Adaptation to forest institutions in Post-Soviet Russia: The impact of tenure security and market conditions on logging

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Abstract

After the collapse of the Soviet Union, the forestry sector in Russia underwent rapid institutional change. This included privatization of the timber industry and the development of short- and long-term timber concessions. Both of these changes were intended to complement the larger national transition to a market-based economy. Within a market system, the economically efficient allocation of a renewable resource is to maximize its present value, and the optimal single rotation period for a timber stand is when the rate of return from that stand equals the rate of return elsewhere in the economy. These conditions require well-defined and secure property rights. In this paper we analyze how political and economic conditions affected logging rates in post-Soviet Russia to test whether decision-making followed neoclassical economic theory. Specifically, we estimate how tenure security and transportation costs impacted observed logging rates between 1990 and 2005. We use a panel dataset that combines remote sensing observations of forest disturbance from 1990 to 2000 and 2000 to 2005 with region- and district-level data on tenure security and transportation costs in European Russia. We find that transportation costs impacted logging rates with districts that are further away from a major market having more harvesting in 1990-2000. The impact of distance shifted in 2000-2005 with districts closer to major markets experiencing similar rates of harvesting. Road density had a large and positive effect on logging. We also find that tenure security had a positive and significant impact on logging rates, with districts located in regions with above average tenure security experiencing about 20 percent more logging than regions with average tenure security.

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PRELIMINARY DRAFT – PLEASE DO NOT CITE

I. Introduction

Russia contains 20 percent of the world's forests or close to 809 million hectares (ha) of forestland as of 2005 (FAO 2005). Thus, Russia is an important supplier of timber and non-timber forest products for the world. Following the collapse of the Soviet Union in 1991, Russia radically changed its forest governance and institutional structure: decentralizing forest management, privatizing the timber industry, and shifting toward a system of short- and long-term timber concessions. These changes mimicked the broader transition to a market-based economy with the goal of promoting economic efficiency. Despite these institutional changes, industrial logging declined rapidly after transition and continues to remain relatively low within Russia. In 2003, forest output was approximately 23 percent of annual allowable cut and the industrial forest sector's contribution to national gross domestic product only about 3 percent (Torniainen et al. 2006). In-depth case studies and national-level analyses have pointed to several factors associated with the decline in industrial logging in post-Soviet Russia, these include: unclear roles and responsibilities within the state forestry sector following decentralization; short duration of timber concessions; and few supporting mechanisms, such as access to credit, during transition to a market economy (IIASA website; Olsson 2004; Olsson 2008; Torniainen 2009). In this study we examine the drivers of timber harvesting in the first fifteen years after transition for thirty-three regions in European Russia. To understand the impact that adaptation to privatization institutions had on logging outcomes we test two hypotheses related to the political economy of renewable resource use: the effect of tenure security and transportation costs on decision-making. This is the first study to empirically examine the relationship between political economy variables and logging rates in Russia and to combine remote sensing analysis with econometric estimation for such a large area of the country.

We focus our analysis on European Russia because of its accessibility to markets. Historically, European Russia has accounted for about 60 percent of all timber harvesting within Russia (Serebryanny and Zamotaev 2002), and so the impact of privatization institutions on logging in these regions should be relevant for other parts of the country. Our data are unique in that we combine remote sensing analysis of forest disturbance from two time periods – 1990 to 2000 and 2000 to 2005 – with covariates at the district level and measures of institutional strength and governance at the regional level. Data on forest disturbance come from two sources: a Greenpeace-Russia classification of forest disturbance from 1990 to 2000 (Yaroshenko et al., *unpublished*) and a forest disturbance classification from 2000 to 2005 produced by South Dakota State University (Potapov et al., *in review*). Both forest disturbance maps use remote sensing technology to classify the area of forest change within European Russia. Using these measures allows us to mitigate concerns about measurement error associated with using nationally reported harvesting statistics (Yaroshenko, *personal communication*). While remote sensing data is available at a pixel scale, since we are interested in political economy variables we summarize these data to the district level. There are 895 districts within our study region.

Tenure security is defined here as the assurance aspects of a tenure system, which differ from the content or rules of the tenure system (Arnot et al. *forthcoming*). Tenure security affects the expected benefit stream from investments; most empirical studies find that tenure security has a positive impact on investment. We construct a measure of tenure security for each of the 33 regions in our study area over 1990 to 2000 and 2000 to 2005 using a democracy index for Russian regions published by the Carnegie Center Moscow (Petrov 2005). Between 1990 and 2004 Russian regions elected their own governors and had autonomy over legislative decisions. This created a divergence in political and economic outcomes that we hypothesize impacted timber harvesting conditional on the biophysical resources in a district. We also test the impact of transportation costs on timber harvesting decisions following privatization. We use district-level measures of distance to closest major market (defined as either Moscow or St. Petersburg) and road density. We test for differences in the impact of tenure security and transportation costs over the two time periods in our study. We control for district-level biophysical variables in all econometric specifications.

To estimate timber harvesting we fit a multilevel linear model where districts are nested within regions. A multilevel model is considered more efficient than simple linear models when data have a hierarchical structure. This is because conventional statistical models assume independence between levels and often include aggregated or disaggregated data, which requires assumptions about scale effects (Snijders and Bosker 1999). The multilevel model relaxes the assumption of independence between observations by decomposing the error term into hierarchical components – in this study regions and districts – and then imposing a structure on the variance and covariance of these terms (Anselin 2002). If the multilevel model is the efficient specification, this variance-covariance structure accounts for heteroscedasticity and serial correlation within the panel data setup and spatial correlation across districts within the same region. Regions and districts enter the multilevel model as random errors, which mean that assumptions about exogeneity must be made at both levels of the data. To ensure that our estimation results are not biased by omitted variables at the regional level we also present results using regional fixed effects as a comparison.

Post-Soviet Russia provides an ideal place to test how political economy variables impact adaptation to institutions like privatization given regional-level heterogeneity in political institutions and economic outcomes from 1990 to 2004 (Stoner-Weiss 1997; Hanson and Bradshaw 2000). A number of scholars have used this variation across Russia to causally test the impact of pro-reform policies and institutional strength on firm-level performance and economic growth (Berkowitz and DeJong 2002; Yakovlev and Zhuravskaya 2004; Slinko et al. 2005; Yakovlev and Zhuravskaya 2008; Libman 2010). In this study we employ a similar strategy for natural resource use. By using variation within the same country we control for the content of property rights and neoclassical variables important to timber supply such as input and output prices. We are thus able to causally test whether and when tenure security and transportation costs impacted logging decisions. We find that tenure security has a positive effect on observed logging rates over the entire 15 year period. This effect is not trivial, with an increase in as much as 20 percent in harvesting rates when tenure security goes from average to above average. Transportation costs also play an important role in timber harvesting decisions. Specifically, road density has a positive impact on harvesting while the impact of distance to a major market shifts over time.

The rest of this paper proceeds as follows. In section II we provide background on changes to property rights and forest governance in post-Soviet Russia. In Section III we outline our conceptual model for timber supply in Russia. In Section IV we describe the data and our estimation strategy. In Section V we present summary statistics and econometric results. In Section VI we discuss these results and in Section VII we conclude.

II. Changes to Forest Institutions in Post-Soviet Russia

The first official forestry law in post-Soviet Russia was the 1993 Principles of Forest Legislation that split forest management and industrial forestry activities. The state maintained responsibility for forest management activities such as sanitary cuts and reforestation, while former state logging enterprises and wood processing centers were privatized. Ownership of natural resources was excluded from privatization but user rights, specifically the right to lease forests for industrial logging, were regulated in 1992 (Nysten-Haarala 2001). Leases for timber concessions could be short-term (less than five years) or long-term (up to 49 years). The responsibilities of the leaseholder under these initial contracts were limited to harvesting activities with maintenance and reforestation delegated to the state forestry sector until 2007. In addition to changes to property right structure, forest management was decentralized to local forest administrators in 1993 (Krott et al. 2000;

Eikeland et al. 2004). Several studies have focused on local-level outcomes after decentralization, concluding that management was highly inefficient and corrupt (Krott et al. 2000; Eikeland et al. 2004; Torniainen et al. 2006). The reasons for this outcome seem to be the lack of technical skills and training provided to local-level state employees and legislation that took away the primary source of funding for local forestry employees: forest harvesting. The newly privatized timber industry also faced many hurdles in the initial years following transition. Once state subsidies ended, many firms went bankrupt due to a shortage of capital. This was one of the reasons behind the significant concentration in firm ownership and production output that has occurred within the timber industry (Kortelainen and Kotilainen 2003; Torniainen et al. 2006). Firms were also adversely affected by the budget cuts in the state forestry sector since high taxes and fees were often tacked on to lease contracts. Access to timber rights was greatly influenced by the interplay of political and economic actors within a region (Torniainen 2009).

In 1997 new forestry legislation was passed that recentralized forest authority but did not change the content of forest property rights. The 1997 Forest Code took the decision-making authority away from local forest administrators and bestowed it to the regional forest authorities. This shift in authority helped reconcile the problem of high taxes and fees placed on firms by making contracts more transparent. However, it failed to address the perverse incentives faced by local forestry units to cut timber through the guise of sanitary logging in order to generate their own income (Torniainen et al. 2006). The volume of industrial logging began to pick-up in the late 1990s. This was partly due to restructuring after the Russian financial crisis in 1998 that led to a deregulation of the ruble and was also a result of an overall upturn in the Russian economy following the new economic policies of President Vladimir Putin in 2001. In 2004, the central government completely recentralized forest authority, paralleling broader shifts in national governance and regional sovereignty: in 2004, President Vladimir Putin abolished free elections of regional governors. Again, no changes were made to the content of property rights for Russian forests. In 2007 Russia released its latest version of the Forest Code. This new Forest Code once again decentralized decision-making powers to the regional level and made the first substantive changes to the content of property rights, designating several new responsibilities to firms and extending the duration of concessions up to 99 years (Torniainen et al. 2009).

Given changes in regional governance and the content of forest property rights after the mid-2000s, we focus this study on the first fifteen years following transition. During this period the substance of timber property rights remains the same even though the level of forest sector authority shifts between the local and regional level. We do not feel that this shift from local to regional authority is a major concern to our measure of tenure security for two reasons. First, experts suggest that very few substantive changes occurred in the types of forest management decisions made by national, state and local forest sector employees despite decentralization (Yaroshenko, *personal communication*; Laestadius, *personal communication*). This was due to the unclear roles and responsibilities following new legislation; little enforcement of formal rules; and few supporting mechanisms for implementation of decentralization policies (Olsson 2008; Torniainen 2009). Second, our measure of tenure security is not exclusive to the timber sector, but a broader measure of institutional strength and governance within a region. Therefore our measure of tenure security is not affected by forest sector employees *per se*, but captures the larger legislative and legal climate within a region.

III. Conceptual Framework

The economically efficient rotation period of timber under a market-system can be found using the Faustmann formula. The Faustmann formula represents the present value of a stand under infinite rotation. Assuming an even-aged stand, the Faustmann formula is:

$$\max \pi = \frac{PQ(T)-C}{(e^{\delta T}-1)} \tag{1}$$

where:

π=profit

P=timber price

Q(T)=volume of timber at time, T

C=replanting costs

δ=discount rate

The optimal rotation period is found by taking the first order condition and solving, which gives:

$$P\frac{dQ(T)}{dT} = [PQ(T) - C]\delta + \delta\pi \tag{2}$$

The left-hand side of this equation is the marginal benefit of waiting to cut. The right-hand side is the marginal cost of waiting to cut and consists of two parts: the foregone interest from not cutting the stand and the rental value of delaying all future harvests on the land (Conrad 1999). Until 2007 forest property rights allowed timber concessions for a maximum of 49 years and the majority of these concessions were for five years or less (Yaroshenko, *personal communication*). Given this short duration of property rights, the opportunity costs of delaying future harvests were not internalized and the problem faced by decision-makers can be modeled as the decision to maximize the present value from a single rotation. The optimal single rotation period for a timber stand can be represented by the following maximization problem:

$$\max[PQ(T)e^{-\delta T}] \tag{3}$$

Which has the solution:

$$P\frac{dQ(T)}{dT} = \delta PQ(T) \tag{4}$$

The left-hand side of Equation 4 is again the marginal benefit of waiting to cut and the right-hand side the marginal cost of waiting. Equation 4 can be rewritten as: $\frac{dQ(T)/dT}{Q(T)} = \delta$. Thus, the optimal time to cut is when the rate of return from the stand equals the rate of return elsewhere in the economy. The assurance of property rights, or tenure security, directly affects the discount rate and thus whether to harvest (Bohn and Deacon 2000; Deacon and Mueller 2003; Ferreira and Vincent, *in press*). Ferreira and Vincent (*in press*) describe two separate impacts of tenure security on the discount rate and thus investments in natural resource use. Because tenure insecurity reduces the value of future resource rents it can make current extraction look more attractive, this is known as the depletion effect. Several theoretical and empirical studies have found that deforestation rates are higher under insecure tenure (Dasgupta and Heal 1979; Bohn and Deacon 2000; Barbier et al. 2005; Arnot et al. *forthcoming*). The second effect of tenure insecurity moves in the opposite direction of the depletion effect. Since a higher discount rate reduces the present value of the resource, it creates investment risk for the user. This can decrease incentives to invest in natural resource uses, especially when they are capital-intensive, such as industrial logging or petroleum extraction (Bohn and Deacon 2000; Ferreira and Vincent, *in press*; Arnot et al., *forthcoming*). The overall impact of these two effects on the discount rate is theoretically ambiguous and is related to the resource stock and the amount of capital required for extraction (Ferreira and Vincent, *in press*).

Once the decision to cut or not is made, the economic decision of where to harvest in any given year is based on the prospect of rents – revenue minus costs – from a timber stand. The privatization of the timber industry in Russia was done with the expectation that this would lead to the internalization of revenues and costs and thus greater economic efficiency in timber harvesting.

However, previous research suggests ambiguous results in terms of the effectiveness of privatization in inducing market-oriented behavior. Specifically, a qualitative assessment in eight regions of market conditions in 1998 found that only six percent of timber enterprises were displaying market-oriented behavior such as adhering to hard budget constraints or setting prices determined by supply and demand (Olsson 2008). This behavior was not unique to the timber industry but was part of a larger system of bartering and trade that developed in Russia after transition (Gaddy and Ickes 2002). Thus, whether decision-makers in Russia responded to market constraints in their decisions of where to harvest timber is not clear.

Timber supply is typically modeled using measures of the price of timber, prices of variable inputs, the volume of timber, quantities of fixed inputs and the timber industry's discount rate (Binkley 1987; Ferreira and Vincent, *in press*). We discussed the impact of tenure security on the discount rate above. Since our study area is within the same country, many of the differences in prices and costs faced by decision-makers are expected to vary primarily due to transportation costs. Typical measures of transportation costs include road density and distance to roads. Since we do not focus on stand-level decisions but the aggregate amount of harvesting within a district we substitute distance to a major market (defined as either Moscow or St. Petersburg) for the latter. Differences in the volume of timber can be controlled for with measures of forest cover or growing stock. Quantities of fixed inputs can refer to differences in logging machinery or logging roads that would impact extraction costs. Other factors that might impact extraction costs include biophysical characteristics of the stand such as slope or elevation. Additional factors that might create differences in the price of timber include the type of tree species and its age.

IV. Data and Methods

Data

Our dependent variable is the area (km^2) within a district that went from forest to non-forest and is measured using remote sensing analysis. Measures of forest change from 1990 to 2000 come from an unpublished analysis by Greenpeace-Russia (Yaroshenko et al. *unpublished*). This assessment covers twenty unique regions in European Russia. While there was no accuracy assessment associated with these data, an internal assessment of the product's accuracy was around 90 percent. The 2000-2005 measure of forest change comes from Potapov et al. (*in review*) and is available to the public on their project website. This forest disturbance assessment covers forty-seven regions in European Russia. The accuracy assessment of this data was in the 90^{th} percentile. In remote sensing, forest change is mapped using 30-meter by 30-meter pixels. Since we are not interested in pixel-level harvesting but decisions at the district- and regional-level, we aggregate forest disturbance to the district level. This gives us greater variability in our dependent variable then if we had aggregated at the region level and allows us to control for differences in biophysical characteristics and transportation costs at the district level.

Even though the remote sensing analyses were for two discrete time periods, some variation and thus overlap in the satellite images is to be expected. For example, the 2000 to 2005 change product uses images from 1999 to 2002 to measure 2000 forest cover and images from 2003 to 2005 to measure 2005 forest cover (Boreal Forest Monitoring project website). Contact with the authors of the Greenpeace-Russia dataset indicate that images from 1988 to 1992 were used to measure 1990 forest cover and images from 1998 to 2001 were used to measure 2000 forest cover. We annualize the rate of forest change to create our dependent variable. This allows for a more straightforward interpretation on the coefficient parameters. To account for differences in assessment and accuracy across these two datasets we include a dummy variable in all econometric specifications. Even with overlaps in remote sensing data and processing errors we feel that measurement error is greatly reduced by using remote sensing data on forest change versus national statistics of timber harvesting. National statistics of volume harvested are reported on an annual basis but are subject not only to human reporting error but may have been systematically misreported in a way that relates to our governance measures. Deforestation is not a major land use in our study region since all forest is owned by the state and will theoretically be put back into forest after harvesting. Thus, any forest disturbance found in remote sensing can be attributed to logging.

We also use the remote sensing data to obtain district-level measures of forest cover in 1990 and 2000. Potapov et al. (*in review*) provide a change classification of undisturbed forest cover; we added this to the amount of change from 2000-2005 to recreate 2000 forest cover. Unfortunately, there was no change classification of undisturbed forest cover in the Greenpeace-Russia dataset. To approximate 1990 forest cover we used the above 2000 measure of forest cover and added the area of forest change from 1990-2000 to it. Given low rates of forest change in Russia between 1990-2000 (on average, 2.6 percent annually in our study region) and the greater land-use change process of afforestation (Lerman et al. 2004), this estimation is probably an overestimation of forest cover in 1990.

In a review of the literature on tenure security, Arnot et al. (*forthcoming*) find a great deal of variation in the definition and measures used for tenure security. In this study we follow Deacon

(1994, 1999), Bohn and Deacon (2000), Deacon and Mueller (2003), and Ferreira and Vincent (*in press*) and use measures of government integrity to describe the assurance of property rights. Government integrity consists of corruption, bureaucratic quality and rule of law. Many of these studies also use a measure of government stability; however, we did not feel that political unrest posed a major threat to logging in our study area. We construct our measure of government integrity from the democracy index published by the Carnegie Center Moscow (Petrov 2005). The democracy index consists of ten measures related to democratic institutions and good governance across Russian regions. Independent experts were asked to rank the following components on a scale of one to five where five was the highest value: political organization, transparency, independence of media, corruption, economic liberalization, civil society, multiple political elites, and quality of local governments. These scores were then averaged to create an overall democratic score for each region. Two different assessments have been published: one for 1991-2001 and one for 2000-2005. Petrov (2005) indicates that these two assessments are comparable. While there is slight discrepancy in years, we chose to treat these assessments (i.e., 1991-2001 and 2000-2005) as equivalent to our dependent unit of analysis: 1990-2000 and 2000-2005.

The entire democracy score was not relevant for our measure of tenure security. Thus, we selected indicators that were most relevant to the definition of government integrity: corruption, economic liberalization, political organization, and quality of local governance. Most of the research on governance and natural resource use has focused on the impact of administrative corruption, defined as the use of public power for private gain, on resource use (Bohn and Deacon 2000; Barbier et al. 2005; Ferreira and Vincent, *in press*). In the democracy index corruption measures administrative corruption as well as what is referred to as "grand" corruption or state capture. Grand corruption refers to the use of private payments to public officials to change the legislation, rules or laws. Kaufmann et al. (2005) define corruption in terms of both petty (or administrative) corruption and grand corruption and state capture. There is strong evidence that grand corruption has impacted economic growth within Russia and that particularly, elite firms have been able to use their new wealth to influence regional legislation and gain preferential treatments (Yakovlev and Zhuravskaya 2004; Slinko et al. 2005). Economic liberalization, as defined by the Carnegie Center's democracy index, measures the integrity of regional laws and practices toward privatization. Regional political organization is defined as a measure of the balance of power between executive and legislative actors and reflects independence of courts and protection of rights. We considered these indicators to be comparable to those measuring the "rule of law" in macroeconomic assessments of governance

(Kaufmann et al. 2005). The last indicator – quality of local governance – is defined as a measure of the existence of elected local bodies of governance, their activity and influence in Russian regions. We felt that local competence and bureaucracy would have a direct effect on the security of property rights within the timber industry and considered this measure comparable to the Kaufmann et al. (2005) indicator "government effectiveness" which measures the competence of the bureaucracy and quality of public service delivery.

These four measures of regional governance cover three of the six dimensions used by the World Bank and other international organizations to categorize governance effectiveness (Kaufmann et al. 2005) and are most related to the concept of government integrity and assurance of property rights. The correlation between these four variables ranged from a high of 0.6 between economic liberalization and quality of local governance to a low of 0.2 between corruption and quality of local governance. We decided to average the four indicators instead of using each one separately since averaging helps reduce measurement error when the governance concepts are similar (Knack 2002; Ferreira and Vincent, *in press*). Our constructed measure of government integrity ranged in value from 1.75 to 4.25; we reconverted this to a three-point scale based on a normal distribution curve. Values of one represent below average tenure security, values of two average tenure security, and values of three above average tenure security in the study area. By using regional measures of governance versus indicators specific to the timber industry we avoid concerns of simultaneity bias in our econometric models.

We measure transportation costs at the district level as distance to closest major market (defined as either Moscow or St. Petersburg) and road density (defined as the length of roads per square kilometer). Measures of distance were calculated from the centroid of each district to major markets in ArcGIS using Albers equal area projection. Measures of road density were calculated in ArcGIS as the length of roads divided by the total area in a district. Additionally we control for slope within a district and measure variability of slope using ArcGIS. Slope is measured in degrees. Our final study region covers 33 regions and 895 districts; this represents the area where we had remote sensing data and could collect data on other variables of interest.

Overview

Given the nestedness of districts within regions a multilevel linear model – also known as the hierarchical linear model – is the preferred method of estimation. Multilevel models are considered more efficient than simple linear models when data have a hierarchical structure because conventional statistical approaches assume independence between levels and often include aggregated or disaggregated data, which requires assumptions about scale effects (Snijders and Bosker 1999). Estimating the multilevel model avoids the problem of assuming that regional data can be assigned equally to all districts, which can lead to underestimation of the standard errors on key variables. Multilevel models also relax the assumptions of independence between observations by decomposing the error term into hierarchical components – in our case regions and districts – and then imposing a structure on the variance and covariance of these terms (Anselin 2002). If the spatial dependency is only related to the nested hierarchy of individuals and groups, then multilevel analysis can control for all correlation between observations.

Our multilevel model has two levels: a level-two regional level effect and a level-one district level effect. A district- and regional-level random error component enter the model and can be used to estimate the intraclass correlation, or the amount of variation in the dependent variable that can be explained by each level of the data. The level-one model can be expressed as:

$$Y_{ijt} = \beta_{0j} + \alpha X_{ijt} + r_{ij} + \varepsilon_{ijt} \tag{5}$$

Y_{ijt} is the amount of forest change in district *i* nested in region *j*; the *t* subscript indexes for time. This variation is explained by a region-specific effect for all districts within the same region, β_{0j}, a vector of covariates, X_{ijt}, and a district-level error term, r_{ij}. The residual error is captured by ε_{ijt}. X_{ijt} includes all variables that vary at the district-level that effect the decision of whether to harvest a timber stand or not. In this study we include measures of: original forest area, variation in slope, and transportation costs. Only forest area varies over time. We take the natural logarithm of Y_{ijt} and all level-one covariates in X_{ijt}. We do this to correct for skewness in the data, particularly in the forest change and forest cover data. We tested measures of variation in slope and elevation in our regression models but found very strong correlation between the two measures (>0.9); we felt variation in slope would be a better indicator of extraction costs so use it in all specifications presented below.

The level-two effects enter Equation 5 as:

$$\beta_{0j} = \gamma_{00} + \psi Z_{0jt} + \mu_{0j} \tag{6}$$

In this equation, μ_{0j} is the region-specific random effect and γ_{00} is the average outcome for the population. Z_{0jt} is the vector of covariates that vary across regions and time, and includes our measure of tenure security. We use a dummy variable specification to measure the impact of tenure security on forest change. The empirical literature suggests that tenure insecurity has a linear and positive effect on deforestation (Barbier et al. 2005; Deacon and Muller 2003) but a nonmonotonic effect on capital-intensive activities like petroleum extraction and industrial logging (Bohn and Deacon 2000; Ferreira and Vincent, *in press*). Based on this literature and the construction of our tenure security measure as a three-level index we chose to include security as a dummy variable omitting category two – average tenure security – so that we could interpret the impact of having below or above average tenure security on logging in post-Soviet Russia. By using a dummy variable specification we impose no structure on the relationship between tenure security and logging and allow for different functional forms between below average tenure security and logging and above average tenure security and logging.

Combining Equations 5 and 6 and adding a time dummy variable gives:

$$Y_{ijt} = \psi Z_{0jt} + \alpha X_{ijt} + t_{00t} + \gamma_{00} + \mu_{0j} + r_{ij} + \varepsilon_{ijt} \qquad (7)$$

Again, the time dummy controls for differences attributable to the two different datasets used to construct Y_{ijt}. We estimate Equation 7 using restricted maximum likelihood estimation in Stata11. In addition to the model above we test for differences in the sign and magnitude on transportation costs and tenure security variables across the two time periods by interacting them with the time dummy. For transportation costs, the economically efficient response would be that higher transportation costs –districts further from major markets and with lower road density – have a negative effect on the area harvested. We expect that transportation costs have become more important to harvesting decisions over time and that the signs expected under neoclassical theory hold at least for 2000-2005. Based on our conceptual model, we expect that differences in tenure security across regions impact the timber industry's discount rate and thus the total amount of logging observed. Given the capital required for logging, we hypothesize that tenure security has a positive impact on harvesting. We hypothesize that differences might exist between tenure security across time periods but do not make any *a priori* assumptions about what these effects might be.

The potential disadvantage of the multilevel model is that because the region- and district-level error terms enter Equation 7 as random effects, endogeneity bias at both levels is a concern. Endogeneity occurs if one of the random effects is correlated with the error term and results in biased estimators. Endogeneity has many causes, some of the most common are: omitted variables, simultaneity bias, and measurement errors. In our specification there are two possible reasons that the random effects could cause endogeneity bias. First, as mentioned in the conceptual model, there are several neoclassical variables in a typical timber supply function. While we feel that most of the variation in prices and costs are captured through our biophysical variables (i.e., forest cover and slope) and transportation costs (i.e., road density and distance), if there are large differences in the type of forest – coniferous versus deciduous – or the quantity of inputs such as machinery across districts or regions then we might have an omitted variables problem.

Second, there might be concern that there is correlation between unmeasured regional characteristics and our measure of tenure security. This would be the case if tenure security was related to other regional characteristics that also impacted the amount of timber harvested. The only potential threat we conceived was that regions with more development or economic growth might also have better institutions and more economic activity such as industrial logging. However, based on the development literature we felt that causality was more likely to run from better institutions (including tenure security) to development and economic growth and not the other way around (Knack and Keefer 1995; Knack 2002; Acemoglu et al. 2002). Within Russia, a recent study by Libman (2010) supports this conclusion, estimating that the causal link is from good political institutions (using the same democracy index used in this study) to economic growth and not vice versa. If this pathway is correct, then including a region-level random effect should not create endogeneity bias.

However, because we cannot fully mitigate concerns about omitted variables bias since we do not have data on type of tree species or logging equipment, we present results from our preferred specification using random effects for districts but fixed effects for regions. Using regional fixed effects buys security in terms of omitted variables bias, and is a stricter test to pass in terms of causality of tenure security and transportation costs on harvesting rates. If an effect on tenure security or transportation costs is found in this specification we can be especially confident that a significant impact exists. The major disadvantages of using region fixed effects is that we have to make assumptions that regional-level variation in tenure security can be uniformly applied to districts and if the multilevel model is the correct specification using fixed effects results in a loss of efficiency. We estimate the fixed effects model using the xtreg command in Stata 11 and cluster our standard errors at the regional level. Cluster-robust standard errors control for all functional forms of serial correlation and heteroscedasticity in the panel data model and allow for spatial correlation across districts within the same region (Cameron and Trivedi 2005).

V. Results

Summary statistics

Descriptive statistics for the key district-level variables are presented in Table 1. Forest change exhibits a large degree of variation across districts with the average value skewed toward zero. The median value is actually much lower, at approximately 11 km^2. Using the average amount of forest cover in districts the average amount of forest change was about 2.6 percent over these fifteen years. We analyzed this change between the two time periods and found an average amount of forest change of about 3.7 percent in 1990-2000 and 1.5 percent in 2000-2005.

Table 1. Summary Statistics for district-level variables*

Variable	Mean	Standard deviation	Minimum	Maximum
Forest change (km^2)	50.906	141.253	0	2157.347
Forest area (km^2)	1969.536	3796.209	0	32923.33
Slope standard deviation (degree)	0.379	0.286	0	2.891
Road density	0.013	0.033	0	0.399
Distance to closest market (km)	540.585	334.696	0	2359.169

*Before transforming values to logarithms

Figure 1 shows the annualized percent change in forest disturbance across districts. The map represents the relative proportion of logging occurring across districts in the two different time periods but is not indicative of the actual annual percent harvested since we do not have annual rates. Forest disturbance was mapped for a smaller number of districts in 1990-2000 as indicated by the missing values (i.e., districts in white).

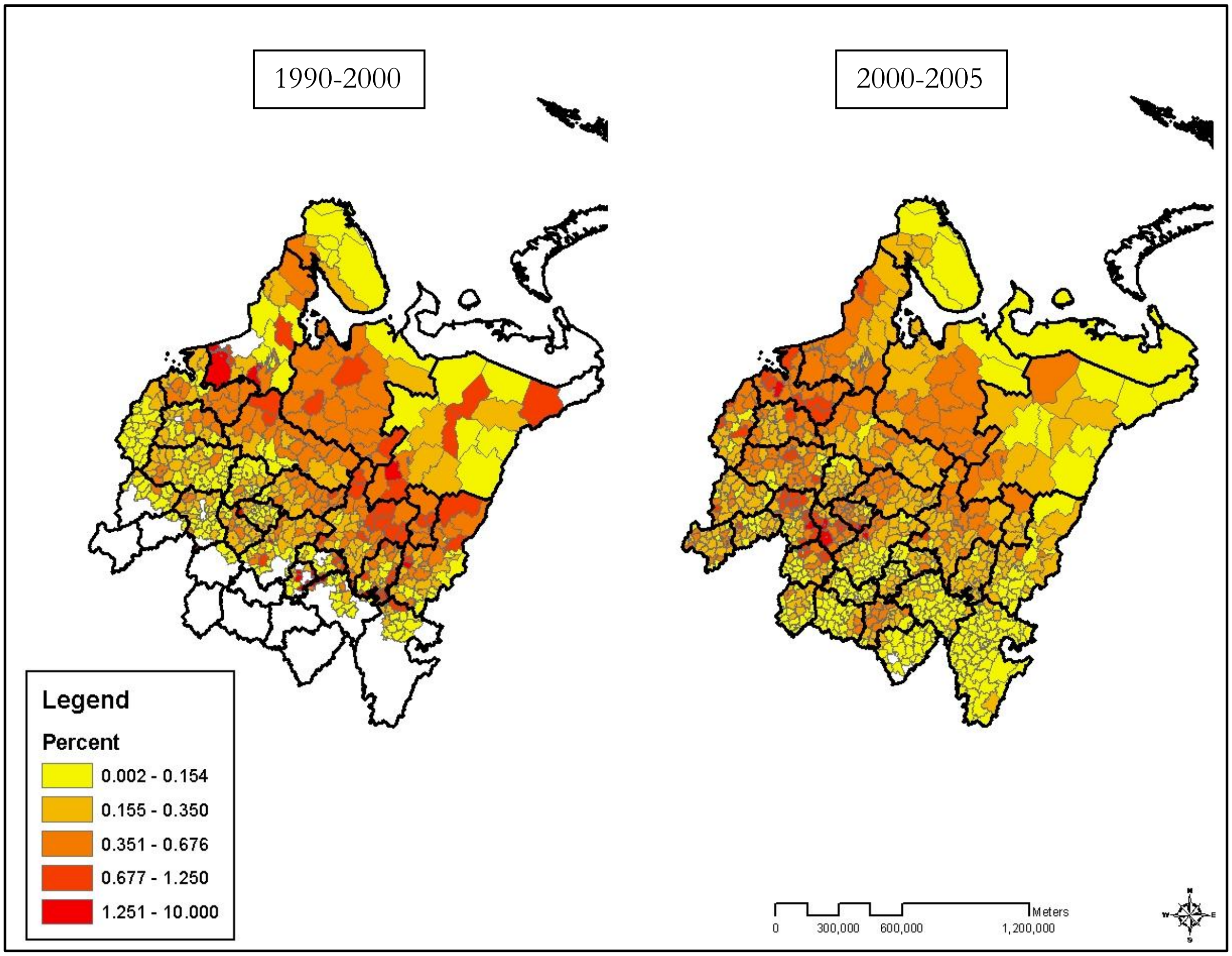

Figure 1. Annualized percent change of forest disturbance in 1990-2000 and 2000-2005

Since our measure of tenure security is a dummy variable we present the number of districts and regions characterized as a one, two or three in 1990-2000 and 2000-2005 in Table 2. There is an overall increase in tenure security between the two periods.

Table 2. Number of districts and regions with different levels of tenure security

Tenure Security	1990-2000	2000-2005
Number of Districts		
Below average (1)	391	284
Average (2)	199	224
Above average (3)	312	394
Number of Regions		
Below average (1)	12	8
Average (2)	8	8
Above average (3)	13	17

In Figure 2 we graph the average value of forest disturbance (in logarithmic form) by tenure security category and years of change. From 1990-2000 the average amount of forest disturbance was similar between districts with average ("2") and above average ("3") tenure security but districts with below average ("1") tenure security had lower harvesting rates. Differences in the distribution become more distinct in 2000-2005, with the average amount of change increasing as tenure security improves.

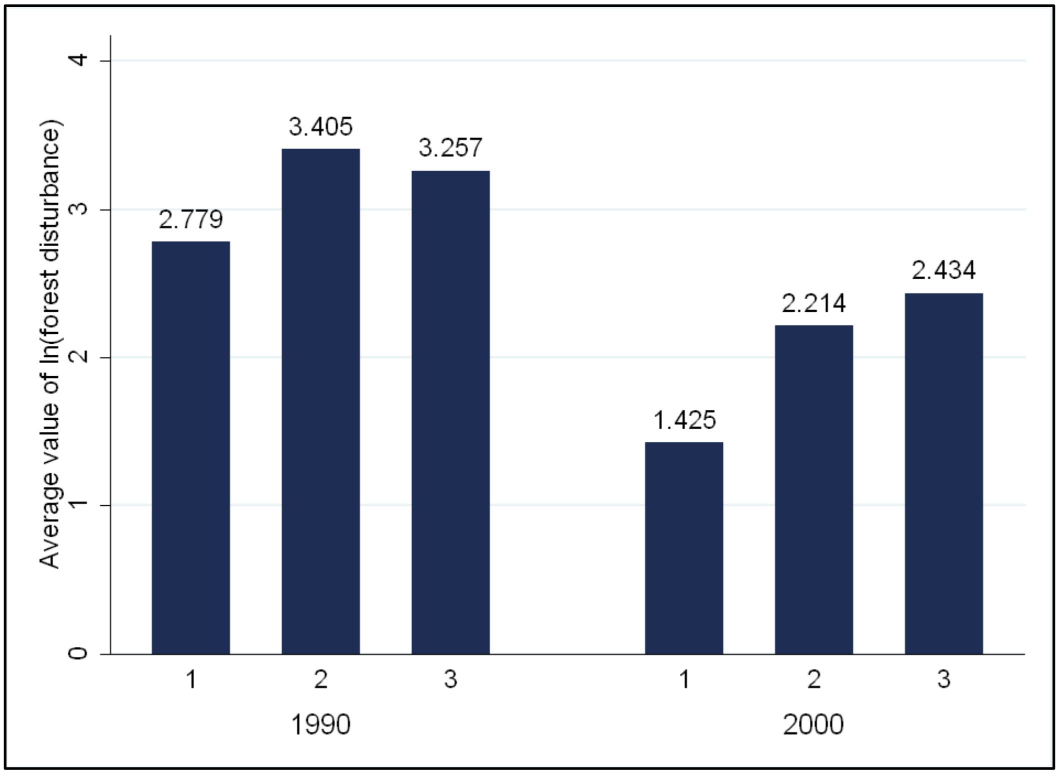

Figure 2. Forest disturbance by tenure security and year

Econometric Analysis

<u>Multilevel Model Results</u>

We present three specifications using the multilevel model (Table 3). In Model 1 we present the null, or unconditional, multilevel model. There are 33 regions and 895 districts in the dataset and an average of 1.6 observations per district. The likelihood ratio test indicates that the multilevel model is a much better fit to the data than a simple linear model. The null model can be used to calculate the intraclass correlation coefficient, or the percentage of observed variation in the dependent variable explained by different levels in the model. Denoting the variance from r_{ij} in Equation 7 as

σ, and the variance from μ_{0j} as ω, the percentage of observed variation attributable to region-level characteristics is: $\rho = \frac{\omega}{\omega+\sigma}$. Using the variation in Model 1 we find that region-level characteristics account for 61 percent of variation. This is a very high amount and indicates that differences across regions are larger than differences across districts.

Model 2 includes all covariates of interest from Equation 7 without any interactions with the time dummy. We see a significant improvement in explanatory power, with the deviance statistic decreasing. All covariates are statistically significant at the one percent level except for the dummy variable measuring below average tenure security. Since all variables except tenure security and time dummy are logarithms, we can interpret the coefficients as elasticities – or the percent change in logging for a one percent change in the covariate. The magnitude on road density is much larger than any of the other covariates in the model, indicating that forest change is very elastic with respect to road density. There is a positive and significant coefficient on the dummy variable measuring above average tenure security but the difference between average and below average tenure security is insignificant. Using the formula by Kennedy (1981) to estimate the percentage impact of a dummy variable in semilogarithmic equations, we find that districts within regions with above average tenure security had on average 37 percent more harvesting than regions with average tenure security.

In Model 3 we interact our transportation costs and tenure security variables with the time dummy variable to test for differences in sign and magnitude across the two change periods. The sign and significance for forest cover and slope remain the same. Road density stays significant and positive in the model but there is no statistically different effect across 1990-2000 and 2000-2005. In 1990-2000 more harvesting is observed further away from major markets but in 2000-2005 this effect is not as strong – it remains positive but is inelastic with a coefficient around 0.03 versus 0.4. The difference between average and above average tenure remains significant at the 5 percent level and there is no statistical difference for this effect across the two time periods. The impact of moving from average to above average tenure security is an increase of about 17 percent in harvesting (Kennedy 1981). The difference between average and below average tenure security becomes significant in this model at the 6 percent level, with below average tenure security having an overall negative impact on logging rates. The magnitude of this effect changes between 1990-2000 and 2000-2005 with a much smaller, but sill negative, coefficient in the latter period. The overall percentage impact of being in a region with below average tenure security versus average tenure security is a decrease in harvesting of 23 percent. The deviance statistic and overall model fit is better for Model 3 versus Model 2.

Table 3. Multilevel regression results

	Model 1	**Model 2**	**Model 3**
Variable Name	Coefficient Standard error	Coefficient Standard error	Coefficient Standard error
Parameters			
Forest cover		0.404***	0.401***
		0.015	0.015
Slope (standard deviation)		-0.772***	-0.764***
		0.145	0.144
Road density		3.770***	3.984***
		0.792	1.265
Road density*2000-2005 Time Dummy			-0.707
			1.275
Distance to major market		0.176***	0.419***
		0.047	0.052
Distance to major market*2000-2005 Time Dummy			-0.386***
			0.036
Below Average Tenure Security		0.103	-0.210*
		0.114	0.114
Below Average Tenure Security*2000-2005 Time Dummy			0.162*
			0.086
Above Average Tenure Security		0.358***	0.201**
		0.082	0.087
Above Average Tenure Security*2000-2005 Time Dummy			-0.034
			0.077
Time Dummy		0.078**	2.376***
		0.032	0.235
Constant	1.236***	-2.469***	-3.755***
	0.160	0.304	0.325
Variance components			
Region-level error	0.902	0.430	0.409
	0.116	0.063	0.059
District-level error	0.479	0.238	0.275

	0.023	0.028	0.023
Residual	0.566	0.530	0.491
	0.016	0.015	0.014
Number of observations	1438	1438	1438
Number of districts	895	895	895
Number of regions	33	33	33
Deviance statistic	3,241.936	2,617.674	2,514.234

*** p<0.01, ** p<0.05, * p<0.1
The dependent variable for all models is the annualized rate of forest change. The dependent variable and all explanatory variables except tenure security and time dummy are logarithms and can be interpreted as elasticities.

Robustness checks

To ensure that the results in Table 4 are not affected by endogeneity bias, we present Model 2 and 3 using regional fixed effects and cluster-robust standard errors. We do not list the regional fixed effects due to space constraints. The coefficient and signs on results are quite similar for most variables. The variance components are also quite similar, with district-level variation around 0.3 and population-level variation around 0.7. The major difference between the two specifications is that the coefficient on below average tenure security is not significant in Model 3, but its interaction with the time dummy variable is. We tested the joint significance and below average tenure security remains significant at the 6 percent level in Model 3. The magnitude of the coefficient on above average tenure security is actually higher under the fixed effects specification.

Table 4. Regression results using regional fixed effects

	Model 2	**Model 3**
Variable Name	Coefficient Standard error	Coefficient Standard error
Parameters		
Forest cover	0.391***	0.387***
	0.047	0.047
Slope (standard deviation)	-0.721***	-0.716***
	0.277	0.264
Road density	3.390**	3.652***
	1.370	1.307
Road density*2000-2005 Time Dummy		-0.809
		0.643
Distance to major market	0.189**	0.432***
	0.083	0.069
Distance to major market*2000-2005 Time Dummy		-0.378***
		0.040

Below Average Tenure Security	0.280	-0.114
	0.354	0.226
Below Average Tenure Security*2000-2005 Time Dummy		0.201**
		0.087
Above Average Tenure Security	0.415***	0.219***
	0.088	0.075
Above Average Tenure Security*2000-2005 Time Dummy		-0.028
		0.108
Time Dummy	0.091	2.328***
	0.081	0.280
Constant	-3.611***	-4.621***
	0.802	0.644
Variance components		
District-level error	0.177	0.230
Residual error	0.499	0.462
Intraclass correlation	0.112	0.199
Number of observations	1438	1438
Number of districts	895	895
Number of regions	33	33
R2 within	0.117	0.244
R2 overall	0.733	0.749

*** p<0.01, ** p<0.05, * p<0.1
The dependent variable for all models is the annualized rate of forest change. The dependent variable and all explanatory variables except tenure security and time dummy are logarithms and can be interpreted as elasticities.

VI. Discussion

Post-Soviet Russia provides an ideal place to test the impact of adaptation to privatization on forest outcomes given regional divergences following transition. While a number of empirical studies have focused on the content of property rights in post-Soviet Russia this is the first empirical analysis of the role of tenure security on logging within the country. By focusing within Russia we restrict the content of property rights to the system instituted after the collapse of the Soviet Union. We find that tenure security does play a role in investments in logging and that this effect has not changed much over time. Specifically, we find that regions with above average tenure security harvested more timber than other regions conditional on biophysical resources and transportation costs at the district level. When we account for differences across time we also find that having below average tenure security reduces the amount of timber harvested compared to having average tenure security.

The security of property rights depends on the supporting institutions and governance system within a country and this security of rights impacts whether resources are used efficiently or not. Depending on the capital intensity of the resource use, when tenure is insecure investments can decrease or extraction can accelerate. In this study we find that increasing tenure security leads to more investment in logging, suggesting that the investment effect is more prevalent than the depletion effect. This result is similar to the one found in Ferreira and Vincent (*in press*) in a cross-section of 90 developing countries. Because insecure property rights have discouraged investments in logging in Russia, improvements in governance and institutional strength could actually lead to more forest harvesting.

We were also interested in examining whether logging rates at different levels of tenure security were affected by secondary variables such as the number of forest sector employees and the number of logging firms, but did not have enough variation in the dataset to explore these relationships through regression analysis. Below we present some graphical evidence that suggests that differences exist in harvesting as the number of employees and firms changes across tenure security categories. The first graph shows how the amount of harvesting changes as the number of forest sector employees increases across tenure security categories (Figure 3). The slope for above average tenure security is flat while the slope for average tenure security is increasing; however, the slope for below average security is negative. This suggests that in regions with better governance increasing the number of forestry employees facilitates logging transactions, but has the opposite effect under weak institutions.

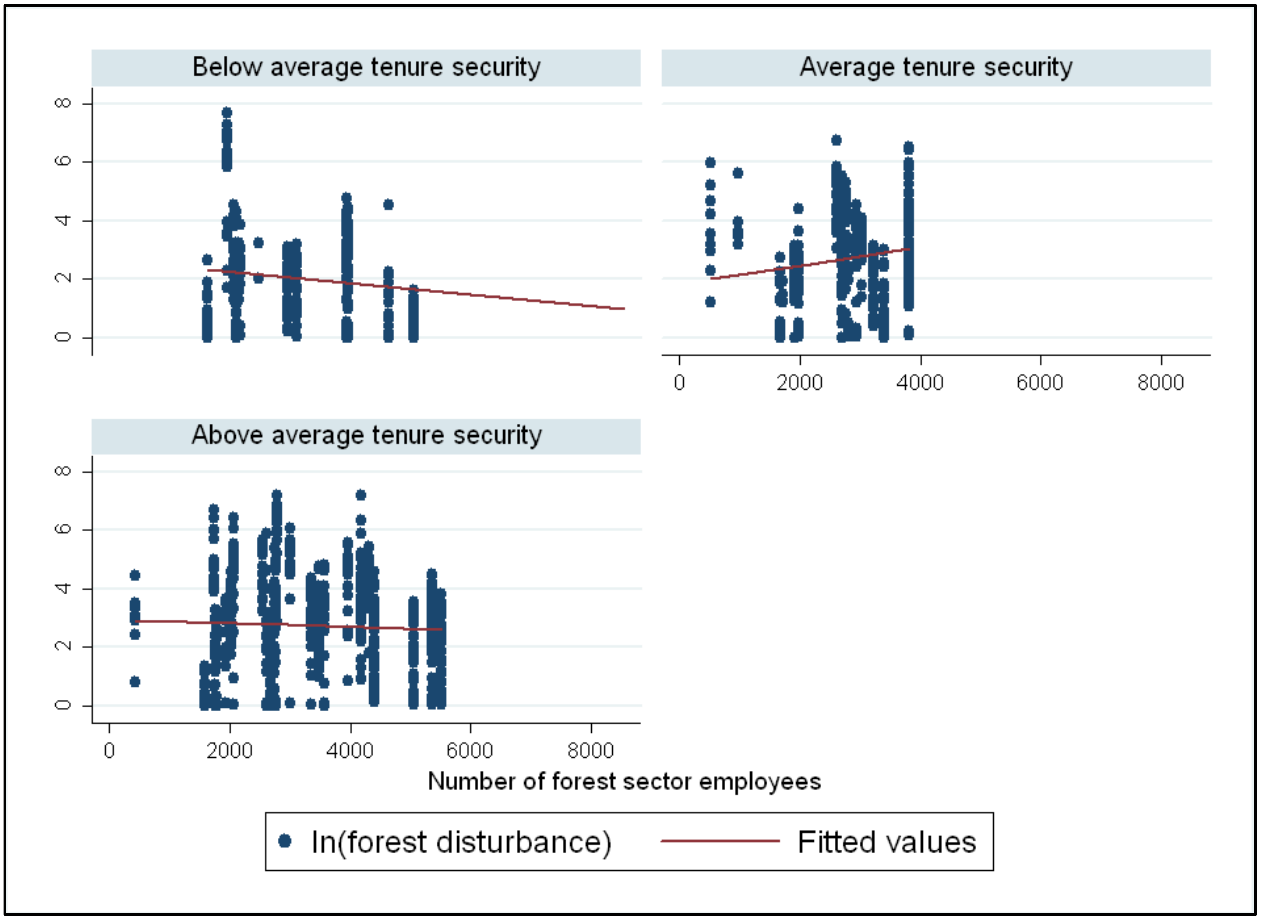

Figure 3. The effect of employees on forest disturbance across tenure security groups

The second graph shows how harvesting rates change with the number of logging firms across tenure security categories (Figure 4). We find that the slope on harvesting is positive across all tenure categories but that it is steeper when tenure security is above average. It is also clear that the number of firms found under different tenure security groups varies considerably. Specifically, regions with average or above average tenure security tend to have more logging firms. This makes intuitive sense given that a firm should be more likely to locate and or be profitable in districts with secure property rights.

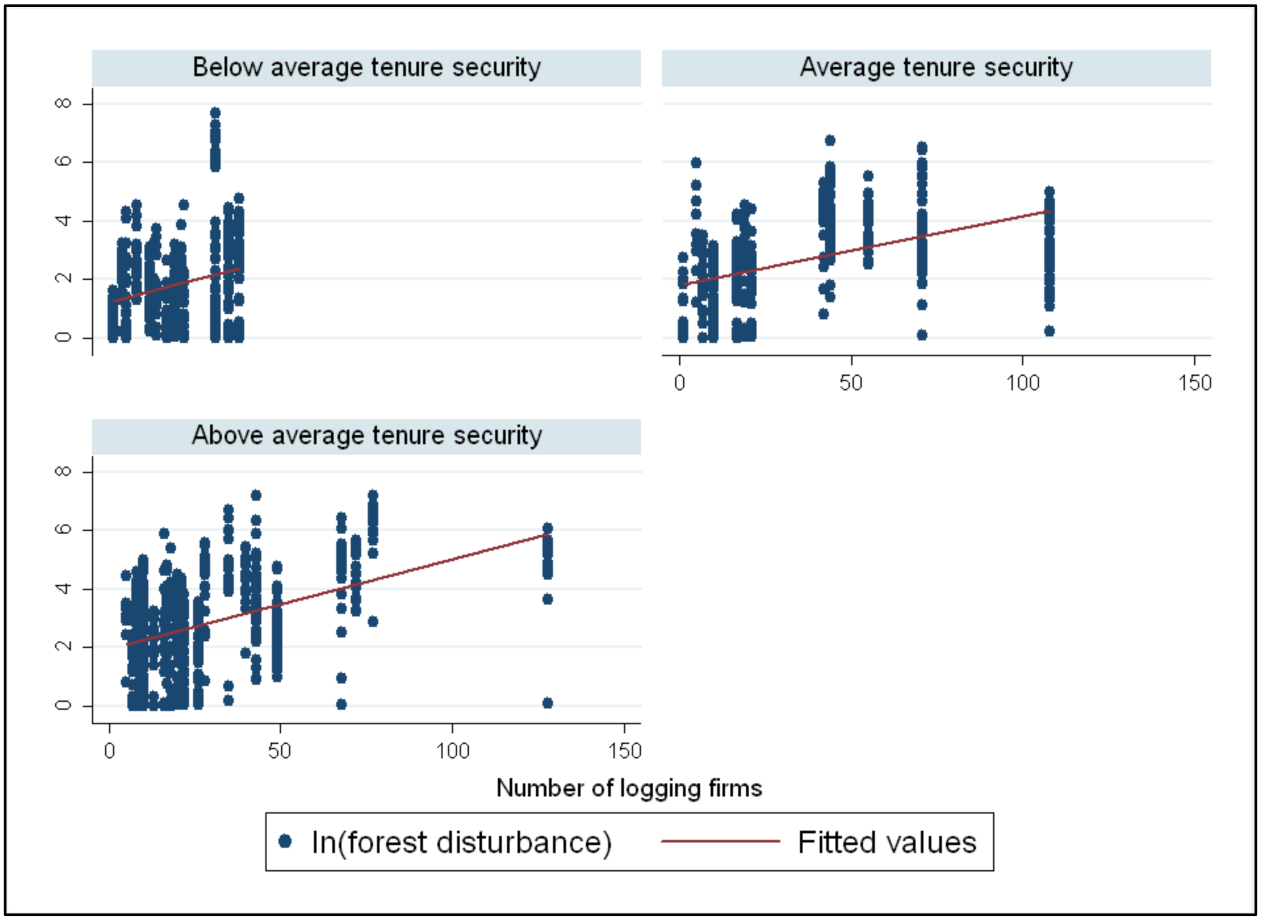

Figure 4. The effect of firms on forest disturbance across tenure security groups

Our econometric results also indicate that transportation costs play a large and significant role on where forest harvesting occurs in European Russia, and that this effect has changed over time. We find that district-level road density has a positive impact on logging rates overall but that the difference across time periods is not significant. Being located further away from a major market had an overall positive effect on harvesting rates but over time there has been a shift toward districts closer to major markets. These results tentatively suggest that timber harvesting has become more responsive to economic conditions and that prices and costs factor into timber industry decisions. The magnitude of the coefficient on road density, when significant, is much larger than any other variable in the analysis, including distance, suggesting that an increase in transportation infrastructure in European Russia would probably greatly increase the amount of logging.

VII. Conclusion

In this study we examined the drivers of timber harvesting in the first fifteen years following the transition to private timber management in European Russia. We found that political and economic variables play a significant role in the amount of timber being harvested across districts and where timber was being harvested conditional on biophysical resources. We also found that responsiveness to neoclassical variables in harvesting decisions has increased slightly over time. If Russia is interested in increasing the output of the timber industry, improvements in transportation infrastructure would be the most straightforward and significant investment. Revisions to the latest Forest Code in 2007 focus exclusively on the content of property rights (Torniainen 2009) but our analysis suggests that investing in institutions that assure property rights would also bring greater efficiency to the timber industry. Improving government integrity and tenure security is obviously a more long-term process.

While this analysis was focused on Russia, the causal link between tenure security and timber investments is important for other countries. A growing body of literature shows the importance of assurance of rights for investments in natural resource use – this can be for conservation or extractive purposes (Bohn and Deacon 2000; Deacon and Muller 2003; Ferreira and Vincent, *in press*; Arnot et al., *forthcoming*). In many timber-rich countries, government integrity and stability is weak and can impact the efficient allocation of forest resources. This research provides further evidence that for capital-intensive natural resource use – industrial logging – improving tenure security can increase investments. This result also implies that restructuring property rights through privatization rules or through formal titles alone is not the sole solution to improving economic efficiency. Without supporting mechanisms and institutions, changes to the content of property rights cannot have their intended effect. Finally, this study provides evidence that assurance of property rights, and thus natural resource outcomes, can vary widely within the same country. This has implications for natural resource use as several forest-rich countries experiment with decentralization of natural resource governance and provides some understanding on why decentralization has had such mixed impacts on resource management: the integrity of local governance systems and incentives to promote efficient resource use will vary across local political units leading to different outcomes.

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References

Acemoglu, Johnson, and Robinson. 2002. Reversal of Fortune: Geography and Institutions in the Making of the Modern World Economy. *Quarterly Journal of Economics* 117(4): 1231-1296.

Anselin, L. 2002. Under the Hood: Issues in the Specification and Interpretation of Spatial Regression Models. *Agricultural Economics* 27: 247-267.

Arnot, C., Luckert, M.K., and P.C. Boxall. *Forthcoming*. What is tenure security? Conceptual implications for empirical analysis. *Land Economics*.

Barbier, E.B., Damania, R., and D. Léonard. 2005. Corruption, trade, and resource conversion. *Journal of Environmental and Economic Management* 50:276-299.

Berkowitz, D. and D.N. DeJong. 2002. Accounting for growth in post-Soviet Russia. *Regional Science and Urban Economics* 32: 221-239.

Binkley, C.S. 1987. Economic models of timber supply. In: Kallio, M., Dykstra, D., Binkley, C.S. (eds) The global forest sector: an analytical perspective. John Wiley & Sons, Chichester, UK.

Bohn, H., Deacon, R.T. 2000. Ownership risk, investment, and the use of natural resources. *American Economic Review* 90:526-549.

Boreal Forest Monitoring project website. Geographic Information Science Center for Excellence, South Dakota State University. Online: http://globalmonitoring.sdstate.edu/projects/boreal/index.html

Cameron, A.C. and P.K. Trivedi. 2005. Microeconometrics: Methods and applicatons. Cambridge Press.

Conrad, J.M. 1999. Resource Economics. Cambridge University Press.

Dasgupta, P.S., Heal, G.M. 1979. Economic theory and exhaustible resources. Cambridge University Press, Cambridge UK.

Deacon, R.T. 1994. Deforestation and the rule of law in a cross-section of countries. *Land Economics* 70(4): 414-430.

Deacon, R.T. 1999. Deforestation and ownership: evidence from historical accounts and contemporary data. *Land Economics* 75(3): 341-359.

Deacon, R.T. and B. Mueller. 2003. Political Economy and Natural Resource Use. In: Lopez, R., Toman, M.A. (eds) Economic Development and Environmental Sustainability: new policy options. Oxford University Press, UK.

Eikeland, S., Eythorsson, E., and Ivanova, L. 2004. From management to mediation: local forestry management and the forestry crisis in post-socialist Russia. *Environmental Management* 33: 285-293.

FAO. 2005. Global Forest Resources Assessment. Online: http://www.fao.org/forestry/fra/fra2005/en/

Ferreira, S. and J.R. Vincent. *In press*. Governance and Timber Harvests. *Environmental and Resource Economics*.

Gaddy, C.G. and B.W. Ickes. 2002. Russia's virtual economy. Brooking Institution Press.

Hanson, P. and M. Bradshaw. 2000. Regional Economic Change in Russia. Edward Elgar Publishing.

IIASA (International Institute for Applied Analysis) website. "Institutions and the Emergence of Markets – Transition in the Russian Forest Sector". Online: http://www.didaktekon.se/mats/ii-publ.htm

Kaufmann, D., Kraay, A., and M. Mastruzzi. 2005.Governance matters IV: Governance indicators for 1996-2004. World Bank Policy Research Working Paper 3630.

Kennedy, P. 1981. Estimation with Correctly Interpreted Dummy Variables in Semilogarithmic Equations. *American Economic Review* 71, p.801.

Knack, S. 2002. Governance and growth: measurement and evidence. Paper presented at forum series on the role of institutions in promoting economic growth, IRIS Center, University of Maryland, College Park, February 25, 2002.

Knack, S. and P. Keefer. 1995. Institutions and economic performance: cross-country tests using alternative institutional measures. *Economics & Politics* 7:207-227.

Kortelainen, J. and Kotilainen, J. 2003. Ownership Changes and Transformation of the Russian Pulp and Paper Industry. *Eurasian Geography and Economics* 44(5): 384-402.

Krott, M, I. Tikkanen, A. Petrov, Y. Tunystsya, B. Zheliba, V. Sasse, I. Rykounina, and T. Tynytsya. 2000. Policies for Sustainable Forestry in Belarus, Russia and Ukraine. European Forest Institute Research Report No. 9. Koninklijke Brill NV, Leiden.

Laestadius, Lars. Personal communication, November 1, 2009. World Resources Institute.

Lerman, Z., C. Csaki, and G. Federer. 2004. Evolving farm structures and land-use patterns in former socialist countries. *Quarterly Journal of International Agriculture* 43:309-335.

Libman, A. 2010. Democracy, Size of Bureaucracy, and Economic Growth: Evidence from Russian Regions. Electronic copy available at: http://ssrn.com/abstract=1576442.

Olsson, Mats-Olov. 2004. Barriers to Change? Understanding the Institutional Hurdles in the Russian Forest Sector. Licentiate Thesis in Political Science (2004:79). Lulea: Lulea University of Technology (203 pp.).

Olsson, Mats-Olov. 2008. Continuity and Change: Institutions and Transition in the Russian Forest Sector. Doctoral Thesis in Political Science (2008:32). Lulea: Lulea University of Technology (253 pp.).

Nysten-Haarala, S. 2001. Russian property rights in transition. International Institute for Applied Systems Analysis Interim Report IR-01-006.

Petrov, N. 2005. Demokratichnost' Regionov Rossii, Moscow Carnegie Center Briefing 7.

Potapov P., Turubanova S., Hansen M.C. I*n review*. Regional-scale boreal forest monitoring using Landsat data composites: first results for European Russia. *Remote Sensing of Environment*.

Serebryanny, L., and I. Zamotaev. 2002. Deforestation and degradation of forests. In: Shahgedanova, M. The physical geography of northern Eurasia. Oxford University Press, pp. 511-526.

Slinko, I., Yakovlev, E. and E. Zhuravskaya. 2005. Laws for Sale: Evidence from Russia. *American Law and Economics Review* 7(1): 284-318.

Snijders, T.A.B., Bosker, R.J. 1999. Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modelling. Sage, New York.

Stoner-Weiss, K. 1997. Local Heroes. Princeton University Press.

Torniainen, T.J., O.J. Saastamoinen, and A.P. Petrov. 2006. Russian forest policy in the turmoil of the changing balance of power. *Forest Policy and Economics* 9(4): 403-416.

Torniainen, T. 2009. Institutions and forest tenure in the Russian forest policy. Dissertationes Forestales 95. Finnish Society of Forest Science, Vantaa, Finland.

Yakovlev, E. and E. Zhuravskaya. 2004. State Capture: From Yeltsin to Putin. CEFIR Working Paper.

Yakovlev, E. and E. Zhuravskaya. 2008. Reforms in Business Regulation: Evidence from Russia. Working Paper. Online at: http://www.hse.ru/data/353/229/1237/paper-Zhuravskaya.pdf

Yaroshenko, Alexey. Personal communication, August 01, 2009. Greenpeace Russia, Moscow.