The impact of institutional quality on manufacturing sectors in Russia: panel data analysis

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ABSTRACT

We use the 2005-2012 data for Russian regions to show that higher regional institutional quality strongly benefits institutionally-dependent manufacturing sectors in terms of both gross output levels and growth rates. Unlike the existing literature on this topic, which uses essentially cross-sectional specifications, we emphasize the results of panel data analysis. This approach mitigates endogeneity concerns and allows for calculating full marginal effects of institutions on manufacturing sectors with different degrees of institutional dependence. Our results imply that significant institutional improvements are needed in order for the Russian economy to diversify away from heavy reliance on oil and natural gas.

Keywords: relationship specificity, institutional quality, allocation of industry, Russian economy
JEL Codes: D02, O14, P27

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1. Introduction

For a long time the Russian economy has been heavily dependent on oil and natural gas, which is a sector with the lowest dependence on institutional quality. The Russian government claims that it has been trying to diversify away from hydrocarbons, but so far without much success.[1] Despite the presence of certain advantages such as relatively highly skilled labor force,[2] Russia's most institutionally-dependent manufacturing sectors have not been growing in relative economic importance as fast as the government might have hoped. Although the share of most institutionally dependent manufacturing sectors (machinery, transportation equipment, and electronics and communications equipment) in all manufacturing output increased from 19.9% in 2005 to 23% in 2012, this share declined again to 20.7% in 2016.[3] We argue that at least in part the inability to foster institutionally-dependent manufacturing is due to poor and stagnant institutional quality in the country. Thus, according to World Bank's World Governance Indicators data, Russia's scores for the rule of law, regulatory quality, and corruption control went from, respectively, -0.93, -0.13, and -0.82 in 2005 to -0.79, -0.42, and -0.82 in 2016.[4]

In order to support our argument, we exploit institutional quality data for a panel of Russian regions to show that manufacturing sectors with higher institutional dependence tended to be

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[1] As Gaddy and Ickes (2013) argue, measuring the importance of oil and natural gas for the Russian economy can be confusing. For example, according to the Russian national accounts the share of value added in mining, the lion's share of which is produced in the oil and natural gas sector, to total value added in the economy declined from about 12% in 2005 to 10% in 2011, and then remained approximately the same through 2015. However, these numbers do not take into account the fact that domestic oil prices are significantly lower than world market prices and that oil and gas rents subsidize domestic producers of equipment, railroad transportation, etc. The share of hydrocarbon exports represents perhaps a cleaner measure of the Russian economy's reliance on oil and gas. This share fluctuates with world prices, but according to World Bank data, it was about 60% in both 2005 and 2015 despite real world market prices of oil being lower in the latter year (see https://wits.worldbank.org/CountryProfile/en/Country/RUS/Year/LTST/Summary).

[2] Russia places 20th-30th among world countries on most measures of educational human capital (see Alexeev 2018) while it was ranked 50th in per capita national income in purchasing power parity terms (UNDP 2016).

[3] The data are from the Russian statistical agency, Rosstat (www.gks.ru).

[4] World Governance Indicators aggregate many different surveys of institutional quality and standardize the results for each year to the mean of zero and standard deviation of 1. Therefore, strictly speaking, the quoted numbers indicate only Russia's relative position among world countries. However, as Kaufmann et al. (2007) argued, there is no clear evidence of a trend in average governance quality in the world over time.

larger and grow faster in the regions and years with better institutional quality.[5] Given the weak institutions in the country at large, this result provides at least a partial explanation for the lack of significant progress in Russia's diversification into sophisticated institutionally-dependent manufacturing industries. (We use the terms "sector" and "industry" interchangeably.)

Our approach generally follows Nunn (2007) and Feenstra et al. (2013) but with some important differences. Nunn (2007) uses cross-country data with country and industry fixed effects, and legal origin instruments for the quality of the legal system to estimate the coefficient of the interaction between "relationship specificity" of an industry and the country's judicial quality on the industry's export volumes.[6] Nunn's approach may suffer from the fact that it is difficult to account for the potentially relevant differences among countries and industries within them in a cross-country regression even with country and industry fixed effects. In this sense, the data on regions in a single country over time might be more reliable. Feenstra et al. (2013) pool the data for 23 industries in 30 Chinese provinces for 1997-2007 to estimate the impact of similar interaction terms on the provincial manufacturing exports.[7] Here, judicial quality of the provinces is instrumented by different colonial powers which used to occupy the respective provinces. Although Feenstra et al.'s data constitute a panel, their specification amounts to a sequence of cross-sectional regressions pooled together because the instruments are time-invariant. Therefore, instead of a panel regression, Feenstra et al. (2013) use OLS with province-year and industry fixed effects.

Our most important contribution to this literature is the explicit use of the panel structure of the data. We do this by obtaining the conventional "within" fixed effects estimator, which is equivalent to using region-industry and year fixed effects, as well as estimating a system-GMM

[5] In our benchmark regressions we use relationship specificity measures of three-digit manufacturing sectors based on Nunn (2007). We also check the robustness of our results by using Herfindahl-Hirschman index of a sector's intermediate inputs as a measure of the sector's institutional dependence (see Cowan and Neut 2007). We provide a detailed description of these measures in the data section.

[6] Levchecko (2007) also uses cross-country regressions with country and industry fixed effects to estimate the impact of institutional quality within countries on their shares in the US imports from institutionally intensive sectors. He measures institutional intensity of a sector by the diversity of its inputs measured by Herfindahl-Hirschman index, Gini coefficients, etc. Levchencko (2007) does not instrument for countries' institutional quality.

[7] Wang et al. (2014) also focus on Chinese provinces using the cross-sectional data from a 2008 survey of firms.

dynamic panel specification. The latter specification is especially important because it addresses potentially pervasive endogeneity issues via internal instruments. We note that system-GMM approach is particularly appropriate in this case, given the large cross-sectional dimension of the panel which consists of region-industry pairs. The explicit panel specification also allows for calculating full marginal effects of institutional quality on manufacturing sectors with different degrees of institutional dependence. This was not possible in cross-sectional specifications in the earlier literature because part of these marginal effects were subsumed in jurisdiction fixed effects (country in Nunn's and Levchenko's cases, and province in Feenstra et al.'s specifications). For this reason, the earlier literature could evaluate only the impact reflected in the interaction term between the sector's institutional intensity and institutional quality of a jurisdiction. We find that the marginal effects of institutional quality of a jurisdiction increase in institutional intensity of a sector, are reasonable in size, and are statistically significant at least for industries with high institutional intensity.

In addition to using explicit panel specifications, we replicate the essentially cross-sectional approaches from the earlier literature as robustness checks. Also, unlike the other papers, we use both levels and growth rates of manufacturing sectors instead of only output (or export) levels. Using growth rates is important because growth rates are indicative of the current trends and are more likely to reflect current institutional environment. Moreover, the use of the growth rates as a dependent variable serves as another tool in helping mitigate the potentially significant endogeneity in the data because reverse causality between industries' growth rates (as opposed to industry size) and the quality of institutions in a region is less likely to occur. Finally, we test robustness of the results by using different measures of institutional intensity of a sector.

In all our main specifications the interaction term between relationship specificity of an industry calculated based on Nunn's (2007) US data and institutional quality of a region positively and significantly affects both the output of a sector and its growth rate at least at relatively high values of relationship specificity. The only statistically insignificant coefficients of our main interaction term obtain in some robustness checks where we use an alternative measure of institutional intensity of a sector (Herfindahl-Hirschman Index, or HHI) which we argue is inferior to the relationship specificity measures used in our main regressions. And even HHI-based results are highly statistically significant in the main panel specifications.

Although our findings are qualitatively similar to the benchmark results of Nunn (2007) and Feenstra et al. (2013), our main results utilize panel structure of the data, which is less likely to be subject to potential endogeneity biases. Another important difference between our results and the earlier literature is that our instruments in the cross-sectional instrumental variables (IV) regressions pass the overidentification tests.[8] Although the overidentification tests are not foolproof, this is nonetheless encouraging.

The next section describes our data. Empirical specifications are presented in section 3 and the results, including robustness checks, are shown and discussed in section 4. Section 5 concludes.

2. The Data

In our benchmark regressions we use the data for all of Russia's 83 regions, for which the data on output of different manufacturing sectors are available.[9] We limit our regressions to 2005-2012 period because this is the only time during which the Russian statistical agency Rosstat used industry classification largely consistent with 3-digit ISIC.

Our two dependent variables are the logarithm of gross output of a manufacturing sector deflated by the wholesale price index set to unity for 2005 and the logarithm of the growth rate of gross output. Rosstat breaks down manufacturing output into 13 sectors as well as the "Other" category. We match these sectors with the appropriate groups of 6-digit sectors for which Nunn (2007) calculates relationship specificity measures and aggregate these measures to obtain relationship specificity for each of the Russian 3-digit sector. More specifically, we use the share of intermediate inputs in a sector's production that are neither sold on an organized exchange nor reference priced. This share measures relationship specificity of a sector because

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[8] The instruments in Nunn (2007) fail overidentification tests and Feenstra et al. (2013) do not report the results of their overidentification tests. Wang et al. (2014) use a single instrument (provincial enrollment in Christian primary schools in 1919) and thus cannot perform overidentification tests.

[9] The internal structure of the Russian Federation changed somewhat during the period covered by our data. Some very small regions were merged with larger regions. We do not include these merged small regions in our data.

inputs that are sold on organized exchanges presumably do not require established relationships or even significant negotiations between the buyer and the seller in order to conduct a transaction. The prices of some inputs not sold on an organized exchange may be quoted in trade publications. Such publications exist only for the goods that are bought and sold in relatively thick markets. In such markets, some negotiation between a buyer and a seller might be necessary but it does not usually depend on the existence of a long-term relationship. If the parties cannot agree on the parameters of a transaction in a reference priced good, they can always turn to other counterparts willing to buy or sell this good. In other words, our measure reflects the share inputs that require significant negotiations and/or established relationship between the buyer and the seller in order to accomplish a transaction. The greater the share of such inputs for a sector, the greater is "relationship specificity" of this sector.

In one check of robustness of the results we use the dispersion of a sector's inputs, namely, the Herfindahl-Hirschman index (HHI) of a sector's intermediate inputs, as a measure of industry's institutional dependence. This measure is calculated from an input-output (I-O) matrix. Unfortunately, the earliest Russian I-O matrices available to us are for 2011. Since our data on manufacturing sectors output are for 2005-2012, this creates an additional possibility for endogeneity. For this reason, we either instrument the Russian HHI with the HHI for the US industries from Cowan and Neut (2007) or simply use US-based HHI. Although HHI for inputs has been used by other authors for measuring institutional dependence of industries, we view it as somewhat inferior to the relationship specificity measures because the diversity of inputs might not reflect high institutional dependence if many of these inputs are traded on exchanges or are reference priced.

Following Nunn (2007) and Levchenko (2007) we include the interactions between industries' skill intensity and human capital endowments of the regions as well as the interaction of industries' capital intensities and regional capital stocks as control variables in all our regressions. Both skill intensity and capital intensity data are based on US industries. Skill intensity is calculated as the fraction of the total wage bill for the sector's workers with at least some college education (Autor et al. 1998). We measure the stock of human capital in a region as the logarithm of the number of individuals with college degrees in the work force. Capital intensity data are obtained as one minus labor intensity measure from Levchenko and Zhang (2016; online appendix). We interact capital intensity with the logarithm of the book value of the stock of physical capital in a region obtained from Rosstat, which is also the source for the real per capita gross regional product (GRP) data.

We use the investment risk index by rating agency Expert as our measure of institutional quality. This is the most popular measure of institutional quality of Russia's regions and the only measure available for all of our regions for all years. To the best of our knowledge, no other measures of regional institutional quality in Russia comes even close in terms of its coverage and popularity among researchers.[10] The index is an aggregation of several components of institutional and economic environment, including the quality of regional legislation, management, finances, crime rates, and ecological and sociological situation. The data for the components of the index are obtained from the official statistics and from private experts. The weights used in the aggregation represent proprietary information of the agency. We use an inverse of this index, so that higher values of the index correspond to better institutional quality. Note that this index, among other factors, takes into account regional economic trends and financial situation of regional governments and private enterprises. Therefore, in part by construction, it is correlated with the regional per capita output (coefficient of correlation is about 0.3). For this reason, we control for the interaction of industry institutional intensity and per capita GRP in our regressions.

Brief descriptions, descriptive statistics, and the sources for all variables are presented in Tables A1 and A2 in the Appendix. Also, Table A3 shows how we match Nunn's (2007) 6-digit industry codes and the Russian 3-digit industries in our data.

3. Empirical specifications

We estimate two types of regressions using four different estimation techniques. Our benchmark equation is a panel version of Nunn (2007) and Feenstra et al. (2013). The panel

[10] See Baranov et al. (2015) for a survey of the Russian regional institutional quality measures.

nature of our data allows for inclusion of institutional quality measure not only in the interaction term but also on its own:

$$q_{ijt} = \beta_1(RS_j \times InstQ_{it}) + \beta_2 InstQ_{it} + \beta_3(h_j \times H_{it}) + \beta_4(k_j \times K_{it}) + \beta_5(RS_j \times PCGRP_{it-1}) + \beta_6 PCGRP_{it-1} + FE + \varepsilon_{ijt} \qquad (1)$$

where q_{ijt} denotes a logarithm of gross output of sector j in region i and year t deflated by wholesale price index; RS_j is the US-based relationship specificity of sector j; $InstQ_{it}$ stands for institutional quality of region i in year t measured by the investment climate index; and h_j, k_j, H_i, and K_{it} are skill intensity and capital intensity of industry j and the stocks of human and physical capital in region i in year t, respectively. $PCGRP_{it-1}$ denotes the logarithm of real per capita gross regional product (GRP) in 2005 Russian rubles. As noted earlier, the $PCGRP_{it-1}$ and $RS_j \times PCGRP_{it-1}$ control variables are important because our measure of institutional quality is correlated with per capita GRP. Finally, FE denotes various fixed effects which differ depending on specification. Our main regressions use region-industry and year fixed effects to obtain a conventional "within" panel estimator (i.e., the group variable for the panel is region-industry). In addition, we estimate equation (1) by system-GMM, in which case we include a lagged dependent variable as one of the regressors. System-GMM uses internal instruments to address the potential endogeneity of the OLS FE estimator. In order to obtain marginal effects of institutional quality for different levels of industry's institutional dependence, we also add $InstQ_{it}$ and $PCGRP_{it-1}$ terms to the regression.

As a robustness check, we estimate regression (1) using region-year and industry-year fixed effects, which is essentially a cross-sectional regression of Nunn (2007) and Feenstra et al. (2013).[11] Just as the OLS FE "within" estimator, this approach might suffer from endogeneity. To deal with this problem, we estimate eq. (1) using 2-stage least-squares (2SLS) IV regressions. The two instruments are the interaction of a sector's institutional intensity with the region's status as an autonomous republic and the logarithm of the region's distance from Moscow as two instruments. The autonomous republics within the Russian Federation are regions with

[11] These regressions do not include institutional quality and per capita GRP outside of interaction terms because these variables are subsumed in region-year fixed effects.

relatively large shares of ethnically non-Russian populations. For various historical and cultural reasons, these regions tend to be less developed and have weaker market institutions than the rest of the country. The regions located far away from Moscow also tend to have lower institutional quality perhaps because they have been settled later and are more dependent on natural resources. We realize that these instruments might not necessarily satisfy exclusion restrictions. However, the same argument can be made with respect to the instruments used by Nunn (2007) and Feenstra et al. (2013). The advantage of our instruments is that they easily pass overidentification tests (see next section). Although these tests do not guarantee instrument validity, they provide some measure of confidence in the instruments.

Similarly to OLS FE, the IV regressions include region-year and industry-year fixed effects. Note that we cannot use region-industry fixed effects in the IV regressions because our instruments are invariant with respect to these fixed effects. Standard errors in all regressions are clustered by region.

The second type of regressions differs from (1) in that the dependent variable is a logarithm of the growth rate of gross output, i.e., $\Delta q_{ijt} = q_{ijt} - q_{ijt-1}$. In addition, the right-hand side includes a lagged logarithm of gross output of a sector, q_{ijt-1}:

$$\Delta q_{ijt} = \beta_0 q_{ijt-1} + \beta_1 (RS_j \times InstQ_{it}) + \beta_2 InstQ_{it} + \beta_3 (h_j \times H_{it}) + \beta_4 (k_j \times K_{it}) + \beta_5 (RS_j \times PCGRP_{it-1}) + \beta_6 PCGRP_{it-1} + FE + \varepsilon_{ijt} \quad (2)$$

The inclusion of q_{ijt-1} makes it possible to estimate the rate of β-convergence of sectoral growth. Although this is an important control variable, the β-convergence estimates are not particularly informative because in the presence of fixed effects, the convergence takes place to a region-specific steady-state (Islam 1995).

4. Estimation results

We begin by estimating equations (1) and (2) using OLS FE panel specification using region-industry pairs as a group variable and controlling for year fixed effects with errors clustered by region. Our data allows for this because although the intertemporal variability of regional institutional quality is not very large (mean coefficient of variation is about 0.035), it appears to be adequate for the task. The conventional fixed effects "within" estimators are shown in columns 1 and 3 of Table 1. These estimates might suffer from endogeneity due to both reverse causality (more institutionally intensive industries might push the regions to improve their institutions) and omitted variables, although the latter problem is less likely to arise for a "within" estimator. In a panel setting, however, we can take advantage of the system-GMM approach which uses internal instruments to deal with endogeneity while at the same time taking into account the dynamic nature of the panel.[12] System-GMM is particularly appropriate in our setting because our panel has a large cross-sectional dimension. These estimates are shown in columns 2 and 4 for the level and growth rates regressions, respectively. Our main coefficients of interest (i.e., those of the interaction term between sector relationship specificity and regional institutional quality) are statistically significant in all regressions at least at 5% level. Also, the coefficients of the main interaction term do not differ significantly between system-GMM and OLS FE specifications but the coefficient of the institutional quality term itself is significantly larger in system-GMM specification, resulting in a large difference in marginal effects between the two specifications. This difference might be due to the inclusion of the lagged dependent variable in system-GMM regression, which complicates calculation of marginal effects (see below). Both system-GMM regressions easily pass the AR(2) and instrument overidentification tests, and the number of instruments is dramatically lower than the number of groups, implying that we do not need to worry about instrument proliferation problems.

As stated earlier, the main advantage of the panel structure of our regressions is that we can calculate full marginal effects of institutional quality because unlike in the earlier literature, we can include the institutional quality measures both in the interaction term and directly. Table 1 shows marginal effects of institutional quality measure for a median and the highest values of relationship specificity of a sector. As expected, institutional quality positively and statistically significantly affects both output and growth rates of institutionally intensive industries and

[12] See Arellano and Bover (1995) and Blundell and Bond (1998) as well as a "pedagogical" paper by Roodman (2009).

marginal effects increase in relationship specificity. According to the estimates in the first column of Table 1, one standard deviation improvement in institutional quality of a region (i.e., 0.086 increase; see Table A2 in the Appendix) raises output of a sector with median relationship specificity (textiles and apparel) by about 8% while the impact on the sector with the highest relationship specificity (transportation machinery and equipment) is about 20%. Marginal effects of institutional quality on sector growth rates are of the same order of magnitude.

Unfortunately, calculating marginal effects and their standard errors in dynamic panels is somewhat problematic because of the presence of the lagged dependent variable on the right hand side of the regression equation. Therefore, in the system-GMM columns, we present marginal effects of institutional quality calculated without regard to the dynamic nature of the regression. Marginal effects calculated in this manner are substantially greater than those obtained from OLS FE regressions. According to these estimates, the impacts of one standard deviation increase in institutional quality on output of sectors with median and highest relationship specificity are, respectively, 44% and 56%. Similar issues arise when we include lagged sector output in growth regressions. Here we can also calculate marginal effects abstracting from the feedback loop generated by the lagged sector output.[13]

In terms of other results that are consistent across specifications, the regressions in Table 1 reflect complementarity between the sector's capital intensity and the region's capital stock in terms of their positive effect on the size and growth rate of the sector. Also, the estimates of growth rate regressions provide evidence of conditional β-convergence of sector size. We note, however, that the interpretation of these convergence estimates is very different from the conventional cross-sectional estimates of β-convergence because the estimates we obtain via fixed effects regressions reflect convergence to potentially different steady-states for each region-industry, which are in part determined by the fixed effects. As Islam (1995) puts it referring to panel estimates of convergence among countries, "…the faster convergence that we observe is conditional. … the points to which [the countries] are converging remain very

[13] We can run OLS FE regressions for growth rates without including lagged output of a sector. In this case, marginal effect of institutional quality at the median value of relationship specificity is negligible while at the highest relationship specificity it is close to that for the OLS FE regression in levels.

different.” (p. 1162) We also note that the consistently negative and significant coefficients of per capita GRP should not be interpreted on their own because this variable enters both on its own and as part of the interaction term with industry’s relationship specificity, which has a positive coefficient.

As one of our robustness checks and for comparability with the findings of Nunn (2007), Levchenko (2007), and Feenstra et al. (2013), we run Table 1 regressions without direct terms for institutional quality and per capita GRP and also estimate cross-sectional versions of equations (1) and (2) using region-year and sector-year fixed effects. The results of the former regression are shown in Table 2. The coefficients of the interaction term between sector’s relationship specificity and regional institutional quality in system-GMM regressions are close to those in Table1, but the corresponding coefficients in OLS FE regressions are smaller in Table 2 than in Table 1, although the difference is not statistically significant in the level regressions. These results suggest that the absence of direct terms of institutional quality probably does not significantly bias the coefficients of the main interaction terms in the level regressions although the bias appears to be present in the growth regressions.

Table 3 presents the cross-sectional regression results. Due to region-year fixed effects, institutional quality measure cannot be included in these regression on its own. Columns 1 and 2 in Table 3 show OLS estimates while columns 3 and 4 contain the results of the IV regressions. Consistent with the findings of Nunn (2007) and Feenstra et al. (2013), the coefficients of the main interaction term of interest are statistically significant at least at 5% level in all regressions, supporting the hypothesis of a positive link between regional institutional quality and the size and growth of institutionally dependent sectors in the region.

Although the estimates in Table 3 do not allow for calculating marginal effects of institutional quality, we can still evaluate its relative impact on the output levels and growth rates of different industries. Thus, if we treat the relationship as causal and use OLS point estimates in columns 1 and 2, we can infer that institutionally intensive industries benefit substantially more from higher quality of institutions than do other sectors. One standard deviation increase in institutional quality of a region results in about 37% greater output of a sector with the highest relationship specificity than of the sector with the median relationship specificity. The corresponding impact of institutional quality on growth rates is about 11 percent.[14] These impacts are larger than those implied by the estimates in Table 1 but not dramatically so. Also, note that the coefficients of the main interaction terms in OLS FE regressions Table 3 are significantly larger than those in Table 2. However, we need to keep in mind that the interpretation of these coefficients is quite different. Tables 1 and 2 show “within” panel estimators while Table 3 presents essentially “between” estimators.

As mentioned earlier, all OLS FE regressions may suffer from endogeneity. In the panel specifications, we addressed this issue by estimating system-GMM regressions which employ “internal” instruments. In the cross-sectional regressions, where endogeneity due to omitted variables is particularly likely, we need to use external instruments to deal with this issue.

Nunn (2007) and Feenstra et al. (2013) try to address endogeneity by instrumenting institutional quality with, respectively, countries’ legal origin dummy variables and Chinese provinces’ historical colonial powers dummy variables. It is unclear, of course, whether these instruments satisfy the exclusion restriction.[15] Both legal origin and historical colonial powers might affect the respective jurisdictions in many ways and thus influence exports by different manufacturing sectors through channels other than judicial quality. This is particularly true with respect to the colonial powers instrument. Moreover, Nunn’s legal origin instruments fail overidentification tests and Feenstra et al. (2013) do not present such tests.

Finding good external instruments is always difficult and our case in no exception. Nonetheless, we rerun the regressions from Table 3, instrumenting institutional quality with the regional status as a republic and by a logarithm of the distance of a region from Moscow.[16] That is, we

[14] As noted earlier, the highest relationship specificity is 0.861 while the median is 0.493. Standard deviation of institutional quality measure is 0.086. Given that the coefficient of the product of relationship specificity and institutional quality is about 9.9, the change in the logarithm of output of the most institutionally intensive sector due to one standard deviation of institutional quality improvement is $9.9 \times 0.861 \times 0.086 = 0.733$. The corresponding logarithm of output change of a sector with the median relationship specificity is 0.420. The resulting ratio of outputs of the sectors is then $\exp\{0.733 - 0.420\} \approx 1.37$. Similar calculations produce the result for the growth rates.

[15] Nunn (2007) acknowledges as much in his study.

[16] Russia has 22 regions with the status of a “republic”. As mentioned earlier, these are regions with a majority or at least a substantial share of non-Russian ethnicities. Due to historical and cultural reasons, these regions typically have weaker institutions than the regions with overwhelmingly ethnically Russian population. The regions further removed from Moscow also tend to have weaker institutions.

instrument the interaction between sector's relationship specificity and region's institutional quality with the interaction between sector's relationship specificity and, respectively, the republican status and the logarithm of the distance to Moscow. The results are shown in Table columns 3 and 4 of Table 3. The instruments pass standard overidentification tests but they are relatively weak. The Kleibergen-Paap rank Wald F statistic is either slightly above or below the Stock-Yogo critical values for 25% maximal IV relative bias. This weakness, however, is due to clustering by region. If we adopt a less conservative assumption of errors being correlated only within region-year or within region-industry pairs, the instruments become very strong while overidentification tests are still satisfied. In addition, our main coefficients of interest all become significant at 1% level. A problematic aspect of IV regressions in Table 3, however, is that the coefficients of our main interaction term in the level regressions become much larger than in the OLS regressions, implying perhaps an unreasonable degree of benefit that institutionally intensive sectors obtain from changes in institutional quality of a region.

In another robustness check, we replace the relationship specificity measure of a sector with the Herfindahl-Hirschman index (HHI) of the sector's intermediate inputs. The lower the HHI, the more complex is the sector's intermediate inputs structure and thus the expected signs of the HHI-based measures should be opposite in our regressions from the signs of the coefficients of relationship specificity. This HHI was employed by Cowan and Neut (2007) to measure the complexity of intermediate inputs of a sector and it was used by Levchenko (2007) and others as a measure of institutional intensity of an industry. We note, however, that although HHI is a highly intuitive measure of a sector's institutional intensity, it is, in our view, somewhat inferior to relationship specificity measure for our purposes, because even a sector with low HHI might still not have to rely much on institutions if most of these inputs can be purchased from easily substitutable suppliers. For this reason, we expect the HHI-based results to be weaker than those for relationship specificity measures.[17]

[17] As mentioned earlier, we use US-based HHI to alleviate endogeneity concerns. However, the results for the Russian HHI based on 2011 I-O tables are remarkably close to those for the US-based HHI, which is not surprising, given that the correlation coefficient between the two indices is 0.74. The Russian-based HHI regressions are available upon request.

The results of regressions for the HHI measure similar to those in Tables 1-3 are shown in Tables 4-6. In the panel regressions (Table 4), the marginal effects of institutional quality have expected positive signs, are highly statistically significant both at the median and at the lowest HHI values, and are decreasing in HHI. These and all other panel-based results are consistent with those for the relationship specificity measure. Similarly to the main system-GMM regressions in Table 1, the regressions in Table 4 pass all the appropriate validity test. Regression results in Table 5 are weaker than those in Table 2. The coefficients of the main interaction term in the OLS FE regressions are not statistically significant. However, this is not particularly surprising, given that these regressions lack the stand-alone terms for institutional quality and per capita GRP which are highly statistically significant in the OLS FE regressions in Table 4. Moreover, statistical significance of the main interaction term is restored in system-GMM regressions (columns 2 and 4).

Finally, Table 6 presents cross-sectional regression results, which are broadly similar to those for the relationship specificity measure (Table 3). The main interaction term is significant in all four regressions at least at 5% level. Also, as in the IV regressions in Table 3, the instruments are only marginally strong but they easily pass overidentification tests.

To sum up, we use both panel and cross-sectional specifications and different estimation techniques to obtain strong confirmation of a highly statistically significant and economically important positive marginal effect of institutional quality on both the size and growth rates of institutionally intensive manufacturing sectors in Russia.

5. Conclusions

We use panel data for the Russian regions for 2005-2012 to show that stronger regional institutions disproportionately benefit manufacturing sectors with greater institutional dependence. This benefit is both statistically significant and economically important. Although similar findings have been made for cross-country data and for the Chinese provinces, we make several contributions to this literature. Most important, unlike the previous research which relied on cross-sectional specifications, our results hold in both panel and cross-sectional regressions, including system-GMM approach. The use of panel structure of the data allows for calculating full marginal effects of institutional quality on different manufacturing sectors while at the same time accounting for region-sector and year fixed effects, mitigating omitted variable problem. Moreover, our instruments, both in system-GMM regressions and in cross-sectional IV specifications, satisfy standard overidentification tests which was not the case in the earlier papers. In addition, we show that regional institutional quality benefits not only the output of highly institutionally dependent sectors but also their growth rates. This is important because growth rates are presumably less likely to suffer from reverse causality with the regional institutional environment. Finally, our paper is the first to utilize the Russian data.

Given weak and stagnant institutional quality in Russia, our results provide at least a partial explanation for the apparent inability of the Russian economy to diversify away from the oil and natural gas sector into more sophisticated manufacturing despite the presence of relatively well educated labor force. In fact, we would argue that even a significant government investment into further accumulation of human and physical capital is unlikely to be successful without substantial improvement in overall institutional quality in the country.

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Table 1. OLS FE "within" and system-GMM estimators with region-sector and year fixed effects (institutional dependence measure: Share of inputs that are neither traded on organized exchanges nor reference priced)

Independent variables \ Dependent variables	Ln(Sector output(t))		ΔLn(Sector output(t))	
	OLS FE	GMM	OLS FE	GMM
	(1)	(2)	(3)	(4)
Dependent variable ($t-1$)		0.603***		-0.132**
		(0.000)		(0.012)
RelSpecificity×Institutional quality	3.365	2.562**	5.117**	3.993***
	(0.148)	(0.034)	(0.033)	(0.004)
Institutional quality	-0.756	2.995**	-1.977	0.678
	(0.561)	(0.015)	(0.148)	(0.639)
Skill intensity×Human capital stock	-0.246	-0.394**	-0.173	-0.327*
	(0.527)	(0.036)	(0.610)	(0.051)
Capital intensity×Capital stock	0.554***	1.022***	0.498**	0.898***
	(0.006)	(0.000)	(0.010)	(0.000)
RelSpecificity×Ln(PC GRP ($t-1$))	3.411***	-0.191	2.237*	0.492
	(0.010)	(0.652)	(0.062)	(0.271)
Ln(PC GRP ($t-1$))	-1.982***	-0.533**	-1.334**	-0.798***
	(0.008)	(0.036)	(0.049)	(0.003)
Ln(Sector output($t-1$))			-0.826***	-0.330***
			(0.000)	(0.000)
Marginal effect of institutional quality	0.903**	4.258***	0.546	2.646**
at RelSpecificity = 0.493 (median)	(0.021)	(0.000)	(0.196)	(0.017)
Marginal effect of institutional quality	2.142***	5.200***	2.429***	4.115***
at RelSpecificity = 0.861 (highest)	(0.010)	(0.000)	(0.004)	(0.000)
Arellano-Bond test for AR(2) (p-value)		0.150		0.378
Hansen test of over-id. restrictions (p-value)		0.998		0.998
R-squared (within)	0.010		0.390	
Number of clusters	83	83	83	83
Observations	7,727	7,643	7,643	6,496
Number of instruments		134		127
Number of groups (region-sector pairs)	1,147	1,137	1,137	1,123

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-sector and year fixed effects

Table 2. OLS FE "within" and system-GMM estimators without direct term for institutional quality (institutional dependence measure: Share of inputs that are neither traded on organized exchanges nor reference priced)

Independent variables \ Dependent variables	Ln(Sector output(t))		ΔLn(Sector output(t))	
	OLS FE	GMM	OLS FE	GMM
	(1)	(2)	(3)	(4)
Dependent variable ($t-1$)		0.623***		-0.307***
		(0.000)		(0.000)
RelSpecificity×Institutional quality	1.730**	2.468***	1.542**	2.018***
	(0.018)	(0.001)	(0.036)	(0.001)
Skill intensity×Human capital stock	-0.307	-0.310*	-0.200	-0.236
	(0.438)	(0.091)	(0.563)	(0.116)
Capital intensity×Capital stock	0.308	0.987***	0.352*	0.751***
	(0.139)	(0.000)	(0.068)	(0.000)
RelSpecificity×Ln(PC GRP ($t-1$))	0.862	-0.549*	0.409	-0.453
	(0.130)	(0.076)	(0.422)	(0.140)
Ln(Sector output($t-1$))			-0.821***	-0.144***
			(0.000)	(0.005)
R-squared (within)	0.007		0.387	
Arellano-Bond test for AR(2) (p-value)		0.134		0.291
Hansen test of over-id. restrictions (p-value)		0.650		0.609
Number of clusters	83	83	83	83
Observations	7,687	7,604	7,604	6,470
Number of instruments		98		95
Number of groups (region-sector pairs)	1,137	1,146	1,137	1,123

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-sector and year fixed effects

Table 3. OLS FE and IV regressions with region-year and sector-year fixed effects (institutional dependence measure: Share of inputs that are neither traded on organized exchanges nor reference priced)

Independent variables \ Dependent variables	Ln(output(t))	ΔLn(output(t))	Ln(output(t))	ΔLn(output(t))
	OLS FE	OLS FE	IV Second	Stage
	(1)	(2)	(3)	(4)
RelSpecificity×Institutional qual.	9.864**	3.193**	40.816***	8.112**
	(0.026)	(0.019)	(0.003)	(0.022)
Skill intensity×Human cap. stock	0.093	0.031*	0.072	0.027*
	(0.105)	(0.061)	(0.172)	(0.075)
Capital intensity×Capital stock	2.877**	0.498*	4.964***	0.826**
	(0.013)	(0.086)	(0.000)	(0.018)
RelSpecificity×Ln(PC GRP ($t-1$))	-1.897***	-0.457***	-2.564***	-0.537***
	(0.001)	(0.004)	(0.001)	(0.003)
Ln(Sector output($t-1$))		-0.156***		-0.158***
		(0.000)		(0.000)
R-squared (within)	0.613	0.181		
Hansen over-id. test (p-value)			0.914	0.980
Number of clusters	83	83	83	83
Observations	7,727	7,643	7,727	7,643

Independent variables \ Dependent variable	IV (First stage) RelSpecificity×Institutional quality	
RelSpecificity×Republic	-0.041**	-0.036**
	(0.034)	(0.033)
RelSpecificity×Ln(Dist. to Mosc.)	-0.016**	-0.016**
	(0.021)	(0.017)
Skill intensity×Human cap. stock	0.001*	0.001**
	(0.083)	(0.026)
Capital intensity×Capital stock	-0.042***	-0.043***
	(0.005)	(0.003)
RelSpecificity×Ln(PC GRP ($t-1$))	0.021	0.016
	(0.171)	(0.193)
Ln(Sector output($t-1$))		0.000
		(0.490)
Under-id. test (p-value)	0.000	0.000
Weak id. test (see notes below)	6.71	7.48

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-year and sector-year fixed effects
Under-identification test is Kleibergen-Paap rank LM statistic, which provides Chi-sq (2) p-value;
Weak identification test is Kleibergen-Paap rank Wald F statistic; the corresponding Stock-Yogo critical values for 25% maximal IV relative bias is 7.25

Table 4. OLS FE "within" and system-GMM estimators with region-sector and year fixed effects (institutional dependence measure: Herfindahl-Hirschman index (HHI) of intermediate inputs)

Dependent variables / Independent variables	Ln(Sector output(t))		ΔLn(Sector output(t))	
	OLS FE	GMM	OLS FE	GMM
	(1)	(2)	(3)	(4)
Dependent variable ($t-1$)		0.579***		-0.113**
		(0.000)		(0.023)
HHI×Institutional quality	-1.076	-0.856***	-2.108**	-1.151***
	(0.195)	(0.007)	(0.021)	(0.002)
Institutional quality	1.899***	5.242***	2.542***	4.308***
	(0.005)	(0.000)	(0.001)	(0.000)
Skill intensity×Human capital stock	-0.059	0.119	-0.067	0.188
	(0.879)	(0.480)	(0.845)	(0.244)
Capital intensity×Capital stock	0.628***	0.701***	0.557***	0.620***
	(0.003)	(0.000)	(0.006)	(0.000)
HHI×Ln(PC GRP ($t-1$))	-1.338***	0.014	-0.941**	-0.118
	(0.006)	(0.902)	(0.030)	(0.413)
Ln(PC GRP ($t-1$))	1.008**	-0.461**	0.665	-0.276
	(0.032)	(0.016)	(0.100)	(0.235)
Ln(Sector output($t-1$))			-0.832***	-0.381***
			(0.000)	(0.000)
Marginal effect of institutional quality	1.105***	4.610***	0.986***	3.458***
At HHI = 0.738 (median)	(0.001)	(0.000)	(0.008)	(0.001)
Marginal effect of institutional quality	1.623***	5.022***	2.003***	4.013***
at HHI = 0.256 (lowest)	(0.001)	(0.000)	(0.000)	(0.000)
Arellano-Bond test for AR(2) (p-value)		0.158		0.429
Hansen test of over-id. restrictions (p-value)		0.999		0.996
R-squared (within)	0.020		0.395	
Number of clusters	83	83	83	83
Observations	7,727	7,643	7,643	6,496
Number of instruments		134		127
Number of groups (region-sector pairs)	1,147	1,137	1,137	1,123

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-sector and year fixed effects

Table 5. OLS FE "within" and system-GMM estimators without direct term for institutional quality (institutional dependence measure: Herfindahl-Hirschman index (HHI) of intermediate inputs)

Independent variables \ Dependent variables	Ln(Sector output(t))		ΔLn(Sector output(t))	
	OLS FE	GMM	OLS FE	GMM
	(1)	(2)	(3)	(4)
Dependent variable ($t-1$)		0.574***		-0.157***
		(0.000)		(0.002)
HHI×Institutional quality	0.030	-0.642*	-0.614	-1.078***
	(0.959)	(0.084)	(0.287)	(0.005)
Skill intensity×Human capital stock	-0.005	0.663***	-0.056	0.490**
	(0.990)	(0.005)	(0.871)	(0.048)
Capital intensity×Capital stock	0.706***	0.326**	0.622***	0.429***
	(0.001)	(0.045)	(0.002)	(0.007)
HHI×Ln(PC GRP ($t-1$))	-1.051***	0.103	-0.695**	-0.099
	(0.010)	(0.373)	(0.049)	(0.402)
Ln(Sector output($t-1$))			-0.829***	-0.298***
			(0.000)	(0.000)
R-squared (within)	0.015		0.392	
Arellano-Bond test for AR(2) (p-value)		0.126		0.240
Hansen test of over-id. restrictions (p-value)		0.112		0.101
Number of clusters	83	83	83	83
Observations	7,727	7,643	7,643	6,496
Number of instruments		70		71
Number of groups (region-sector pairs)	1,147	1,137	1,137	1,123

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-sector and year fixed effects

Table 6. OLS FE and IV regressions with region-year and sector-year fixed effects (institutional dependence measure: Herfindahl-Hirschman index (HHI) of intermediate inputs)

Dependent variables / Independent variables	Ln(output(t))	ΔLn(output(t))	Ln(output(t))	ΔLn(output(t))
	OLS FE	OLS FE	IV Second	Stage
	(1)	(2)	(3)	(4)
HHI×Institutional qual.	-3.141***	-1.345***	-7.612**	-1.990**
	(0.006)	(0.001)	(0.026)	(0.036)
Skill intensity×Human cap. stock	1.037***	0.237***	1.400***	0.285***
	(0.000)	(0.001)	(0.000)	(0.003)
Capital intensity×Capital stock	2.052**	0.368	2.450**	0.428
	(0.049)	(0.165)	(0.023)	(0.107)
HHI×Ln(PC GRP ($t-1$))	0.543***	0.150***	0.725***	0.173***
	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Sector output($t-1$))		-0.159***		-0.160***
		(0.000)		(0.000)
R-squared (within)	0.617	0.184		
Hansen over-id. test (p-value)			0.538	0.543
Number of clusters	83	83	83	83
Observations	7,727	7,643	7,727	7,643

Dependent variable / Independent variables	IV (First stage) HHI×Institutional quality	
HHI×Republic	-0.056***	-0.052***
	(0.010)	(0.010)
HHI×Ln(Dist. to Mosc.)	-0.014**	-0.013**
	(0.047)	(0.040)
Skill intensity×Human cap. stock	0.054***	0.050***
	(0.002)	(0.004)
Capital intensity×Capital stock	0.046	0.053
	(0.221)	(0.119)
HHI×Ln(PC GRP ($t-1$))	0.032*	0.027*
	(0.064)	(0.077)
Ln(Sector output($t-1$))		-0.001
		(0.221)
Under-id. test (p-value)	0.000	0.000
Weak id. test (see notes below)	7.13	7.59

Notes: Robust p-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Errors are clustered by region; all regressions include region-year and sector-year fixed effects
Under-identification test is Kleibergen-Paap rank LM statistic, which provides Chi-sq (2) p-value;
Weak identification test is Kleibergen-Paap rank Wald F statistic; the corresponding Stock-Yogo critical values for 25% maximal IV relative bias is 7.25

APPENDIX

Table A1. Descriptions of variables and sources for them

Variable	Description	Source
Sector output	Logarithm of one plus gross output of a 3-digit manufacturing sector deflated by wholesale price index for manufacturing goods (2005=1)	Gross output in current prices: Rosstat; Wholesale price index: Rosstat and authors' calculations
Relationship specificity of a sector	Share of inputs of appropriate US manufacturing sectors that are neither sold on organized exchanges nor reference priced	Authors' calculations based on Nunn (2007); see also Table A3
Herfindahl-Hirschman index (HHI) of intermediate inputs based on US and Russian I-O tables	$HHI = \sum_{i=1}^{N}(s_i)^2$, where s_i stands for the share of i-th input in all intermediate inputs of a sector (US HHI is standardized)	US HHI: Cowan and Neut (2007); Russian HHI: authors' calculations based on the Russian 2012 I-O tables
Institutional quality of a region	Composite investment risk index of Russian regions	Rating agency Expert RA (https://raexpert.ru/ratings/regions)
Skill intensity of a sector	The fraction of the total wage bill for the US sector's workers with at least some college education	Autor et al. (1998)
Human capital stock	Logarithm of the number of individuals with college degrees in the work force	Rosstat
Capital intensity	$1 -$ labor intensity	Calculated from Levchenko and Zhang (2016; online appendix)
Capital stock	Logarithm of the book value of the stock of physical capital in a region in million rubles	Rosstat
Per capita GRP	Logarithm of real per capita GRP in million 2005 rubles	Rosstat and authors' calculations
Republic	Dummy variable set to 1 if the region has a status of a republic and zero otherwise	Constitution of the Russian Federation
Distance to Moscow	Logarithm of one plus the distance from regional center to Moscow by highway	Various sources

Table A2. Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Log(Sector output)	11.538	3.248	0.000	19.434
Relationship specificity	0.493	0.203	0.068	0.861
HHI (US)	1.042	0.943	0.256	4.105
HHI (Russia)	0.158	0.082	0.080	0.356
Investment risk (inverse)	0.944	0.086	0.634	1.095
Sector skill intensity	0.448	0.177	0.229	0.863
Log(Human capital stock)	4.904	1.008	1.380	8.099
Capital intensity	0.597	0.073	0.515	0.756
Log(Capital stock)	13.164	1.237	9.878	18.614
Log(Per capita GRP)	-2.256	0.701	-4.049	0.432
Republic	0.253	0.437	0.000	1.000
Log(Distance to Moscow)	7.082	1.382	0.000	9.211

Table A3: Correspondence between the Russian industrial classification and the ISIC, and the resulting relationship specificity of the Russian manufacturing sectors

Manufacturing sector (Russian classification)	Relationship specificity		ISIC
	Spec 1	Spec 2	
Food, beverages, and tobacco products	0.370	0.620	311111 - 312229
Textiles and apparel	0.498	0.873	313100-315900
Leather and leather products, incl. footwear	0.640	0.898	316100-316900
Wood and wood products	0.571	0.708	321113-321999
Paper and products, printing and publishing	0.443	0.933	322110-323122
Coke, refined petroleum products	0.068	0.756	324110-325120
Chemical and chemical products	0.343	0.908	325130 - 325998
Rubber and plastic products	0.397	0.971	326110 - 326290
Non-metallic mineral products	0.354	0.965	327111 – 327999
Basic metals and fabricated metal products	0.325	0.795	331111 – 33299A
Manufacture of machinery and equipment	0.708	0.974	333111 – 333298; 333219-33399A
Electrical machinery, electronic and optical equipment	0.789	0.973	333314-333315; 334111-335999
Transportation equipment	0.861	0.985	336110 - 336999
Other manufacturing	0.539	0.824	337110 - 511200

Notes: Spec 1 denotes share of inputs that are neither traded on organized exchanges nor reference priced; Spec 2 stands for share of inputs that are not traded on organized exchanges