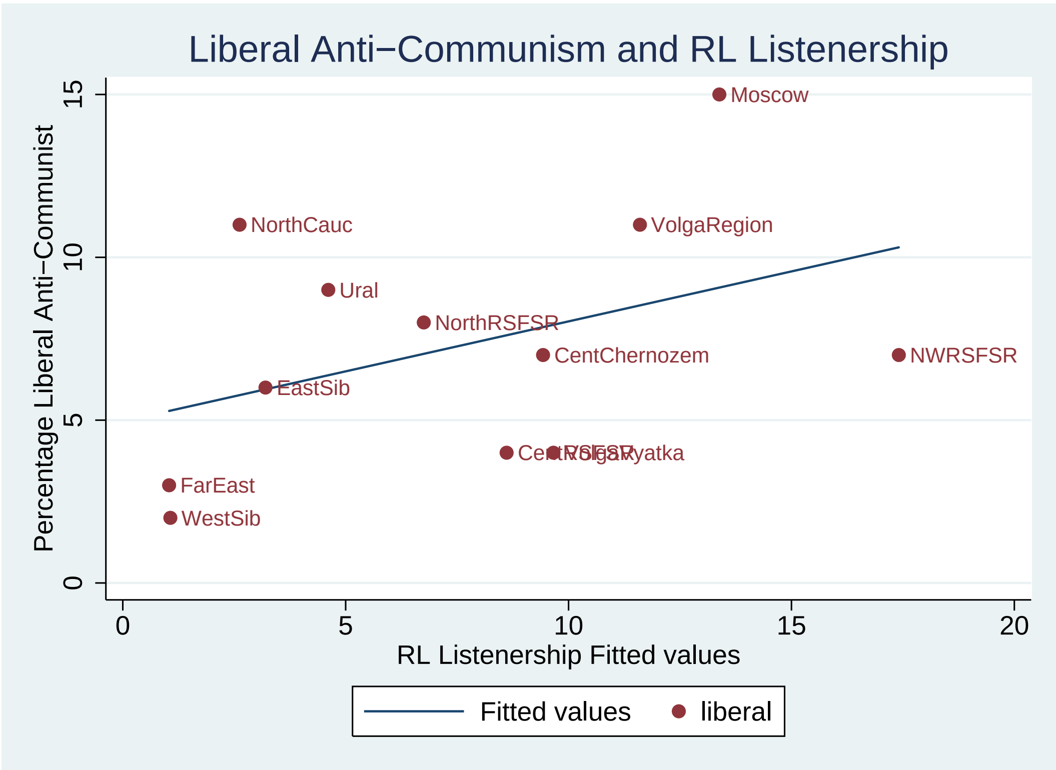

Figure 6: Second Stage Liberal Anti-Communism on Fitted RL Listenership.

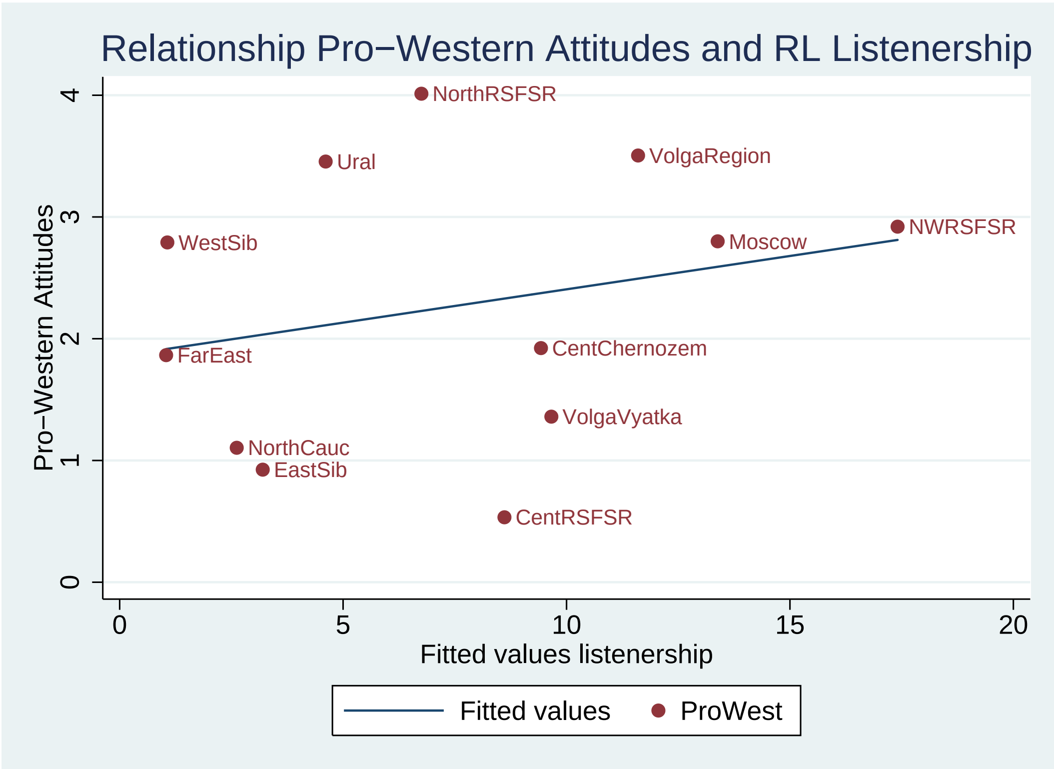

Figure 7: Second Stage Regression Pro-Western Attitudes on Fitted RL Listenership.

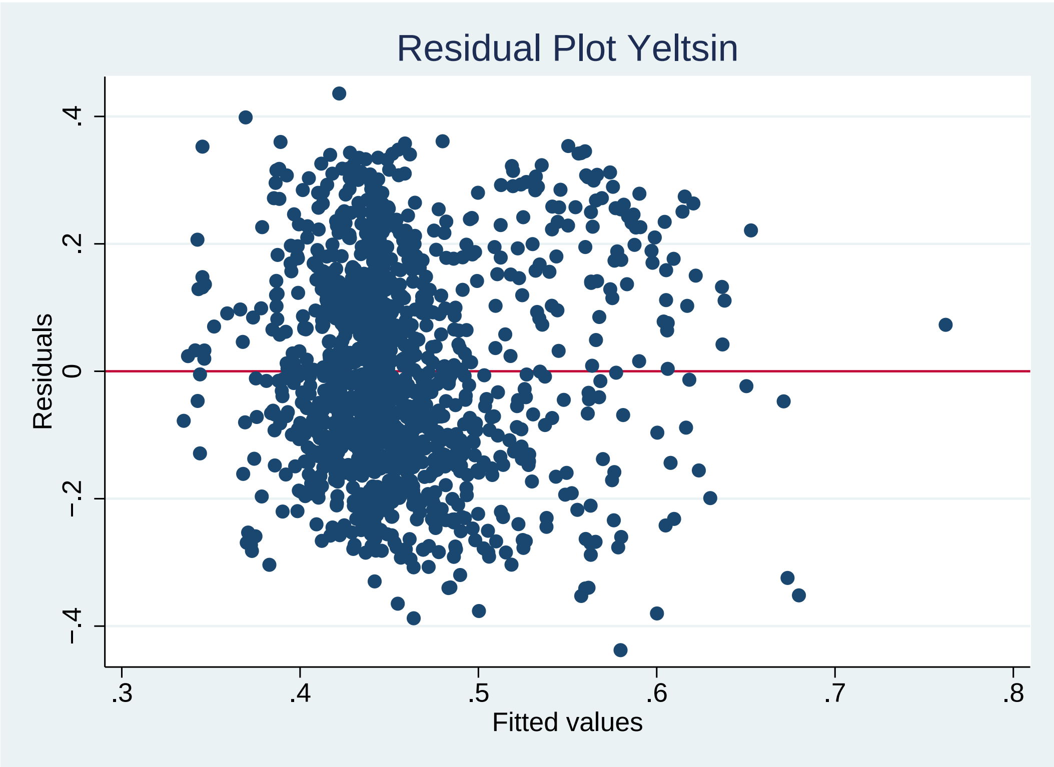

Figure 8: Used for the outliers removal analysis.

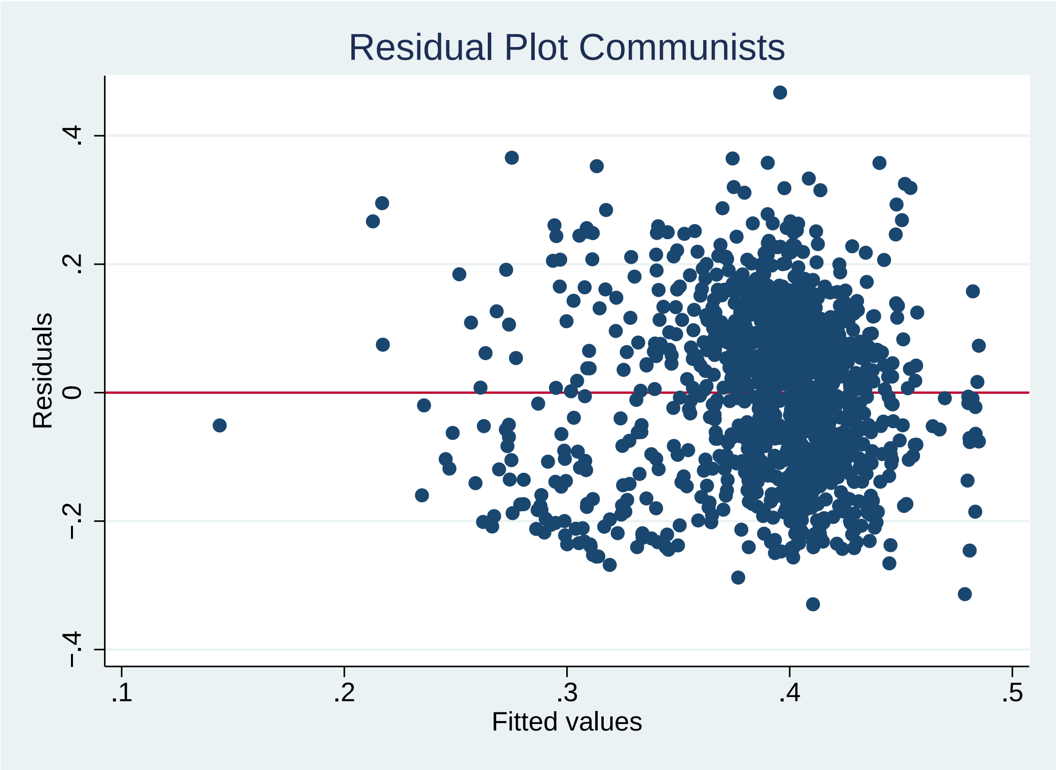

Figure 9: Used for the outliers removal analysis.

Table 1: Listener Rates and Ionization

	(1) Radio Liberty Short-run Listener rates 1991-1993	(2) Radio Liberty Short-run Listener rates 1991-1993
Electron Density	1.1695**	2.6641*
	(0.1038)	(1.3584)
City Fixed Effects	No	Yes
Geographic Variables	Yes	Yes
Observations	30	30
Seasonal Variation	No	Yes
F-statistic	[2.33]*	[99.93]***
R^2	0.2687	0.0891

Notes: Listener data is collected from all the Russian media surveys, which are kept in the Hoover Archives, between 1991 and the beginning of 1993. Listenership measures the percentage of respondents for each survey in each city who tuned in to Radio Liberty during the days that each survey was conducted. Electron density is constructed averaging at night for the days of each survey in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors clustered at the city level in parentheses. F-statistics in brackets.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 2: First Stage Vox Populi Survey

	Radio Liberty Listenerhip September, 1991
Reception Quality	10.9153**
	(4.8079)
Log Average Distance Pals	-12.7480**
	(4.5582)
Observations	12
F-statistic	[4.76]**

Notes: Listenership data is obtained for each Russian region using the September 1991 Vox Populi survey found in the Hoover Archives. The average quality instrument comes from the same survey, in which listeners to Radio Liberty had to gauge its reception quality on a 1-5 scale. Robust standard errors in parentheses. F-statistics in brackets
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 3: Correlates of Ionization in 1991

	Electron Density in 1991
Population logged	-0.0206
	(0.01704)
Urban percentage	-0.0022
	(0.0376)
Men percentage	0.8236
	(0.5642)
Region fixed effects	Yes
Geographic Controls	Yes
Observations	1155
F-statistic socioeconomic controls	[0.72]
R^2	0.5477

Notes: The main variables are measured at the district level. Electron density is constructed in Column (1) averaging at night in 1991 before the elections in the F layer at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses. F-statistics in brackets.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 4: Effect of Electron Density on Yeltsin's Vote Share in 1991

	(1) Yeltsin Vote Share in 1991	(2) Yeltsin Vote Share in 1991	(3) Yeltsin Vote Share in 1991
Electron Density 1991	1.4278**	0.8746***	0.7883**
	(0.5429)	(0.3076)	(0.3013)
Population, logged		0.0703***	
		(0.0088)	
Urban percentage		0.0935**	
		(0.0935)	
Men percentage		-0.1952	
		(0.3394)	
Region fixed effects	Yes	Yes	Yes
Fourth-order polynomial of demographic variables	No	No	Yes
Geographic controls	Yes	Yes	Yes
Observations	1279	898	898
R^2	0.4667	0.5943	0.6055

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1 and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 5: Effect of Electron Density on the Communist Vote Share in 1991

	(1) Communist Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Communist Vote Share in 1991
Electron Density 1991	-1.2742***	-0.8902***	-0.7993***
	(0.3987)	(0.2659)	(0.2632)
Population, logged		-0.0572***	
		(0.0074)	
Urban percentage		-0.0796**	
		(0.0369)	
Men percentage		0.0594	
		(0.2851)	
Region fixed effects	Yes	Yes	Yes
Fourth-order polynomial of demographic variables	No	No	Yes
Geographic controls	Yes	Yes	Yes
Observations	1279	898	898
R^2	0.4708	0.5710	0.5843

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1 and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 6: Effect of Electron Density on Zhirinovsky's Vote Share in 1991

	(1) Zhirinovsky Vote Share in 1991	(2) Zhirinovsky Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Electron Density 1991	-0.1741	0.0127	0.0105
	(0.1617)	(0.0815)	(0.0811)
Population, logged		-0.0124***	
		(0.0024)	
Urban percentage		-0.0130	
		(0.0155)	
Men percentage		0.1089	
		(0.1099)	
Region fixed effects	Yes	Yes	Yes
Fourth-order polynomial of demographic variables	No	No	Yes
Geographic controls	Yes	Yes	Yes
Observations	1279	898	898
R^2	0.4350	0.5826	0.5868

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1 and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 7: The Effect of Electron Density between 1988 and 1991

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Electron Density 1988-1991	1.9754***	-1.7598***	-0.2342
	(0.7170)	(0.5282)	(0.1724)
Region fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Observations	1279	1279	1279
R^2	0.4678	0.4721	0.4351

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1, 1988, and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 8: IV: Second Stage Vox Populi Survey

	(1) Liberal Anticommunism	(2) Pro-Western Attitude
Fitted RL Listenership	0.3068*	0.0548
	(0.1684)	(0.0433)
R^2	0.5354	0.1318
	(0.0071)	(0.0059)
Observations	12	12

Notes: Dependent variables are obtained from the September 1991 Vox Populi survey at the region level.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 9: Correlation Matrix Electron Density 1985-1991

	TEC 1985	TEC 1986	TEC 1987	TEC 1988	TEC 1989	TEC 1990	TEC 1991
TEC 1985	1.0000						
TEC 1986	0.9992	1.0000					
TEC 1987	0.9983	0.9972	1.0000				
TEC 1988	0.7978	0.7980	0.8147	1.0000			
TEC 1989	-0.1252	-0.1258	-0.0945	0.4920	1.0000		
TEC 1990	0.0410	0.0405	0.0716	0.6297	0.9850	1.0000	
TEC 1991	-0.3856	-0.3855	-0.3572	0.2434	0.9602	0.9025	1.0000

Table 10: Extended Specification and Jamming Pre-1988 Tests

	F-statistic
Joint Test Electron Density Years Between 1988 and 1991	[7.18]***
Joint Test Electron Density Years Between 1962 and 1963	[0.57]
Joint Test Electron Density Years Between 1968 and 1973	[1.49]
Joint Test Electron Density Years Between 1981 and 1987	[1.17]
Electron Density 1991	Yes
Yearly Electron Density 1960-1990	Yes
Region fixed effects	Yes
Geographic controls	Yes
Observations	1279

	Communist Vote Share in 1991
Average Electron Density 1988-1991	-8.5292**
	(4.0748)
Yearly Electron Density 1960-1987	Yes
Region fixed effects	Yes
Geographic controls	Yes
Observations	1279

Notes: The main variables are measured at the district level. The dependent variable is the communist vote share by district in 1991. Results are obtained with a extended specification which includes, in addition to 1991 variation until the elections, electron density at night measured between 1960 and 1990 in the F layer at the midpoint between the transmitter and the receiver. F-statistics in brackets. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 11: Placebo Test Using Post-1991 Elections Ionospheric Variation

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Average Electron Density 1988-1991	1.8932**	-1.7137***	-0.23096
	(0.7328)	(0.5434)	(0.2146)
Average Electron Density 1992-1995	1.3090	-0.7343	-0.3918
	(1.3258)	(1.0297)	(0.3427)
Region fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Observations	1279	1279	1279
R^2	0.4685	0.4725	0.4360

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1, 1988, and June 11, 1991, and between 1992 and 1995, in the F layer at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 12: Electron Density Effects in 1996 on the 1996 Russian Presidential Elections

	(1) Yeltsin First Round Vote Share in 1996	(2) Zyuganov First Round Vote Share in 1996	(3) Yeltsin Second Round Vote Share in 1996	(4) Zyuganov Second Round Vote Share in 1996
Electron Density 1996 First Round	0.3185	-0.8341		
	(0.6623)	(0.8455)		
Electron Density 1996 Second Round			0.8944	-1.0158
			(0.6869)	(0.7196)
Region fixed effects	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
Observations	1486	1486	1223	1223
R^2	0.7206	0.6637	0.7227	0.7153

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote in the two respective rounds of the 1996 elections. Electron density is constructed averaging at night over 1996 before the corresponding election day in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 13: Electron Density Effects between 1993 an 1996 on the 1996 Russian Elections

	(1) Yeltsin First Round Vote Share in 1996	(2) Zyuganov First Round Vote Share in 1996	(3) Yeltsin Second Round Vote Share in 1996	(4) Zyuganov Second Round Vote Share in 1996
Electron Density 1993-1996 First Round	0.1859	-0.5085		
	(0.6555)	(0.9010)		
Electron Density 1993-1996 Second Round			0.5963	-0.7451
			(0.8371)	(0.8863)
Region fixed effects	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
Observations	1486	1486	1223	1223
R^2	0.7205	0.6634	0.7220	0.7145

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote in the two respective rounds of the 1996 elections. Electron density is constructed averaging at night between 1993 and 1996 before the corresponding election day in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 14: Robustness Test BBC and Voice of America

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Electron Density 1991 Radio Liberty	1.6627***	-1.4470***	-0.2224
	(0.5711)	(0.4062)	(0.1790)
Electron Density 1991 BBC and VOA	1.9712	-1.3249	-0.4809
	(1.2791)	(1.0986)	(0.3191)
Region fixed effects	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes
Observations	1279	1279	1279

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Exposure is measured averaging electron density at night in 1991 before the elections in the ionospheric F layer at the midpoint between the respective transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 15: Leaving Out Moscow and Leningrad

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Yeltsin Vote Share in 1991	(4) Communist Vote Share in 1991
Electron Density 1991	1.4142**	-1.2701***		
	(0.5549)	(0.4094)		
Average Electron Density 1988-1991			1.9346**	-1.7389***
			(0.7396)	(0.5490)
Region fixed effects	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
Observations	1203	1203	1203	1203
R^2	0.4708	0.4758	0.4717	0.4768

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night in 1991 before the elections in the F layer at the midpoint between the transmitter and the receiver, and between 1988 and 1991 up to the elections. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 16: The Effect of Electron Density at Noon on the 1991 Elections

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Yeltsin Vote Share in 1991	(4) Communist Vote Share in 1991	(5) Yeltsin Vote Share in 1991	(6) Communist Vote Share in 1991
Electron Density 1991 Noon			0.4783	-0.3635	0.6443*	-0.5135*
			(0.3448)	(0.2768)	(0.3348)	(0.2624)
Electron Density 1991 Night	1.8665**	-1.6996***			1.9868**	-1.7954***
	(08489)	(06328)			(0.8675)	(0.6470)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1279	1279	1279	1279	1279	1279

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at noon and at night over the two months before the elections in the ionospheric region between 200 and 300 km in altitude at the midpoint between the respective transmitter and the receiver. Robust standard errors adjusted for clusters in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Appendix 1: Spatial Standard Errors

In order to account for the spatial correlation of ionospheric variation, I present in this Appendix the results of the main specification using spatial standard errors. To do so, I take into account the distance between each observation and the transmitter site, using distance cut-offs of 50 kilometers. In Table A1, I report the impact of ionospheric variation in 1991 on 1991 electoral outcomes. Standard errors are lower than clustering by region, so it follows that results remain pretty much unchanged.

In Table A2, I show the results using distance cut-offs of 100 kilometers rather than 50 kilometers. Once again, results remain significant at 5 percent level.

Table A1: The Effect Radio Liberty in 1991 Using Spatial Standard Errors with a Cut-off of 50 kilometers

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Electron Density 1991	1.4278***	-1.2742***	-0.1741*
	(0.3027)	(0.2326)	(0.1007)
Region fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Observations	1279	1279	1279
R^2	0.4667	0.4708	0.4350

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1, 1991, and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Spatial standard errors using a cut-off of 50 kilometers and taking into account the distance between each district and the transmitter in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table A2: The Effect Radio Liberty in 1991 Using Spatial Standard Errors with a Cut-off of 100 kilometers

	(1) Yeltsin Vote Share in 1991	(2) Communist Vote Share in 1991	(3) Zhirinovsky Vote Share in 1991
Electron Density 1991	1.4278***	-1.2742***	-0.1741*
	(0.3319)	(0.2633)	(0.1009)
Region fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Observations	1279	1279	1279
R^2	0.4667	0.4708	0.4350

Notes: The main variables are measured at the district level. All dependent variables are measured in percentages of total vote. Electron density is constructed averaging at night between January 1, 1991, and June 11, 1991 in the ionospheric region between 200 and 300 km in altitude at the midpoint between the transmitter and the receiver. Spatial standard errors using a cut-off of 100 kilometers and taking into account the distance between each district and the transmitter in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Appendix 2: Implementation Two-Sample Two-stage Least Squares Procedure

In this section of the Appendix, I explain in detail how I implement the two-sample two-stage least squares (TS2SL) procedure, which was introduced by Inoue and Solon in their influential 2010 paper.

In their seminal article, Angrist and Krueger (1992), explained that under certain conditions, consistent instrumental variables is still possible when Y and Z (but not X) are observed in one sample, and only X and Z (but not Y) are observed in a second distinct sample. My first sample (Sample 1) is the large sample, with 1279 observations, I use for the main reduced-form results presented in Section 5.2 of the paper. In particular, Y_1 is a 1279×1 vector with the aggregate vote share of Yeltsin or the communist candidates in the 1991 Russian elections. Then, Z_1 embeds the instruments measured in this first sample. In particular, Z_1 is a 1279×5 matrix containing a constant, electron density at the midpoint for 1991 up to the elections, latitude for each district, longitude for each district, and distance logged between the transmitter and each district.

Sample 2 is the sample used for the first stage. We have 30 observations at the city level retrieved from all the listener surveys available at the Hoover Archives. The first stage is presented in Column 1 of Table 1 and it is explained in Section 4.2 of the paper. I use the following terminology: X_2 is a 30×1 vector with Radio Liberty listener rates while Z_2 is a 30×5 matrix with the data for the instruments in this second sample.

Inoue and Solon introduced the TS2SLS estimator, which uses a correction for differences between the two samples in their empirical covariance for the instruments, making this estimator more asymptotically efficient that the TSIV estimator proposed by Angrist and Kruger in 1992. These two are numerically distinct, and as it is customary in the empirical labor literature (e.g., Bjorklund and Jantti 1997; Currie and Yelowitz 2000; Dee and Evans 2003; Borjas 2004) I use the TS2SLS estimator.
In particular, the estimator is:

$$\widehat{\beta}_{TS2SLS} = (\widehat{X}_1'\widehat{X}_1)^{-1}\widehat{X}_1'Y_1$$

where $\widehat{X}_1 = Z_1(Z_2'Z_2)^{-1}Z_2'X_2$.