Waxing Power, Waning Pollution: The Effect of COVID-19 on Russian Environmental Policymaking

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ABSTRACT

Like most countries globally, COVID-19 continues to have a demonstrable health, economic, and environmental impact on Russia. The purpose of this paper is to examine the possible ramifications for environmental quality in Russia during and following the coronavirus pandemic. Our work builds on the framework of Elinor Ostrom, as we argue that the pandemic and subsequent lockdown in Russia has highlighted the need for a more polycentric, de-centralized approach to environmental protection. We provide evidence for this point using a novel econometric strategy: given the tight centralization of environmental policymaking, we proxy for de facto decentralization using the amount of influence a regional governor has at the federal level. Using timely data on pollution in major Russian cities both before and during the pandemic, we employ an instrumental variable analysis which shows that pollution in a particular Russian region is negatively related to the amount of influence a Russian governor has at the federal level. Thus, the more powerful a governor is in their ability to set their own course, the better results they have in environmental quality. We conclude that Russia's environmental policy needs a fundamental rethink – and extensive decentralization – in a post-COVID-19 world.

I.   Introduction

Like most countries globally, COVID-19 has had a demonstrable health, economic, and environmental impact on Russia. From the first official cases recorded on January 31, 2020, to the surge in cases beginning at the end of March (28,248 new ones as of December 20, 2020), Russia has seen a cumulative total of over 2,500,000 citizens infected with the coronavirus and over 50,000 deaths. To combat the spread of the disease, Russian President Vladimir Putin declared a "national holiday" in late March which turned into more traditional lockdown measures across Russia's regions, including social distancing, closure of "non-essential" businesses, and orders to stay at home except for essential services. With the prohibition on economic activity came a predictable contraction of economic activity across the country, and the Central Bank of Russia (CBR) is forecasting a drop in GDP in 2020 between 4% and 6%.

The cessation of over a third (by some estimates) of Russia's economy has resulted in environmental impacts as well, but in a manner which highlights the unsustainable nature of Russia's current industrial complex. Various types of pollution and environment challenges have been problematic across Russia,[1] as cities in central and northern Russia (and of course the capital of Moscow) have long been plagued by dangerous air quality – in February 2020, Krasnoyarsk was the most polluted city in the world with an air quality index (AQI) of 226 - while mining towns such as Norilsk suffer from the legacy of both air and water pollution (Hønneland and Jørgensen 2003) and continue to face ecological catastrophe (as in the diesel oil spill from Norilsk Nickel subsidiary Norilsk-Taimyr Energy's power plant in May 2020). The measures taken to prevent the spread of COVID-19 in its first wave in Russia have shifted the overall environmental

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[1] Generally, environmental challenges in Russia can be classified into several categories, including climate change and its consequences, air pollution, water pollution, natural resources exploitation and waste management, preservation of biodiversity, and radiation hazards (Feldman and Blokov 2012; Henry and Douhovnikoff 2008; Ministry of Natural Resources and Environment of the Russian Federation 2019; Smith 2006). For a discussion of socioeconomic consequences and economic policies related to other environmental issues in Russia, see, for instance, Otrachshenko and Popova (2019) and Otrachshenko et al. (2017, 2018, 2021) on global warming, Wiesmeth and Starodubets (2020) on waste management, Libman and Obydenkova (2014) on forestry, and Feldman and Blokov (2012) on a diversity of environmental challenges in Russia.

picture in Russia, however, as there was a dramatic decline in various types of pollution from the start of the pandemic, one which decreased further with increasingly stringent isolation orders in different regions. Of course, the vast Russian landmass saw environmental changes to different extents in different cities and at different times; in Moscow, for example, while some pollutants have remained at high levels, for the most part, air quality has improved demonstrably since the end of February (Figure 1).

Figure 1. Plume Air Quality Index for Moscow, November 2019 – May 2020
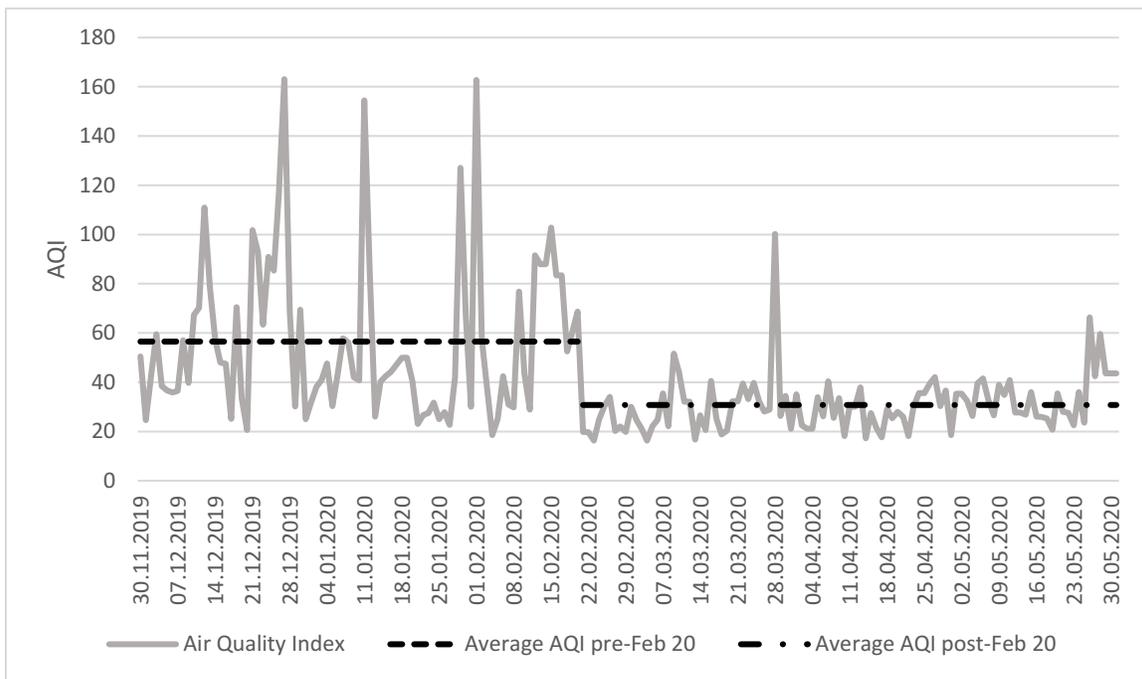
Source: Derived from data provided by Plume Labs World Air Map, https://air.plumelabs.com/air-quality-in-moscow-2cy9. Air quality is calculated as a formula of thresholds of five major pollutants, namely O3, NO2, SO2, PM10, and PM2.5.

Two specific factors have been driving Russia's problematic environmental outcomes over the past 20 years. The first, in line with the Coase (1960) Theorem, is a pervasive lack of property rights across Russia (Gans-Morse 2017), a situation which has created disincentives for environmental protection at the firm and individual level. Much as during Soviet times, the commons "were no one's property, they were under no one's protection" (Kotov and Nikitina 1993:12-13). At the same time, the tenuous nature of property rights in the country has allowed for a cozy alliance between business and politicians regarding environmental regulation, halting any real progress in market-based industrial restructuring after the

Soviet Union, while entrenching large state-owned companies in more pollution-intensive industries (Thorton 2009). Practically, this has resulted in "all types of costs associated with environmental protection… viewed as drains upon economic growth" (Kotov and Nikitina 1993:13), with government able to override individual preferences for cleaner air and water simply by holding the commanding heights of the economy.[2]

The second issue behind Russia's environmental degradation has been more pervasive and immediate than its overarching *economic* institutions and instead is related to its *political* institutions and, in particular, its environmental policymaking. Russia's environmental policy (like much of its governance) is highly centralized and directed from the Kremlin (Martus 2017): despite a brief period of decentralization in the mid-1990s, the ascension of Vladimir Putin in 2000 returned ultimate oversight of environmental powers to Moscow, where it was combined with and subsumed to other economic imperatives, most notably natural resource extraction. Successive administrative reorganizations of the environmental bureaucracy have "led to overlapping jurisdictions that increase inspections without improving control [over environmental quality]" (Crotty and Rodgers 2012:15). In addition, this top-down environmental approach has created a massive disparity between federal policy formulated in Moscow and its implementation in the regions (Crotty 2003), leading to local concerns being bypassed (Hitchcock 2011) and a perception that the Kremlin is forcing locals to conquer nature in order to raise revenue (Gladun and Zakharova 2017).

During the coronavirus pandemic of 2020, these two issues have only intensified. The eagerness of Russian authorities to sacrifice environmental targets in favor of other policy goals was manifest in the government's response to a letter from the Russian Union of Industrialists and Entrepreneurs (RSPP) in

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[2] According to the World Values Survey (wave 6) conducted in Russia in 2011, over 50% of respondents said that protecting the environment should be given a priority over economic growth and job creation, while 36% of respondents preferred economic growth to environment protection (Inglehart et al. 2014).

April 2020 asking for a suspension of environmental regulations during the pandemic. The 73-point letter was not adopted in its entirety, but some points, including the suspension of public hearings on the environmental impact of projects and the postponement of the fulfillment of business reforestation obligations for up to three years, were accepted by the Ministry for Natural Resources and entered into force in July 2020 (see Alexandrov 2020). Additionally, while regions have been given some leeway in their handling of the lockdown, there has been no formal devolution of environmental protection; indeed, the government's actions in the RSPP case have shown how the pandemic has further concentrated environmental policymaking power in Moscow over the heads of the regions.

Given this state of affairs, the purpose of this paper is to examine the possible ramifications for environmental quality in Russia during and following the coronavirus pandemic. Our hypothesis builds on the framework of Elinor Ostrom (2009) and her husband and collaborator Vincent Ostrom (Ostrom *et al.* 1961) on polycentrism, as we argue that the pandemic and subsequent lockdown has reinforced the need to move towards a more polycentric, de-centralized approach to environmental protection to deal with the diversity of Russia's environmental issues (a point also made in Libman and Obydenkova [2014]). As suggested in Vincent Ostrom's book examining the "compound republic" (V. Ostrom 1987), polycentrism offers a check on despotic tendencies emanating from the center (Wagner 2005), which, in the context of environmental policy, can override local desires for more environmental protection or prevent a healthy balance between resource use and environmental protection. Shifting towards polycentrism and away from monocentrism could also then allow for both improved environmental policymaking and outcomes informed by local desires (Newig and Fritsch 2009), even in a country such as Russia, where the top layer (and many layers underneath) of political institutions are themselves non-democratic. Indeed, the polycentric approach creates other poles of power centered on environmental protection – and beyond the formality of environmental policymaking - thus creating at the sub-national level a "demand [for] mechanisms for the inclusion of citizens in the reflection of the systems performance" (Niemeyer

2020:18). In this sense, polycentrism creates mini-democracies and localized markets, processing and disseminating information that simply cannot be available to a policymaker eleven time zones away.

We provide evidence for the possible effectiveness of polycentrism in Russia using a novel econometric strategy: given the tight centralization of environmental policymaking, we proxy for de facto decentralization using the amount of influence a regional governor has at the Kremlin. Using timely data on pollution in major Russian cities both before and during the pandemic, our econometric analysis shows that pollution in a particular Russian region is negatively related to the amount of influence a Russian governor has in the Kremlin.[3] Thus, the more powerful a governor is in their ability to set their own course, the better results they have in environmental quality. We also show that a stricter self-isolation policy during the pandemic mediates this effect.

Our contribution to the literature builds on a line of papers exploring the center-periphery governance relationships in Russia (for example, Turovskii [2010] or Reuter and Szakonyi [2019]), but the natural experiment of the coronavirus and ensuing lockdown allows us to explore the differential effects of governors on environmental outcomes in a short period of time. We are the first to our knowledge to provide empirical evidence for the importance of political influence on various environmental metrics in a highly centralized regime. This work will then have policy ramifications for Russia going forward as it emerges from lockdown and restarts its economy.

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[3] Air quality was chosen because it is one of the most severe environmental problems in Russia. According to different estimates, a half to two-thirds of the Russian population lives in areas with air pollution levels exceeding air quality standards (Feldman and Blokov 2012; Smith 2006; Wernstedt 2002). Thus, while Russia's environmental challenges are legion, air quality is the issue with the ability to affect the greatest number of Russians. Our focus on air pollution as an indicator of environmental quality is also driven by timely data availability, as we require an environmental quality indicator measured on a daily basis in 2020. Upon data availability in future, further studies are encouraged to analyze the consequences of COVID-19 and temporary decentralization in Russia on other indicators of environmental quality.

II.   Best Practices in Environmental Governance…

Despite nearly a half-century of environmental regulations globally – and a much longer pedigree of private environmental initiatives – the keys to effective environmental governance and in particular environmental *institutions* remain contentious and, in many ways, under-explored. As Bennett and Satterfield (2018:1) note, "governance is one of the most important factors for ensuring effective environmental management and conservation actions. Yet, there is still a relative paucity of comprehensive and practicable guidance that can be used to frame the evaluation, design, and analysis of systems of environmental governance."

As Brondizo *et al.* (2009:523) noted, "proposals to protect… ecosystems by changing the institutional rules of use and by the way these rules are monitored and enforced, however, frequently focus on a single level. Most often this is at the level of national governments." Advances in environmental governance are often also complicated by the fact that environmental governance is context- and path-dependent, and one-size-fits-all solutions have little effectiveness in the face of complex, trans-boundary environmental challenges (Scarlett 1997, Volokh *et al.* 1998, Epstein *et al.* 2015, Bodin 2017). At the same time, the political process through which much formal environmental policy at the national level runs is predicated on is dominated by particular interests and a lack of expertise (Oates and Portney 2003), meaning a focus on command and control and short-term metrics rather than tangible outcomes. In this sense, political institutions and their composition and/or ordering also have a major impact on environmental governance (Crepaz 1995, Bernauer and Koubi 2009, Liefferink *et al.* 2009, Jahn 2016) and can dramatically influence the path of environmental outcomes.

An alternative to the top-down approach of environmental governance of common pool resources was suggested in the entire oeuvre of Elinor Ostrom, who examined localized, decentralized, and polycentric approaches to environmental policymaking (Ostrom 2009, 2010), a topic also favored and advanced by her husband, Vincent (V. Ostrom *et al.* 1961). Given the inherent complexity of

environmental challenges, especially in relation to common pool resources (where exclusion is costly and usage reduces availability for others, see Ostrom *et al.* [1999]), local solutions based on the knowledge of participants and repeated interaction yield better (and more sustainable) environmental outcomes (Newig and Fritsch 2009; Ostrom 2010). Such solutions would be predicated on *inter alia* rules that were appropriate to the local conditions, provided access to rule-making procedures for the vast majority of those affected, had conflict resolution mechanisms, were nested in multi-layer governance structures, and where the rights of localities to make their own decisions were respected by (or at least not unduly interfered with by) government (Cox *et al.* 2010).

The beauty of a polycentric approach is the insight that actors may act independently of each other within a multi-layer governance system (V. Ostrom *et al.* 1961) and, most importantly, policies/rules need not necessarily be officially coordinated or approved. The recognition of this reality moves the focus on effective environmental decision making away from the nation-state – and its national government - as the sole unit of analysis, acknowledging that formal environmental policy is only one way (and not necessarily the best or even second-best way) in which environmental outcomes may be improved. As Forsyth and Johnson (2014:1104) note "an important aspect of polycentric analysis is its ability to incorporate a wide variety of formal/informal and state/non-state actors whose power to decide different resource governance outcomes varies in relation to different modes of governance." This recognition of different poles of power connected to environmental *decisions* (taken at a local level and encompassing the actual implementation of environmentally relevant projects or actions), as opposed to merely *policy* (broader and generalized precepts usually codified in related to legislation and frameworks), means that polycentrism can exist even is a structure that is at its top layer non-democratic.

Put another way, while the formal political system may restrict access for others in creating and implementing environmental policies, environmental decisions can still be taken at local and regional levels; this decentralized nature of environmental action may still deliver environmental improvements in

an adaptive manner, but improvements are predicated on "internal power dynamics among the components of a system, their competitive versus collaborative patterns of interaction, and the emergence of functional operational linkages" (da Silveira and Richards 2013:219). In reality, marginal improvements may be found in polycentrism even if there is a high level of political centralization *if* the top layer of governance does not attempt to aggregate all the decision-making power for itself (Morrison *et al.* 2019): Libman and Obydenkova (2014) show this precisely in the case of Russia, where polycentrism worked for a time in forestry until the federal apparatus attempted to dominate other actors, while da Silveira and Richards (2013) show a similar pattern in China. In both cases, however, improvements were made in environmental protection at the local level across various environmental issues, but this progress was bounded by these same power relations and did not reach their potential contribution.

One of the key ways in which a polycentric approach can contribute to progress even in a highly centralized atmosphere is that it "also captures the important idea that different resources (e.g., land, water, air, etc.) have different governance dynamics, implying that resource attributes, social dynamics and institutional arrangements (defined as rules and norms) will have important bearing on resource sharing, conservation and distribution" (Forsyth and Johnson 2014:1104). In this sense, polycentrism can also allow for recognition of additional attributes of resources beyond their economic or environmental use, allowing for the interaction of cultural, social, or religious norms as part of governance (illustrated in Mosse 1997). But more importantly, given the fact that different environmental challenges must be dealt with differently (using different rules of thumb, approaches, and institutional forms), polycentrism helps to devolve action to those most likely affected, with examples abounding even of polycentric orders helping to overcome the boundary problem of certain resources (Hagendra and Ostrom 2012).[4]

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[4] The boundary problem is succinctly described as "matching the boundary of those who benefit and those who contribute with the boundary of a resource" (Nagendra and Ostrom 2012:118).

Elinor Ostrom herself was to make clear that a polycentric approach did not necessarily mean a knee-jerk genuflection to local governance for environmental protection, but rather an acknowledgement that various strata of governance have their own roles in common pool resource management (Andersson and Ostrom 2008). The key function of such polycentrism would then not be either the iron-clad rule of the local in place of the national, but rather the creation of a series of laboratories which provide for "greater experimentation, learning, and cross-influence among different levels and units of government, which are both independent and interdependent" (Cole 2011:395). The precursor to any such small-scale, governmentally-focused experimentation would have to be some degree of decentralization from the center to the regions, a process which would seem to be easier to achieve within a federal system than in a unitary state. Only by such devolution of practice could some tangible progress be achieved, and possibly lead to true polycentrism, i.e., the inclusion of non-state and informal/local actors in their own governance networks.

III.   …and the Russian Approach

The challenges of environmental policymaking in Russia were summed up by Martus (2017a:137), speaking specifically of Lake Baikal but in a manner applicable to all of Russia, as "a policy process characterized by high levels of intervention from political leadership, frequent changes in direction, and an insular decision-making context with only limited input from environmental actors." Environmental policymaking in Russia can be divided into three distinct periods of its post-Soviet evolution, starting with the enshrining of environmental protections in federal law from 1991 to 1993, a shift to de facto local solutions as the center of governance collapsed from 1994 to 1999, and a complete and total reversal with centralization of environmental decision-making from 2000 onward.

During the first phase accompanying the transition from communism towards a market-based economy, economic concerns surrounding the transformation dominated but environmental protection was accepted as part of the package of reforms necessary to successfully transition Russia. As Henry and Douhovnikoff (2008:439) noted, "environmental protection gained further stature following the collapse of the Soviet system. One of the first laws passed by the newly independent Russian Federation was the 1991 Federal Act on the Protection of the Natural Environment… the Ministry of the Environment [was created and] Russia also progressively, if mostly rhetorically, committed itself to the principle of sustainable development." While this represented the height of power for Russian environmental policy at the federal level (Glushenkova 1999), there was a corresponding lack of capacity and funding, meaning the national environmental approach changed to stress "not improvement of the environmental situation but, rather, its stabilization and conservation of that which has not yet been destroyed" (Kotov and Nikitina 1993:13). As part of this approach, the Act on Protection also empowered citizens and activists in the environmental sphere and gave them legal protections, in the hopes of deputizing them as stewards of the local environment (Bond and Sagers 1992).

The second phase of Russia's environmental policymaking saw an overall "systematic eroding of national environmental institutions… through a period of institutional turbulence" (Mol 2009:229). By 1996, the Ministry had been downgraded to "committee" status, which it had held before the Soviet Union's collapse (Peterson and Bielke 2001), and a move towards decentralization of environmental protection had begun in earnest. This decentralization did not follow any organized plan, however, but was rather the consequence of Moscow's inability to fund any environmental initiatives; indeed, as an extensive debate about the relative merits of overall policymaking from the center or the periphery has illustrated (Reisinger 2013), the decentralization across the board observed in the 1990s was really a form of bargained state collapse (Alexseev 2001). Given the preoccupation of high-level policymakers with

staving off economic disaster, the imperatives of growth dominated, and any sense of coordinated environmental policymaking was shoved aside (Esty 1997).

Given the slow progress of economic institutional reform – i.e., the little progress made on property rights – such a de facto decentralization could have gone seriously awry in such a dysfunctional institutional environment (Kotov and Nikitina 1993); in particular, it was surmised that regional governors and local authorities were even less accountable than Moscow and much more corrupt (Glushenkova 1999), while Bahry (2005) noted that the center's inability to provide basic institutions meant that regions had little sovereignty to develop economic bases independent of Moscow. But despite this state of affairs, the tentative decentralization of environmental functions appeared to be fairly successful in tough circumstances (Kotov and Nikitina 2002), with local administrations "being the only institutions which… perform environmental protection activities regionally and local" (Glushenkova 1999:161). While much of the environmental progress that Russia made during this time came from de-industrialization rather than a shift to a new green growth path (Oldfield 2000), the shift to the regions allowed for much more experimentation in environmental policies (Henry and Douhovnikoff 2008) and made the lack of an effective federal regulatory system less pressing (Crotty 2003). Of course, the diversity of regions meant that there was also a diversity of approaches, from a patchwork of initiatives and continued reliance on the federal government in Murmansk (Hønneland and Jørgensen 2003) to a shift towards ecological protection and away from natural resource extraction in Samara (Crotty 2003). More importantly, there was a move towards private initiative, as the "diminishing power of the environmental state" meant that environmental protection shifted to newly forming coalitions of firms and environmental NGOs in various regions, setting standards and demanding region-specific environmental improvement (Aksenova and Nedelkov 2002). Despite a lack of funding or capacity (in its traditional sense, that is, well-trained staff and infrastructure), these initiatives continued to experiment with polycentric forms of decision-making;

indeed, the actors involved showed high levels of capacity with regard to local knowledge and often tailored their decisions towards actions which did not require large amounts of funding (Graybill 2007).

This heyday of environmental experimentation was to come to an abrupt halt in the last (and continuing) phase of Russian environmental policymaking, as the ascendance of Vladimir Putin as President in 2000 led to a new equilibrium of highly centralized decision-making. Almost immediately upon his assumption of power (ten days after, to be exact), Putin issued a decree dissolving the State Committee for Environmental Protection and bringing its functions (as well as that of the Forestry Service) under the purview of the Ministry for Natural Resources (Peterson and Bielke 2001). With a move back to Moscow, regional environmental staff was cut substantially, but implementation of federal directives was still expected to be done by regional governmental entities (without any say in the creation of these same directives). In the fact of this power shift, informal coalitions in the regions continued to form, uniting behind the threat of extreme centralization to reach some tentative progress on environmental assessments at the local level (Cherp and Golubeva 2004) and especially in the realm of forestry (Libman and Obydenkova 2014). Unfortunately, these small-scale initiatives had little effect in the face of a federal apparatus focused on resource extraction rather than protection. As Mol (2009:239) noted, the Russian governance of the environment at the federal level, rather than embedding environmental quality into the policy process, had undergone a process of "environmental deinstitutionalization" in the 2000s: "formally, environmental protection institutions are still present. However, these institutions are de facto no longer functioning as an authoritative structure with rules and resources that direct environmental reform."

Tokunaga (2010) called attention to the drivers behind this state of affairs, noting that Russian policymakers were essentially focused on short-term ecological improvement so long as this did not conflict with the imperatives of extraction and resource use, a centralized approach that regional actors were then expected to implement irrespective of the suitability of such an approach to a particular region.

Moreover, whereas the smaller private enterprises in the region were driving environmental improvement in the late 1990s and to some extent still in the 2000s (Kotilainen *et al.* 2008) - and while Russia still has an active non-governmental sector of civil society organizations dedicated to the environment (Henry 2010) - it has more often been the large, state-owned behemoths who used environmental regulation to consolidate their positions and force out foreign competition (Tokunaga 2010). Indeed, although Russia instituted a highly centralized (and essentially closed) process for environmental policymaking after 2000 – replete with a labyrinth of compliance and bureaucracy - politically connected businesses have been able to circumvent or vitiate environmental restrictions or utilize them to their own benefit (Martus 2017b). Rather than having to deal with regional authorities and local concerns, the re-centralization of Russian environmental policymaking has allowed state businesses to bypass governors and deal with the rest of the state directly. This has been aided and abetted by a muzzling of civil society, with environmental activists based in Moscow and St. Petersburg (or receiving Western funding) in particular targeted as "anti-Russian" (Newell and Henry 2016).

Applying Polycentrism in Russia: The Role of Governors?

As just shown, Russia's post-Soviet transformation environmental policymaking has been dominated by the political process and especially the political institution of the executive: the center eased up on control of policymaking when it was unable to actually fund environmental protection, but the economic stabilization post-1998 resulted in a re-centralization of environmental policy. Apart from the issues of institutional volatility and their effect on the environment, the equilibrium which Russia now finds itself in is sub-optimal, as the centralized apparatus has allowed the government to set aside Russian-wide and localized environmental goals in pursuit of industrial production or resource extraction. Finally, this centralization has also provided a pathway for interests to grapple for control of the regulatory process, and environmental scientists, once a preeminent group during the Soviet years, are now seen as just another interest group in a lower tier of influence [Ostergren and Jacques 2002]).

These outcomes could have been predicted by any number of studies on public choice or environmental policymaking, pointing a way towards a different structure of environmental governance in Russia. Indeed, one of the issues in fashioning appropriate environmental responses at a central level can be traced directly to the sprawling landmass that is Russia, stretched out over eleven time zones and with a climate that runs from subtropical in Sochi to the tundra in the north near Arkhangelsk. The sheer size and diversity of ecological challenges across the country should make apparent the limits of centralized decision-making (even in a weak and uneven institutional environment). This suggests that a much more decentralized approach to environmental policy, along the lines of Ostrom (2009), would be more effective in improving Russia's environmental performance across a broad host of indicators and geographic spaces.

Applying the framework developed by the Ostroms to Russia would likely resemble a return to the status quo of the 1990s, where localities had much more of a say in environmental policymaking, but with a further de-scaling of environmental powers to emergent actors in local business, environmental NGOs, and local stakeholders. In addition, to harmonize with the successful rules of common pool resources, it would also require the federal authorities to recognize the right of regions, municipalities, and localities to create and devise their own environmental rules, including in cooperation with business and NGOs. Simply put, there are few avenues for polycentrism in Russia, as the combination of a tightly centralized regime with scant attention to property rights means that movement for private actors is restricted (along with, as noted, the attempts to silence environmental activists). The situation was compounded by the centralization of governance in Russia as part of the 2004 gubernatorial reforms, which eliminated the direct election of governors and instead had them appointed by the President.

However, this re-centralization only lasted eight years, as there was a reversal of the reform in 2012, allowing again for direct election of governors. Such a change may have been partly cosmetic, as the process at the regional level was tightly circumscribed (DeBardeleben and Zherebtsov 2014) and

monitored by the Kremlin (see Goode 2013 for an excellent summary), redefining the contract between regional leaders as part of the national electoral structure under a strong executive (Golosov 2012). But even such a tightly controlled process has created a greater diversity of governors than under the previous regime, with the political standing of a specific appointee both at home and in Moscow widely varying from governor to governor (Golosov and Konstantinova 2016); some have been able to consolidate local power bases, some have had relatively lower profiles or have had only weak ties to their regions (a common problem during the direct appointment of governors), and some have wielded greater influence at the federal level.

This variation in influence has formed a sort of de facto decentralization, as governors which are more influential in Moscow may act in a more independent (decentralized) manner on various policies and may have greater power in swaying even more local election process such as mayoral contests (Panov 2016). Such an effect already has some evidence: Beazer (2015), examining economic performance in various parts of Russia, showed that regions which had little political competition pre-reform were bolstered by the newfound favor shown by the center and saw better economic outcomes. Of course, this is not to say that influential governors are able to translate their influence into autonomy across all facets of decision-making, as even during the current pandemic, governors were not given freedom in deciding on operations of major industrial enterprises and business and administrative activities vital for their region (President of the Russian Federation Decree 2020b). In addition, during the meetings of the State Council, an advisory body to the head of the state on issues of high priority in internal and external policies, each governor's activities may be given a "valuation" that may have implications for the future of his/her position as a governor (Orlov 2020). This suggests that the ability to have high influence across-the-board may still be limited for governors.

However, in an arena where the center has exhibited little appetite for progress, like the environment, environmental decisions and actions may be an arena for decentralization to advance. Indeed, the Kremlin

has displayed little interest in following through on broad-based environmental commitments, subordinating them to utilization (rather than protection) of natural resources and outsourcing (as noted) implementation of environmental decrees to underfunded regional authorities. Combined with the benefits of local accountability via local elections (Beazer and Reuter 2019), influential governors could actually have the power to act as another pole in a polycentric system, allowing for flexibility outside of the formal governmental sphere, creating space for local decisions (and not just implementation of federal regulations), and, eventually, delivering better environmental outcomes.[5] Moreover, the effects of this influence could be heightened during a crisis (as in a pandemic), as the center is even more preoccupied (Burns and Tobin 2018), creating additional space for governors to allow local, decentralized action.

IV.   Russia in the Time of Coronavirus

The first case of COVID-19 was registered in Russia in the end of January 2020, but the number of infected did not begin to rise sharply until the end of March 2020. As of the end of December 2020, Russia had the highest number of registered coronavirus cases in Europe and the fourth highest in the world after the US, India, and Brazil.[6] Almost half of all cases in Russia were (and continue to be) registered in Moscow.

Formally, a lockdown was never introduced in Russia but, in response to an increasing number of COVID-19 cases, on March 25, 2020, President Putin signed a decree introducing "non-working" days in Russia (President of the Russian Federation Decree 2020a). However, the "non-working" days decree comprised a set of policies very similar to the lockdowns being instituted elsewhere, including a temporary

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[5] A common issue heard with a return to 1990s-style devolution is that it will just create corrupt and centralized governance structures similar to the Kremlin in the regions, just on a smaller scale. This argument was conclusively examined in Gel'man and Ross (2016), who concluded that the threat of "sub-national authoritarianism" in Russia had receded dramatically since the 1990s and in particular the current federal structure would prevent such eventualities at the scale seen in the first decade of transition.

[6] Current as of December 21, 2020.

suspension of flights, restriction of entry to the country, and cancellation of mass cultural and sport events (all of this was accompanied by the mobilization of the healthcare system). Aid measures for vulnerable businesses and population groups were introduced countrywide shortly thereafter in a flurry of legislation at the beginning of April.

An interesting feature of the COVID-related policies in Russia has been a temporary decentralization of decisions from the federal center to the regional authorities. The regime of temporary decentralization came into force from April 2, 2020, when the President's decree put the decisions and policy implementation for preventing the spread of coronavirus on the shoulders of regional governors (President of the Russian Federation Decree 2020b). In particular, the governors were given the right to decide the scope and duration of prophylactic and restrictive measures in their region, to limit business activity, and to regulate the movement of individuals and transportation vehicles, except for the administration and business activities that are vital for a region (President of the Russian Federation Decree 2020b).[7]

According to the decree, the regional governors could also potentially regulate the operation of major industrial enterprises and scientific and educational organizations in their region, though only upon agreement with the Federal Government. As a result, most Russian regions introduced self-isolation regimes and restrictions on non-essential activity (including introducing distance learning programs) while stopping short of restricting the operations of the major industrial enterprises which are one of the sources of air pollution in Russia. Subsequently, governors were also allowed to decide when and how to exit the self-isolation regime and to develop recovery measures to support the affected businesses in their territory (President of the Russian Federation Decree 2020d).

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[7] According to the President's Decree (2020b), such activities include public services, medical support, food supply, infrastructure maintenance, urgent repair and construction, financial services, etc.

For most governors, the new powers delegated during the coronavirus epidemic came unexpectedly. Indeed, some governors, unaccustomed to the autonomy afforded by the pandemic and unable or unwilling to bear responsibility for these decisions, decided to resign directly after the "non-working" days introduction and decentralization of power (Goryashko et al. 2020; Smeltzer 2020).[8] This surge of resignations also could be tied to political strategy for each individual governor: according to Russian legislation, a governor who was dismissed from his/her position by the President cannot participate in the following election, and with the next regional elections scheduled for September 2020, governors whose term is about to expire can resign and thus allow for prolonging their mandate without having to deal with the consequences of the pandemic. To utilize this strategy, a governor needs to resign at least three months before the elections, meaning that post-lockdown was a perfect time to avoid any consequences of their newfound autonomy while retaining the option to run again in September (when, likely, autonomy would once again be circumscribed).

As a result of this temporary decentralization, the strictness of self-isolation policies varied from region to region. For instance, in Moscow, a system of electronic permits was introduced to restrict movement within the city (Moscow Mayor Decree 2020). About 20 Russian regions have followed the example of Moscow and introduced mandatory self-isolation, while other regions issued merely recommendations on self-isolation. Non-essential businesses and services have been closed and remained closed in Moscow even after the abolishment of "non-working" days, while in most regions, the policies have been less strict (Roache 2020). In fact, preliminary estimates of the COVID-19 effects on the Russian

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[8] According to Russian legislation, since 2012, in most regions of Russia, except for several ethnic republics and autonomous regions, governors are elected by voters for a period of five years. However, to participate in the elections, a candidate who is not nominated by any political party should get a certain number of supporting signatures from the voters in the region, while a candidate who is nominated by a political party should get supporting signatures from the members of the municipal parliaments in the region. Before the elections, the President can have consultations with the political parties who nominate candidates or with candidates who self-nominate themselves. In recent years, most candidates for regional governor are nominated by the dominant political party, "United Russia".

economy show that in May 2020, as compared to December 2019, production sectors were not affected substantially, while services and retail suffered much more, confirming that the self-isolation policies mostly had an effect on small business and services sectors but not on industry (Centre of Development Institute 2020).

V.   Data and Methodology

a.   Data sources

To understand the impact of decentralization and lockdown on pollution, we utilize several novel data sources across both environmental metrics and political institutions (Table A1 in appendix presents summary statistics on all data used in the paper).

The first source we draw on is the Air Quality Open Data Platform which collects daily data on the PM_{10}, $PM_{2.5}$, CO, SO_2, and NO_2 emissions, as well as on meteorological conditions, including mean daily temperature, humidity, wind speed, and atmospheric pressure in 380 cities around the globe.[9] For Russia, data on air quality are collected for six industrial cities with the population over one million, including Moscow, Saint Petersburg, Nizhniy Novgorod, Chelyabinsk, Krasnoyarsk, and Novosibirsk.[10] Table A2 in appendix shows the mean AQI for the Russian cities in the studied period, February 22-June 30, 2020. Missing data on meteorological conditions are complemented by the data from the Federal Service for Hydrometeorology and Environmental Monitoring of Russia. All pollution data is measured as the Air Quality Index (AQI) according to the US Environmental Protection Agency (EPA) standard (see EPA 2018). We use mean daily AQI and maximal daily AQI. The AQI index takes values from 0 to 500 that are divided into six categories according to the levels of risk for human health: good air quality (AQI 0-50), moderate

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[9] Data are available at https://aqicn.org/data-platform/covid19/ (last accessed July 1, 2020).
[10] Data on $PM_{2.5}$ and PM_{10} are also available for Tomsk. However, the information on other pollutants such as CO, SO_2, and NO_2 is missing for this city. Differently from other cities in the sample, Tomsk also has a population lower than one million. Therefore, we exclude it from the analysis.

air quality (51-100), unhealthy for sensitive groups (101-150), unhealthy (151-200), very unhealthy (201-300), and hazardous air quality (301-500).

The second data source is the data on the regional governors' influence scores recently made available by Orlov (2020). The scores are calculated monthly based on the average of an evaluation by 27 Russian experts, including representatives of academia, regional NGOs, and regional media; the question asked is "How would you evaluate the influence of each Russian governor at the federal level (i.e. President's Administration; Government of the Russian Federation; Federal Assembly of the Russian Federation; party and business elites), using a ladder from 1 (very low influence) to 10 (very strong influence)?"[11] In our sample, the highest influence score belongs somewhat unsurprisingly to the Governor of Moscow, while the lowest accrues to the Governor of Novosibirsk region (see Table A2 in appendix). Importantly for our econometric analysis – and in line with the reality of Russian politics - there is substantial variation in the influence scores of governors between regions over time and even within one region (Figure 2), meaning that this is by no means a time invariant indicator.

Figure 2. Governors' influence score, August 2018-June 2020.

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[11] The full list of experts is available from Orlov (2020).
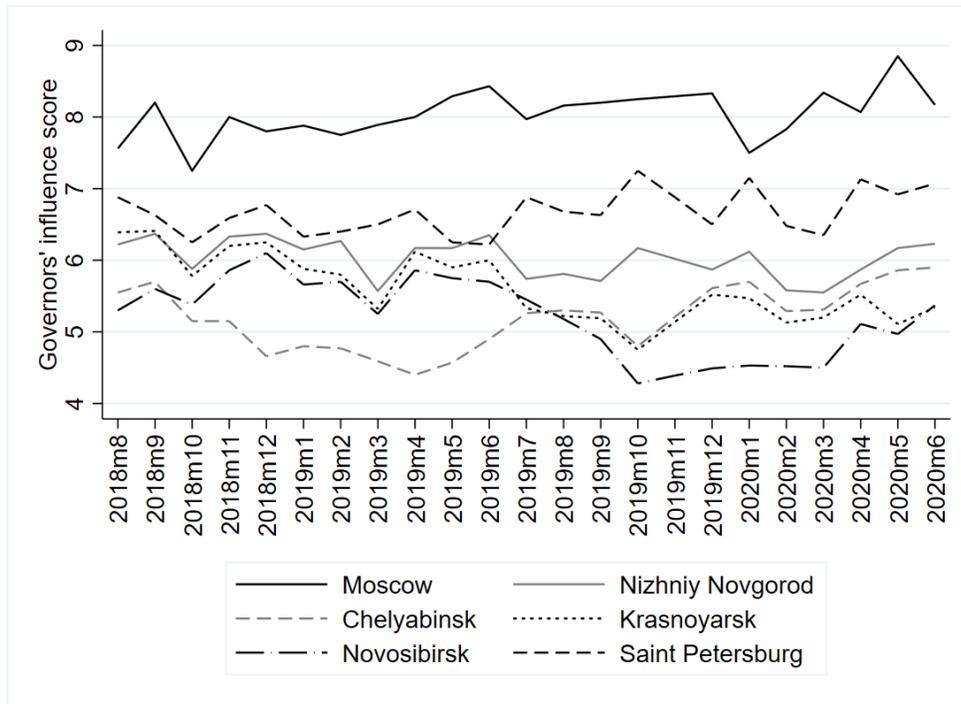
Source: Authors' construction based on Orlov (2020). Notes: The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence).

Finally, we employ the Yandex Self-Isolation Index, recently developed by Yandex, the leading technological company in Russia which offers applications and services for both business and private users, including a search engine, navigation products, transportation services, logistics, human resources services, corporate health insurance, and online sales registers.[12] Yandex search data have previously been used in research on climate change in Russia, see Losch et al. (2019), but their self-isolation index was launched in February 2020 and has not been utilized before. The Index is calculated based on the use of various services and mobile applications of Yandex and ranges from 0 (no self-isolation) to 5 (complete self-isolation). The index shows the daily level of urban activities in the period from February 22, 2020 till June 30, 2020. The index compares urban activities during the coronavirus period to activities in a typical

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day before the coronavirus outbreak.[13] The value of 0 corresponds to a rush hour during a typical workday and the value of 5 corresponds to quite night hours during a typical day. Figure 2 documents the level of this index in Russia from March 2 till June 30, 2020.

Figure 3. Self-isolation in Russia.
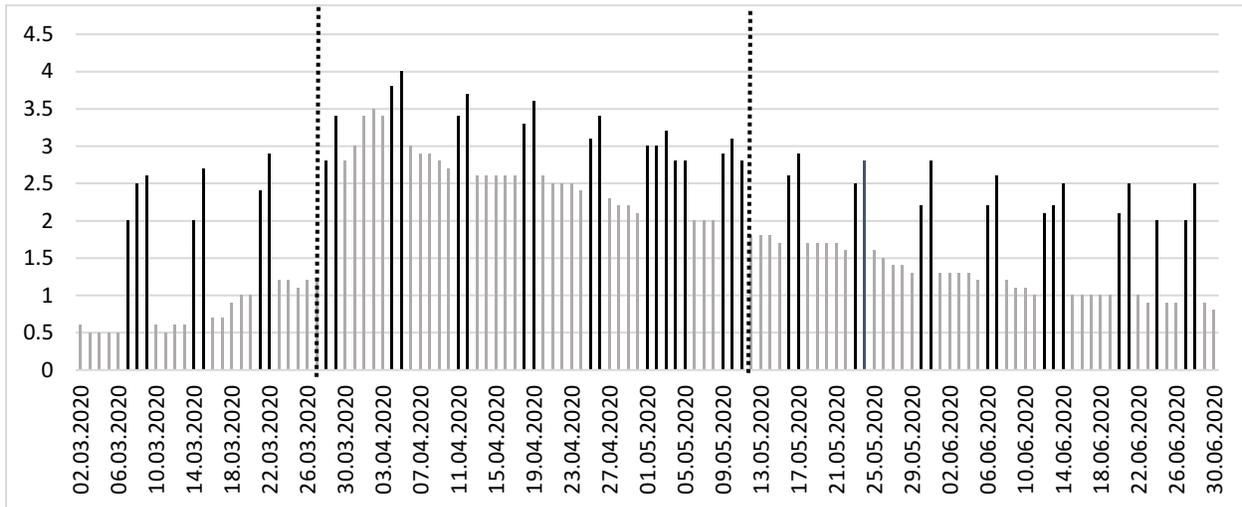
Source: Authors' construction based on the Yandex Self-Isolation Index for the whole of Russia. Notes: The Yandex self-isolation index is measured on a scale from 0 (no self-isolation) to 5 (complete self-isolation). The index is calculated as an average of self-isolation indices in the Russian cities with the population over 1 mln. Black bars correspond to weekends and public holidays, while grey bars correspond to workdays. The period between the dashed lines is the "non-working days" policy period (28.03.2020-11.05.2020).

b. **Case selection**

We use a panel data set of five Russian cities, including Saint Petersburg, Nizhniy Novgorod, Chelyabinsk, Krasnoyarsk, and Novosibirsk, during the period February 22 to June 30, 2020, to analyze the role of regional governors' influence in the federal politics and self-isolation on pollution. As shown in Table A3 in the appendix, the five cities in our sample are representative of other Russian industrial cities in terms of most economic characteristics, including in the influence score of the governor, size (area), fixed assets investment, total fixed assets, value added in mining, manufacturing, energy sector, and

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[13] A typical day activity is defined as the average level of urban activity in the days before the coronavirus outbreak in Russia (March 2-March 5, 2020).

construction and retail revenue.[14] The sample cities are slightly larger in population and have a higher average nominal monthly wage compared to the remaining 11 cities in Russia, but these differences are likely due to the inclusion of Saint Petersburg in the sample. The results without Saint Petersburg are available in Table A9. Similarly, Moscow is an extreme outlier in terms of most socioeconomic characteristics, and it is thus excluded from the main analysis.[15]

As noted in Section I, poor air quality is one of the most severe environmental problems faced by Russian cities and, in 2018, 58% of Russian cities had air pollution levels above national air quality standards.[16] As noted, we acknowledge that other issues plague the Russian landscape apart from air quality, including water pollution and waste management issues, and these problems are not unique to major industrial cities (Feldman and Blokov 2012; Lyahovenko and Chulkov 2017). For instance, small cities often have a mono-industrial structure and face as serious environmental problems as major cities (Lyahovenko and Chulkov 2017). However, during the COVID-19 pandemic, we are highly constrained by the availability of air quality data across the Russian landmass, and thus have chosen air quality as our key environmental issue for both pervasive nature in Russia and our access to data on its current state.

A final note on air quality is in order, as our chosen cities are also representative of the differences in initial air quality levels across various locales: according to the Russian classification of cities with high air pollution, there are four levels of air quality, corresponding to low, upper-middle, high, and very high level of pollution. By this classification, in 2019, Saint Petersburg and Nizhniy Novgorod had a low level of

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[14] Overall, there are 16 industrial cities in Russia that have a population over one million.
[15] The case of Moscow is also exceptional in terms of the governor's influence. The Moscow governor steadily holds the highest influence score and is in fact, more flexible and has more power in decision-making than other governors. For instance, the decisions and policies of the Moscow governor implemented in the first months of the pandemic often served as a focal point for other governors. Given that the governor of Moscow can be seen in many ways an extension of the central government, it was excluded here.
[16] This indicator has decreased over the recent decade from being 83% in 2010. However, as noted by Feldman and Blokov (2012), the Russian air quality standards are lower than the ones in the US and Europe, implying that the air quality might be even worse than reported.

pollution, Chelyabinsk and Novosibirsk an upper-middle level, and Krasnoyarsk had a high level of pollution, meaning we have selected cities across the distribution.[17]

c. Econometric model and identification

We estimate the following equation using a fixed effects regression:

$$pollution_{cd} = \beta_0 + \beta_1 score_{cm} + \beta_2 weekend_d + \boldsymbol{\gamma'weather_{cd}} + \mu_c + \varepsilon_{cd} \quad (1)$$

where *c* corresponds to a city, *d* corresponds to a day, and *m* corresponds to a month. *Pollution* is a set of AQI indicators for different types of pollution, including PM_{10}, $PM_{2.5}$, CO, SO_2, and NO_2. *Score* is the regional governor's influence at the federal level measured as score from 1 (very low influence) to 10 (very strong influence), as noted above. *Weekend* is a dummy variable equal one for weekends and public holidays and zero otherwise. **Weather** is a set of meteorological conditions, including mean daily temperature (in °C), wind speed (in meters per second), humidity (in %), and atmospheric pressure (in mm). μ is the unobserved city fixed effect, and ε_{cd} is a stochastic disturbance. β_0, β_1, β_2, and **γ** are the model parameters. Standard errors are robust to heteroskedasticity. Since our sample includes only five cities (clusters), standard errors might be underestimated. To ensure this is not the case, we also conduct the wild cluster bootstrap as suggested by Roodman et al. (2019). P-values of all estimates from this bootstrapping confirm the main findings and are available up on request. Given that our sample is relatively short and is based on a very recent daily data (February 2020-June 2020), city fixed effects also serve as a proxy for the city-level economic performance during the studied period.

The coefficient β_1 shows to what extent the governor's influence affects city pollution levels during the pandemic. We hypothesize that decentralization, i.e., a stronger power of regional governors, helps

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[17] According to data from the Federal Service for Hydrometeorological and Environmental Monitoring and the Voeikov Main Geophysical Observatory. See http://voeikovmgo.ru/?option=com_content&view=article&id=681&Itemid=236&lang=ru (last accessed December 20, 2020).

to reduce pollution levels through influencing regional environmental policies. During the pandemic, one such policy tool that was delegated to regional governors was the lockdown (or self-isolation policy) and the regulations regarding the operation of non-essential businesses. To understand whether the self-isolation policy indeed mediates the effects of governor's influence on pollution, we introduce the intensity of lockdown as an additional control in Eq. (1):

$$pollution_{cd} = \tilde{\beta}_0 + \tilde{\beta}_1 score_{cm} + \delta isolation_{cd} + \tilde{\beta}_2 weekend_d + \widetilde{\boldsymbol{\gamma}}' \boldsymbol{weather_{cd}} + \mu_c + \tilde{\varepsilon}_{cd} \quad (2)$$

In Eq. (2), *isolation* is the Yandex self-isolation index as described above, while the other variables are the same as in Eq. (1). $\tilde{\varepsilon}_{cd}$ is a stochastic disturbance, and $\tilde{\beta}_0$, $\tilde{\beta}_1$, $\tilde{\beta}_2$, δ, and $\widetilde{\boldsymbol{\gamma}}$ are the model parameters, where δ shows the effect of lockdown on city pollution.

In Eq. (2), the estimate of coefficient $\tilde{\beta}_1$ is the effect of governor's influence score on pollution adjusting for the self-isolation policy or, in other words, the effect of governor's influence on pollution that is not visible via the self-isolation policy channel. Thus, if the self-isolation policy mediates the impact of governor's score on pollution, then the estimate of coefficient $\tilde{\beta}_1$ will have a lower magnitude and statistical power than the estimate of coefficient β_1 (MacKinnon 2008).

One potential concern is that the observed level of self-isolation is solely due to the governor's influence, implying a high collinearity between the two. However, there is a low correlation between these two variables (see Table A3 in appendix), suggesting that, even though regional governors affect the extent of self-isolation, this is only one of a myriad of possible policies through which governors may influence pollution.

Potentially more troubling is the reality that the estimates in Eq. (1) are consistent and unbiased only if the governor's influence score is exogenous. In the first instance, a more influential candidate may prefer to become a governor in a region with a lower pollution level, in order to better carry out industrial development and increase their influence even further. If this latter issue is at play, then our estimate on

the governor score might also be biased due to self-selection. However, pollution levels are likely to serve not as primary factors in the candidate's decision to become a governor in a particular region. As shown above, candidates may have low possibilities to "choose" a region where to become a regional governor, as the candidates to this position are often first formally or informally approved by the federal authorities and regional elites. Thus, the issue of selection bias is likely to be minimal.

On the other hand, and more plausibly, although environmental policies are mostly centralized and designed at the federal level in Russia, the influence of a regional governor may be endogenously determined by the stringency and enforcement of environmental regulations at the regional level before the pandemic. To account for this possible endogeneity, we use an instrumental variable approach applied to the fixed effects model presented in Eq. (1). A suitable instrument in this case should fulfill two criteria, namely that it is correlated with the governor's influence score but is unrelated to pollution (and thus affect pollution only through the governor). For this examination, keeping these criteria in mind, we utilize the time spent by a governor in office (in years) as an instrument.[18]

The reasoning behind this selection is that candidates to a governor position are often first formally or informally approved by the federal authorities, meaning that the newly appointed governor may have a high influence score initially; conversely, governors with a longer history in office may build either a good (or bad) reputation at the federal level leading to a higher (lower) influence score. This reality is confirmed in our correlation analysis, as the correlation between the governor's influence score and the time spent in office is -0.233, statistically significant at 1% level and satisfying the first criterion. For the second portion, our instrument is also likely to influence pollution only through the governor's score as regional governors are only able to influence environmental regulations once they have a high influence score at the federal level. Put another way, given that environmental policies are highly centralized,

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[18] For each day in the sample period, the variable is calculated as the number of days since the start of the governor's term in office divided by 365.

governors without a high influence score have a very limited possibility to influence and enforce environmental regulations at the regional level.

As a robustness check, we also use an alternative instrument, namely the governor's age rather than their tenure in office (for each day in the sample period, the variable is calculated as the number of days since the governor's date of birth divided by 365). Much like governors who have been on the job longer, older governors are survivors and may know the rules of the game better to be able to build influence at the federal level quickly. In our sample the correlation between the governor's influence score and the governor's age is 0.206 and is statistically significant at 1% level. Like length of time in office, the governor's age is less likely to be connected with pollution due to the centralization of environmental regulations.

VII.   Results

This section provides evidence on the relationship between the power of regional governors and pollution, and on the mediating role of self-isolation policy during coronavirus in this relationship. We first briefly discuss the correlation between governors' score and pollution and the results of our regressions, following with a discussion on the possible causal mechanisms at play (including, in line with our theory above, how governor influence may have created a space for polycentrism).

In Figure 4, we present the correlation between the governor influence score and the particulate matter $PM_{2.5}$ concentration. The scatter plot is based on six Russian industrial cities, including Chelyabinsk, Krasnoyarsk, Nizhniy Novgorod, Novosibirsk, and Saint Petersburg, and Moscow. As shown, in the group of regional centers, a governor's influence in federal politics is negatively correlated with pollution, while for Moscow, this correlation is mildly positive. As shown in Table A4, the corresponding correlation coefficients are -0.438 for regions (statistically significant at 1% level) and 0.057 for Moscow (not statistically significant). This implies that there is a systematic pattern between the *de facto*

decentralization which took place during the first wave of the pandemic, the power/influence of regional governors, and the environmental outcome of lower pollution.

Figure 4. Correlation between the governor influence score and PM$_{2.5}$.
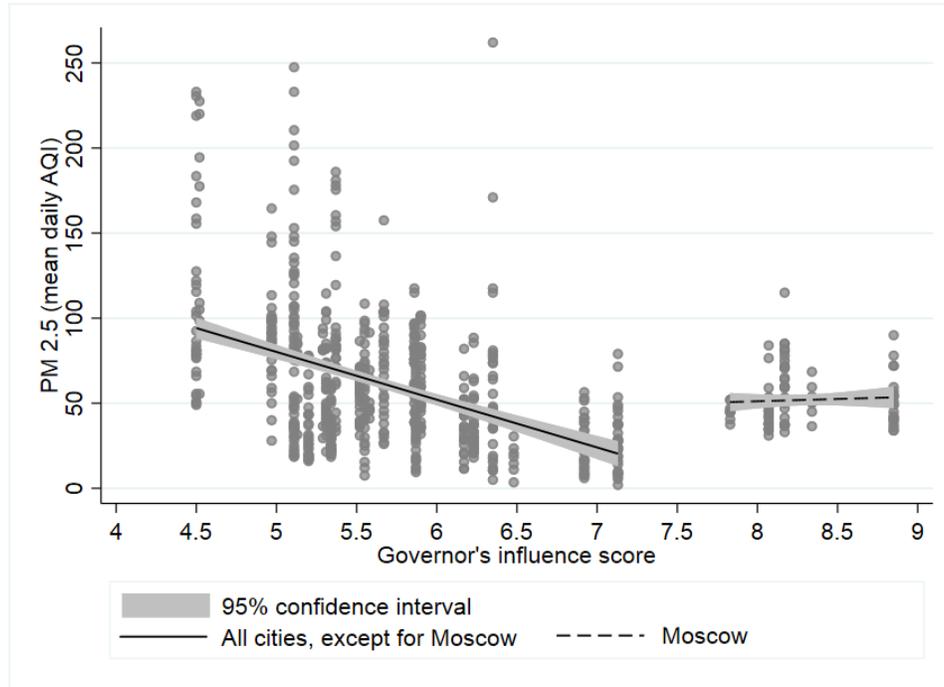
Source: Authors' construction. Notes: PM$_{2.5}$ is measured as the mean daily AQI according to the US Environmental Protection Agency standard. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, Novosibirsk, and Moscow.

We next present the regression results for this relationship for several major pollutants in Table 1. As noted above, the governor's score is likely to be endogenous (confirmed econometrically in Table 1), and therefore we focus on the results of the fixed-effects IV estimation (while the fixed effects estimation results without IV are shown as a reference). Firstly, the results suggest that the instrument employed for the estimation, time spent by a governor in office, is not weak and performs well. In terms of our variables of interest, as shown in Table 1, a higher influence score of a regional governor is indeed associated with lower pollution (again, given the special nature of the capital, Moscow is excluded from all regressions). This result confirms the graphic analysis also for other pollutants, including PM$_{10}$, CO, SO$_2$, and NO$_2$. In fact, the IV regression results suggest that if a regional governor's influence score increases by 1, the air

quality indices for PM_{10}, $PM_{2.5}$, CO, SO_2, and NO_2 decrease by 43.6, 84.1, 6.4, 13.1, and 19.5 points, respectively. In relative terms, this means a decrease in pollution by 139%, 136%, 107%, 120%, and 133%, respectively.[19]

While such a reduction of pollution would appear to be good *a priori*, this environmental improvement is substantial even if placed in a cost/benefit framework matching benefits of pollution reduction with the costs of pollution abatement. Table 2 shows the current (as of 2018) costs of the regulatory budgets in each of the cities under examination here and the corresponding pollution levels, expressing pollution costs as the regulatory expenses divided by pollution. Using this as a baseline to translate pollution into monetary costs, the reductions in pollution predicted by our model equate with a reduction in costs of approximately USD 164.4 million annually.[20]

Several control variables are also statistically significant, and their effects are in line with the previous literature. The findings suggest that higher temperature increases pollution levels, while stronger wind and higher humidity decrease it. Also, in line with general trends of economic activity, pollution is lower during the weekends. As noted above, as a robustness check, we also provide the results with the alternative instrument of a governor's age, and these results confirm the main findings shown in Table 1 (the robustness check is shown in Table A6 in the appendix). In addition, we provide results with maximal daily pollution levels instead of mean daily pollution. The results are reported in Table A8 in appendix. The results confirm that a higher influence score of a regional governor is associated with lower pollution, but the impact is almost two times larger in absolute value when maximal daily pollution is used as a dependent variable instead of mean daily pollution; this suggests that not only was the decentralization

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[19] These numbers are computed as follows (43.6/31.17)*100, (84.1/61.62)*100, (6.4/5.93)*100, (13.1/10.88)*100, and (19.5/14.59)*100. The nominator is the estimated effect of governor's score on a specific type of pollution from Table 1, while denominator is the mean pollution in the sample from column (7) in Table A2 in appendix. The first stage results are reported in Table A5 in appendix.

[20] The total annual reduction is calculated as follows 36+35.2+27.7+31.1+34.4=164.4 mln. USD. All estimates are taken from Table 2. A fuller calculation of costs would also include longer-term disruptions in regional GDP, but unfortunately such data is not available at this time.

of environmental policymaking good at the midpoint of the distribution, it also helped to dramatically reduce the right tail as well.

Figure 5 summarizes the IV regression results on the governor score and pollution from Table 1. As shown, the effects on PM_{10} and $PM_{2.5}$ are larger, but less precisely estimated, and thus the confidence intervals are correspondingly wider. The effects on CO, SO_2, and NO_2 are more precise and statistically different from the effect on $PM_{2.5}$. One possible explanation for such finding relates to the nature of polycentric governance and the way in which environmental action may result in changes in environmental quality: at the level of regional governance, a governor is likely to have more policy instruments to influence the emissions of specific pollutants such as SO_2, NO_2, and CO compared to PM_{10} and $PM_{2.5}$, which represent a mixture of solid particles in the air with the diameter of 10 mm and 2.5 mm, respectively. Thus, particulate matter is a longer-term issue requiring sustained action across many actors -and is much harder to target via direct regulation – meaning an area ripe for extended experiments in polycentrism, but not necessarily one which can deliver results in a short time span.

Table 1. Governor's influence and pollution.

VARIABLES	(1) PM_{10} FE	(2) PM_{10} IV	(3) $PM_{2.5}$ FE	(4) $PM_{2.5}$ IV	(5) CO FE	(6) CO IV	(7) SO_2 FE	(8) SO_2 IV	(9) NO_2 FE	(10) NO_2 IV
Governor influence score	-21.315**	-43.601***	-24.545*	-84.089***	-2.064*	-6.446***	-1.775	-13.073***	-4.329	-19.537***
	(3.669)	(6.602)	(10.446)	(9.612)	(0.754)	(0.951)	(2.065)	(3.448)	(2.926)	(2.376)
Weekend day	-0.929	-1.097	0.704**	-0.380	0.133	0.049	0.000	-0.292	-2.074***	-2.367***
	(1.625)	(2.546)	(0.248)	(2.740)	(0.518)	(0.280)	(0.143)	(0.904)	(0.442)	(0.610)
Mean daily temperature (C)	-0.188	0.376	-0.067	0.994***	0.043	0.120***	0.130	0.320***	-0.092	0.174**
	(0.530)	(0.233)	(0.512)	(0.253)	(0.029)	(0.025)	(0.148)	(0.093)	(0.179)	(0.072)
Mean daily wind speed (m/sec)	-4.844*	-4.950***	-6.711***	-7.252***	-0.505*	-0.549***	-0.641*	-0.785***	-1.495**	-1.646***
	(1.920)	(0.977)	(1.452)	(0.927)	(0.195)	(0.081)	(0.267)	(0.248)	(0.439)	(0.216)
Mean daily humidity (%)	-0.189	-0.198**	-0.194	-0.293***	0.007	-0.001	-0.079	-0.098***	-0.053	-0.080***
	(0.205)	(0.091)	(0.241)	(0.096)	(0.015)	(0.008)	(0.044)	(0.034)	(0.078)	(0.030)
Mean daily atmospheric pressure (mm)	0.210	0.133	0.284	0.160	0.022	0.014	-0.162	-0.171**	0.076	0.048
	(0.320)	(0.185)	(0.401)	(0.197)	(0.019)	(0.019)	(0.170)	(0.080)	(0.073)	(0.049)
Ho: IV is weak; F-statistics		490.18***		364.75***		319.53***		256.87***		319.53***
p-value		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
Ho: Governor's score is exogenous; P-value		0.000		0.000		0.000		0.000		0.000
Observations	486	486	616	616	581	581	476	476	581	581
R-squared (within)	0.121	0.097	0.165	0.006	0.107	0.010	0.069	-0.011	0.171	-0.031
Number of cities	4	4	5	5	5	5	4	4	5	5

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and Orlov (2020).

Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$. Robust standard errors in parentheses. Daily data from 22.02.2020 till 30.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM_{10} in Krasnoyarsk and on SO_2 in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). Governor's time in office is used as an instrument for governor's influence score.

Table 2. Estimated annual reduction in pollution in mln. USD.

Cities:	Regional budget costs on environmental protection in 2018, mln. USD	Total air pollution in a region in 2018, tonnes	Costs in mln. USD per tonne	Reduction in costs due to PM10 reduction, mln. USD	Reduction in costs due to PM2.5 reduction, mln. USD	Reduction in costs due to CO reduction, mln. USD	Reduction in costs due to SO2 reduction, mln. USD	Reduction in costs due to NO2 reduction, mln. USD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Krasnoyarsk	6.8	2,319,000.0	0.000003	9.5	9.3	7.3	8.2	9.1
Nizhnyi Novgorod	6.1	92,000.0	0.000066	8.5	8.3	6.5	7.3	8.1
Chelyabinsk	6.6	488,000.0	0.000014	9.2	9.0	7.1	7.9	8.8
Saint Petersburg	5.4	84,000.0	0.000065	7.5	7.4	5.8	6.5	7.2
Novosibirsk	1.0	126,000.0	0.000008	1.3	1.3	1.0	1.2	1.3
Total	25.9	3,109,000.0	0.000008	36.0	35.2	27.7	31.1	34.4
Total reduction in %				139.0	136.0	107.0	120.0	133.0

Source: Authors' calculations. Notes: Data on regional costs on environmental protection and total air pollution are from the Russian State Statistics Service and the regional Ministries of Finance. Exchange rate is 69.36 Rub/USD (as of 31.12.2018). All columns represent amounts per year. Column (3) is computed by dividing column (1) by column (2). Columns (4)-(8) are computed by multiplying the total pollution reduction in % (see footnote 11 for computation) by column (2), column (3), and dividing the resulting amount by 100%.

Figure 5. The effects of the governor's influence score on different types of pollution.
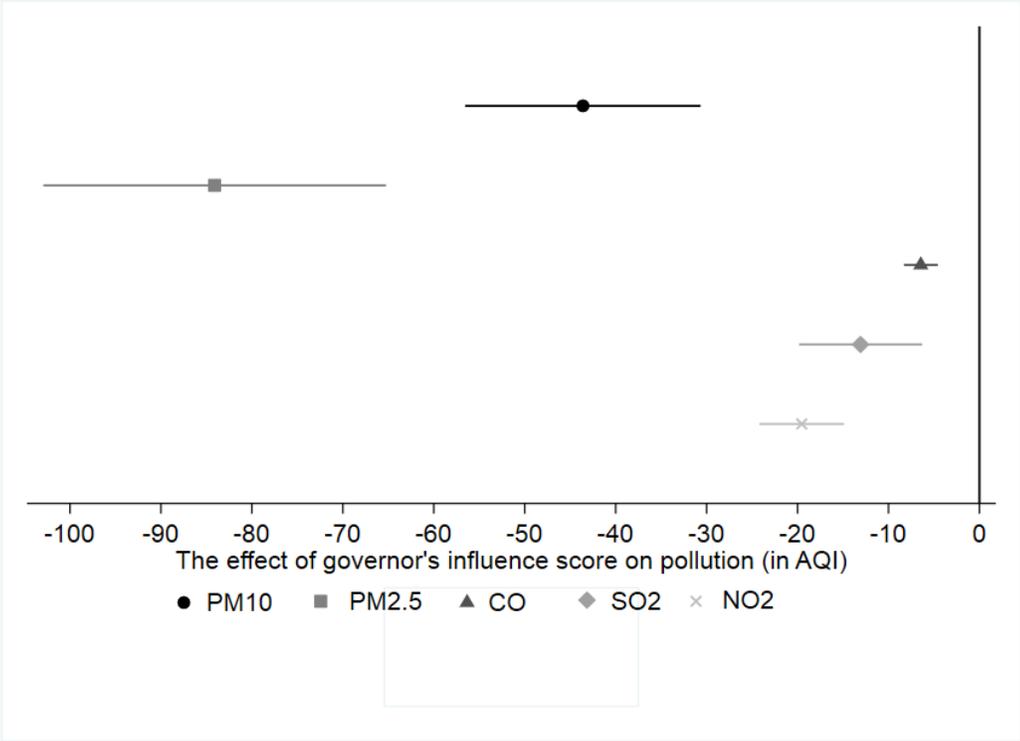
Source: Authors' construction based on the estimates from Table 1 with the 95% confidence intervals. Notes: All emissions are measured as mean daily AQI according to the US Environmental Protection Agency standard. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk.

As hinted at above, during the COVID-19 pandemic, one specific instrument that was given into the hands of regional governors was the self-isolation policy and regulations regarding movement and classification of "non-essential" business activities. As seen in Figure 6 and Table A7 in appendix, self-isolation policies reduced pollution, with an effect similar for both the regions and for Moscow. As shown in Table A4 in the appendix, the corresponding correlation coefficients are -0.103 for regions (statistically significant at 5%) and -0.317 for Moscow (statistically significant at 5%).

Figure 6. Correlation between the self-isolation and PM$_{2.5}$.
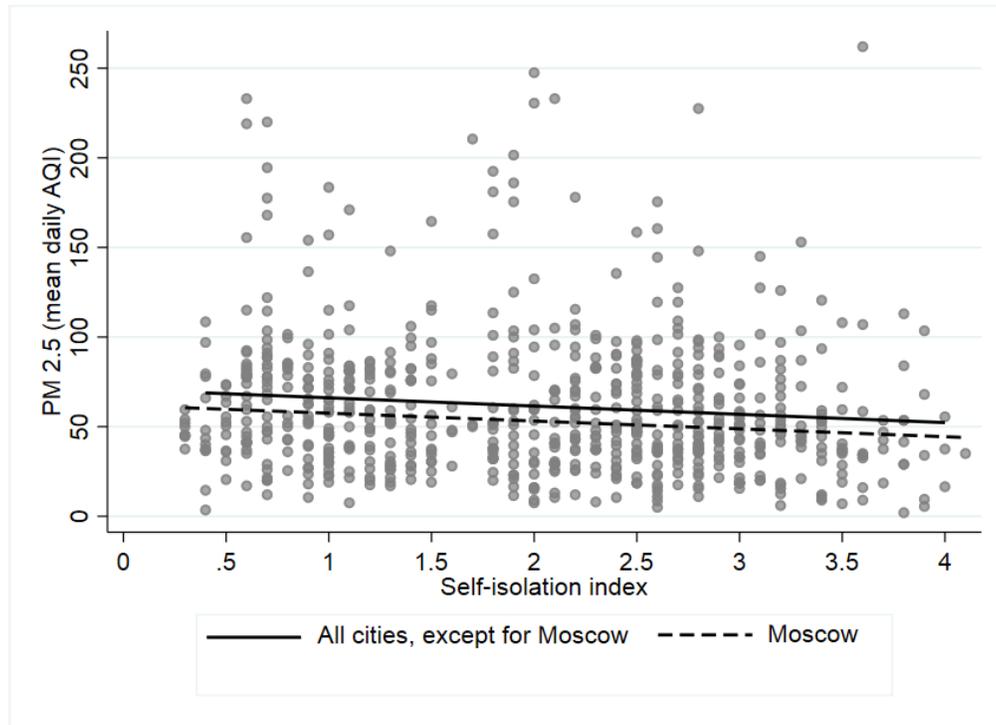
Source: Authors' construction. Notes: PM2.5 is measured as mean daily AQI according to the US Environmental Protection Agency standard. The self-isolation index is measured on a scale from 0 (no self-isolation) to 5 (complete self-isolation). Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, Novosibirsk, and Moscow.

Could the self-isolation policy have been the reason for the reduction in pollution? Could this one area of decentralization, the most limited form of polycentrism and one only peripherally related to environmental action, be the driver of these results? To test whether this policy has a mediating effect on the effect of a governor's influence on pollution, we add the self-isolation index into baseline model. Table 3 shows the IV estimation results with self-isolation index as an additional control and the governor's time in office as an instrument. As shown in this table, when self-isolation is included into the model, the estimated effect of governor's score on pollution is slightly larger in magnitude in absolute value in case of all pollutants. The effect also retains its significance in case of all pollutants. This suggests that the self-isolation policy indeed helps to mediate or even reinforce the impact of regional governor's score on pollution, but by no means it is the only driver of the improvement in Russia's environment during the pandemic. In each regression, the governor's influence remains the

key factor driving pollution, suggesting that polycentric governance beyond merely isolation orders is at work.

Table 3. Governor's influence and pollution. Self-isolation policy as a mediator.

VARIABLES	(1) PM$_{10}$	(2) PM$_{2.5}$	(3) CO	(4) SO$_2$	(5) NO$_2$
Governor influence score	-47.494***	-90.197***	-6.719***	-14.529***	-21.271***
	(7.450)	(10.628)	(1.023)	(3.758)	(2.768)
Self-isolation index	4.230**	6.713***	0.200	1.364*	1.389***
	(1.755)	(2.027)	(0.209)	(0.734)	(0.505)
Weekend day	-4.753*	-6.498*	-0.095	-1.534	-3.560***
	(2.736)	(3.422)	(0.372)	(1.053)	(0.866)
Mean daily temperature (C)	0.563**	1.219***	0.125***	0.357***	0.221***
	(0.269)	(0.289)	(0.028)	(0.105)	(0.080)
Mean daily wind speed (m/sec)	-5.051***	-7.464***	-0.553***	-0.823***	-1.681***
	(0.995)	(0.957)	(0.081)	(0.249)	(0.225)
Mean daily humidity (%)	-0.129	-0.195**	0.001	-0.084**	-0.063**
	(0.088)	(0.099)	(0.009)	(0.038)	(0.029)
Mean daily atmospheric pressure (mm)	0.212	0.255	0.017	-0.163**	0.064
	(0.183)	(0.198)	(0.019)	(0.082)	(0.049)
Ho: IV is weak; F-statistics	511.20***	343.61***	267.80***	218.73***	267.80***
Ho: Governor's score is exogenous; P-value	0.001	0.000	0.000	0.000	0.000
Observations	482	611	576	472	576
R-squared (within)	0.103	0.001	0.006	-0.016	-0.054
Number of cities	4	5	5	4	5

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, Orlov (2020), and the Yandex Self-Isolation Index. Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$. IV estimation results are reported. Governor's time in office is used as an instrument for governor's influence score. Robust standard errors in parentheses. Daily data from 22.02.2020 till 30.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM$_{10}$ in Krasnoyarsk and on SO$_2$ in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). The self-isolation index is measured on a scale from 0 (no self-isolation) to 5 (complete self-isolation).

Overall, our findings suggest that greater power in hands of regional governors has the potential to reduce pollution and deliver better environmental outcomes. COVID-19 provided a natural experiment to support this finding, as more decentralized policymaking during the pandemic saw air quality in Russia improve. Indeed, our findings show that self-isolation policy introduced by regional

governors in time of pandemic mediated the effect of a regional governor's power and influence in the federal politics, but the environmental effects could only partially be attributed to the lockdown policy itself. Thus, we may conclude that the coronavirus pandemic revealed the environmental benefits of decentralization of governance in Russia, although, as this early stage, we cannot specify exactly what form the specific governance in each city took. Indeed, continuing the explore the various types of polycentrism which arose to address environmental challenges in Russia is an ongoing project.

VIII.   Conclusions

The travails of Russian environmental policymaking have been well-covered in the literature but mainly from the standpoint of desirable policies and available instruments rather than as an institutional issue to overcome. This paper took a different view, examining Russia's environmental policies and institutions as part of a polycentric order containing various decisionmakers and stakeholders, all with their roles to play, and posited that there could be major benefits to environmental outcomes from decentralizing the highly centralized decision-making process in Russia. Our econometric analysis, using novel data and new variables to proxy for limited decentralization during the coronavirus pandemic of 2020, confirmed that Ostrom's (2009) framework can indeed provide a way forward for Russia: greater local control, even in a short space of time, resulted in improved environmental outcomes (even though it had little effect on formal policymaking). This result held even when controlling for the major shock which would have been expected to reduce economic activity, namely the lockdown accompanying the pandemic.

A host of research could follow on from this paper. In the first instance, one could backdate the gubernatorial influence index to see if this relationship – between influence and environmental progress - held in previous years, or perhaps explore the use of other de facto decentralization metrics in Russia. Secondly, this paper has concentrated on one particular country with a history of centralized

decision-making, and a further extension would be to expand this work beyond Russia, comparing various degrees of decentralization across a panel dataset. Such an empirical analysis of Ostrom's framework could also delve into other subtleties not explored here, such as there are different poles in a polycentric order which are more important than others. A panel approach could also control for different levels of property rights which, as noted in our introduction, are low but uniform across Russia. We acknowledge that it is also interesting to check if our arguments hold beyond the major industrial cities and for other indicators of environmental quality in Russia. While we cannot address this issue in our analysis due to data availability constraints, we encourage future research in this direction, as well as identifying the specific polycentric mechanisms at work, i.e., is it only occurring at the regional governor's level (probable during a short time span), or is shifting the burden of environmental action to private and local actors?

In any event, the policy recommendations which follow from this paper for Russia appear quite straightforward, namely that Russia might benefit from a substantial decentralization of its environmental policymaking in the years to come; more importantly, policymaking itself might be secondary to allowing the space for environmental experimentation at the regional and local level to emerge, focused on solutions rather than policies. This finding is in contrast with Zhang et al. (2018), who argue that the centralization of environmental regulation leads to a lower level of emissions in China; in the Russian case, even if regional governors with no interest in the environment come into power, their lack of top-down imposition may still allow for the space for polycentric governance to emerge and environmental outcomes to improve.[21] As Hartwell (2014) argued in a presentation to Russian policymakers, Russia should be utilizing its regions as laboratories to experiment with various forms of market-based and stakeholder-based environmental protection. While there is no guarantee that regions may immediately be environmentally conscious – the worries of sub-national

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[21] Thanks to both an anonymous referee and participant at the ECPR Annual Conference who asked about the situation if a governor who neglected environmental policy (or even created poor regulations) should be elected.

authoritarians as in the 1990s still remain – the extant literature shows that any form of polycentrism

may lead to gains in environmental protection (and such an approach now has some empirical backing

via our exercise). In reality, the diversity of environmental challenges across the landmass of the

Russian Federation and calls for innovation in a local, decentralized, and polycentric framework.

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Table A1. Descriptive statistics.

VARIABLES	N	Mean	St. dev.	Min	Max
PM_{10} (mean daily AQI)	486	31.17	33.31	1.5	256.5
$PM_{2.5}$ (mean daily AQI)	616	61.62	41.34	2	262
CO (mean daily AQI)	581	5.93	6.04	0.1	36.25
SO_2 (mean daily AQI)	476	10.88	9.99	0.85	97.3
NO_2 (mean daily AQI)	581	14.59	8.3	2.35	53.8
PM_{10} (max daily AQI)	486	59.38	65.03	2	491
$PM_{2.5}$ (max daily AQI)	616	114.3	76.64	3	456
CO (max daily AQI)	581	10.23	10.92	0.1	61.7
SO_2 (max daily AQI)	477	20.76	19.27	0.1	194.5
NO_2 (max daily AQI)	581	27.68	15.55	3.4	107.1
Mean daily temperature (°C)	620	8.41	9.22	-16.5	93.3
Mean daily wind speed (m/sec)	620	3.48	1.74	0.2	9.7
Mean daily humidity (%)	620	61.03	17.31	21	100
Mean daily atmospheric pressure (mm)	620	750.5	10.55	721.3	780.8
Self-isolation index (0=no self-isolation; 5=complete self-isolation)	645	1.94	0.92	0.4	4
Governor influence score (1=the lowest influence, 10=the highest influence)	650	5.73	0.70	4.5	7.13
Weekend day (1=weekend or public holiday, 0 otherwise)	650	0.35	0.48	0	1
Governor's age (years)	650	53.50	9.91	40.53	66.35
Governor's time in office (years)	650	2.26	0.63	0.93	3.06

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, the Yandex Self-Isolation Index, and Orlov (2020). Note: Daily data from 22.02.2020 till 30.06.2020 are used. The Air Quality Index (AQI) is calculated according to the United States Environmental Protection Agency standard. For the governor influence score, monthly data are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk.

Table A2. Descriptive statistics by city.

VARIABLES	(1) Moscow N	mean	(2) Nizhniy Novgorod N	mean	(3) Chelyabinsk N	mean	(4) Krasnoyarsk N	mean	(5) Novosibirsk N	mean	(6) Saint Petersburg N	mean	(7) Cities except Moscow (columns (2)-(6)) N	mean
PM10 (mean daily AQI)	96	69.23	130	16.59	130	31.33	n.a.	n.a.	130	56.88	96	15.90	486	31.17
PM2.5 (mean daily AQI)	96	51.91	130	44.42	130	68.54	130	42.83	130	108.6	96	37.38	616	61.62
CO (mean daily AQI)	96	7.41	130	4.05	95	16.68	130	0.17	130	5.41	96	6.34	581	5.93
SO2 (mean daily AQI)	96	3.01	125	17.12	n.a.	n.a.	130	6.46	125	9.73	96	10.26	476	10.88
NO2 (mean daily AQI)	96	19.51	130	12.35	95	10.83	130	13.44	130	21.65	96	13.37	581	14.59
PM10 (max daily AQI)	96	134.5	130	30.47	130	60.23	n.a.	n.a.	130	109.5	96	29.47	486	59.38
PM2.5 (max daily AQI)	96	95.42	130	80.15	130	128.9	130	80.01	130	202.5	96	67.80	616	114.3
CO (max daily AQI)	96	14.64	130	6.42	95	29.41	130	0.25	130	9.08	96	11.51	581	10.23
SO2 (max daily AQI)	96	5.87	126	32.66	n.a.	n.a.	130	12.31	125	18.03	96	20.14	477	20.76
NO2 (max daily AQI)	96	37.38	130	24.16	95	20.95	130	26.06	130	39.66	96	25.07	581	27.68
Self-isolation index (0=no self-isolation; 5=complete self-isolation)	129	2.18	129	2.07	129	1.81	129	1.95	129	1.84	129	2.02	645	1.94
Governor influence score (1=the lowest influence, 10=the highest influence)	130	8.33	130	5.93	130	5.66	130	5.28	130	4.96	130	6.84	650	5.73
Governor's age (years)	130	61.89	130	40.7	130	47.3	130	66.17	130	49.35	130	63.98	650	53.5
Governor's time in office (years)	130	9.52	130	2.59	130	1.11	130	2.58	130	2.88	130	2.13	650	2.26

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, the Yandex Self-Isolation Index, and Orlov (2020).

Notes: Daily data from 22.02.2020 till 30.06.2020 are used. The Air Quality Index (AQI) is calculated according to the United States Environmental Protection Agency standard. For the governor influence score, monthly data are used. n.a. denotes that data are not available.

Table A3. Socioeconomic characteristics of the largest cities in Russia

	Mean of 15 cities with population over 1 mln.	Mean of 5 sample cities with population over 1 mln.	t test for differences in means (p-value)
Governor's score (mean over Feb-June 2020)	5.275	5.676	0.09
Population (thsd. Inhabitants)	1,463.46	2,103.54	0.04
Area (thsd. sq. meters)	0.67	0.64	0.65
Average monthly wage (nominal value, Rub)	41,269.23	44,141.18	0.04
Total investment in fixed assets (nominal value, mln. Rub)	169,227.90	191,460.40	0.65
Total fixed assets (nominal value, mln. Rub)	2,070,252.00	2,017,560.00	0.91
Value added, mining (nominal value, mln. Rub)	21,125.47	8,869.38	0.31
Value added, manufacturing (nominal value, mln. Rub)	494,610.50	716,683.50	0.11
Value added, energy sector (nominal value, mln. Rub)	63,387.94	88,328.94	0.05
Value added, construction (nominal value, mln. Rub)	69,665.89	113,381.30	0.20
Retail total revenue (nominal value, mln. Rub)	228,503.50	388,705.30	0.06

Source: Authors' calculations based on the 2017 data from the Russian Federal State Statistical Service.

Notes: Moscow is excluded from calculations. 15 cities with population over one million are Voronezh, Rostov-on-Don, Volgograd, Kazan, Samara, Perm, Ufa, Ekaterinburg, Omsk, Krasnodar, Saint Petersburg, Nizhniy Novgorod, Chelyabinsk, Krasnoyarsk, and Novosibirsk. Sample cities are Saint Petersburg, Nizhniy Novgorod, Chelyabinsk, Krasnoyarsk, and Novosibirsk. t test for difference in means is performed. H_0 is no difference in means of a particular characteristic between the sample of 15 cities and the sample of 5 cities.

Table A4. Variables correlation matrix (Moscow vs. regions).

	Sample including Moscow		Sample excluding Moscow		Moscow	
	Governor influence score	Self-isolation index	Governor influence score	Self-isolation index	Governor influence score	Self-isolation index
Self-isolation index	0.148***	1	0.130***	1	0.167*	1
	(0.000)		(0.001)		(0.058)	
PM_{10} (mean daily AQI)	0.082*	-0.058	-0.465***	-0.087*	-0.129	-0.148
	(0.050)	(0.165)	(0.000)	(0.056)	(0.212)	(0.150)
$PM_{2.5}$ (mean daily AQI)	-0.308***	-0.121***	-0.438***	-0.103**	0.057	-0.317**
	(0.000)	(0.001)	(0.000)	(0.011)	(0.583)	(0.002)
CO (mean daily AQI)	-0.116***	-0.032	0.079*	-0.050	-0.024	0.025
	(0.003)	(0.407)	(0.057)	(0.230)	(0.819)	(0.811)
SO_2 (mean daily AQI)	-0.165***	-0.038	0.170***	0.110	-0.158	-0.265**
	(0.000)	(0.367)	(0.007)	(0.825)	(0.123)	(0.009)
NO_2 (mean daily AQI)	0.030	-0.143***	-0.283***	-0.158***	0.080	-0.243**
	(0.442)	(0.000)	(0.000)	(0.000)	(0.441)	(0.017)
Governor's age	0.378***	0.048	0.206***	0.011	0.253***	0.020
	(0.000)	(0.229)	(0.000)	(0.785)	(0.004)	(0.825)
Governor's time in office	0.785***	0.098**	-0.233***	0.034	0.253**	0.020
	(0.000)	(0.010)	(0.000)	(0.396)	(0.004)	(0.819)

Notes: Bivariate correlations are reported. P-values are in parentheses. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, Novosibirsk, and Moscow.
*** $p<0.01$; ** $p<0.05$; * $p<0.1$.

Table A5. First stage results for Table 1

VARIABLES	(1) PM_{10}	(2) $PM_{2.5}$	(3) CO	(4) SO_2	(5) NO_2
Governor's time in office	2.476***	2.126***	2.226***	2.213***	2.226***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exogenous controls from Table 1	YES	YES	YES	YES	YES
Ho: IV is weak; F-statistics	490.18***	364.75***	319.53***	256.87***	319.53***
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	486	616	581	476	581
R-squared	0.740	0.573	0.551	0.511	0.551

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and Orlov (2020).

Notes: Dependent variable is the governor's influence score. Exogenous controls from Table 1 include weekend, mean daily temperature, wind speed, humidity, and atmospheric pressure. *** $p<0.01$; ** $p<0.05$; * $p<0.1$. Robust standard errors in parentheses. Daily data from 22.02.2020 till 30.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM_{10} in Krasnoyarsk and on SO_2 in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence).

Table A6. Governor's influence and pollution with the governor's age as an instrument

VARIABLES	(1) PM_{10}	(2) $PM_{2.5}$	(3) CO	(4) SO_2	(5) NO_2
Governor influence score	-42.711***	-83.305***	-6.451***	-12.787***	-19.562***
	(6.508)	(9.562)	(0.955)	(3.423)	(2.402)
Weekend day	-1.091	-0.366	0.049	-0.285	-2.367***
	(2.543)	(2.735)	(0.280)	(0.901)	(0.611)
Mean daily temperature (C)	0.353	0.980***	0.120***	0.315***	0.175**
	(0.233)	(0.252)	(0.025)	(0.093)	(0.072)
Mean daily wind speed (m/sec)	-4.946***	-7.245***	-0.549***	-0.781***	-1.647***
	(0.975)	(0.925)	(0.082)	(0.248)	(0.216)
Mean daily humidity (%)	-0.198**	-0.292***	-0.001	-0.097***	-0.080***
	(0.090)	(0.096)	(0.008)	(0.034)	(0.030)
Mean daily atmospheric pressure (mm)	0.136	0.162	0.014	-0.170**	0.048
	(0.185)	(0.197)	(0.019)	(0.080)	(0.049)
Ho: IV is weak; F-statistics	489.9***	365.26***	320.69***	256.8***	320.69***
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ho: Governor's score is exogenous; P-value	0.000	0.000	0.002	0.044	0.000
Observations	486	616	581	476	581
R-squared (within)	0.098	0.010	0.010	-0.007	-0.031
Number of cities	4	5	5	4	5

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and Orlov (2020).

Notes: *** p<0.01; ** p<0.05; * p<0.1. Robust standard errors in parentheses. Daily data from 22.02.2020 till 05.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM_{10} in Krasnoyarsk and on SO_2 in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). Governor's age is used as an instrument for governor's influence score.

Table A7. Self-isolation and pollution.

VARIABLES	(1) PM10	(2) PM2.5	(3) CO	(4) SO2	(5) NO2
Self-isolation index	-0.942	-2.139	-0.499*	-0.316	-0.824
	(1.246)	(1.641)	(0.206)	(1.127)	(0.390)
Weekend day	0.238	3.199	0.660	0.376	-1.170*
	(1.782)	(1.802)	(0.615)	(1.080)	(0.541)
Mean daily temperature (C)	-0.752	-0.544	-0.001	0.095	-0.181
	(0.536)	(0.361)	(0.012)	(0.098)	(0.112)
Mean daily wind speed (m/sec)	-4.703*	-6.428***	-0.470*	-0.617	-1.418**
	(1.660)	(1.317)	(0.189)	(0.267)	(0.451)
Mean daily humidity (%)	-0.191	-0.180	0.002	-0.082*	-0.058
	(0.217)	(0.247)	(0.012)	(0.030)	(0.073)
Mean daily atmospheric pressure (mm)	0.272	0.311	0.020	-0.162	0.075
	(0.292)	(0.391)	(0.020)	(0.169)	(0.068)
Observations	482	611	576	472	576
R-squared (within)	0.100	0.141	0.101	0.068	0.160
Number of cities	4	5	5	4	5

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and the Yandex Self-Isolation Index.

Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$. Fixed effects results are reported. Robust standard errors in parentheses. Daily data from 22.02.2020 till 30.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM10 in Krasnoyarsk and on SO2 in Chelyabinsk. Self-Isolation Index is measured on the scale from 0 (no self-isolation) to 5 (complete self-isolation).

Table A8. Governor's influence and maximal daily pollution

VARIABLES	(1) PM_{10}	(2) $PM_{2.5}$	(3) CO	(4) SO_2	(5) NO_2
Governor influence score	-78.394***	-134.739***	-10.854***	-28.847***	-34.093***
	(12.712)	(17.192)	(1.770)	(6.615)	(4.596)
Weekend day	-1.834	0.552	0.154	-0.593	-4.308***
	(4.947)	(4.954)	(0.526)	(1.744)	(1.176)
Mean daily temperature (C)	0.574	1.498***	0.209***	0.657***	0.353**
	(0.451)	(0.449)	(0.047)	(0.177)	(0.139)
Mean daily wind speed (m/sec)	-9.363***	-12.622***	-1.010***	-1.738***	-3.034***
	(1.912)	(1.693)	(0.150)	(0.444)	(0.420)
Mean daily humidity (%)	-0.408**	-0.579***	-0.011	-0.222***	-0.177***
	(0.175)	(0.168)	(0.015)	(0.065)	(0.058)
Mean daily atmospheric pressure (mm)	0.248	0.238	0.029	-0.320**	0.101
	(0.364)	(0.362)	(0.036)	(0.159)	(0.094)
Ho: IV is weak; F-statistics	490.18***	364.75***	319.53***	256.71***	319.53***
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ho: Governor's score is exogenous; P-value	0.000	0.000	0.000	0.000	0.000
Observations	486	616	581	477	581
R-squared (within)	0.093	0.023	0.018	-0.015	-0.041
Number of cities	4	5	5	4	5

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and Orlov (2020).

Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$. Robust standard errors in parentheses. Daily data from 22.02.2020 till 05.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Saint Petersburg, Krasnoyarsk, and Novosibirsk. No data on PM_{10} in Krasnoyarsk and on SO_2 in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). Governor's age is used as an instrument for governor's influence score.

Table A9. Governor's influence and pollution (without Saint Petersburg)

VARIABLES	(1) PM_{10}	(2) $PM_{2.5}$	(3) CO	(4) SO_2	(5) NO_2
Governor influence score	-52.698***	-97.791***	-5.592***	-14.811***	-22.511***
	(8.539)	(12.295)	(1.021)	(4.999)	(3.245)
Weekend day	-2.307	-0.669	0.148	-0.262	-2.458***
	(2.649)	(2.996)	(0.280)	(1.083)	(0.708)
Mean daily temperature (C)	0.395	0.928***	0.088***	0.281**	0.176**
	(0.251)	(0.273)	(0.024)	(0.111)	(0.083)
Mean daily wind speed (m/sec)	-6.487***	-8.710***	-0.494***	-0.952***	-1.852***
	(1.223)	(1.082)	(0.086)	(0.323)	(0.261)
Mean daily humidity (%)	-0.233**	-0.422***	-0.012	-0.137***	-0.115***
	(0.103)	(0.105)	(0.008)	(0.041)	(0.035)
Mean daily atmospheric pressure (mm)	-0.291	-0.351	-0.007	-0.327***	0.022
	(0.231)	(0.218)	(0.020)	(0.115)	(0.063)
Ho: IV is weak; F-statistics	431.11***	276.06***	220.44***	159.09***	220.44***
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ho: Governor's score is exogenous; P-value	0.000	0.000	0.000	0.000	0.000
Observations	390	520	485	380	485
R-squared (within)	0.103	-0.052	-0.008	0.003	-0.054
Number of cities	3	4	4	3	4

Source: Authors' calculations based on data from the Air Quality Open Data Platform, Federal Service for Hydrometeorology and Environmental Monitoring of Russia, and Orlov (2020).

Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$. Robust standard errors in parentheses. Daily data from 22.02.2020 till 05.06.2020 are used. Cities included are Chelyabinsk, Nizhniy Novgorod, Krasnoyarsk, and Novosibirsk. No data on PM_{10} in Krasnoyarsk and on SO_2 in Chelyabinsk. The governor influence score is measured on a scale from 1 (the lowest influence) to 10 (the highest influence). Governor's age is used as an instrument for governor's influence score.