The Puzzling Politics of R&D: Signaling Competence through Risky Projects

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Abstract

Why do some leaders devote significant funds to research and development (R&D) even though such investments are risky, less visible to the public than many other investments, and typically bear fruit only after the incumbent has already left office? This paper suggests that investing in R&D improves the incumbent's perceived competence among voters. Using a formal model of signaling, survey experiments conducted in the US and Russia, and corroborating cross-country evidence, I demonstrate that investment in R&D improves perceptions of incumbent competence and approval of the government among the citizenry.

Keywords: public policy, research and development, signaling, survey experiments

JEL Classification: O31, H42

1. Introduction

Governments have historically had a major hand in science and technology through investment in research and development (R&D), the key input in creation of new technologies (Izsák, Markianidou and Radošević, 2013). From a social welfare standpoint, the rationale for government investment in R&D is clear: Many research projects are risky and may require a long-term commitment of resources and infrastructure (ibid). As the creator of new knowledge is unlikely to reap all the benefits, the societal benefits of R&D generally exceed its private benefits. Stiglitz (2015) notes that "Knowledge can be viewed as a public good, and the private provision of a public good is essentially never optimal." Not surprisingly, governments worldwide spend a great deal of money on promoting R&D.[1]

While the normative argument for government involvement in R&D is more or less clear, the positive explanation of its existence is very much less so. Why do political actors who control government resources have incentives to invest in R&D instead of, say, sponsoring voters' consumption? The political incentives that governments face are in many respects similar to the incentives of private companies. Studies of economic voting (Cohen and Noll, 1991; Duch and Stevenson, 2006; Fiorina, 1978; Lewis-Beck, 1986; HUBER, HILL and LENZ, 2012) emphasize that voters care only about recent policy benefits, a shortsightedness that provokes inefficient public policy due to the responsiveness of government policies to citizens' preferences (Page and Shapiro, 1983). Galiani et al. (2016) provide experimental evidence that voters are especially sensitive to recent economic activity. Vasilyeva and Nye (2013) show that the provision of public goods is closely related to the political competition. However, if electoral rewards for beneficial policy decay rapidly, then reelection pressures induce policymakers to lean toward opportunistic short-term policies, underinvesting in welfare-enhancing policies with benefits that take longer to materialize (Achen and Bartels, 2008; Keech, 1980; Sobel and Leeson, 2006).

In a paper justifying retrospective voting analysis, Key and Cummings (1966) note: "[Voters] are not likely to be attracted in great numbers by promises of the novel or unknown". Similarly,

[1] In 2010, the EU outlined five main long-run goals for the 2020 Strategy and pledged to devote 3% of GDP to R&D support. In the US, the government spent $39.9 billion on R&D in 2017 (Sargent, 2018), comparable to the $44.3 billion budgeted for elementary and secondary education.

promises of future good performance are discounted completely in Ferejohn (1986). Yet investment in R&D is unlikely to boost incumbent's popularity from the perspective of retrospective voting either: the fruits of government R&D policy rarely ripen by the time the incumbent stands for re-election. Wittman, Weingast and Hibbs (2009) points to the lack of consensus in empirical work on whether prospective voting, retrospective voting, or their mixture, provides the best explanation for voter behavior. But given the importance of recent economic outcomes on reelection probability, why would policymakers spend money on risky long-term projects?

The explanation I offer is that voters consider R&D investment to be a signal of leaders' competence. While they cannot reap the benefits of these investments before the election, they realize that an incompetent leader, being unable to select proper projects, would be more willing to spend on consumption goods. Voters' preferences to reelect competent leaders therefore create incentives for R&D investments. Of course, the signaling nature of such investments creates incentives even for an incompetent leader to invest in R&D, as she would want to pool, in equilibrium, with a competent one. In the theoretical model, I analyze conditions under which a separating equilibrium exists; naturally, separation is welfare-enhancing. Then, I investigate the empirical implications of the model using a cross-country data set and survey experiments in the US and Russia.

Both theoretical and empirical investigations of the political foundations of R&D need to take into account the specifics of this type of government activity. First, *the time between the investment and utilization of the new technology is longer than that for most projects and often exceeds the officeholder's term in office.* For example, in medicine, the average time lag between a scientific finding and its implementation is 17 years (Morris, Wooding and Grant, 2011). Second, *investment in R&D is less visible than other forms of government investment*, such as infrastructure and education. This, in turn, makes it harder for the incumbent to expect a boost in popularity as a consequence of welfare-promoting policy. By contrast, projects that are more visible can help incumbents gain public support even before their completion. For example, in an analysis of construction of the Autobahn network in Nazi Germany, Voigtlander and Voth (2017) show that highway construction was effective in boosting popular support for the government not only through its impact on the economy but also by sending a powerful signal related to the competence of the incumbent responsible for the construction.

The third distinctive feature is that *new technologies can empower new actors.* The incumbent elite may fear being deposed by those who are empowered by a new technology, an effect that (Acemoglu and Robinson, 2006) terms "political displacement". Sometimes, governments block innovation in an attempt to shield the established elite from economic losses (Mokyr, 1990, 1992). This view makes the political decision to promote innovation an even greater puzzle.[2] Finally, *investment in R&D is riskier than other types of government investment*, since knowing whether a certain technology resulting from it will be successful prior to its outcome is at best difficult.

Given the factors that seemingly make investment in R&D unattractive for incumbents, why do governments do so at such high levels and opportunity cost? Examining observational data from OECD countries and a cross-national opinion survey, I find that governments that increased their R&D funding enjoyed higher approval ratings. The effect is greater than the effect of increased government spending on education. To know what to condition on to make a causal claim requires making assumptions about how a web of variables influence each other, the treatment, and the outcome. This is formalized by constructing a directed acyclic graph (DAG) that expresses our assumptions about which variables (do not) influence each other. From this DAG we can determine the appropriate variables to control for. I employ a plausible DAG, and test whether the conditional independences implied by such a DAG hold in the data or not (Pearl et al., 1989), effectively a generalization of falsification tests such as balance testing. Given the difficulty of identifying causal effects in a cross-country setting, I further apply a sensitivity analysis (Cinelli and Hazlett, 2018) to my main results. To fully eliminate the discovered effect of the government R&D expenditures on citizens' attitudes, the unobserved confounders (orthogonal to the covariates) would have to be able to explain more than 17.6% of the residual variance of both the treatment and the outcome.

While the cross-country evidence is suggestive of the argument that government investment

[2]A situation in which incumbent leaders empower certain interest groups with a long-run technological advantage is discussed in detail in Lamberova (2019).

in R&D can improve the perceptions of citizens, it is not conclusive. To provide additional evidence not subject to confounding concerns, I conduct a paired-vignettes survey experiment in the USA, a country that has a robust tradition of government support of R&D, and Russia, where the modern history of government involvement in R&D started, for all practical purposes, in 2008. The results of the experiment suggest that pro-R&D politicians are regarded as more competent than those that prioritize infrastructure or education spending. This to true in the the contexts of both democratic politics in the US and authoritarian politics in Russia. Still, there are some significant dissimilarities between the two countries: e.g., in the US, R&D spending raises expectations of competence but not on overall economic performance, while in Russia competence perceptions and economic expectations are highly correlated.

The rest of the paper is organized as follows: Section 2 briefly reviews the existing literature. Section 3 contains the theoretical model. Section 4 introduces the cross-country evidence. Section 5 analyzes the survey experiment. Section 6 provides discussion, while Section 7 concludes.

2. Related Literature

The importance of technological development for economic growth has long been recognized by scholars, and many have studied the role of government policy in this domain. Indeed, Google Scholar offers more than 220,000 articles evaluating the impact of government R&D policy on different aspects of the economy. Moreover, current literature in economics suggests that government R&D policies matter. For example, Akcigit, Baslandze and Stantcheva (2016) suggest that lower R&D taxes spur the inflow of the most productive researchers from abroad. Using a natural experiment in UK tax policy toward R&D, Guceri and Liu (2017) show that each dollar of government expenditure in R&D leads to more than a dollar of increase in private R&D spending. In addition, Akcigit, Ates and Impullitti (2018) demonstrate that the introduction of the 1981 Experimentation Tax Credit in the US generated large welfare gains over the long run. Acemoglu et al. (2016) recommend that the transition from dirty to clean technologies be aided by both government subsidies for R&D and tax credits. Along with direct R&D subsidies and tax incentives, incumbents can influence innovative activity by altering intellectual property protection policies. Such policies do not necessarily boost overall inventiveness but can sometimes redirect inventive efforts to new areas Moser (2005). In addition, governments can establish prizes targeted at the creation of specific technologies. For example, medical innovation prizes create a buy-out mechanism to compensate pharmaceutical firms for developing drugs that are socially valuable but unattractive for private firms to produce and market Kremer and Williams (2010). Such *ex ante* prizes and patent buyout mechanisms, together with the publicity they generate, could deliver an additional boost to invention after the awarding of a prize, as discussed by Moser and Nicholas (2013).

Despite the abundance of literature evaluating the impact of government R&D investment, I failed to find a single study evaluating political incentives to make such investments. This paper excludes consideration of R&D specific to military innovation, as the incentives for such investment are self-evident[3]. In the most closely related paper available, Akcigit, Baslandze and Lotti (2017) argue that government R&D subsidies led to greater profits for politically connected firms with no change in their efforts to produce new technologies.

This paper also relates to the wide literature on government popularity and approval. In their paper "What Makes Governments Popular?" Guriev and Treisman (2016) assess a panel of government ratings from 128 countries including both democracies and authoritarian states, over the years 2005-2014. They find that strong economic performance is robustly correlated with higher approval in both democracies and non-democracies, approval is higher in the year of a presidential election in both types of regimes. In non-democracies, information matters: greater press freedom and internet penetration result in lower approval while internet censorship is associated with higher approval. In another paper Guriev and Treisman (2018) closely examine autocratic regimes and show that autocrats artificially boost their popularity by convincing the public they are competent. In particular, they study how autocrats use propaganda and silence informed members of the elite by co-optation or censorship. My work does not contradict their findings, but suggests that policy choice could also be applied as a useful tool to signal competence both in democratic and autocratic settings using the results of survey

[3]See Taylor, 2016 for a review.

experiment in United States and Russia.

This paper also relates to the wide literature on economic voting: (Key and Cummings, 1966; Ferejohn, 1986; Wittman, Weingast and Hibbs, 2009) emphasize the importance of the past economic results for future voter behavior. Some studies have argued that the choice of economic policy can be used as a signal of competence: Voigtlander and Voth (2017) analyze construction of the Autobahn network in Nazi Germany to demonstrate that highway construction was effective in boosting popular support beyond the direct economic benefits (such as declining unemployment near construction sites). Harding and Stasavage (2013) suggest that, in an environment in which attributing outcomes to executive actions is difficult, electoral competition can lead to changes in policies for which executive action is verifiable. In the context of African primary education, for example, they found that electoral competition gave government an incentive to abolish school fees—a more visible action but one that had less effect on the provision of school inputs, since executive actions on these issues were more difficult to monitor. These papers highlight the importance of visibility of government policy for electoral benefit. Apart from citizens' inability to observe a policy outcome in time to update their perceptions concerning a politician's type before reelection, citizens can value short-term policies per se. Using both municipality-level data and a survey experiment conducted in Brazil, Bursztyn (2016) shows that low-income voters are likely to favor redistributive programs, such as cash transfers that increase their incomes in the short run, over investments in education, as demonstrated by their survey and incentivized choice experiments.

In this context, employing R&D expenditures to signal competence seems counterintuitive, as such investments are less visible to voters compared to other types of public goods provision. Such expenditures target long-run outcomes and are also highly risky, since the majority of R&D projects fail. However, I argue, conversely, that the risky nature of R&D projects allows incumbents to showcase their competence. Harbaugh (2010) proposes a model that demonstrates how, in gambles involving both skill and chance, a strategic desire to avoid appearing unskilled generates behavioral anomalies consistent with prospect theory's concepts of loss aversion, framing effects, and probability weighting. Under a set of conditions, the agent is better off taking risks in an environment where failure is more likely and an observer can infer the agent's type before the outcome of the gamble is observed. Furthermore, the importance of skill signaling increases in more volatile environments. This intuition holds in the context of market volatility: Ochoa (2013) finds a positive and statistically significant cross-sectional relation between reliance on skilled labor and expected returns, which increases in times of high aggregate volatility and decreases by one-third when volatility decreases to normal levels.[4]

In short, the abundance of literature investigating the impact of government R&D expenditure on technological development and the economy in general suggests the importance of this issue. At the same time, specific traits of R&D expenditures make it seemingly unappealing for politicians, given existing theories of political economy. This paper aims at reconciling this apparent contradiction.

3. The Model

In this section, I introduce a simple model in which a leader makes a decision on whether to invest in R&D and voters decide whether to re-elect the leader.

3.1. Setup

There are two strategic agents: 1) an incumbent political leader, who can be of one of the two types of τ, either competent ($\tau = \tau_H$) with probability θ or incompetent ($\tau = \tau_L$) with probability $(1 - \theta)$; and 2) the median voter. The leader can either commit to investing in a safe project that guarantees immediate results or to pursuing a risky policy such as investment in R&D. The median voter observes the leader's choice and decides whether to reelect the incumbent.

The leader receives utility from retaining her office. If she is reelected, she receives utility V from staying in power and 0 otherwise. Additionally, she cares about the result of her policy. The payoff of a risky project depends on the competence of the incumbent. If she is competent, she selects a project that generates a high expected payoff. If she is incompetent, she is less likely

[4] Interestingly, Galor and Savitskiy (2017) find that, in an environment characterized by aggregate productivity shocks, loss aversion is a more sustainable trait, whereas in an environment characterized by greater volatility, loss-neutrality can generate higher success rates.

to select R&D projects with good prospects yet is equally able to carry out the safe alternative. The leader knows her own type, and the voters have a common prior of a high type θ.

I assume that investment in R&D by a competent leader with ability $\tau = \tau_H > 0,$ results in a payoff of R with probability τ_H discounted at a rate δ and a payoff of 0 with probability $1 - \tau_H$. An investment by an incompetent leader (τ_L) always results in a failure. An investment in a safe project results in the payoff of W. This amount represents the opportunity cost, e.g., foregone consumption, of the risky project.

Voters care both about economic returns and the leader's competence. For clarity, I assume that the leader's skill level enters the median voter's utility function directly, with the parameter α being the relative weight assigned to the leader's skills. Denote by s the strategy profile. Then,

$EU_v = \mathit{Returns} + \alpha E(\tau|s)$,

where $\mathit{Returns} = W$ if the safe project was chosen, $\mathit{Returns} = 0$ if the R&D project was chosen by the incompetent leader, and $\mathit{Returns} = R$ if the R&D project was chosen by the competent leader. Finally, $E\left(\tau|\cdot\right)$ is the expected contribution of the leader's type to the voter's payoff; this expectation is conditional on both the policy that the voter observed and the reelection decision she makes. If the incumbent is retained, the expectation in $E\left(\tau|\cdot\right)$ is conditional on the observed policy choice; if the leader is new, $\tau = \tau_H$ with probability θ and 0 with probability $1 - \theta$. If indifferent, the voter reelects the incumbent.

The timing of the game is as follows:

1. The incumbent leader is assigned a skill level $\tau \in \{\tau_L, \tau_H\}$, with probabilities θ and $1 - \theta$, respectively.

2. The leader commits to pursuing either a safe or a risky project.

3. Upon observing the leader's choice, the voter decides whether to reelect the incumbent.

4. Players receive their payoffs.

I focus on perfect Bayesian equilibria of the game (Osborne and Rubinstein, 1994).

Figure 1 shows the game tree.

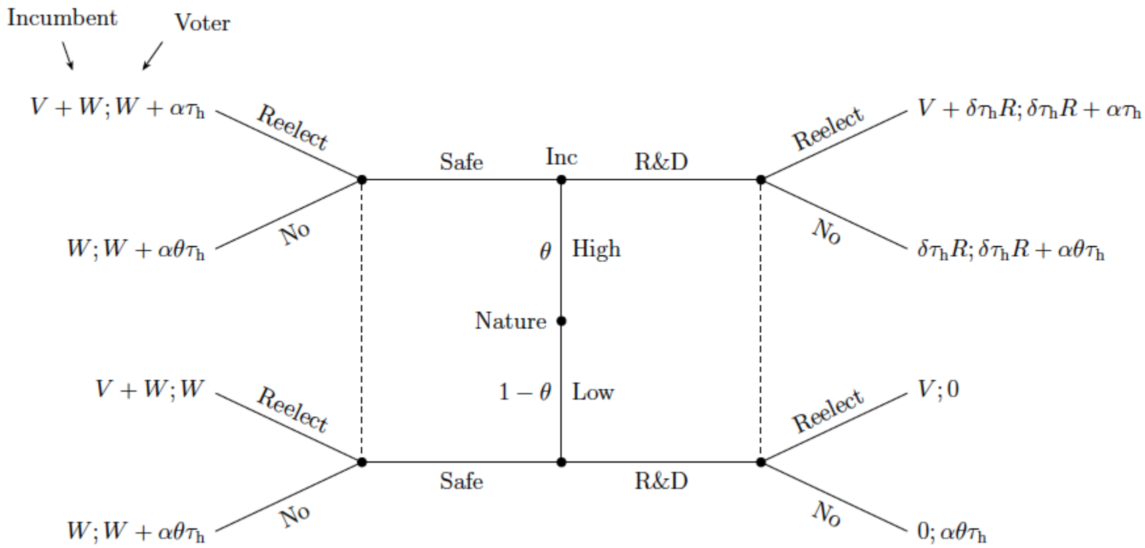


Figure 1: Game Representation

3.2. *Analysis*

Let us start by considering the possibility of a separating equilibrium. In a perfect Bayesian equilibrium, this is possible only if the high type chooses R&D while the low type chooses the safe investment. If this is the case, the median voter's expected utility from reelecting the incumbent is W, conditional on the announcement of the safe project, and $\delta\tau_H R + \alpha\tau_H$ if the R&D project is announced. Replacing the incumbent if the risky project is chosen results in expected utility of $\theta\delta\tau_H R + \alpha\theta\tau_H$, as the low-skilled challenger will not be able to complete the R&D project. If the safe project is announced, replacing the incumbent brings expected utility of $W + \alpha\theta\tau_H$.

The median voter supports the high-skilled incumbent that committed to R&D if and only if

$$(1-\theta)(\delta R + \alpha)\tau_H > 0,$$

which is always true as $\tau_H > 0$.

The high-skilled leader never deviates from R&D policy in a separating equilibrium, because $W \neq \delta$, so a separating equilibrium in which a high-skilled incumbent chooses the safe project is impossible. Thus, after observing the choice of the safe project, the voter knows that the leader is incompetent. It is straightforward to verify that in this case the incumbent is not reelected. Still, it might be optimal for the incompetent incumbent to choose the safe project as long as the benefits of having the office, V, are not too high:

$$W > V.$$

Finally, it is incentive compatible for the high-type leader to choose R&D if and only if

$$\delta \tau_H R > W.$$

The following proposition summarizes the above discussion.

Proposition 1. *There exists a separating equilibrium in which the high-skilled leader signals her type by choosing the R&D project and is re-elected, and the low-skilled leader chooses the safe alternative and is replaced by the challenger, as long as the following conditions are fulfilled:*

$$\delta \tau_H R \geq W \geq V. \tag{1}$$

These conditions are fulfilled for a wider range of other parameters when the expected reward, R, is high, when the future is not discounted too much (δ is high), and when the "skill differential" τ_H is high.

The comparative statics is very intuitive. If the value of the office is not very high (for example, in a low-corruption term-limited environment), policy choice signals politician's competence.

Naturally, if the value of the office is very high, candidates cannot use (binding and, therefore, costly) campaign promises to signal their type, as the low-type candidate prefers to pool even at a high cost. Here, if the value of office is high relative to the expected returns of the safe project, candidates necessarily pool. Under what conditions do both types of the incumbent pool, pursuing the same strategy?

To describe pooling equilibria, we need to analyze the beliefs that voters have upon observing the chosen policy. Suppose that the observed policy choice is R&D and let p denote the probability that the leader is of the competent type. For the median voter, re-electing the incumbent results in the expected payoff of $p\,(W + \alpha\tau_H) + (1-p)\,W$. Voting for the challenger brings, in expectation, $p\,(W + \alpha\theta\tau_H) + (1-p)\,(W + \alpha\theta\tau_H)$. Re-arranging terms, the voter chooses to reelect the incumbent if and only if the probability that the leader is of the high type is $p \geq \theta$. Similarly, assuming that the safe project is chosen, let q denote the probability that the leader is of high type. The voter chooses to reelect the incumbent if and only if $q \geq \theta$.

Given our assumption that the voter, if indifferent, reelects the incumbent, it is straightforward to show that there is no pooling equilibrium where both types of incumbents choose safe project: it is always profitable for the competent incumbent to choose R&D policy, since, after observing this deviation, the voter would infer that the incumbent is competent and reelect him. Thus, the competent leader receives $V + W \leq V + \delta\theta R$ after deviation.[5]

On the other hand, a pooling equilibrium where both types choose R&D is indeed possible. In a high-corruption, no term limit environment less competent incumbent prefers to choose RD policy at a cost of economic loss to choosing a safe project and revealing her incompetence.

Suppose that both types of politicians invest in R & D. Again, the voter knows with certainty the incumbent's type if two types choose different actions, and assigns beliefs θ and $1-\theta$ to high type and low type, respectively, if two types choose the same action. The voter will reelect the incumbent that played R & D: $\theta(\delta\tau_h R + \alpha\tau_h) = \theta(\delta\tau_h R + \alpha\theta\tau_h) + (1-\theta)\alpha\theta\tau_h$.

The payoff of the high-skilled incumbent is $V + \delta\tau_h R$. Deviating to the safe project, she will get $V + W$. Since $\delta\tau_h R > W$, deviation is not profitable. The payoff of the low-skilled incumbent is V. Deviation gives her W that is less that she has in the pooling profile. Formally, we can state the following proposition.

Proposition 2. *Suppose that $V > W$ and $\delta\tau_h R > W$. Then there exists a pooling equilibrium in which both candidates choose the R&D project, and the median voter reelects the incumbent.*

The simple theoretical model suggests that at relatively low levels of gains from office, there is a separating equilibrium for competent and incompetent politicians, in which the former

[5] Assuming that the voter re-elects the incumbent, if indifferent, is without much loss of generality: the resulting pooling equilibrium with both types investing in safe project would not survive the "intuitive criterion" (Cho and Kreps, 1993).

invests in R&D and the latter in the safe project, while the voter, interpreting the policy choice as a quality signal, chooses to reelect only the pro-R&D politician. At the moderate levels of gains from office, it is the expected outcome of each policy that determines the equilibrium: if expected gains from the R&D policy exceed the expected gains from the safe project, even the low-skilled politician will choose to invest in R&D, while voters reelect only a pro-R&D politician. Otherwise, there is a possibility of signaling: the low-skilled politician always invests in the safe project, while the high-skilled politician invests in R&D (again, voters reelect a pro-R&D politician only). For very high gains from office, there is no signaling in choosing the R&D policy as the candidates 'pool': both types of politicians invest in R&D. In this situation, there is overinvestment in R&D, which is suboptimal from a social welfare point of view.

4. Cross-Country Evidence

In this section I present a cross-country evidence consistent with the effect of government R&D expenditures on government approval among citizens. In the absence of a verifiable source of causal identification, the analysis relies heavily on the set of assumptions. I illustrate the causal assumptions of my cross-country study according to the method proposed by Pearl (1995). This approach allows me to state a set of assumptions about the data-generating process and to choose a set of control variables consistent with them. Figure 2 displays a directed acyclic graph (DAG), where nodes represent variables and edges, or arrows, the causal links between them, including the direction of influence. For instance, as shown by the direction of the arrow at the top left of the graph, *Institutions* have an impact on *Economic Volatility*, but the reverse is not true. The absence of edges between nodes constitutes an important assumption in the DAG. The variable *Skill Preference*, which is unobserved, corresponds to α in the theoretical model discussed in Section 2. The variable $Approval_{t-1}$ represents government approval in the previous period (lagged), whereas the variable *Approval* is government approval in the current period. Similarly, RD_{t-1} is the government's investment in R&D in the previous period, whereas *RD* is government investment in R&D in the current period. $Approval_{t-2}$ and RD_{t-2} stand for twice-lagged approval and R&D expenditures, respectively. *Political Competition* is a measure of political competition, and the variable *Country* denotes time-invariant country-specific effects (its inclusion in a model is just inclusion of country fixed effects). Though simplified, this representation of the real-world situation clarifies the assumptions made in the cross-country study. A choice of DAG, such as this one, prescribes which variables should (and should not) be conditioned on in order to estimate a causal effect of government R&D expenditures on popular approval of the government.

Figure 2 presents the structure of assumptions employed in my cross-country study.

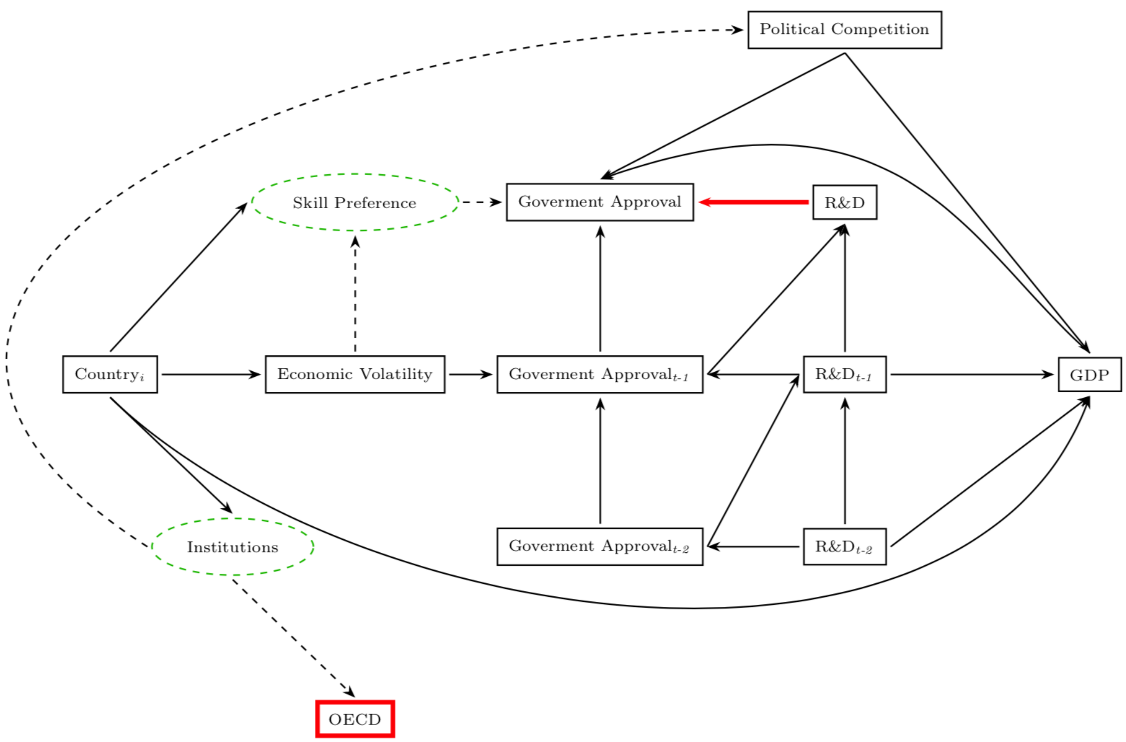


Figure 2: Directed Acyclic Graph

Applying the backdoor criterion to the graph implies the existence of adjustment sets, controlling for which would allow me to make causal claims about the effect of government R&D expenditures on citizen approval of the government. Among them, I choose the adjustment sets that do not include *Institutions* or *Skill Preference* (as those are unobserved) and include the variable *OECD*, since our sample is focused on OECD countries. This leaves us with three sets of variables that we could adjust for to identify effect of government R&D expenditures on popular approval under this DAG, shown in Table 1. They present two different sets of controls necessary to calculate the total effect of government R&D expenditures on popular approval (Total Effect 1 and Total Effect 2) and one adjustment set that recovers the direct effect.

Table 1: Feasible Adjustment Sets for Effect of R&D on Approval

	Adjustment Sets for effect of R&D (Education) on Approval
Total Effect 1	GDP, lag.Approval, political.competition, lag.R&D, Country
Total Effect 2	GDP, lag.Approval, political.competition, lag.R&D, Volatility, Country
Direct Effect	GDP, lag.Approval, political.competition, Volatility, Country

One major concern in cross-country panel data is unobserved country-specific but time-invariant confounders. Including country fixed effects addresses the bias that these confounders introduce. An important assumption in these models is that past treatments and outcome outcomes do not directly influence current treatment and outcomes — or that they do so only for a limited number of years shorter than the duration of the panel (see Imai and Kim (N.d.)); here I assume that past government R&D only directly affects future R&D for one yaer, and likewise with government approval. Similar assumption are commonly made in existing work examining government approval, (see e.g. Lebo and Norpoth, 2011). Similarly, researchers have often estimated the effect of government R&D using a single lag (see e.g. Levy and Terleckyj, 1983).

In quasi-experimental designs, it is common practice to demonstrate that treatment and control groups are balanced in their distributions of pre-treatment variables, lending credibility to the claim that treatment assignment does not depend on potential outcomes. An analogous but more extensive set of tests is possible in that DAGs produce a number of observable implications in the form of conditional independence relationships that should hold in the data if the DAG is correct. For this DAG, there are 33 such expected conditional independences, each detailed in the Appendix. Each such relationship can be tested similarly to a balance test. Results are presented in Figure 3. I find that most of conditional independencies hold, with the exception of positive relation between political competition and lagged R&D expenditures.

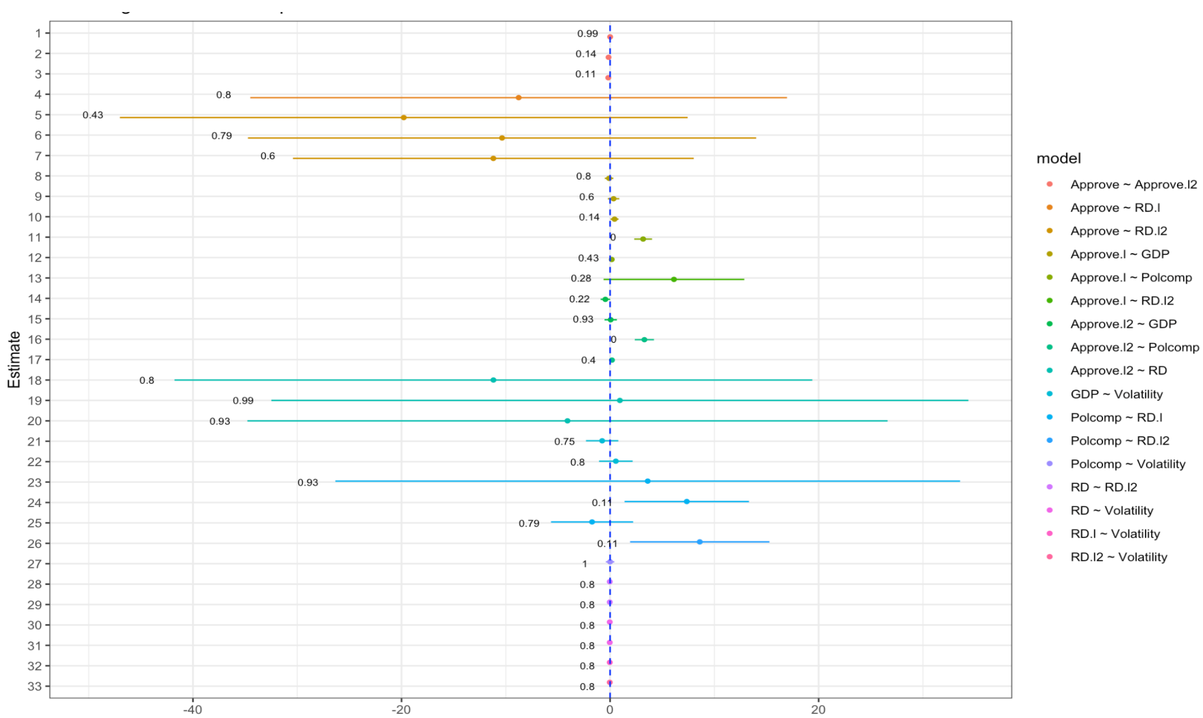


Figure 3: Conditional Independencies

Having estimated models using these conditioning sets presented in Table 1, I recognize that the assumptions captured in this DAG — specifically regarding confounders omitted from it — may be incorrect. I thus employ sensitivity analyses that characterise the types of omitted confounders that would alter the conclusions reached in my analysis 4.1.3.

4.1. *Government R&D Spending and Government Popularity*

4.1.1 Data The data required for this analysis are cross-country data on government R&D expenditures and government budgets. I have these only for OECD countries, reported by UNESCO OECD (2017). While this sample is restricted to OECD countries, it also accounts for more than 90% of all government expenditures in the world. Government approval here derives from GALLUP (2018), denoting the approval ratings of the government obtained from a representative sample of citizens for each country on a yearly basis. The respondents are asked the following question: "In this country, do you have confidence in each of the following, or not? How about national government?". Despite the fact that they do not address popular perceptions of politician quality, the Gallup data are widely used as a marker of approval of government actions in the literature Hetherington (1998). I calculate the economic volatility variable by summing the number of times log.GDP falls below the 5-year moving average for each country. Due to the fact that the latter was only available for the 2006-2017 time period, I had only 300 country-year observations. The information about the extent of political competition comes from Comparative Politics Dataset Armingeon et al. (2018).

4.1.2 Analysis and Results We consider two ways of measureing the outcome, y_{it}: as the government expenditures on R&D as a share of GDP, and as the government expenditures on R&D as a share of the budget. For each, we can consider three models suggested by the three adjustment sets determined above. A first estimate of the total effect (Total Effect 1) is given by β_4? in

$$y_{it} = \alpha_{1t} + \beta_1 \texttt{GDP} + \beta_2 \texttt{approval}_{it-1} + \beta_3 \texttt{political.competition}_{it} + \beta_4 \texttt{R\&D}_{it-1} + \beta_5 \texttt{Country}_i + \epsilon_{it}.$$

The second estimate of the total effect (Total Effect 2) is given by β_4 in

$$y_{it} = \alpha_{1t} + \beta_1 \texttt{GDP} + \beta_2 \texttt{approval}_{it-1} + \beta_3 \texttt{political.competition}_{it} + \beta_4 \texttt{R\&D}_{it-1} + \beta_5 \texttt{Country}_i + \epsilon_{it}.$$

Finally, the Direct Effect estimate is given by β_4 in

$$y_{it} = \alpha_{1t} + \beta_1 \texttt{GDP} + \beta_2 \texttt{approval}_{it-1} + \beta_3 \texttt{political.competition}_{it} + \beta_4 \texttt{R\&D}_{it-1} + \beta_5 \texttt{Country}_i + \epsilon_{it}$$

In addition, I repeat the models for government expenditures on education as a share of GDP and government expenditures on education as a share of budget to put the results of government expenditures on R&D in context.

Note that under the set of assumptions presented in the DAG, the coefficients on variables other than the treatment are not interpretable, so I do not report them.

Table 2: Effect of R&D Expenditures(%GDP) on Government Approval

	Dependent variable:		
	Government.approval		
	(1)	(2)	(3)
	Total Effect 1	Total Effect 2	Direct Effect 1
rd (%gdp)	24.011*	24.011*	14.221
	(13.940)	(13.940)	(9.777)
Observations	194	194	206
R^2	0.613	0.613	0.713
Adjusted R^2	0.507	0.507	0.637
Residual Std. Error	8.308 (df = 92)	8.308 (df = 92)	8.210 (df = 101)
Partial $R^2_{Y=D\|X}$	0.036	0.36	0.018
Robustness Value	0.175	0.175	0.129
F Statistic	12.838*** (df = 28; 165)	12.838*** (df = 28; 165)	16.148*** (df = 31; 174)

Note: *p<0.1; **p<0.05; ***p<0.01

While Table 2 captures the effect of government R&D expenditures as a percentage of GDP on government approval, it does not illustrate the trade-offs of budget allocations across different policies. That is, voters can value greater government expenditures overall, and the increase in government approval could reflect these preferences. Thus, we additionally measure government R&D expenditures as a a percentage of the budget. This new measure captures the fact that growth in government R&D expenditures comes at the expense of other government policies. Results are presented in Table 3.

Table 3: Effect of R&D Expenditures(%Budget) on Government Approval

	Dependent variable:		
	Government.Approval		
	(1)	(2)	(3)
	total.effect.1	total.effect.2	direct.effect.1
rd(%budget)	15.156	15.021	6.938
	(10.102)	(9.992)	(7.458)
Observations	118	118	129
R^2	0.613	0.613	0.713
Adjusted R^2	0.507	0.507	0.637
Residual Std. Error	8.308 (df = 92)	8.308 (df = 92)	8.210 (df = 101)
Partial $R^2_{Y=D\|X}$	0.057	0.057	0.026
Robustness Value	0.217	0.217	0.153
F Statistic	5.821^{***} (df = 25; 92)	5.821^{***} (df = 25; 92)	9.301^{***} (df = 27; 101)
Note:			*p<0.1; **p<0.05; ***p<0.01

While we have captured the effect of government R&D expenditures on government approval, it is important to put our findings into context. To do that, we run a similar set of models substituting government R&D expenditures with government education expenditures (see Table 4). This comparison was chosen for several reasons. First, government expenditures on education also have a long-run effect on the economy. However, they tend to be more observable by citizens and are less risky than R&D expenditures. We rely on the same set of assumptions as in case of R&D expenditures, thus making the models fully comparable. One must note that the treatment coefficients vary significantly between models. This is explained by the fact that the baseline level of government expenditures on education is much higher: around 6%, compared to the 2% average of government expenditures on R&D. The results of the models are similar for logged versions of the treatment variables and are available upon request.

Table 4: Effect of Education Expenditures(%GDP) on Government Approval

	Dependent variable:		
	Government.Approval		
	(1)	(2)	(3)
	total.effect.1	total.effect.2	direct.effect.1
education	1.308 (1.237)	1.308 (1.237)	1.273 (1.259)
Observations	142	142	143
R^2	0.767	0.767	0.747
Adjusted R^2	0.707	0.707	0.685
Residual Std. Error	7.835 (df = 112)	7.835 (df = 112)	8.090 (df = 114)
Partial $R^2_{Y=D\|X}$	0.031	0.031	0.037
Robustness Vlaue	0.164	0.164	0.177
F Statistic	12.709*** (df = 29; 112)	12.709*** (df = 29; 112)	12.031*** (df = 28; 114)
Note:			*p<0.1; **p<0.05; ***p<0.01

Similarly, we can explore the effect of government expenditures on education as a percentage of budget on government approval (see Table 5). In this case, the comparison of trade-offs of budget allocation to R&D versus Education is especially striking—1% of additional budget spending on the former can increase government approval by 23%, but the same increase in the latter increases government approval by 2%.

Table 5: Effect of Education Expenditures(%Budget) on Government Approval

	Dependent variable:		
	Government.Approval		
	(1)	(2)	(3)
	total.effect.1	total.effect.2	direct.effect.1
education	1.415	1.415	−2.260
	(2.878)	(2.878)	(2.453)
Observations	142	142	143
R^2	0.761	0.761	0.739
Adjusted R^2	0.699	0.699	0.676
Residual Std. Error	7.936 (df = 112)	7.936 (df = 112)	8.212 (df = 114)
Partial $R^2_{Y=D\|X}$	0.006	0.006	0.007
Robustness Vlaue	0.075	0.075	0.084
F Statistic	12.288*** (df = 29; 112)	12.288*** (df = 29; 112)	11.557*** (df = 28; 114)

Note: *p<0.1; **p<0.05; ***p<0.01

4.1.3 Sensitivity to Confounders Omitted variable bias can seriously impact any analysis of social phenomena. This concern is especially severe for cross-country observational studies. I presented the structure of assumptions that guides the model specification, but there is a strong possibility of unobserved confounders not reflected in the DAG affecting both government R&D expenditures and the approval citizens bestow on the government.

Sensitivity analysis allows us to quantify the threat posed by unobserved confounding. In this section, I adopt the approach presented in Cinelli and Hazlett (2018) to quantify the confounding that would be required to nullify the observed regression results. To do so, I report two measures of the sensitivity of linear regression coefficients. First, the "robustness value" (RV) illustrates the overall robustness of a coefficient to unobserved confounding. If the confounders' association to the treatment and to the outcome (measured in terms of partial R^2) are both assumed to be less than the robustness value, then such confounders cannot "explain away" the observed effect. Second, I report the proportion of variation in the outcome explained uniquely by the treatment, $R^2_{Y\sim D|X}$, which reveals how strongly confounders that explain 100% of the residual variance of the outcome would have to be associated with the treatment in order to eliminate the effect. Both measures are a function of the estimate's t-value and the degrees of freedom.

Cinelli and Hazlett (2018) present the following decomposition of omitted variable bias:

$$|\hat{bias}| = se(\hat{\alpha})\sqrt{\frac{R^2_{Y\sim Z|X,D}R^2_{D\sim Z|X}}{1-R^2_{D\sim Z|X}}(df)}$$

where $se(\hat{\alpha})$ is the standard error of the main coefficient of interest $\hat{\alpha}$, Y is the outcome of interest, D is the main explanatory variable, X is a vector of covariates, Z is the omitted variable, and df is degrees of freedom of the regression.

The absolute value of the bias thus depends upon the strength of association of the outcome with the omitted variable (measured by the partial R^2:$R^2_{Y\sim Z|X,D}$), and the strength of association of the main explanatory variable with the omitted variable ($R^2_{D\sim Z|X}$).

One way to interpret results is by comparison to observed variables. Formally, we can form a working assumption that confounding is "no worse than" a particular observed variable, meaning that confounding is assumed to explain less of the residual variation in treatment and in the outcome than that observed covariate. Guriev and Treisman (2016) suggests that the strongest predictor of government popularity is GDP. Cinelli and Hazlett (2018) provide the means to turn such assumptions into bounds on the degree of confounding that is permissible.

For present purposes, we will choose whatever observable was empirically the strongest predictor of the outcome to make these comparisons. For instance, the Total Effect models for government R&D expenditures have log.GDP as the strongest (conditional) predictor of government approval. This fact does not come as a surprise, as it is widely accepted in the literature that economic performance affects government approval and reelection prospects. The Direct Effect models for government R&D expenditures have economic volatility as the main predictor of government approval. All models of the effect of government expenditures on education have political competition as a main predictor. With this in mind, we can explore the sensitivity of our models to unobserved confounders using these variables for comparison..

Tables 2-5 report the partial R^2 of the treatment with outcome and robustness values. For instance, Total Effect 1 in Table 1 has a robustness value of 17.6%. That suggests that unobserved confounders (orthogonal to the covariates) that explain more than 0.176 of the residual variance of both the treatment and the outcome are enough to reduce the absolute value of the effect size by 100%. Conversely, unobserved confounders that do not explain more than 17.6% of the residual variance of both the treatment and the outcome are not strong enough to reduce the absolute value of the effect size by 100%.

In addition, the proportion of variation in the outcome explained uniquely by the treatment, $R^2_{Y\sim D|X}$, is 3.6. This implies that an extreme confounder (orthogonal to the covariates) that explains 100% of the residual variance of the outcome would need to explain at least 3.6% of the residual variance of the treatment to fully account for the observed estimated effect.

We can also examine how big the unobserved confounder would have to be compared to the biggest observed covariate to nullify the effect of government R&D spending (as a percentage of GDP). Figure 4 presents a bias contour of t-value plot for three models of the effect of R&D expenditures (as a share of the budget) on popular approval of the government.

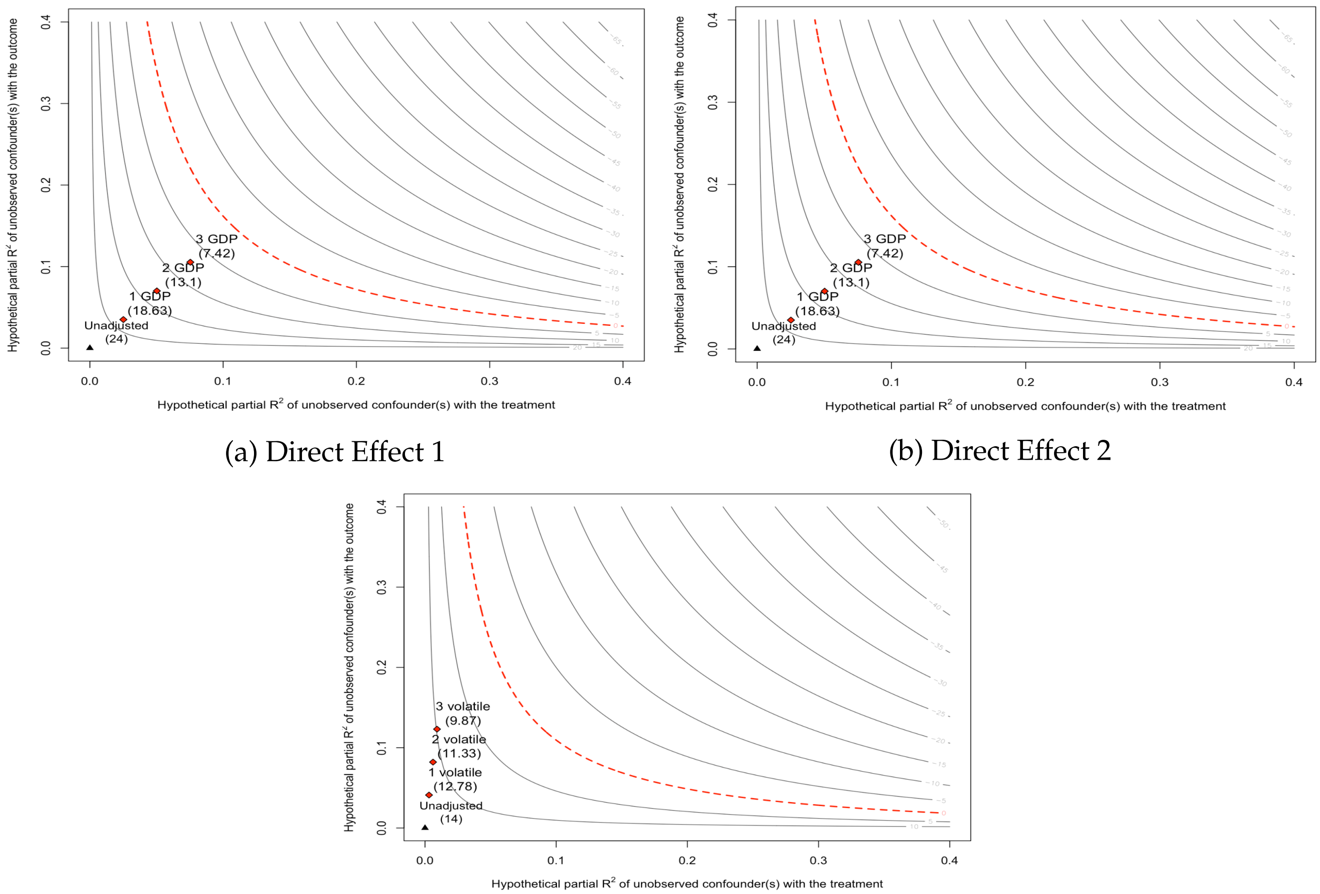
The horizontal axis shows hypothetical values of the partial R^2 of the unobserved confounder(s) with the treatment, interpreted as the percentage of the residual variance of the treatment explained by the confounder. The vertical axis shows hypothetical values of the partial R^2 of the unobserved confounder(s) with the outcome, interpreted as the percentage of the residual variance of the outcome explained by the confounder. The bias contour levels represent the adjusted estimates of the treatment effect. The reference points (in red) are bounds on the partial R^2 of the unobserved confounder if it were k times "as strong" as the observed covariate GDP (for total effects of R&D expenditures), volatility (for direct effect of R&D expenditures) and political competition (for all models of education expenditures). They show what would be the maximum bias caused by orthogonal unobserved confounder(s) if it (they) had the same or less predictive power than R&D expenditures (Education expenditures), with both the treatment and the outcome. Figure 4 suggests that the effect of an unobserved confounder on both treatment and outcome should capture at least 6 times the variance of both treatment and outcome as explained by the most important covariate in the regression—GDP. While $R^2_{Y\sim D|X}$ seems fairly low, it is worth remembering that GDP is seen as a good predictor of government popularity by the literature. For the direct effect, the main predictor was volatility, so the plot features it as a comparison variable for R&D expenditures. For all models of the impact of government expenditures on education, the main predictor was political competition, so the figures feature it as the comparison.

We can see that highest robustness values and partial R^2s are obtained for models with government R&D expenditures as a percentage of budget on government approval. The lowest robustness values and partial R^2s are obtained for models with government education expenditures as a percentage of budget on government approval.

5. Survey experiment design[6]

The cross-country regression evidence above cannot entirely rule out concerns such as confoundinng, but is consistent with the claim that governments can utilize R&D policy to signal their competence. In this Section, we consider an additional form of evidence in which confounding is not a concern, using survey experiments conducted in the US and Russia. These experiments are designed to test whether government pro-R&D policy can build a greater perception of an incumbent's competence, compared to pro-education, pro-infrastructure, or pro-short-term-innovation policy. Repeating the experiment in two countries serves several purposes. First, it allows me to test the proposed theory in two very different settings. Second, it may illuminate the difference between policy choice effects in a setting where the competence of the incumbent can argued to have less effect on the economic performance of a country with a functional system of checks and balances (US) than in a country where this system is lacking (Russia). Third, the Russian economy and foreign policy are more susceptible to shocks, which

[6] This experiment was preregistered. EGAP identification number is 20180529AC. IRB approval numbers: Russian version: 18-000765, US version: 18-000587



(a) Direct Effect 1

(b) Direct Effect 2

(c) Direct Effect 3

Figure 4: Bias Contours of T-value

Note: Sensitivity analysis of the t-value using the partial R2 parameterization, and including benchmark bounds using observed covariates. The horizontal axis shows hypothetical values of the partial R2 of the unobserved confounder(s) with the treatment (the percentage of the residual variance of the treatment explained by the confounder). The vertical axis shows hypothetical values of the partial R2 of the unobserved confounder(s) with the outcome (the percentage of the residual variance of the outcome explained by the confounder). The contour levels represent the adjusted estimates of the treatment effect. The reference points (in red) are bounds on the partial R2 of the unobserved confounder if it were k times "as strong" as the observed covariate GDP, showing that the point estimate was robust to a confounder three times as strong as GDP (Volatility for direct effect).

can generate a higher preference among voters for incumbent competence. Further, the difference in political regimes (democracy and autocracy, respectively) and the level of corruption can generate different gains from holding office for the incumbent, which, in turn, can influence voters' updating about politicians' competence after observing a policy choice. Finally, while both countries engage in substantial government R&D policy, Russia started its efforts to promote innovation fairly recently—from 2007—so voters may have different expectations about the economic outcomes of such efforts.

5.1. Survey experiment design

Data Collection. Surveys were openly posted on MTurk (2200 respondents) and Yandex.Toloka (1300 respondents) in the United States and Russia, respectively. Respondents were free to drop out at any time. Several steps were taken to ensure the validity of the results. First, there are many foreign workers on MTurk and Yandex.Toloka. In addition to requiring respondents to confirm their US residency on the consent form, I also had Amazon show the survey only to workers who had US addresses. Similar measures were taken on the Yandex.Toloka platform. All respondents were 18 years old or older. Next, respondents were told that payment would be contingent on completing the survey and providing a password visible only at completion. In addition, I administered a pre-treatment attention check. Respondents that failed the test encountered a pop-up prompting them to read tasks attentively. I excluded inattentive respondents from the main analysis, but the results for the full sample were calculated as a robustness check and they are not significantly different. I collected the following demographic information: gender, education, income level, employment status, political affiliation (Unites States only), and zip-code. Both MTurk and Yandex.Toloka provide convenience samples and so are not fully representative of their respective populations. Moreover, the two platforms are designed for similar purposes and attract similar demographics, and so both MTurkers and Yandex.Toloka users tend to be younger and relatively better educated than the average of their respective countries. The core assumption I rely on in this experiment is that MTurk and Yandex.Toloka populations do not differ from the general population in terms of their preference for policy choice.[7]

Treatment. In general, the goal of the information treatments was to provide respondents with a paired vignette featuring two similar politicians, one of them favouring pro-RD policy and an-

[7] Despite being a convenience sample, the MTurk population can help us to answer research questions: recent meta-analyses of experimental studies conducted on both Mechanical Turk and US national probability samples suggests high replication rates (Coppock, Leeper and Mullinix, 2018; Coppock, 2018; Mullinix et al., 2015). On the other hand, MTurk samples are especially susceptible to social desirability bias and provide biased results when experiments in which subjects compensation depends on their answers, which is likely not the case for this study.

other favouring one of three control treatments: pro-education policy, pro-infrastructure policy, or policy focusing on bringing existing technologies to the market. Each description featured a short note discussing the long-run effect for the economy in general and for the competitiveness of companies. I present the samples of treatment vignettes employed in Appendix E, where, for the sake of brevity, I show only the first version of the Treatment (Smith-T, Meyerson-C) for RD vs Education, RD vs Infrastructure, and RD vs Short-term Innovation comparisons. The vignettes were designed as broad statements and did not feature specific numbers, so that the treatment would not be conflated with deviations of specific numbers from those expected by respondents. In all cases, the order of treatment and control vignettes, as well as biographies of politicians, was randomized. In the US sample, I employed block randomization by political affiliation. In the Russian sample, I refrained from asking respondents about their political affiliation due to the sensitivity of this question in the Russian setting; hence, no block randomization by political affiliation was possible. I employed the Qualtrics randomization tool to perform block randomization for both surveys using "complete" randomization.

Thus, I employed a paired vignette design that has been shown to closely mimic data obtained by observing actual behavior in a natural experiment setting Hainmueller, Hangartner and Yamamoto (2015). Table 2 of the Appendix presents the block structure for the Yandex.Toloka Survey.

Dependent variables. All respondents were invited to answer a series of questions, with the order of the questions randomized to minimize priming effect. I also hoped to elicit more robust results by employing two different response types: score comparison and a forced choice. The score comparison analysis focused on the differences of scores obtained for each politician on three dimensions: competence, economic expectations of policy, and probability of reelection. The score differences are calculated along each of the dimensions by subtracting the competitor's score from that of the incumbent politician, where the score choices are described below. In this setup, it was possible for respondents to assign equal scores to treatment and control politicians. The questions that were used for the score comparisons for the United States sample are presented below:

Table 6: Questions for score comparison, US survey

How likely are you to support A. Smith (R. Myerson) for a second term? **How likely are you to vote in the next election?**					
6: Very Likely	5: Moderately Likely	4: Slightly Likely	3: Slightly Unlikely	2: Moderately Unlikely	1: Very Unlikely
Do you think that A. Smith's (R.Myerson's) policy will lead to greater prosperity for the American people? **Do you think that A. Smith's (R.Myerson's) policy will lead to your greater prosperity in the future?**					
6: Strongly Agree	5: Agree	4: Somewhat Agree	3: Somewhat Disagree	2: Disagree	1: Strongly Disagree
Evaluate A. Smith's (R.Myerson's) competence on the following six-point Likert scale					
6: Far Above Average	5: Moderately Above Average	4: Slightly Above Average	3: Slightly Below Average	2: Moderately Below Average	1: Far Below Average

Thus, calculating the differences between evaluation of the treatment and control politicians allowed me to assess each participant's preference of treatment over the control politician. Since within each treatment block the order of the politicians' biographies and the biographies themselves were randomized, I can regard the average difference of their scores within a block as solely attributable to the politicians' differences with respect to policy preferences.

The forced choice setup instead focuses on the mean scores the pro-R&D (i.e., the treatment) politician obtained relative to the pro-education, pro-infrastructure, or pro-short-term-innovation politicians (Control). In the survey experiment, I forced respondents to choose between politicians, since I did not allow politicians to be ranked equivalently but rather asked to what degree the respondents preferred one politician over another. To this end, I asked the respondents to choose between two candidates based on whether they were more likely to support A. Smith than R. Myerson for a second term; whose competence they rated as higher; and whose policy they expected to be more effective in promoting economic growth. These choices were on a -3 to 3 scale lacking a 0. Employing forced choice questions allowed me to juxtapose the results where respondents were forced to state their preferences for one politician over another with those of the previously described setup.

Analysis : Since we observed the scores each respondent assigned to both the treatment and control politicians, we can use paired t-test to access the sample average treatment effect within each block for both the United States and Russian samples. Thus, for score difference I employ the paired t-statistic $T = \frac{\bar{d}}{SE(\bar{d})}$, where $d_i = score.treatment_i - score.control_i$. In the case of forced choice, we observe 1 score per respondent per dimension (competence, economic expectations, and reelection) that shows by how much the respondent prefers one politician over the other. I normalize the scores, so that scores in favor of the treatment politician are positive, and scores in favor of the control politician are negative. I perform the t-test within each block: $T = \frac{\bar{d}}{SE(\bar{d})}$, where $\bar{d}$ is the average score the treatment policy receives. Moreover, I employed Welch's difference-in-means t-test to compare the results of the US and Russian samples: $t = \frac{\bar{X_1} - \bar{X_2}}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$, where country 1 is USA and country 2 is Russia. As an additional exercise, we will assess whether a politician's average reelection scores were positively correlated with his competence and economic expectation scores.

5.2. *Results*

5.2.1 Results for the Attentive US Sample The US sample consisted of 2286 respondents, 2246 of whom successfully passed the attention check administered at the beginning of the survey.

Figure 5 presents the mean differences between the scores respondents assigned to the pro-R&D politician and the pro-education, pro-infrastructure, and pro-short-term-innovation politicians. For those respondents who passed the attention check, the top half of the figure show results for the score comparison analysis, whereas the bottom shows the forced choice results. Confidence intervals presented in the graphs are unadjusted for the familywise error rate due to multiple hypothesis testing, while the label shows FDR-unadjusted p-values. Among attentive respondents, a politician that chose the long-term pro-R&D policy was always regarded as more competent, whereas his scores for probability of reelection and economic expectations of his policy remained statistically indistinguishable from those of the control politicians. The results do not change if we look at Democrats and Republicans separately.

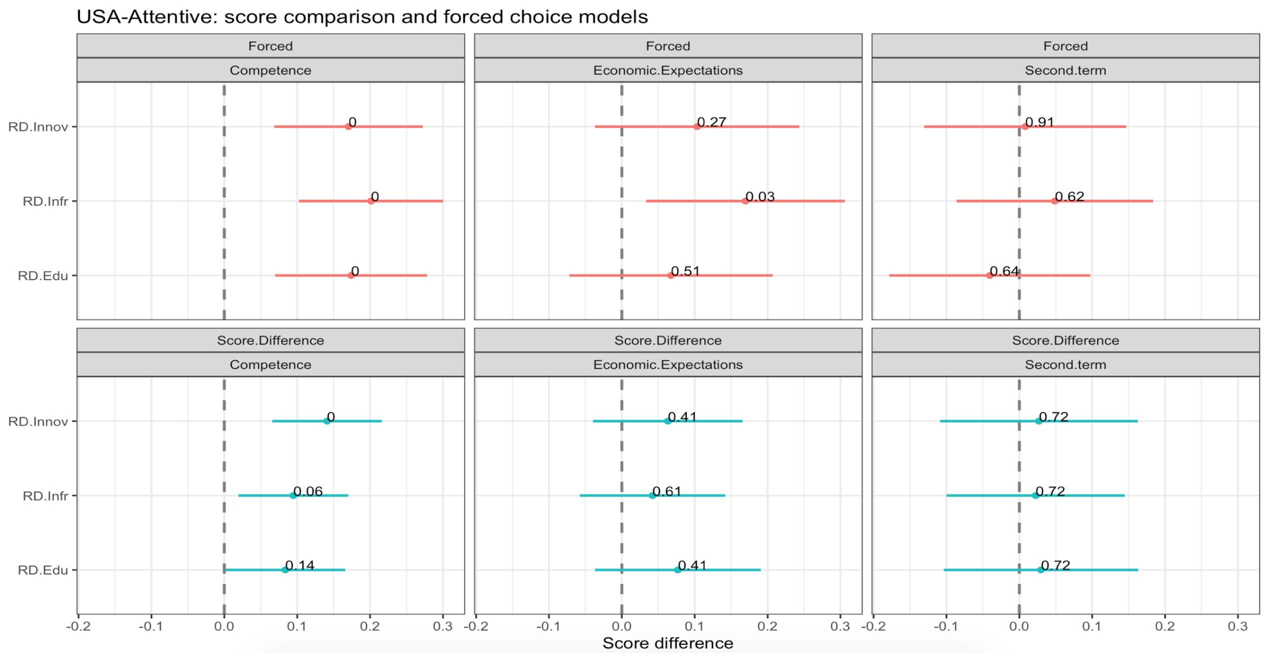


Figure 5: Score Comparison for Attentive MTurkers

Survey results for the whole sample of US respondents (including inattentive ones) are presented in Figure E1 of Appendix E. Note that there is no difference in most instances between pro-R&D and pro-short-term-innovation politicians, signaling that US respondents neither rewarded nor penalized short-term versus long-term policies directed at innovation. However, when compared to a pro-infrastructure politician, the pro-R&D politician was seen as more competent and his policy as generating higher economic expectations. Consequently, respondents indicated a greater willingness to vote for him, and these results did not change if Democrats and Republicans were analyzed separately.

5.2.2 Results for the Attentive Russian Sample The full Russian sample consisted of 1252 respondents, 1013 of whom passed the initial attention check. Figure 6 displays the results of t-tests for both the score comparison and forced choice analyses showcasing the mean differences in scores respondents assigned to a pro-R&D politician and those assigned to pro-education, pro-infrastructure, and pro-short-term-innovation politicians. The confidence intervals shown are unadjusted for multiple hypothesis testing while the label shows false discovery rate (FDR)-adjusted p-values. The respondents in the Russian sample strongly preferred long-run investment in R&D over investment in commercialization of existing technologies. The survey results for the full Russian sample (including inattentive respondents) are presented in Figure E2 of Appendix E.

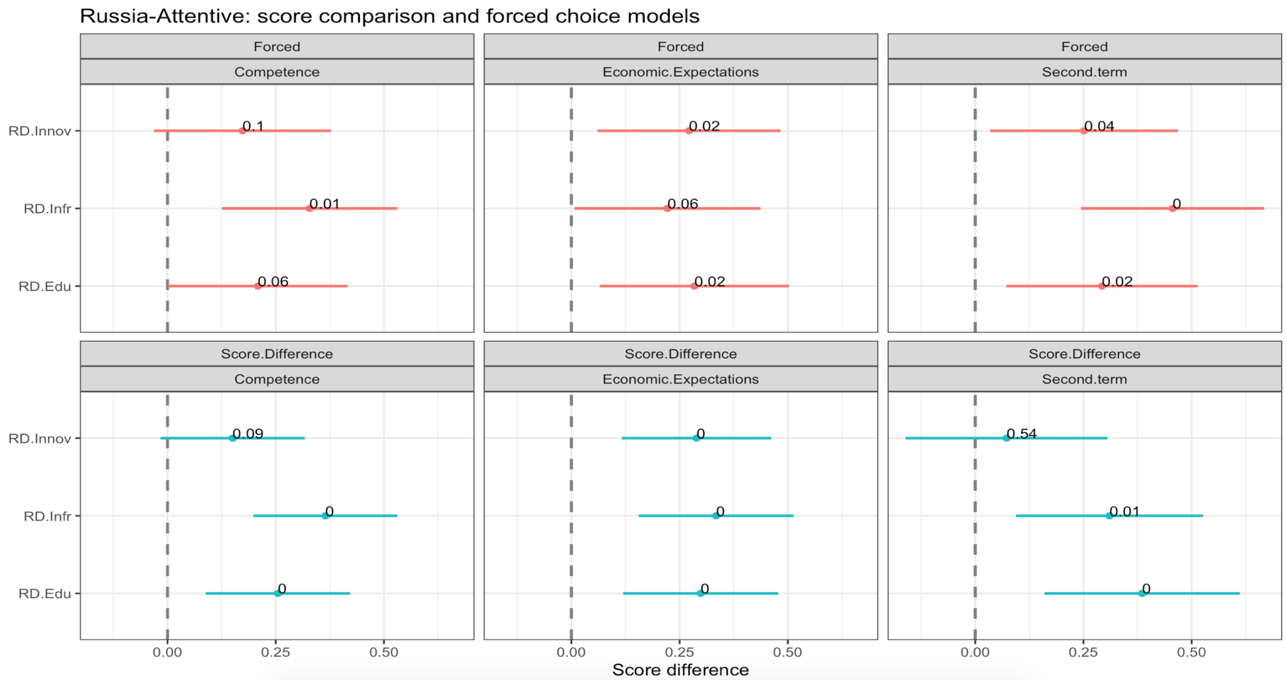


Figure 6: Score Comparison and Forced Choice for Attentive Respondents

As in the US sample, Russian respondents viewed the pro-R&D politician as more competent in all dimensions than the politicians favoring other forms of investment. Unlike the US sample, however, the pro-R&D policy was also seen as generating greater expected economic returns, and the politician advocating this policy was more likely to be reelected. This difference could reflect a difference in skill preference in the Russian and US settings.

Appendix F presents score distributions for each policy comparison for the attentive US and Russian samples; since there are three times as many observations for pro-R&D politicians as for non-R&D politicians, I did not aggregate pro-R&D scores across all comparisons. Figures F2 and F1 shed some light on the puzzling results presented in Section 5.2.1, i.e., that in the US sample a pro-R&D incumbent failed to score higher on the reelection-prospects dimension than a non-R&D incumbent, despite the fact that he did not perform worse than the control politician on the economic expectations dimension and performed better on the competence dimension. The economic expectation scores of pro-R&D politicians are skewed to the right, indicating that the score distribution of economic expectations from R&D policy is wider for both US and Russian samples than the scores from pro-education policy. This can be regarded as a reflection of the risky nature of R&D policies.

Since I employ convenience samples in both the USA and Russia that are not fully representative of the general population of these countries, it is interesting to investigate if there is tangible difference in preferences over treatment and control politicians at different levels of education (cutoff educational achievement is "some college") and wealth (cutoff wealth is 40,000 USD a year in the USA and 30,000 RUR a month in Russia). These cutoffs are median values in both samples. Appendix G presents the results for attentive respondents in both countries.[8]

5.2.3 Comparison of US and Russian Results for Attentive Respondents In this section, I compare experimental results for the attentive Russian and US samples, employing Welch's t-test with unequal variances to test for equality of means for the US and Russian pro-R&D versus policy differences for each of the three dimensions, and the results are presented in Figure 7. Here, we can see that a US pro-R&D politician competing with a pro-short-term-innovation politician has a lower score advantage than the Russian politician on all dimensions. With respect to a pro-infrastructure politician, there was no statistically significant difference in US and Russian performance with a pro-R&D politician. These comparisons hold for both the score-difference and forced-choice analyses. As we compare the performances of a pro-R&D politician with that of a pro-education politician for the two countries, the framing of the question seems to matter. Whereas the score-difference results exhibit no statistically significant difference between the US and Russian samples, based on the forced-choice analysis, US respondents awarded a lower score premium than the Russian respondents did to a pro-R&D politician competing against a pro-education politician.

[8] In the forced choice setting, we do not see a difference in choices made by more educated and less educated respondents in either the USA or Russia. In score comparison settings, more educated US respondents rate the pro-R&D politician higher than the pro-Education politician, but rate both equally on economic expectations and reelection prospects G1. In Russia, the score difference setup reveals that more educated respondents rate the pro-R&D politician lower on all three dimensions than pro-Education politician G2. Exploring the comparison between scores assigned by more and less wealthy respondents, in the USA, we do not detect any difference between the two subsamples G3. In the Russian sample, the pro-R&D politician obtains lower scores from wealthier respondents on reelection prospects compared to the pro-education politician and lower scores on economic expectations in the forced choice setup G4.

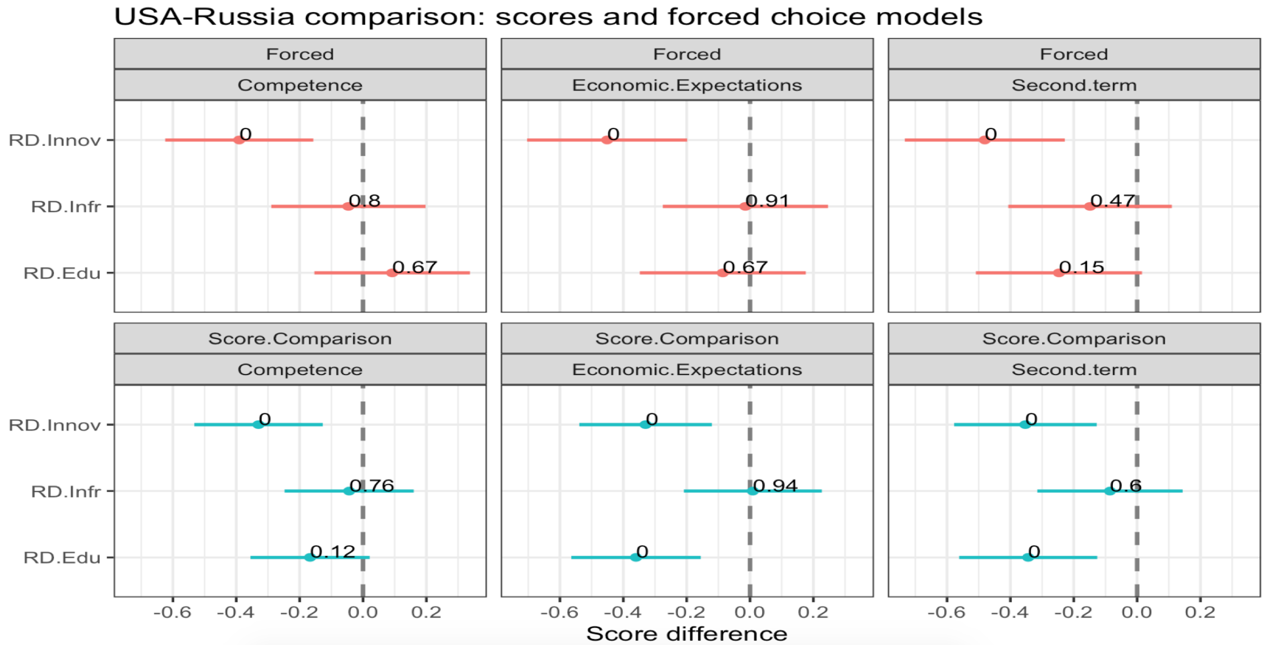


Figure 7: Difference in Scores for Attentive Respondents

The directions of effects for incumbents' policy choices were inspected for both the US and Russia individually and relative to one another. The directions of effects are the same for choosing R&D policy over short-term commercialization (i.e., innovation), infrastructure investment, or education investment, as shown in Section 5.2.1 and Section 5.2.2, but the magnitudes differ significantly. Overall, Russian respondents tended to value R&D policy more than US citizens did. Respondents from both countries updated their beliefs about an incumbent's competence based on his policy choice. The comparison of survey results for the full US and Russian samples is presented in Figure E3 of Appendix E and is similar to those of the attentive sample.

5.3. *Associations between reelection, perceived competence, and economic expectations*

As we have explored the role of a politician's policy choice in forming perceptions about his competence and the economic expectations related to this policy choice, we can now explore the associations between the decision to reelect a politician and these two factors and compare the differences we observed between US and Russian responses. For purposes of illustration, I tested whether voting for a pro-R&D politician was positively correlated with perceptions of his competence and with economic expectations. The results do not establish a causal claim but rather validate previous findings, i.e., that both channels move in the same direction as the respondents' stated voting decisions. To accomplish this, I employed linear regressions based on results derived from both the forced choice and score comparison analyses. The simple OLS regression models to explore the associations in score differences were as follows:

$$\texttt{Score.Diff.Reelection} = \alpha + \beta_1 \texttt{Score.Diff.Competence} + \beta_2 \texttt{Score.Diff.Economics} + \epsilon$$

The model employed to explore the forced choice analysis was as follows:

$$\texttt{Choice.Reelection} = \alpha + \beta_1 \texttt{Choice.Competence} + \beta_2 \texttt{Choice.Economics} + \epsilon$$

The results of the analyses are presented in Table 7. In the score comparison analysis, the variables were the differences between perception of a politician's competence or policy and those of his competitor. Similarly, the reelection prospect was measured as the difference in prospects of a politician and his rival. Thus, the maximum value each variable could take was 5 (if the politician was rated highest on the scale and his rival was rated lowest), and the minimum possible value was 0 (if they were rated to be the same). The order in which the questions appeared to a respondent was randomized. In the forced choice analysis, the results were on a scale running from -3 (prefer much less) to +3 (prefer much more), with the 0 score omitted to facilitate forced choice. The results presented below are restricted to respondents that successfully passed the attention check administered at the beginning of the survey but are robust to inclusion of the whole sample of users.

Table 7: Predicting reelection scores with perceived competence and economic expectations

	Dependent variable:Reelection score	
	Score.difference	Forced.choice
	(1)	(2)
Economic_perceptions	0.622^{***}	
	(0.018)	
Competence	0.461^{***}	
	(0.022)	
Choice.Economic_perceptions		0.588^{***}
		(0.014)
Choice.Competence		0.235^{***}
		(0.018)
Constant	-0.041^{*}	-0.038
	(0.024)	(0.025)
Observations	3,259	3,259
R^2	0.510	0.494
Adjusted R^2	0.510	0.494
Residual Std. Error (df = 3256)	1.353	1.403
F Statistic (df = 2; 3256)	$1{,}696.703^{***}$	$1{,}588.785^{***}$
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 7 presents the results for the pooled Russian and US sample, inattentive respondents excluded.[9] However, when presented with the forced choice, US respondents valued competence more and economic expectations less than did the Russian respondents. Overall, the difference in importance between competence perceptions and economic expectations in predicting reelection prospects was rather small within both the US and Russian samples.

[9]Results are very similar when restricting to the attentive sample, and when adding country-fixed effects.

Thus, the results suggest that both competence signaling and expectation of future economic performance are plausible determinants of incumbents' reelection prospects. One might argue that the survey respondents responded to questions in the same directions due to rationalization. Although I am not able to eliminate this concern, randomization of order of the questions and employing the two different scales (i.e., score comparison and forced choice) should have helped to alleviate this issue to some degree.

Whether voters can anticipate the long-run effects of government investment in innovation so that they can reward an incumbent with their support is an important question. Unlike other long-term government investments (such as education or infrastructure), the results of government investment in R&D are not directly observable by the population until the time needed to develop the technology and bring it to market has elapsed. Furthermore, the survey results provide insight into whether support for an incumbent changes due to changes in perception of the incumbent's competence or due to the anticipated effects of the policy itself.

A battery of tests was performed to test various hypotheses, specifically whether investment in R&D (1) had any positive effect on an incumbent's reelection prospects compared to investment in short-term innovation, infrastructure, and education; (2) generated greater expectations for the economy; (3) was associated with respondent perceptions of increased competence of the incumbent politician; and (4) caused the politician to be ranked higher than the control politician on reelection prospects.

6. A case study: Medvedev and nano-technology

In Section 3 I have shown that the incumbent can reap benefits from investing in R&D, contrary to the specific traits of such a policy as outlined in Section 1. Section 4 provides some evidence on this point, although it cannot be regarded as conclusive due to possible confounding effects. Experimental evidence suggests that citizens regard a pro-R&D politician as more competent than pro-infrastructure, pro-education or pro-short-term-innovation politicians. In what follows, I briefly illustrate that politicians not only invest in R&D policy but also actively broadcast their policy choice. Russia provides a modern example of showcasing government efforts to boost innovation. When Dmitry Medvedev succeeded Vladimir Putin as president in 2008, he put "technological modernization" at the forefront of his agenda and drastically increased funding of nanotechnology. In a statement representative of his agenda, he said, "Instead of the primitive raw material economy, we will create a smart economy generating unique knowledge, new useful things and technologies." [10]As Treisman (2012) shows, this strategy worked initially, and Medvedev's approval was consequently high.

Figure 8 shows mentions of the word "nanotechnology" by itself and in combination with the name "Medvedev" in the Russian media over the 2004-2016 period, as well as government approval among the citizenry. As can be seen, nanotechnology mentions (blue line) began to rise sharply in 2007 (the leftmost dashed line) when Medvedev's election campaign began. Medvedev centered his agenda on the idea of promotion of new technologies and "modernization," resulting in a rise of combined mentions of "Medvedev" and "nanotechnology," and, for a substantial period of time, he enjoyed high approval ratings (bottom figure). In contrast to the Autobahn construction, however, Russian citizens did not see tangible results of Medvedev's investments. Although in part this could be due to the long period of time such investments took to yield a return, it could also be attributable to the large-scale rent-seeking that these projects enabled.

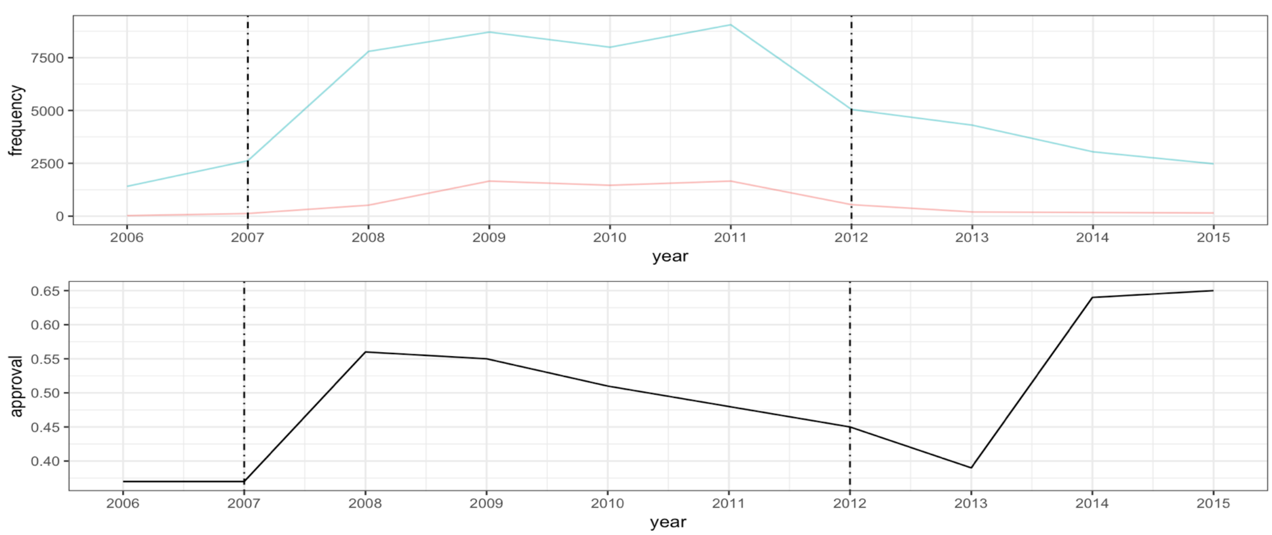


Figure 8: Mentions of Dmitry Medvedev and his technology-pPromoting efforts in Russian media. *Source:* Integrum Database

[10]CNN report: http://edition.cnn.com/2009/WORLD/europe/11/12/russia.medvedev.speech/

In June 2018, I conducted a semi-structured interview with Yuriy Simachev, a deputy CEO of the Interdepartmental Analytical Center. The Center was founded in 1992 by the Russian government as a consulting body for government industrial policy. Later on it took on the tasks of preparing government R&D policy efforts and monitoring ongoing government R&D projects.[11] Simachev highlighted that the Russian government was interested in "active R&D policy,"where the projects that received support were selected by the official body. He noted that government support for innovation was aimed to have a demonstrative effect, as the government could claim to be aiming for a "proriv" ("breakthrough")—a slogan widely used in times of the USSR planned economy. He also suggested that it helps officials to form an image of the strong "derzhava" ("country").

The Russian example is not the only case of showcasing government R&D policy. Figure 9 presents mentions of the keywords "government," "technology," "President," and "research" in the News section of Lexis Uni (Public Administration topic only), approval ratings of the US government, and government R&D expenditures as a share of GDP.

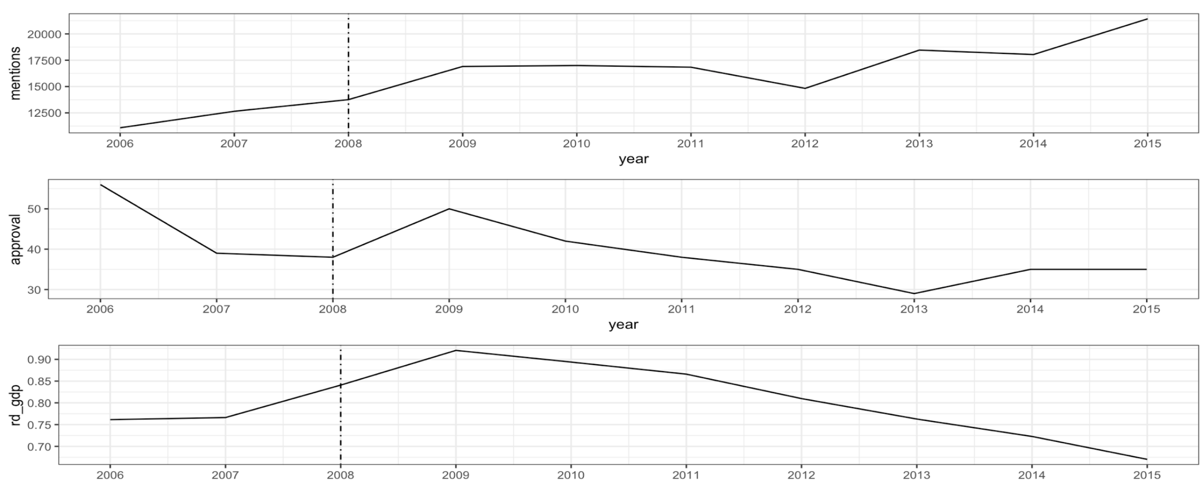


Figure 9: R&D mentions, government approval, and government R&D expenditures in the USA over Time

In these examples, we can see that both mentions of R&D and actual government R&D spending increase in the first year of the new incumbent's term. At the same time, R&D spending is rarely close to the bliss point of the median voter. For example, Eurobarometer (2018)

[11]The Interdepartmental Analytical Center was transformed from a government body to a joint stock company in 2003.

respondents answering the question “And on which of the following would you like EU budget to be spent? (Max 4 answers),” scientific research was mentioned by one in five Europeans, compared to “public health” and “employment and social affairs,”mentioned by 40% of respondents; “economic growth” and “education, training, culture and the media,” mentioned by one-third of respondents; and “climate change and environmental protection” and “defense and security,”mentioned by a quarter of respondents.

7. Conclusion

In this paper, I have explored a political economy puzzle: why do we observe substantial government R&D investment, which carries significant cost and risk and does not provide politicians with apparent short-term results that can boost their reelection chances? This paper focused on a particular mechanism—the ability of politicians to signal their competence by engaging in highly risky and complex policy—and provided a theoretical model showcasing this mechanism. I have tested it using a survey experiment in two countries that actively engage in R&D policy and have found that citizens do indeed exhibit higher perceptions of competence of pro-R&D politicians compared to pro-infrastructure politicians, while the results for pro-short-term-innovation and pro-education politicians differ across countries. At the same time, I failed to establish that the higher competence perception boosts a politician’s reelection prospects. In addition, I performed a cross-country analysis and found suggestive (supposing the structure of assumptions was correctly specified) evidence that government R&D investment boosts government approval among the citizenry. Overall, my empirical findings are consistent with the theorized model and suggest that incumbents can indeed engage in competence signaling via pro-R&D policy. In some cases, it can lead to overinvestment in R&D, since even less competent politicians can choose pro-R&D policy in equilibrium.

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APPENDICES

A. APPENDIX A

CONDITIONAL INDEPENDENCIES

$1. Approve \perp Approve.l2 | Approve.l, RD.l, RD.l2, Volatility$
$2. Approve \perp Approve.l2 | Approve.l, Country, GDP, Polcomp, RD.l, Volatility$
$3. Approve \perp Approve.l2 | Approve.l, Country, GDP, Polcomp, RD, Volatility$
$4. Approve \perp RD.l | Approve.l, Country, GDP, Polcomp, RD, Volatility$
$5. Approve \perp RD.l2 | Approve.l2, Country, GDP, Polcomp, RD.l, Volatility$
$6. Approve \perp RD.l2 | Approve.l, Country, GDP, Polcomp, RD.l, Volatility$
$7. Approve \perp RD.l2 | Approve.l, Country, GDP, Polcomp, RD, Volatility$
$8. Approve.l \perp GDP | Country, RD.l, RD.l2$
$9. Approve.l \perp GDP | RD.l, RD.l2, Volatility$
$10. Approve.l \perp GDP | Approve.l2, RD.l, Volatility$
$11. Approve.l \perp Polcomp | Country$
$12. Approve.l \perp Polcomp | Volatility$
$13. Approve.l \perp RD.l2 | Approve.l2, RD.l, Volatility$
$14. Approve.l2 \perp GDP | Country, RD.l, RD.l2$
$15. Approve.l2 \perp GDP | RD.l, RD.l2, Volatility$
$16. Approve.l2 \perp Polcomp | Country$
$17. Approve.l2 \perp Polcomp | Volatility$
$18. Approve.l2 \perp RD | Approve.l, GDP, Polcomp, RD.l$
$19. Approve.l2 \perp RD | Approve.l, Country, RD.l, RD.l2$
$20. Approve.l2 \perp RD | Approve.l, RD.l, RD.l2, Volatility$
$21. GDP \perp Volatility | Approve.l2, Country, RD.l2$
$22. GDP \perp Volatility | Country, RD.l, RD.l2$
$23. Polcomp \perp RD.l | Approve.l2, RD.l2$
$24. Polcomp \perp RD.l | Volatility$
$25. Polcomp \perp RD.l | Country$
$26. Polcomp \perp RD.l2$
$27. Polcomp \perp Volatility | Country$
$28. RD \perp RD.l2 | Approve.l2, GDP, Polcomp, RD.l, Volatility$
$29. RD \perp RD.l2 | Approve.l, GDP, Polcomp, RD.l$
$30. RD \perp Volatility | Approve.l, Country, RD.l, RD.l2$
$31. RD \perp Volatility | Approve.l, GDP, Polcomp, RD.l$
$32. RD.l \perp Volatility | Approve.l2, RD.l2$
$33. RD.l2 \perp Volatility$

Figure A 1: List of Conditional Independencies

B. Appendix B

Survey Vignettes

- **Treatment 1.**

  A. Smith is 48 years old. He graduated from MIT with a degree in physics and subsequently attended Yale Law School, where he graduated with honors. His budget prioritizes government support for research and development. Some of the prioritized areas include research funding to universities and laboratories, and additional funding to companies involved in creation of new technologies. He believes that, in 10-12 years, these investments would shift American companies to the new technological frontier, and American citizens would enjoy prosperity and a higher quality of life. A. Smith is married and has three children.

  R. Myerson is 45 years old. He studied economics at the University of Chicago and then received his PhD in economics from Harvard. His budget prioritizes education spending. Some of his policies are focused on promoting student achievement and ensuring equal access. He believes that increased investment in education would secure the prosperity, health and security of the American people, and bolster American competitiveness through increased human capital.

- **Treatment 2.**

  A. Smith is 48 years old. He graduated from MIT with a degree in physics and subsequently attended Yale Law School, where he graduated with honors. His budget prioritizes government support for research and development. Some of the prioritized areas include research funding to universities and laboratories, and additional funding to companies involved in creation of new technologies. He believes that, in 10-12 years, these investments would shift American companies to the new technological frontier, and American citizens would enjoy prosperity and a higher quality of life. A. Smith is married and has three children.

R. Myerson is 45 years old. He studied economics at the University of Chicago and received his PhD in economics from Harvard. His budget prioritizes government support for innovation. His main goal is to spur commercialization of ideas by lowering the cost of managing changing technologies and bringing them to market. He believes that in 3-4 years these investments would shift American companies to the new technological frontier, and American citizens would enjoy prosperity and higher life quality.

- **Treatment 3.**

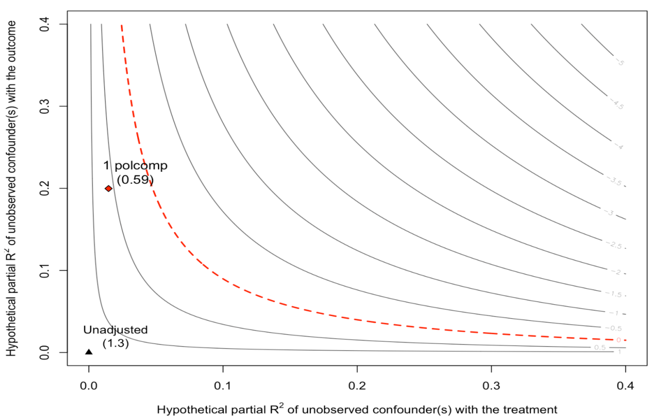
A. Smith is 48 years old. He graduated from MIT with a degree in physics and subsequently attended Yale Law School, where he graduated with honors. His budget prioritizes government support for research and development. Some of the prioritized areas include research funding to universities and laboratories, and additional funding to companies involved in creation of new technologies. He believes that, in 10-12 years, these investments would shift American companies to the new technological frontier, and American citizens would enjoy prosperity and a higher quality of life. A. Smith is married and has three children.

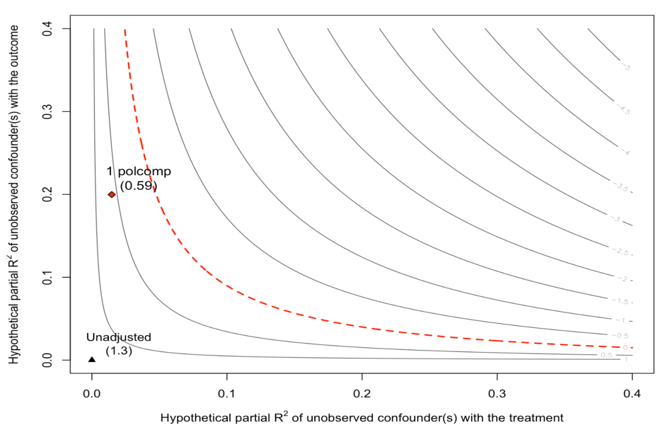
R. Myerson is 45 years old. He studied economics at the University of Chicago and then received his PhD in economics from Harvard. His budget prioritizes infrastructure spending. He is committed to repairing and rebuilding aging infrastructure and improving transportation system. He believes that increased investment in infrastructure would secure the prosperity and security of the American people, and that American companies would and bolster American competitiveness.

C. Appendix C

Bias contour of t-value plot for three models of effect of R&D expenditures (as a share of budget) on popular approval of the government.

(a) Total Effects of education Expenditures





(b) Direct Effect of education Expenditures

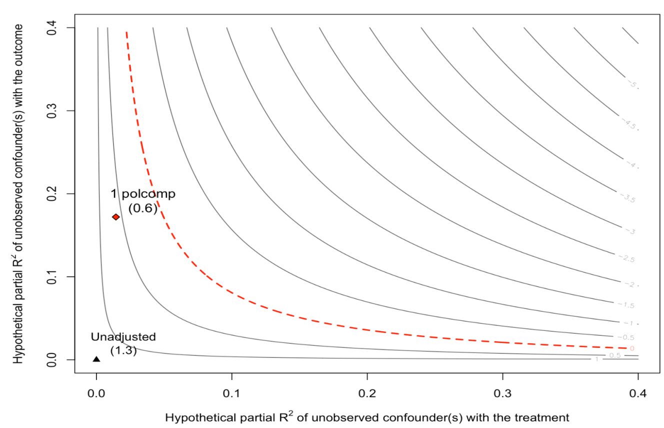


Figure C0: Bias contours of t-value

D. Appendix D

Structure of block randomization

	Democrat	Republican	Independent/No answer
R&D vs Education	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;
R&D vs Infrastructure	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;
R&D vs Short-term Innovation	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;	Smith-T, Meyerson-C; Meyerson-C, Smith-T Meyerson-T, Smith-C Smith-C, Meyerson-T;

Table 1: Blocks in MTurk Survey

	Yandex.Tolokers
R&D vs Education	Smith-T, Myerson-C; Myerson-C, Smith-T Myerson-T, Smith-C Smith-C, Myerson-T;
R&D vs Infrastructure	Smith-T, Myerson-C; Myerson-C, Smith-T Myerson-T, Smith-C Smith-C, Myerson-T;
R&D vs Short-term Innovation	Smith-T, Myerson-C; Myerson-C, Smith-T Myerson-T, Smith-C Smith-C, Myerson-T;

Table 2: Blocks in Yandex.Toloka Survey

E. Appendix E

Survey results for Full US and Russian samples

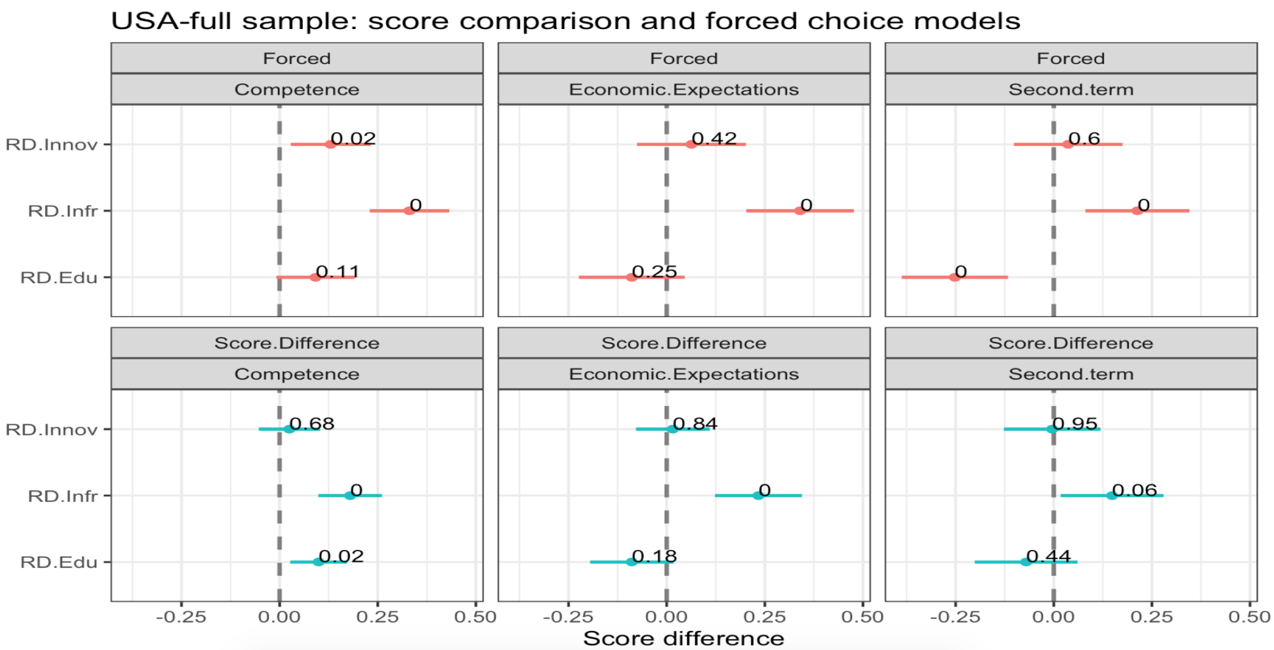


Figure E1: Survey Results: Full US Sample

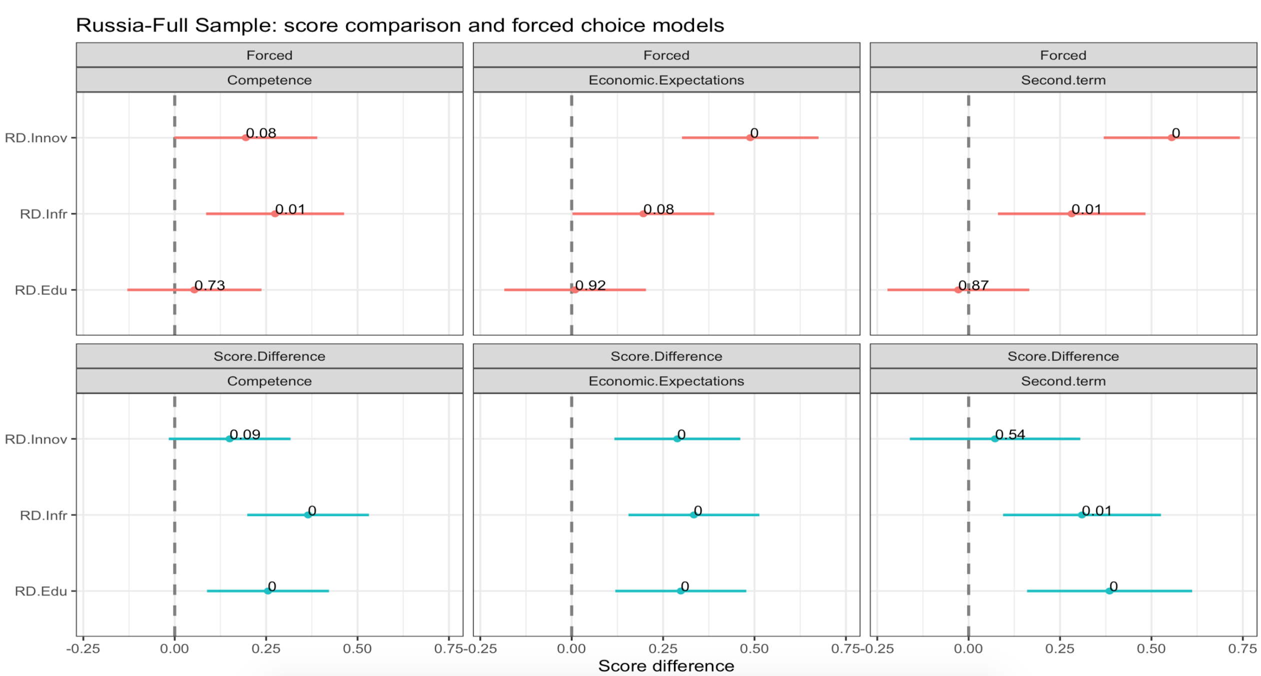


Figure E2: Score comparison and Forced choice for the full Russian sample

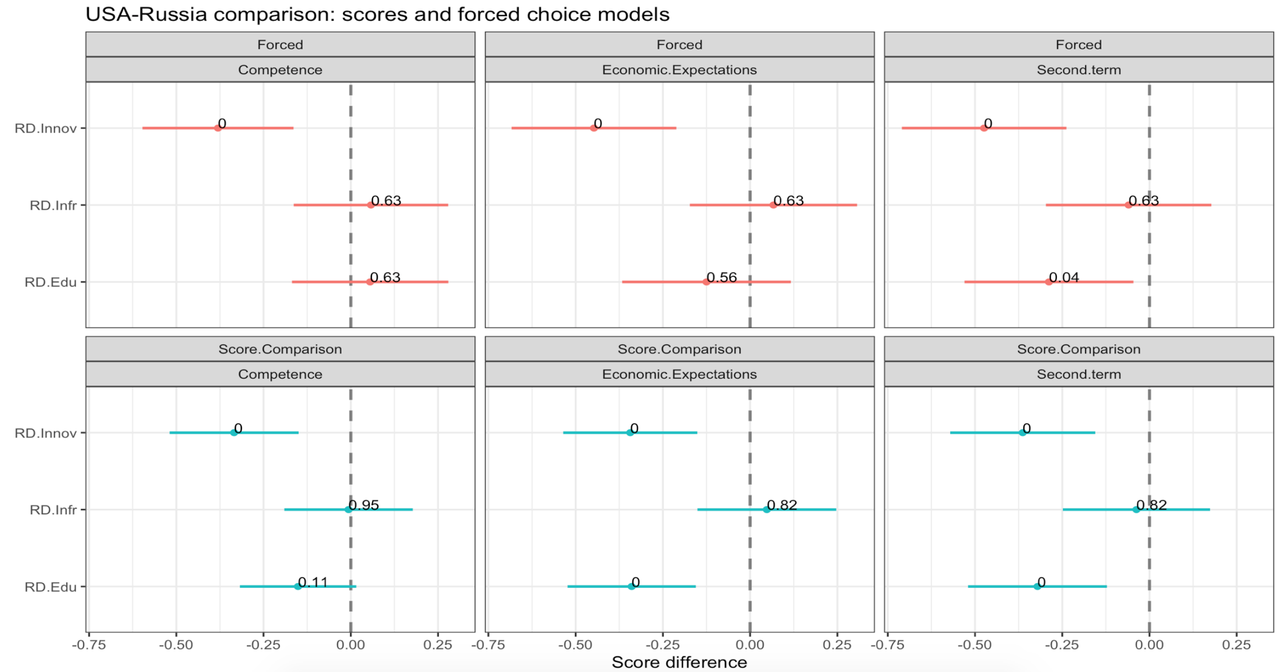


Figure E3: Forced choice and score difference comparison for US and Russian results: Full sample

F. Appendix F

Score Distributions for Attentive samples

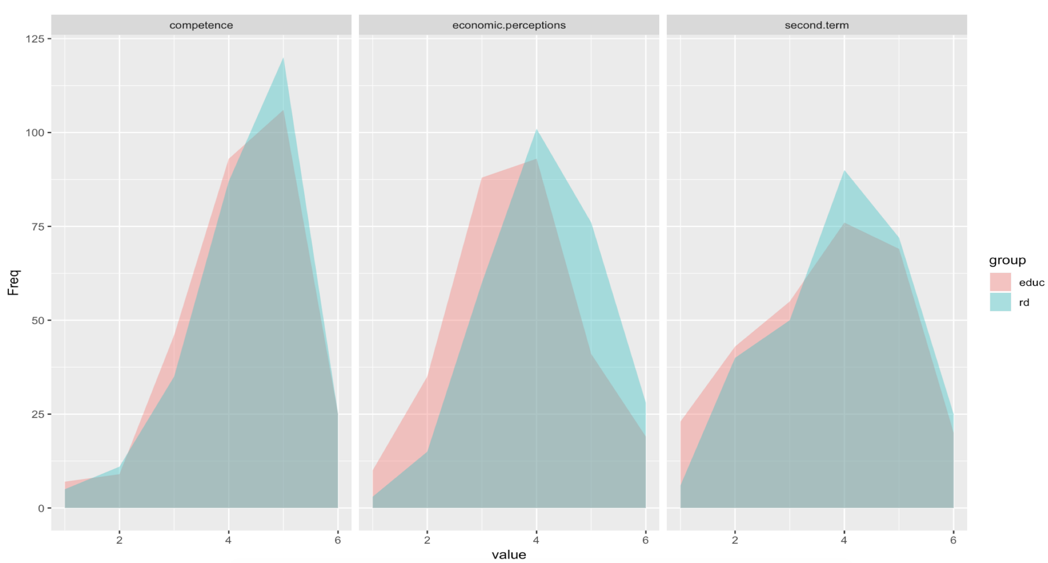


Figure F1: Russian Attentive sample: pro-R&D vs pro-Education scores

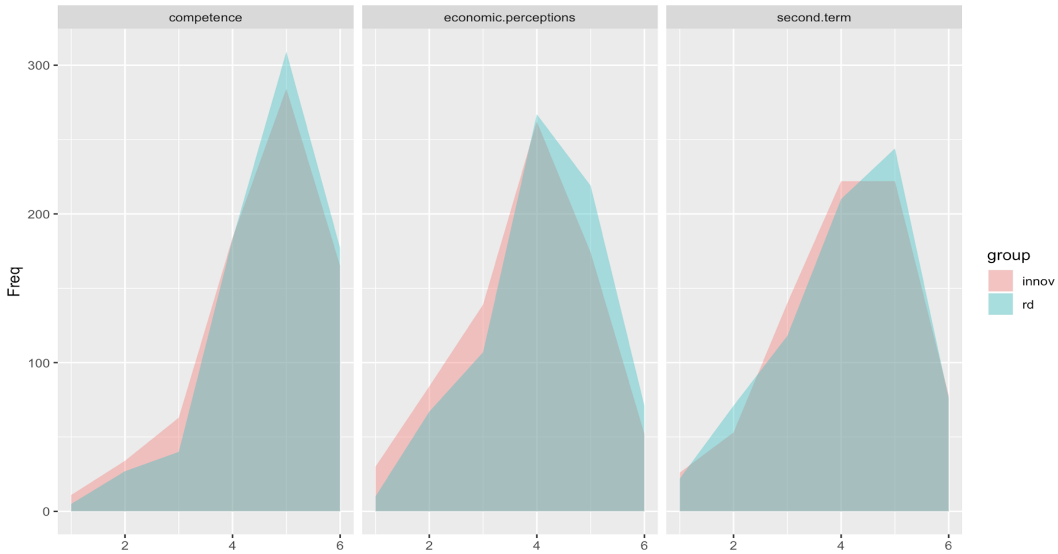


Figure F3: US Attentive sample: R&D vs Innovation

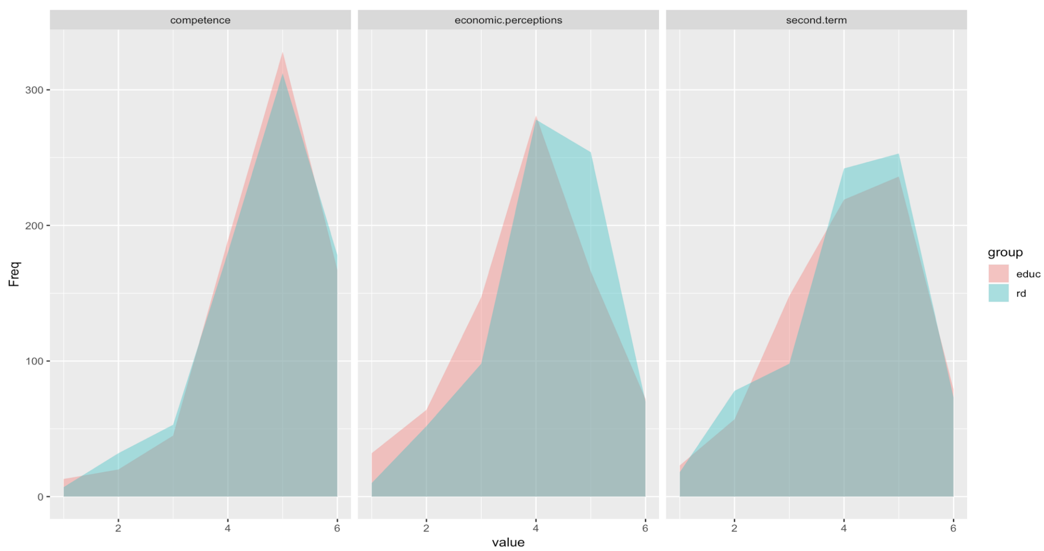


Figure F2: US Attentive sample: pro-R&D vs pro-Education scores

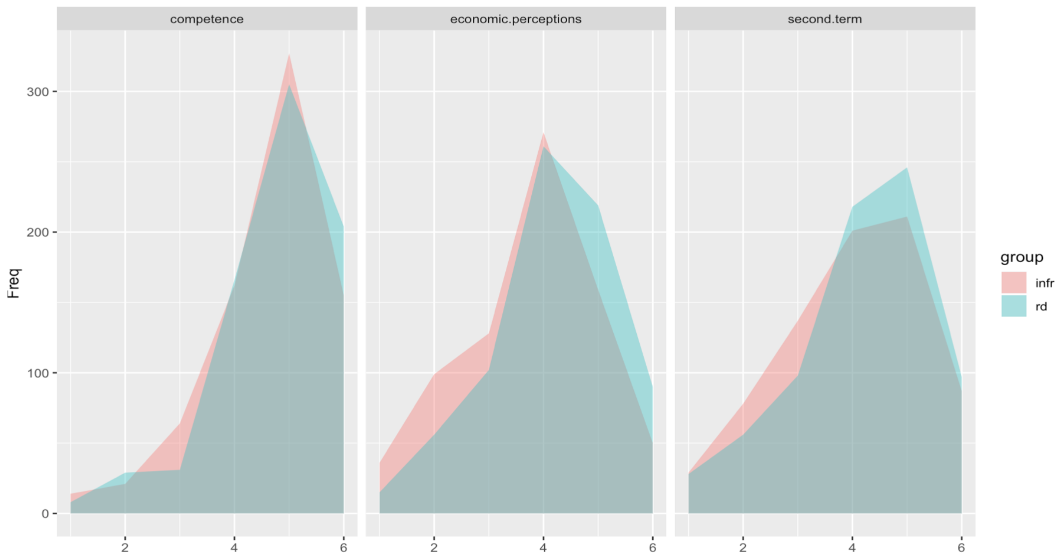


Figure F4: US Attentive sample: R&D vs Infrastructure

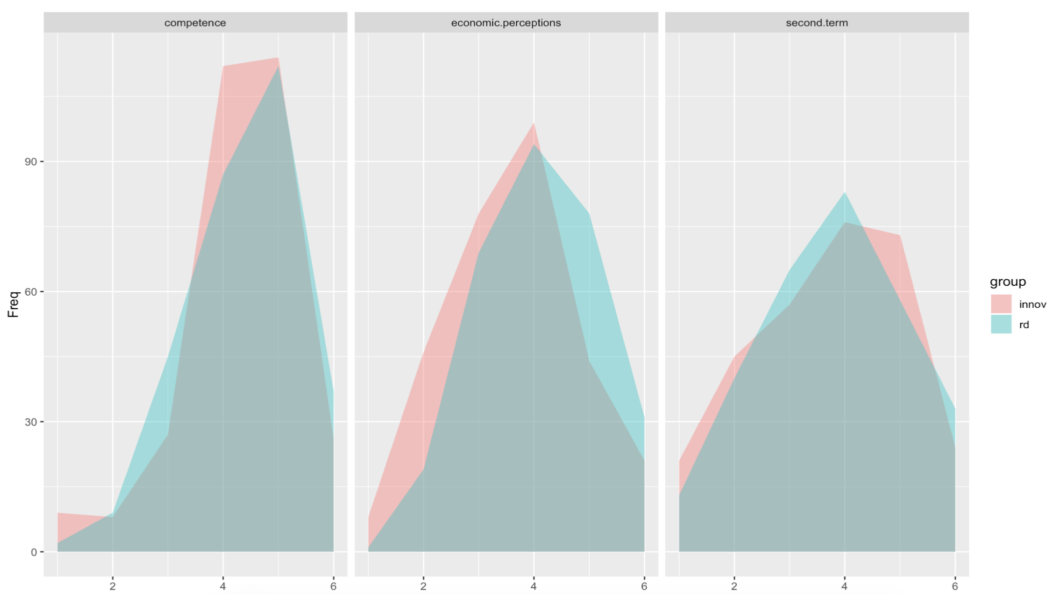


Figure F5: Russia Attentive sample: R&D vs Innovation

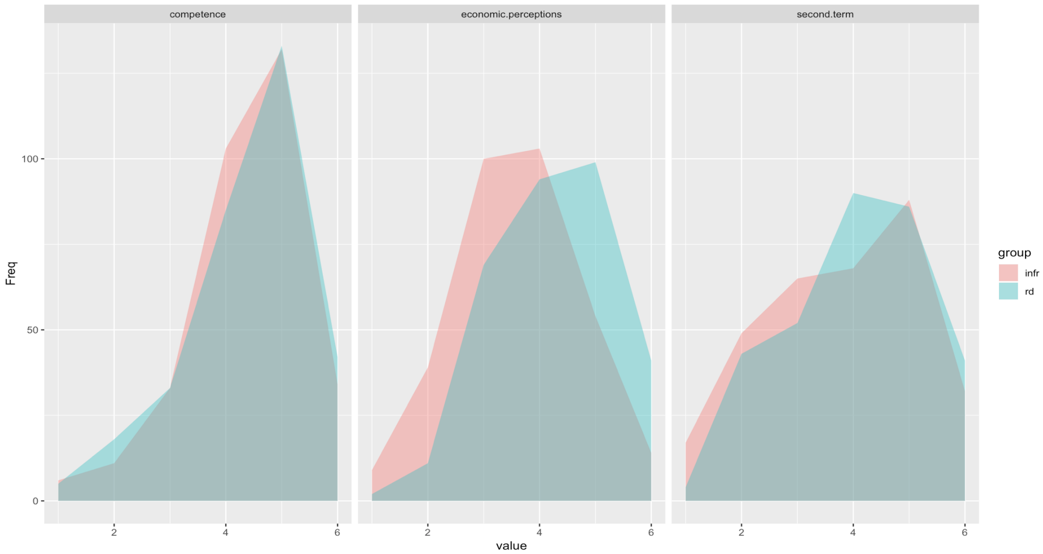


Figure F6: Russia Attentive sample: R&D vs Infrastructure

G. Appendix G

Survey Results in sub-samples

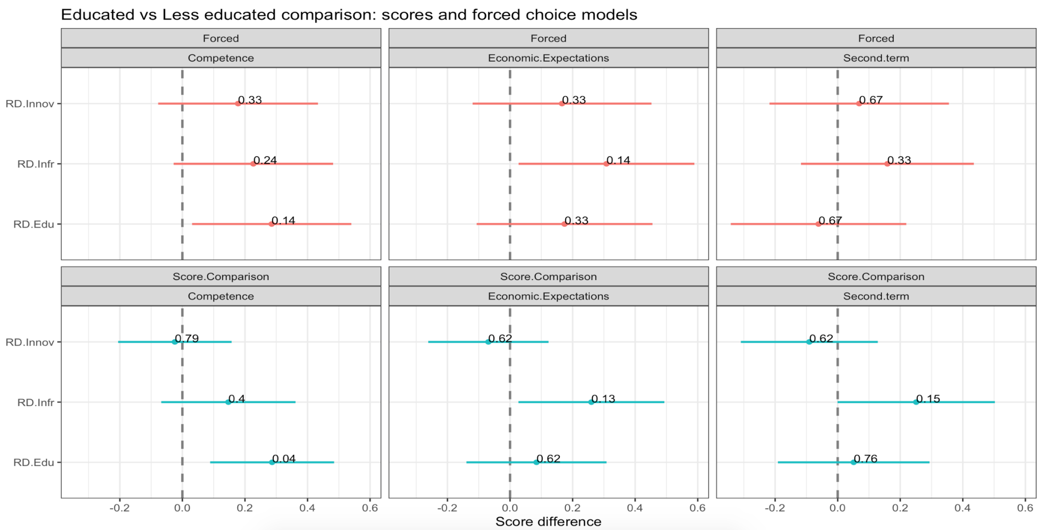


Figure G1: Difference in scores assigned by more educated and less educated respondents, Attentive US sample

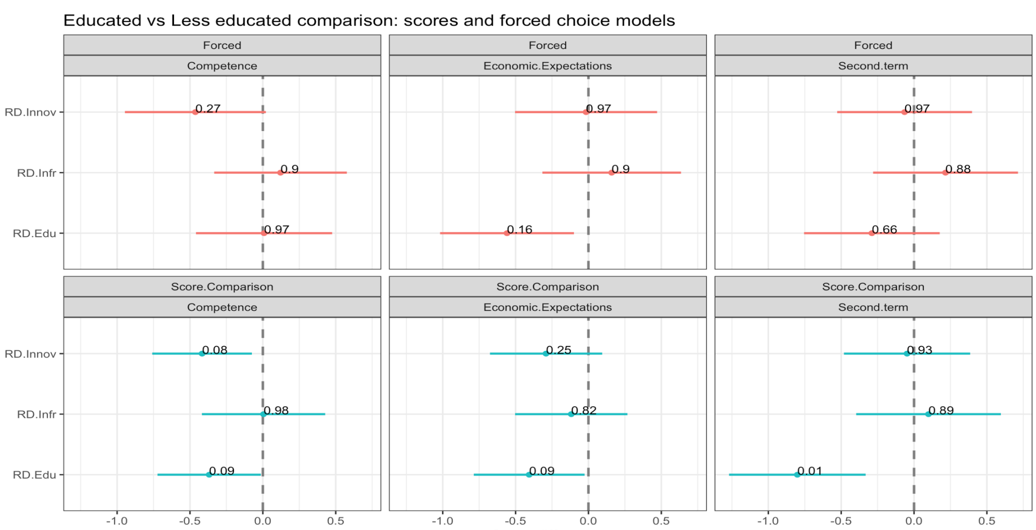


Figure G2: Difference in scores assigned by more educated and less educated respondents, Attentive Russian sample.

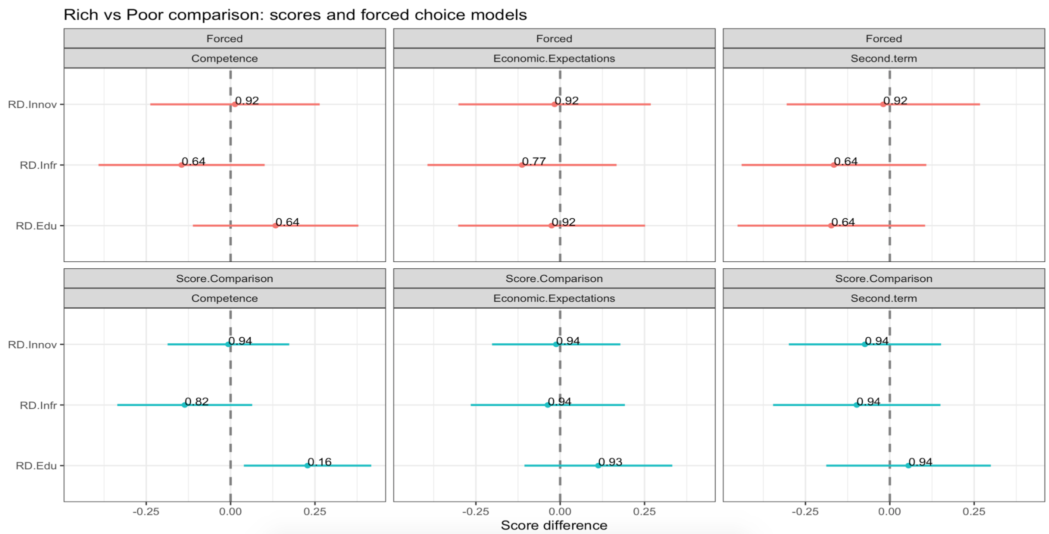


Figure G3: Difference in scores assigned by more wealthy and less wealthy respondents, Attentive US sample

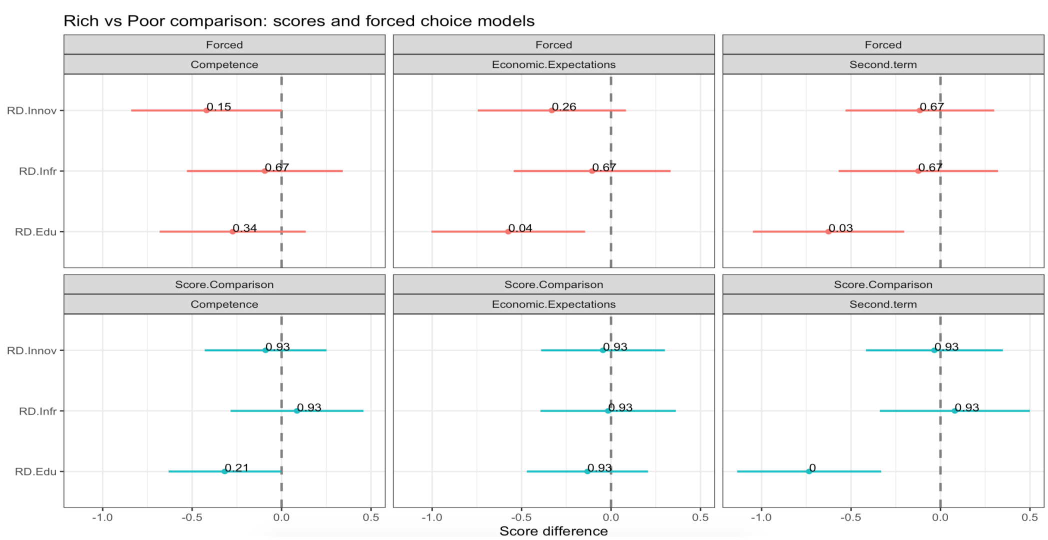


Figure G4: Difference in scores assigned by more wealthy and less wealthy respondents, Attentive Russian sample.