Resource Demand Changes and Spatial Development: Evidence from Above

Alexander Pearson

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Abstract

This paper analyzes the effects of recent demand changes to various resource commodities on the spatial development, at a district level, of resource abundant locations across 250 countries. Using night time luminosity data from 1992 to 2013 and identifying over 350 000 resource locations around the world, I track the prices of these commodities and use first difference estimation with interaction and fixed affects to determine the extent of growth to districts with various degrees of resource abundance.

1 Introduction

The growth of developing economies like China can be felt significantly on the world economy, most specifically on resource locations that are attempting to quench the demand for materials that they need to build manufactured goods and large scale infrastructure projects. For instance, Iron ore production tripled between 1992 and 2013 and at the same time prices went from a stable 33 USD per dry metric ton (dmtu) in 1992 to 151 USD/dmtu in 2008 until coming down to 127 USD/dmtu in 2012. Local and national governments that are endowed with an abundance of resources are deeply interested in the regional effects that this phenomenon will bring. However, whether resource abundance is a facilitator or hindrance to economic development, both at a country and local level, is still being debated with no clear consensus of evidence.

This paper provides a different approach to measuring the effects of resource abundance on development and is able to look at both between and within countries, a task that had been difficult to study due to data constraints. This allows for the control of country and time specific non observables, such as technologies and institutions that cannot be done at the country level while also allowing for regional analysis to study the agglomeration effects indirectly such as from migration or industrial reorganization. Instead of using income data, population data or capital investment data which are rarely collected at a consistent rate, if at all, for many countries that are of interest, I use night time luminosity data from 1992 to 2013 which has been demonstrated to be a adequate alternative to measure GDP growth when no other data is available (Henderson et al. 2012). In order to quantify the level of abundance a district has in resources, I use spatial data from the United States Geological Survey (USGS) that has surveyed 305 000 different resource locations documenting size, type of resource, and operational activity. Using pricing data from the World Bank Commodity Price data I then estimate the interaction effects of prices, given a level of resource abundance, on yearly night time luminosity. As an alternative exercise (forthcoming), I instead look at 10,000 cities and towns around the world and track there development in relation to there local abundance and price changes.

The organization of this paper is as follows: The next section provides a brief introduction to the literature review related to this paper. Section 3 will discuss the data used while section 4 provides the empirical strategy. Section 5 describes the results and section 6 concludes.

2 Literature Review

The question of whether an areas resource endowment helps or hinders its development has been debated for over 100 years[1] in recent times the idea became again popular with the work of Sachs and Warner (1995, 2001) who showed that countries that had higher resource dependency as a fraction of their GDP would have lower growth than those with lower resource dependence. Similar results were shown by Engerman et al 1997, Sala-i-Martin et al (2004), Melhum et al (2007) and Humphreys et al. (2007). However, a large amount of literature has come out arguing against the idea of resource being a curse to the economy. Manzano and Rigobon (2007) provide 2 issues that they find in the resource curse literature. The first was, if using a cross section of the data, individual country characteristics that may be unobservable could be correlated with the independent variables leading to biased estimates. They provide a 2 time and 4 time data set to control for country fixed effects and find that the negative effects of resources disappear[2] . Secondly, the measure of GDP which is what the majority of these studies use as their dependent variable, includes the resource sector that can create a false relation between resource endowments and growth" Brunnschweiler and Bulte (2008) also note that using the resource dependency, measured by exports of resources over total GDP, leads to endogeneity issues and using stock based measurements of resources would be superior.

More recently, studies have been analyzing how the resource curse can effect regional development using individual countries with, again, conflicting results. Papyrakis, E. and Gerlagh (2007) find that natural resource abundance decreases local investment, schooling and openness when looking at American States. Galina

[1]Adam Smith mention would be the first to be recorded discussing this issue. Later a series. more recently theories for resources causing harm to an economy were argued by Watkins (1963), Corden and Neary (1982) and Auty, R. (1993)

[2]Manzano and Rigobon (2007) are unable to add more time elements due to data constraints for the majority of countries. Collie and Goderis (2012) also provide a panel data approach and find short term gains and long term losses from non agriculture commodities. However this paper also runs into the endogeniety problem of having the dependent variable being a function of resource shares

Ivanova (2014), looking at regions in Queensland Australia, found that the majority of revenue obtained from mining would go to other major metropolitan areas and in some places reduce diversification and forward and backward linkages to other regions. There has also been evidence however that resource endowments actually benefit local regions. Micheals (2011) finds that regions in the southern states of the U.S that had large amounts of oil reserves had higher growth and increased manufacturing employment along with better infrastructure. Domenech (2008) showed that regions in Spain were benefited in regards to industrialization from having higher values of mineral endowments between 1860 and 1936. One negative of looking at regional development with a single country is that the results are difficult to apply to other countries due to country specific observed and unobservable characteristics [3]. This paper will allow for both country-time varying unobservables while still analyzing development changes at a local level for all countries.

Another related field is the literature on short run demand shocks on country and regional development. Examples include Black et al. (2005) who look at the boom, peak and bust of the coal mining industry in 4 U.S states finding positive spillover affects to other districts but no evidence of negative spillover effects. Addison et al (2014) look at commodity pricing shocks in 14 South Saharan Africa countries and estimate, using vector autoregressions, the asymmetric response that prices could have on per capita incomes. Little evidence was found that either unexpected increases or decreases in commodity prices affected per capita income. Collie and Goderis (2012) also use vector autoregression models on a larger sample and longer time period (45 year) and find that positive commodity price shocks have short term benefits and long term consequences at the country level.

[3] There are several more benefits to looking at single country cases by being able to disentangle some of the mechanisms behind how resource endowments affect regional development that this paper has to abstract from. For instance, Borge, Parmer and Torvik (2015), observing resource revenue to local governments from hydro power in Norway found that regions with higher hydro revenue had less efficiency in producing public goods a term they call the paradox of plenty, but find no evidence that the revenue from hydro power causes any less efficiency than from other revenue sources such as taxes.

Lastly, this paper is also related to studies of agglomeration effects of towns and cities Rosenthal and Strange (2004) and Duranton and Puga (2004) provide good surveys of the literature.

3 Data

As mentioned in the preceding section, using resource income as an explanatory variable to explain economic growth can lead into endogeneity issues and, as Brunnschweiler and Bulte (2008) suggest, using stock measures for resource abundance mitigates this problem. Therefore, to identify each district's resource abundance I use the United States Geological Survey's (USGS) Mineral Resource Data System (MRDS) that contains 305 000 different resource locations around the world (USGS 2005). These locations are broken down into over 30 different commodities and provide details on whether the area was a past producer, current producers, occurances not yet actively mined upon, and refining locations. For many of these locations they also provide the size of the resource area whether small medium or large. For this study I include only the top 9 mineral resources. These being iron, copper, aluminum, tin, zinc, nickel, coal, gold and silver.

To capture administrative areas within each country I use the Global Administrative areas (GADM) shapefile for the entire world. These administrative areas are organized by Country(admin 0) State (admin 1) and district/county (admin 2). For this analysis I will be choosing the district/county administrative area. This strategy will allow me to use country-year and if necessary state-year fixed effects [4]. For the alternative analysis using cities and towns, I use Esri's worlds populated areas that contains 10,000 populated.

To proxy for GDP growth I use the Defense Meteorological Satellite Program's

[4]Using both country and state level fixed effects would result in much more explanatory variables for little gain since many of the state fixed effects will be absorbed from the country fixed effects. Therefore for the estimation I will be using country-year fixed effects

(DMPS) Operational Linescan System (OLS) which was primary used to detect cloud cover but also captures light emitted from human activity proceeding sunsets. This data is available yearly from 1992 to 2013 and will be the time period of analysis. The cell size are 30 arc seconds or roughly 1 kilometer by 1 kilometer. Each cell contains a value between 0 and 63 with 0 representing zero light emission and 63 being the brightest that the satellite can measure.

4 Empirical Implementation

To analyze the effects of resource abundance with exogenous prices changes on economic growth I begin with a series of first difference estimation regressions that also include country-time fixed effects that build in detail.

4.1 Aggregated Resources

The first specification will aggregate all 9 resources into one variable abstracting from differences in types of resources. World prices for all commodities will be the weighted average of each commodity price with the fraction of total value of all minerals. This allows the ability to account for some mineral products who may potentially have more significance than comparatively less economically important minerals. Therefore let,

$$y_{i,t} = \beta_0 M_i^{tot} + +\beta_1 (P_{t-1}^{ind} * M_i^{tot}) + \phi_{c,t} + \alpha_i + \epsilon_{i,t} \tag{1}$$

where $y_{i,t}$ is log sum of light in district i at time t, P_t^{ind} is the price index, M_i is the number of resource producers contained within the district and $P_t^{ind} * M_i^{tot}$ is the interaction effect between resource abundance and prices $\phi_{c,t}$ is a vector of country and year interaction dummies along with there coefficients to control for country-time fixed effects, α_i is the unobserved heterogeneity and $\epsilon_{i,t}$. I do not include P_t^{ind} itself since this will be absorbed by the country-year fixed effects $\phi_{c,t}$. Applying first differences gives

$$y_{i,t} - y_{i,t-1} \equiv \Delta y_{it} = +\beta_1(\Delta P_{t-1}^{ind} * M_i^{tot}) + \tilde{\phi}_{c,t} + \Delta\epsilon_{i,t}. \tag{2}$$

I also include further price lags to equation 2 and the proceeding equations but leave them out here for ease of interpretation.

4.1.1 Asymmetric Effects

To allow for possible asymmetries of price effects, I split ΔP_{t-1}^{ind} into two groups. Let

$$\Delta P_{t-1}^{ind+} = max[0, \Delta P_{t-1}^{ind}].$$
$$\Delta P_{t-1}^{ind-} = min[0, \Delta P_{t-1}^{ind}].$$

I can then rewrite equation 2 as

$$\Delta y_{i,t} = \beta_1(\Delta P_{t-1}^{ind+} * M_i^{tot}) + \beta_2(\Delta P_{t-1}^{ind-} * M_i^{tot}) + \tilde{\phi}_{c,t} + \Delta\epsilon_{i,t}. \tag{3}$$

4.2 Multiple Resource Specification

Disaggregating mineral types gives the benefit of knowing what resources have greater effect to local development than others, if any at all. This also alleviates any possible measurement error due to the construction of the price index created in section 4.1. Given the 9 mineral products denoted as $s \in S$ I can rewrite equation 2 to be

$$\Delta y_{i,t} = \sum_{s=1}^{S} \beta_1^s(\Delta P_{t-1}^s * M_i^s) + \tilde{\phi}_{c,t} + \Delta\epsilon_{i,t} \tag{4}$$

This again can be split among positive and negative price changes to determine asymmetries of the effect on light growth. Furthermore, growth of previous years may be strongly correlated with growth in the current year. Therefore I add to equation 4 lagged light growth so that.

$$\Delta y_{i,t} = \beta_1 \Delta y_{i,t-1} + \sum_{s=1}^{S} \beta_2^s (\Delta P_{t-1}^s * M_i^s) + \tilde{\phi}_{c,t} + \Delta \epsilon_{i,t} \tag{5}$$

This of course leads to endogeneity problems since $\epsilon_{i,t-1}$ shows in both $y_{i,t}$ and $y_{i,t-1}$ so that $E[\Delta y_{i,t-1}, \Delta \epsilon_{i,t}] \neq 0$. To account for this, I follow the suggestions of Arellano and Bond (1991) and use $y_{it-2}, y_{it-3}, \ldots$ as instruments.

An issue arises when adding in country-year fixed effects with the explanatory variables leads to a high dimensional matrix that needs to be inverted which can be computationally difficult. As a solution, I implement the algorithm of Guimaraes and Portugal (2010) that converges to the solution instead of inverting a large matrix full of dummy variables.

4.3 Identification

A number of different identification issues arise when using mining location data and night time luminosity satellite data to determine growth from resource abundance. The first issue is that mining locations emit large amounts of light. Therefore increased mining activity will increase the total light in a district regardless of how mining activity affects the overall local economy. To account for the unwanted light I used the spatial location of the mineral resources and create buffer regions around each. I then erase the light data that are contained within the buffered region, leaving presumably all other economic activity in the region. I use various buffer distances for robustness 4km 6km and 10km. This does create possibilities where these buffer areas erase light data other than mining activity such as towns and cities. There is also still an issue that not all mines or resource areas are documented in the area. If these are randomly distributed the estimates would not be biased. However, if these unobserved mines are strongly correlated to past and existing mines then the effect of resource abundance will be biased upwards since these unobserved mines will not be erased from the light data. A supplemental approach that I incorporate(forthcoming) is to look at populated areas using Esri spatial data for cities and Natural Earth's population areas derived from census data and Landscan satellite imagery. This allows the collection of light growth specifically at cities and towns that will be able to disregard mines that are predominately found farther from the cities [5]

Another potential concern could be that mines become shut down and new ones emerge within the time period of study. Accounting for this (forthcoming), I split the time periods into 3 groups. For 1992 to 1998, I use past producers as the active mines. For 1999 to 2006 I use current producers and for 2006 to 2013 I use occurrences. Lastly, the effects of China's investment and growth, potentially in areas with mining activity may be affecting world prices by themselves. For this reason I provide estimations that exclude Chinese districts [6]

5 Results

Following the same structure as section 4, Table I begin with showing the results when aggregating all mineral products together and using a price index found in 1 . Regressing log interaction between prices and number of mines on total light growth as in Columns 1 through 3 there is a clear negative relation when looking at the aggregate. Using column 3, a 10 percent increase in output per mine two years ago leads to a .023 percent decrease in light compared to other districts in their country. Columns 4 through 6 include lagged light growth which shows that districts that had high light growth the prior year on average see a decrease in growth the current year. Also, while in lagged light growth does not change the significance of the neg-

[5]Using ArcGIS software, I can measure the distances from cities and towns to mines where. This will allow me to exclude towns that have mines too close to where they obstruct their light emission.

[6] I also exclude the U.S along with China for concerns that they could influence world prices from investments or growth in mining districts

ative relationship of light growth and Mine*Price, it does decrease the magnitude. Columns 7 through 9 remove China and the U.S from the estimation with similar results.

Table 2 splits prices into positive and negative growth periods. Positive price changes see a consistent negative relationship especially short term. However there appears to be evidence for a positive relationship when looking at negative price changes. Using column 9 we see that the lagged negative price changes have a higher magnitude effect on light growth than lagged positive price changes. One explanation for this is that when prices increase, part of the revenue from mining activity goes to major metropolitan areas as suggested by (Galina 2014). The remainder is distributed to miners and and other operators located in populated areas close to the mine but this too could leave the mining cities since many miners relocate and send money back to their prior location where they will return to. However when prices fall it may lead to mass lay offs that affect how many people are living in these communities near mining areas.

The next pair of tables breaks down the estimation by resource type using prices for each resource instead of an index. The clear picture that resource abundance of a district had adverse effects to the areas economic growth soon breaks down when taking into account resource type. Table 3 shows the price effect of various resource abundant areas that include Iron, Copper, Tin and Zinc. Table 4 break resources down into Nickel, Silver Aluminum, Gold, and Coal. We see that the resources that were having a negative economic impact on districts when prices rose were primarily gold, silver, tin, Zinc and to some extent copper and coal. However both Iron and Nickel have positive and significant coefficients.

6 Conclusion

Although the resource curse has been challenged at an international level, local effects of resource activity is much less understood. This paper shows how it is important to distinguish what type of resource you are concerned with and that resource extraction may not, on average provide a boost to economic activity to mining communities compared to other regions in their countries. For further work on this topic, I plan to incorportate a city analysis to pinpoint exactly where population centers are and see how these areas get affected. I also want to use production changes instead of price changes to see if the outcomes remain the same.

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Table 1: Growth of total light from price changes and resource abundance: Aggregated Resource

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Diff_logMinePrice_intLag1	-0.00422***	-0.00517***	-0.00538***	-0.000339	-0.00141**	-0.00151**	-0.000409	-0.00103	-0.000779
	(-6.95)	(-7.38)	(-7.24)	(-0.64)	(-2.32)	(-2.34)	(-0.65)	(-1.41)	(-1.01)
Diff_logMinePrice_intLag2		-0.00193***	-0.00233***		-0.00215***	-0.00233***		-0.00125*	-0.000723
		(-2.76)	(-2.72)		(-3.54)	(-3.13)		(-1.71)	(-0.81)
Diff_logMinePrice_intLag3			-0.000605			-0.000275			0.000768
			(-0.81)			(-0.43)			(0.99)
Diff_logSumLightLag1				-0.498***	-0.498***	-0.498***	-0.498***	-0.498***	-0.498***
				(-576.85)	(-576.80)	(-576.68)	(-554.24)	(-554.18)	(-554.06)
Exclude China & U.S	No	No	No	No	No	No	Yes	Yes	Yes
N	1013410	1013158	1012906	1013410	1013158	1012906	936590	936340	936090
R^2	0.000	0.000	0.000	0.248	0.248	0.248	0.248	0.248	0.248

The dependent variable is growth in log sum of light from 1992 to 2013 with mineral resources aggregated into one measure. All estimates use country-year fixed effects and clustered standard errors at the state. Significance levels are: * 0.10, ** 0.05, *** 0.01.

Table 2: Growth of total light from price changes and resource abundance: Aggregated Resource with positive and negative price change measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
logMinePrice_int_posLag1	-0.00868***	-0.00868***	-0.00878***	-0.00428***	-0.00435***	-0.00437***	-0.00536***	-0.00529***	-0.00510***
	(-9.25)	(-9.24)	(-9.31)	(-5.31)	(-5.38)	(-5.39)	(-5.71)	(-5.63)	(-5.42)
logMinePrice_int_negLag1	0.000115	0.000372	-0.000198	0.00352***	0.00189	0.00197	0.00440***	0.00581***	0.00794***
	(0.12)	(0.26)	(-0.13)	(4.36)	(1.54)	(1.50)	(4.69)	(3.61)	(4.57)
logMinePrice_int_posLag2		0.000465	0.0000718		-0.00215*	-0.00198		0.00152	0.00349**
		(0.33)	(0.05)		(-1.76)	(-1.53)		(0.95)	(2.04)
logMinePrice_int_negLag2		-0.000633	-0.00227		-0.000134	-0.000340		0.00121	0.00541***
		(-0.67)	(-1.51)		(-0.17)	(-0.26)		(1.29)	(3.16)
logMinePrice_int_posLag3			-0.00268*			-0.000783			0.00466***
			(-1.75)			(-0.59)			(2.69)
logMinePrice_int_negLag3			0.00251***			0.00229***			0.00269***
			(2.66)			(2.82)			(2.85)
Diff_logSumLightLag1				-0.499***	-0.499***	-0.498***	-0.498***	-0.498***	-0.498***
				(-593.04)	(-592.99)	(-592.87)	(-571.16)	(-571.09)	(-570.98)
Exclude China & U.S	No	No	No	No	No	No	Yes	Yes	Yes
N	1013410	1013158	1012906	1013410	1013158	1012906	936590	936340	936090
R^2	0.048	0.048	0.048	0.295	0.295	0.295	0.299	0.299	0.299

The dependent variable is growth in log sum of light from 1992 to 2013 with mineral resources aggregated into one measure. All estimates use country-year fixed effects and clustered standard errors at the state. The type of estimator used for these regressions was first difference. Significance levels are: * 0.10, ** 0.05, *** 0.01.

Table 3: Growth of total light from price changes and resource abundance: By resource type

	(1)	(2)	(3)
logIron_intLag1	0.0000276***	-0.00000371	-0.00000386
	(6.56)	(-0.85)	(-0.89)
logCopper_intLag1	0.000000832***	0.000000907***	0.000000907***
	(11.90)	(12.82)	(12.82)
logTin_intLag1	-0.000000531***	-0.000000675***	-0.000000678***
	(-3.35)	(-4.00)	(-4.02)
logZinc_intLag1	-0.00000561***	-0.00000507***	-0.00000507***
	(-8.62)	(-7.51)	(-7.52)
logIron_intLag2		0.0540***	0.0445***
		(26.66)	(7.14)
logCopper_intLag2		-0.00414***	0.00201
		(-3.78)	(0.56)
logTin_intLag2		0.0116***	0.00736
		(5.67)	(1.15)
logZinc_intLag2		-0.00436**	-0.0129**
		(-2.26)	(-2.14)
logIron_intLag3			0.0100
			(1.62)
logCopper_intLag3			-0.00643*
			(-1.79)
logTin_intLag3			0.00441
			(0.70)
logZinc_intLag3			0.00897
			(1.50)
N	1013913	1013912	1013911
R^2	0.674	0.675	0.675

The dependent variable is growth in log sum of light from 1992 to 2013 with mineral resources not aggregated . All estimates use country-year fixed effects and clustered standard errors at the state. Significance levels are: * 0.10, ** 0.05, *** 0.01.

Table 4: Growth of total light from price changes and resource abundance: By resource type

	(1)	(2)	(3)
logNickel_intLag1	0.000000679***	0.000000139	0.000000140
	(4.13)	(0.78)	(0.79)
logSilver_intLag1	-0.000465***	-0.000353***	-0.000353***
	(-15.19)	(-11.26)	(-11.27)
logAluminum_intLag1	0.00000453***	-0.00000325***	-0.00000325***
	(6.53)	(-4.36)	(-4.35)
logGold_intLag1	-0.000000381***	-0.000000292***	-0.000000291***
	(-7.30)	(-5.52)	(-5.50)
logCoal_intLag1	-0.000131	0.000140	0.000140
	(-0.79)	(0.73)	(0.73)
logNickel_intLag2		0.0211***	0.0243***
		(10.38)	(3.92)
logSilver_intLag2		-0.0786***	-0.0600***
		(-17.34)	(-4.22)
logAluminum_intLag2		0.0371***	0.0383***
		(22.39)	(7.25)
logGold_intLag2		-0.0154***	-0.0173***
		(-12.53)	(-4.20)
logCoal_intLag2		-0.0418***	-0.0455
		(-3.32)	(-1.31)
logNickel_intLag3			-0.00333
			(-0.54)
logSilver_intLag3			-0.0193
			(-1.37)
logAluminum_intLag3			-0.00124
			(-0.24)
logGold_intLag3			0.00210
			(0.51)
logCoal_intLag3			0.00398
			(0.12)
N	1013913	1013912	1013911
R^2	0.674	0.675	0.675

The dependent variable is growth in log sum of light from 1992 to 2013 with mineral resources not aggregated. All estimates use country-year fixed effects and clustered standard