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Resource dependence and the causes of local economic growth: An empirical investigation*

Rian Hilmawan and Jeremy Clark †

Previous research has found that regional resource dependence in Indonesia has been positively associated with income growth, contrary to a 'resource curse'. We test five potential causal mechanisms for this positive effect: spillovers to manufacturing or to agriculture, higher education provision, improved institutional quality and share of public spending on capital. We follow 390 Indonesian districts from 2006 to 2015, using four alternative resource dependence measures, and instrumenting for their potential endogeneity. We first confirm a positive overall effect of resource dependence on real per capita Gross Regional Domestic Product (GRDP), then test whether district resource dependence positively affects manufacturing, agriculture, education, public capital investment and institutional quality. We finally test whether these factors contribute to GRDP while reducing the remaining effect of resource dependence. We find that resource dependence may aid income in part by raising district institutional quality, which in turn raises GRDP. We also find little support for a 'contingent curse' hypothesis that resource dependence only benefits districts that already have higher institutional quality.

Key words: causal channels, economic growth, institutional quality, resource dependence.

JEL classifications: Q32, Q33, Q38, O13, O43, O47

1. Introduction

There has been ongoing debate whether resource endowments help or hinder economic growth. Traditionally, economic theory assumed resource endowments would benefit a country's economy, either as a source from which to transform economic structures, or as a key input in long-term output (North 1982; Rostow 1959). Yet, after Sachs and Warner (1995, 1999) found a negative correlation between resource dependence and growth in income per

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†Rian Hilmawan is Lecturer at the Department of Economics, Faculty of Economics and Business, Mulawarman University, Samarinda 75119, Indonesia. Jeremy Clark is Associate Professor at the Department of Economics and Finance, University of Canterbury, Private Bag 4800, Christchurch, New Zealand.

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capita, researchers began to investigate a 'resource curse', and transmission channels through which it might operate.

Following conflicting findings, surveys and individual studies have recommended that researchers address the likely endogeneity of resource measures, and unobserved heterogeneity between countries using within-country studies (Aragon *et al.* 2015; Cust and Poelhekke 2015; van der Ploeg 2011; Papyrakis 2016; van der Ploeg and Poelhekke 2016). Many, though not all, within-country studies have found a positive effect of resource dependence (RD) on income (see, e.g., Fleming and Measham 2014 and Fleming *et al.* 2015 for Australia, Case lli and Michaels 2013 for Brazil; Fan *et al.* 2012 for China; and Aragón and Rud 2013 for Northern Peru, with contrary findings for the United States by Papyrakis and Gerlagh 2007 and Douglas and Walker 2016).

Indonesia is a vast South-East Asian developing country that is a major producer and exporter of non renewable resources.[1] The size and variation in RD across Indonesia, coupled with improved availability of its district level data since decentralisation between 1999 and 2004, make it an excellent test case for RD effects. Cust and Rusli (2014) and Hilmawan and Clark (2019), using panel regression and instruments, have found that district government revenues from oil and gas or overall mining's share in district gross regional domestic product (GRDP) are positively associated with real per capita income. While Cust and Rusli distinguish the effects of oil extraction on oil vs. non-oil GDP, neither paper tests more broadly for the causal channels by which RD raises income.

Various causal channels have been proposed through which RD may harm (or advance) economic growth, though fewer studies have sought to test between them. Channels proposed (historically for a resource curse) include 1) crowding out other tradeable sectors (e.g. manufacturing or agriculture) that better aid long run growth, 2) depressing education demand, 3) depressing institutional quality and 4) providing incentives for lower quality public spending (Bhattacharyya and Collier 2014; Collier and Goderis 2009; Karimu *et al.* 2017). Research has been inconclusive about whether RD affects growth through these channels. Some argue negative effects are more likely in developing rather than developed countries (Arezki and van der Ploeg 2011; Frankel 2010). Perhaps a state's pre-existing institutional quality determines whether RD aids or hinders growth – a 'contingent curse'.

This paper's contribution is to test whether the five causal mechanisms above explain the positive effect of RD on Indonesian per capita income found by Cust and Rusli (2014) and Hilmawan and Clark (2019). We do this to better predict the means through which RD will be a blessing, curse, or some of each. This in turn can assist governments in resource abundant countries set in place broader policies beyond resource taxation to maximise

[1] It is the world's 7th largest producer of mineral fuels, 6th largest of coal and 10th largest of natural gas (Brown *et al.* 2017; ICC 2013; Indonesia PwC 2018; World Mining Data 2018).

gains from their resource endowments. Methodologically, we continue the literature's recent practice of using panel methods, multiple dependence measures and instruments. We also test the 'contingent curse' hypothesis.

The paper is structured as follows. Section 2 reviews the five potential transmission channels between RD and income. Section 3 describes our data and estimation strategy, while Section 4 provides results. Section 5 concludes.

2. Literature review

We survey here papers that have used theory or empirics to identify five causal channels through which RD may affect growth. Note that other channels have also been proposed, such as resource price volatility, loss of learning by doing in tradeable sectors, presidential vs. parliamentary democratic governance and others (see Van der Ploeg 2011), but we focus here on factors found important across a variety of studies.

2.1 The dutch disease

An early explanation for RD's negative income effects was the 'Dutch disease', or that resource booms can cause currency and wage appreciation that crowds out a country's other tradeable sectors like manufacturing or agriculture, whose expansion would otherwise generate greater long run growth.

Evidence for crowding out has often come from cross-country comparisons of resource production and the performance of manufacturing or sometimes agriculture. Stijns (2005) for example finds that higher oil and gas reserves are associated with a smaller proportion of manufacturing in exports. In a within-country study of Canada, Papyrakis and Raveh (2014) find that oil, gas and mineral production are negatively associated with growth in non-mineral exports. In Brazil, Cavalcanti *et al.* (2019) find that the share of employment in agriculture is negatively affected by the oil sector, while in the Middle East and North Africa Apergis *et al.* (2014) find value added from agriculture is similarly affected.

Other researchers, however, find no crowding out. Bulte *et al.* (2005) find cases where during oil booms resource-rich countries experience expansions in manufacturing. Van der Ploeg (2011) finds crowding out less likely in a country that initially has a relatively low share of manufacturing in GDP. Sala-i-Martin and Subramanian (2013), using Sachs and Warner's original data, do not find clear positive or negative associations between country RD and manufacturing's share of GDP. Contrary evidence is especially common in within-country studies. Estrades *et al.* (2016) find for Uruguay that resource-driven currency appreciation does not significantly affect output or growth in any sector. Ito (2017) finds that oil-price shocks in Russia that caused exchange rate appreciation did not prevent a slight rise in manufacturing output. More fundamentally, Aragon *et al.* (2015) question whether resource-driven appreciation will lower growth in GDP over time, rather than change its composition, and argue that resource booms can develop related manufacturing.

For Indonesia, little empirical work has tested the effects of resource extraction on manufacturing or agriculture, though descriptive studies suggest a benign effect. Usui (1997) finds that an increased share of petroleum in Indonesian exports over the boom period 1970–1975 raised manufacturing's share of GDP. After the oil boom (1975–1982), when the share of petroleum in exports gradually declined, manufacturing's share in GDP rose substantially. Usui argues Indonesia avoided the Dutch disease because it invested its oil revenue surplus during booms to accelerate growth in tradable sectors such as manufacturing. Looking later at the 2000s, Feryawan (2011) argues that the mining sector, especially oil and gas, has increased induced demand for Indonesia's manufacturing output.

2.2 Human capital

A positive effect of education on growth has been found in many studies (Barro 2001 and Hanushek 2013). Education is often measured using enrolment rates, years of schooling or proportions achieving a given standard.[2]

Some have argued RD weakens incentives for education demand, thus slowing human capital accumulation and growth. Gylfason (2001) and Gylfason and Zoega (2006) argue that dominant resource extraction sectors provide strong demand and wages for low skilled workers, reducing incentives for continued schooling that would lead to skilled employment in non-resource sectors.

Gylfason (2001) tests this hypothesis using country-level data between 1980 and 1997 and finds a negative correlation between natural capital's share in total capital and public education expenditures. Gylfason also shows resource wealth leads to a decline in average years of schooling for girls, and in boys' and girls' secondary school enrolment rates. Black *et al.* (2005) attribute the substantial rise in high school dropout rates in the American Appalachian region in the 1970s to the concurrent coal boom. Douglas and Walker (2016) similarly find a negative effect of coal dependence on high school completion rates in Appalachian counties.

However, some papers find contrary evidence, perhaps because resource windfalls can also fund greater education supply. Blanco and Grier (2012) find no effect of RD on human or physical capital across 17 Latin American countries. Alexeev and Conrad (2011) find per capita oil output has a significant positive effect on primary and secondary school enrolment rates, and a positive association between resource share in GNI and primary school

[2] See Davoodi and Zou (1998), Gylfason and Zoega (2006), and Carmignani and Chowdury (2010).

enrolment rates. Similarly, using American panel data, James (2017) finds resource-rich states have higher public school enrolment rates, public spending on education and teacher salaries, and lower student–teacher ratios. Using provincial data for China, Wu and Lei (2016) similarly find a positive association between resource abundance and human capital accumulation, with both positively correlated with growth.

While evidence for Indonesia is limited, Edwards (2016) finds that mining's share in district GDP is negatively associated with the enrolment rate of senior high school students, using 2009 cross-sectional data.

2.3 Institutional quality

Most growth scholars recognise the importance of good institutions (e.g. Acemoglu *et al.* 2005; North 1991) leading resource curse scholars to investigate RD's effects on institutional quality. 'Rentier state' theory predicts that resource wealth from large 'point' sources makes governments less dependent on taxing their citizens, thus less accountable to them (Deacon and Rode, 2015; Gylfason and Zoega 2006; Isham *et al.* 2005; Ross 2001; Sachs and Warner 1995). This results in poorer quality governance and institutions, and weakens incentives for private innovation, reducing growth.

Evidence supporting this view comes from Bulte *et al.* (2005), who use data from 97 countries and find those with a high share of fuel and mineral exports have lower indicators of rule-of-law and government effectiveness. Similarly, Busse and Groning (2013) use panel data for 129 countries from 1984–2007, and find an increase in resource exports' share in GDP is positively associated with perceived corruption. Ross (2015) surveys additional papers and concludes there is a link between petroleum dependence and durability of authoritarian regimes, corruption and conflict.

As with education, however, others fail to find that RD lowers institutional quality, or even that it improves governance capacity. Alexeev and Conrad (2009) find no significant effect of mining's share of per capita GDP on a rule of law index. Similarly, di John (2011) finds corruption levels in mineral abundant countries were lower and rose less than in non-mineral countries during 1965–1990 and 1990–2000. Brunnschweiler and Bulte (2009) and Brunnschweiler (2008) in cross-country analysis find positive significant effects of total natural capital and subsoil assets on indicators for rule of law and government effectiveness. (These effects were not robust, however, to controlling for initial income.) More recently, Karimu *et al.* (2017) find resource rents' share of GDP significantly raises public investment, though the size of effect depends on institutional quality.

An alternative hypothesis is that a country's institutional quality is not affected by RD, but instead determines whether RD helps or hinders growth (Papyrakis 2016). Mehlum *et al.* (2006) argue that resources slow a country's growth if it already has weak rule-of-law, a high degree of corruption or ineffective bureaucracy. They regress country-level average growth in real

GDP per capita from 1965 to 1980 on primary exports' share in GNP in 1970, institutional quality and their interaction. They find that as institutional quality improves, the negative effect of RD on growth diminishes. This method has subsequently been used by Arezki and van der Ploeg (2011), Bhattacharyya and Hodler (2010) and Oyinlola *et al.* (2015).

Brunnschweiler (2008) provides a rare counter finding, however. She measures resource abundance as either total natural capital or mineral assets, and finds it spurs growth in countries with the poorest institutional quality, an effect offset as institutional quality improves. However, when Brunnschweiler instead measures dependence using share of exports (like Sachs and Warner), her results reverse.

As of yet, we know of no previous examination of the effect of RD on institutional quality in Indonesia.

2.4 Quality of public spending

Under Tiebout's (1956) classical theory of fiscal federalism, local governments may be better informed about local preferences than central governments, so provide better targeted public spending. Optimistically, if resource rents are transferred back to local governments, as done in Brazil and Indonesia under fiscal decentralisation, this may improve accountability and local capital investment, spurring growth.

More pessimistically, Atkinson and Hamilton (2003) argue resource wealth may hinder growth when central governments make poor (not necessarily corrupt) use of resource rents. Cust and Poelhekke (2015) express similar concern about the composition of public spending by capacity-constrained local governments under fiscal decentralisation. Collier *et al.* (2010) argue governments may make inefficient use of rents because they face less pressure to account for their use than more broadly based taxation revenues.

Empirically, Bhattacharyya and Collier (2014) use OECD and developing country data from 1970 to 2007, and find resource rents lower public capital levels. Likewise, using Chinese provincial data, Zhan *et al.* (2015) find RD lowers public spending on education and health. Yet, some papers show positive effects of resource revenues on the size or composition of public spending. Karimu *et al.* (2017) focus on 39 sub-Saharan Africa countries from 1990–2013 and find resource rents are positively associated with government investment, which in turn raises economic growth. Likewise, Case lli and Michaels (2013) find for Brazil that municipal oil revenues increase public investments in housing, urban development, transportation and education. Thus resource wealth can bring positive or negative effects on economic growth via the composition of government spending between investment and consumption.

3. Data and estimation strategy

Our data come primarily from the World Bank's Indonesia Data for Policy and Economic Research (INDO DAPOER).[3] INDO DAPOER gathers official government data from the National Economic Survey, the Indonesia National Statistical Agency (BPS) and the Ministry of Finance. Under Indonesia's decentralisation between 1999 and 2004, provision of many public services passed from the central to district governments. This required substantial transfers from the central authority, and emphasis on local government expenditures and revenue sources, including resource rents based on province and district of extraction. While some district level data are missing pre-decentralisation, almost all series are complete from 2005. Since key variables for our study are only available from 2006, we use that as our base year. Our variables and definitions are in Table S1.

We construct four alternative RD measures. Following Douglas and Walker (2016) and Papyrakis and Gerlagh (2007), the first is 'mining's' share of each district's Gross Regional Domestic Product (GRDP), or MINDEP. GRDP has been found to track household expenditures, a proxy for household income, reasonably well in Indonesia (Hill *et al.* 2008; Hill and Vidyatamma, 2014). 'Mining' includes oil, gas, coal and all quarried minerals, including gold. Our other three measures capture the fiscal dependence of district governments on rents from mining, as done by Casselli and Michaels (2013), Bjorvatn *et al.* (2012), and Cust and Rusli (2014). They are share of district budget revenues from oil, gas and coal (MINREV), oil and gas only (OILGASREV), or coal only (COALREV). They are sourced from the Ministry of Finance and the Audit Investigation Board (BPK).[4]

For our potential causal mechanisms, manufacturing's and agriculture's size come from INDO DAPOER and BPS. District high school enrolment rates come from the Ministry of Education and Culture. Data on capital vs. non-capital spending come from the Ministry of Finance. Capital spending is defined as the share of all expenses paid to produce tangible fixed assets whose benefit continues more than a year. For district institutional quality, we primarily use a narrower measure available for 2006–2015. The Audit Investigation Board annually audits each district's management system, financial responsibility and ability to produce financial statements to an appropriate accounting standard. Scores range from 1 to 4, increasing in compliance.[5] We also try a more comprehensive district performance index available for 2010–2015, published by the Ministry of Home Affairs.[6] This

[3] See http://data.worldbank.org/data-catalog/indonesia-database-for-policy-and-economic-research.

[4] See http://www.bpk.go.id/lkpp for Audit Board publications, and http://www.djpk.depkeu.go.id/?page_id=307 for Ministry of Finance data.

[5] 1=cannot give any opinion; 2=to some degree acceptable; 3=performed well/qualified, with correction(s) needed; and 4=qualified without exception. See http://bpk.go.id/ihps.

[6] See http://otda.kemendagri.go.id/.

index contains subindicators for (a) district compliance with the rules and procedures laid out in national law; (b) the intensity and effectiveness of consultation processes with local residents; (c) transparency in reporting income sources and allocation in budget planning; (d) innovations to improve the district. The broader score ranges from 0 to 4, again increasing in quality. Both schemes set explicit criteria for auditors, though as with any audit system subjectivity cannot be completely excluded. Being available for a longer period, the Audit Investigation Board's score has been used as a proxy for quality of public service delivery by Lewis (2016) and Sutopu *et al.* (2017).

A challenge to following districts over time was their proliferation since 2001 based on government policy (*pemekaran*), pursued to make local government closer to people in the hope of improving service delivery. The number of districts rose from 390 in 2003 to 477 in 2010, to 512 in 2015, in all cases caused by the splitting of larger 'parent' districts into smaller 'child' districts. To facilitate longitudinal analysis of a balanced panel, we merge all child districts for later years back into their parent districts, using the annual population of each child to create appropriate weights. For example, if one child district from a split had twice the population as another for a given year, the consolidated RD measure would be 2/3 times the RD value of the first child, and 1/3 times that of the second. Since all 2015 districts were identifiable from 390 parent districts in 2003, we use this as our district benchmark year, following these 390 districts/consolidated districts over time.[7]

Moving to our empirical estimation strategy, we use a three step procedure. First, we estimate the overall effect of RD on real GRDP per capita using a first difference estimator.[8] First differencing is equivalent to fixed effects for two periods, in that it controls for time-invariant unobserved district characteristics that may be affecting income. By differencing over a multiple year period rather than using annual fixed effects, we allow greater time for changes in RD to affect income per capita, and facilitate the use of high-quality cross section instruments. Our approach first replicates Hilmawan and Clark (2019), albeit for a slightly shorter period (2007–2015) to accommodate data availability.

[7] We exclude Central, West, East and South Jakarta and Kepulauan Seribu because they are not defined as districts under decentralisation, and Tanjung Pinang because it lacked some data.

[8] One potential concern regarding fine district-level analysis would be cross-sectional dependence in the errors, from, for example, changes in RD in adjacent districts affecting change in GRDP in the 'home' district. In analysis not reported here, we try including spatial lags of our ΔRD_i measures, or spatial lags of all independent variables. We do not find their inclusion changes the sign or significance of effect of 'home' district ΔRD_i and the spatial lags themselves (ΔRD_i alone or of all other control variables) are for the most part insignificant. We thus do not pursue them further in the paper.

$$\Delta LnGRDP_i = \gamma + \delta_1 \Delta RD_i + X_i'\beta_2 + \varepsilon_i. \quad (1)$$

$\Delta LnGRDP_i$ is $Ln(GRDP_{i,2015}) - Ln(GRDP_{i,2007})$ for district i, the intercept γ would be the coefficient on a time trend in a level version of the model, and ΔRD_i measures the change in RD for district i between 2007 and 2015 using one of four alternative measures. The X_i' is control variables commonly used in the growth literature, including change in labour force participation rate, 2006 district population (in logs) and the log of 2006 GRDP per capita. We also try specifications with and without 2006 district RD to address the possibility identified by Bloom *et al.* (2014) of spurious estimated effects of (here) ΔRD_i caused by its potential correlation with initial RD_{2006}.[9] Initial population is included to control for potential economies of scale. We also control for the total number of earthquakes over the period as exogenous events that damage (unmeasured) assets and necessitate (measured) reconstruction, along with each district's urban status (DURBAN) and whether it is located on the historically more developed island of Java (DJAVA).

Our ΔRD_i measures have denominators that include GRDP or government budget, so may suffer from endogeneity with our dependent variable (the change in GRDP per capita). We address this using IV-GMM estimation with two types of instruments as in Hilmawan and Clark (2019). First, following Case lli and Michaels (2013) for Brazil, and Cust and Rusli (2014) for Indonesia, we use instruments based on district resource abundance in the 1970s and early 1980s, based on the combined number of oil/fields, and the proportion of each district covered by 'first contract' coal extraction agreements between the central government and coal mining companies. These abundance instruments are described in Hilmawan and Clark and were constructed using historical resource maps of Bee (1982), van Leeuwen (1994) and Friedrich and van Leeuwen (2017), mapped to 2003 district boundaries. Intuitively, we expect subsequent change in district RD to depend on previously established resource abundance, leading to a strong positive correlation between the two. Crucially, since historical abundance was determined by exploration that was funded by central government or international corporations and not district capacity, it should affect subsequent district growth mainly through extraction, and thus RD.[10]

Our second type of instrument is change in physical production of oil, gas and coal from 2007–2015, again as constructed by Hilmawan and Clark (2019). The specific production changes are customised by RD measure (e.g.

[9] If districts who start out highly RD 1) have little capacity to become more so, and 2) are more likely to experience lower subsequent incomes, a first differenced estimator that omitted initial RD could produce upwardly biased estimates of δ_1.

[10] Indonesia had limited fiscal and technological capacity for exploration prior to the 1980s, instead entering production-sharing agreements with multinational companies who presumably targetted exploration where it was most geologically and economically promising.

oil/gas and coal for MINDEP and MINREV, oil/gas for OILGASREV).[11] While changes in physical production should easily be correlated with changes in RD, and an instrument available as a change is better suited to first difference regressions, we are less confident *ex ante* that it will satisfy the exclusion restriction, that is that it will affect income per capita only through changes in RD rather than directly. We note however that in similar level or first differenced estimation of the effects of municipal fiscal oil revenue on household income for Brazil, Case lli and Michaels (2013) use change in offshore oil production as an instrument. Case lli and Michaels (2013) argue, and have data to test that this oil production had little or no spillover effect on non-oil economic activity in the municipalities receiving the associated rents, as measured by non-oil GDP. Cust and Rusli (2014) follow a similar strategy for panel analysis of district fiscal oil revenues for Indonesia. We will use both types of instruments, but check the robustness of step one results using only abundance-based instruments.

We will test necessary conditions for instrument relevance and overidentification using the Stata module implemented by Baum *et al.* (2003). Along with standard first-stage Kleibergen-Paap F tests for instrument weakness, we will also report Olea and Pflueger (2013) (OP) F statistics to correct for potential heteroscedasticity.

For the second step, we estimate whether each potential causal channel is affected by RD:

$$\Delta Manuf_i = \gamma + \beta \Delta RD_i + \sigma_1 X_i' + \varepsilon_i \quad (2)$$

$$\Delta Agric_i = \gamma + \beta \Delta RD_i + \sigma_1 X_i' + \varepsilon_i \quad (3)$$

$$\Delta School_i = \gamma + \beta \Delta RD_i + \sigma_1 X_i' + \varepsilon_i \quad (4)$$

$$\Delta Ins_i = \gamma + \beta \Delta RD_i + \sigma_1 X_i' + \varepsilon_i \quad (5)$$

$$\Delta Spend_i = \gamma + \beta \Delta RD_i + \sigma_1 X_i' + \varepsilon_i \quad (6)$$

The dependent variables are the 2007 to 2015 change for district i in its size of manufacturing ($\Delta Manuf_i$), agriculture ($\Delta Agric_i$), high school enrolment rate ($\Delta School_i$), assessed institutional quality (Δins_i) or proportion of spending on capital ($\Delta Spend_i$). ΔRD_i and X_i' are as in (1), as are the instruments for ΔRD_i. To the extent RD positively affects income in Indonesia and each channel positively contributes to income, we expect the coefficient on ΔRD_i in each equation to be positive.

[11] For MINDEP and MINREV, we use historical abundance of oil/gas and coal, and change in production of all three resources separately. For OILGASREV, we use oil/gas historic abundance and change in oil and gas production levels separately. For COALREV, we use coal's historic abundance and change in production.

We primarily treat differences in scored institutional quality in (4) as cardinal, though we also collapse changes for each district to the three categories ‘improved’, ‘stayed same’ or ‘worsened’, using ordered probit. We estimate the latter with or without instruments using the IV-Probit under Conditional Mixed Process (CMP) module in Stata provided by Roodman (2011).

For the third step, we again regress $\Delta LnGRDP_i$ on ΔRD_i as in (1), but now simultaneously adding the five potential causal channels:

$$\Delta LnGRDP_i = \gamma + \delta_1 \Delta RD_i + \delta_2 \Delta Mabuf_i + \delta_3 \Delta Agric_i + \delta_4 \Delta School_i + \delta_5 \Delta Ins_i + \delta_6 \Delta Spend_i + X_i' \beta_2 + \varepsilon_i \quad (7)$$

We again instrument for ΔRD_i as in (1). As we do not have separate instruments to address the possible endogeneity of our potential causal channels in (7), we first assume them to be exogenous, then also use Dippel *et al.* (2020) causal mediation analysis under the Stata *IVMediate* module. Causal mediation analysis decomposes the effect of ΔRD_i on $\Delta LnGRDP_i$ into a direct and indirect effect via a single causal channel when both the treatment and channel are potentially endogenous, using only a single instrument for both.[12]

These three steps should enable us to test whether the overall positive effect of RD on income in Indonesia operates via the five potential causal channels. The ΔRD_i coefficient in (1) indicates its total effect. The ΔRD_i coefficients in equations (2) to (6) indicate the extent to which RD is affecting these potential causal channels. Finally, the coefficients on the five channels in (7) should indicate the extent to which each affects income, whether its movement is caused by RD or other influences. The ΔRD_i coefficient in (7), presumably smaller than it was in (1), should indicate the remaining effect of RD not explained by the five channels. Overall, if we find that RD raises a channel, and this channel in turn raises income in (7) while the remaining effect of RD on income is reduced, we will take this as suggestive evidence that we have found a causal channel of the resource blessing.[13]

Finally, we test the ‘contingent curse’ hypothesis that the positive or negative effects of RD on growth depend on pre-existing institutional quality. Our main approach is to use 2006 district institutional quality as a benchmark to rank and split the 390 districts into the 195 with highest and lowest measured quality. We then re-estimate equation (1) separately for the

[12] *Ivmediate* can only consider one potential causal factor at a time, using a single instrument at a time. We will use our relevant abundance-based instruments. This approach also assumes that endogeneity of ΔRD and a potential causal channel is not caused by confounding factors that jointly influence both.

[13] It is possible higher RD could cause an increase only in aspects of a causal channel that are not responsible for growth in GRDP, while other aspects of the channel do affect growth, but there seems no *ex ante* reason to expect this.

Table 1 Descriptive statistics

Variable	Mean	SD	Min	Max
ΔReal GRDP per capita (in million IDR)	31.909	111.335	−754.667	1241.01
ΔMining dependence	0.0121	0.1385	−0.6128	0.7932
ΔMining revenue dependence	−0.0118	0.0849	−0.5068	0.2569
ΔOilGas revenue dependence	−0.0271	0.0884	−0.6194	0.2399
ΔCoal revenue dependence	0.0153	0.0461	−0.0601	0.3660
Earthquake	0.4641	0.9363	0.0000	7.0000
ΔLabour force participation rate	0.0670	0.1142	−0.1332	0.4149
GRDP per capita in 2006 (in million IDR)	74.187	128.857	7.103	2016.78
Population in 2006 (thousands)	548.421	576.603	12.607	4121.41
DURBAN	0.2077	0.4062	0.0000	1.0000
DJAVA	0.3026	0.4600	0.0000	1.0000
# Oil and Gas Fields	0.1538	0.6601	0.0000	7.0000
% Area with Coal Deposits	3.6602	14.3272	0.0000	94.2137
ΔOil production (hundreds of thousand of barrels)	−1.6559	33.0406	−220.344	519.313
ΔGas production (tens of thousands of MMBTU)	.2767	3.3453	−33.6334	38.2843
ΔCoal land rent and royalties (tens of billion IDR)	6.1194	48.3250	−369.296	561.459
ΔManufacturing (10's of trillions of IDR, inflation adjusted)	0.0462	0.1586	−0.6538	1.9259
ΔAgriculture (10's of trillions of IDR, inflation adjusted)	0.0277	0.0336	−0.0075	0.2265
ΔShare district spends on capital	0.0009	0.0991	−0.3074	0.4517
ΔNet enrolment ratio	0.1629	0.1186	−0.1722	0.6172
ΔInstitutional Quality (narrow)	1.1667	1.0540	−2.0000	3.0000
Mining dependence, 2006	0.0941	0.1837	0.0000	0.9437
Mining revenue, 2006	0.0539	0.1335	0.0000	0.7682
Oilgas revenue, 2006	0.0463	0.1269	0.0000	0.7516
Coal revenue, 2006	0.0076	0.0220	0.0000	0.2003

Note: There are $N = 390$ observations for all variables. For definitions and sources, see Table S1.

two samples to test whether RD raised growth for the initially stronger districts, and lowered it for the weaker ones. We repeat this exercise using the better but shorter duration institutional quality measure using a 2010 base year.

4. Results

Table 1 provides summary statistics in difference form (2007–2015). The average change in real GRDP per capita is a hefty 31.9 million rupiahs (IDR) (a 45.2 per cent increase), though with a high standard deviation. Districts became slightly more resource dependent on average, though again with high variation. For example, the largest rise in mining's share of GRDP was 79.3 percentage points, and largest rise in district government fiscal dependence on oil, gas and coal revenues combined was 25.6 percentage points.

Focusing on the five channels, average real GRDP from manufacturing rose by 460 billion IDR, and from agriculture by 277 billion.[14] The average high school enrolment rate grew substantially, by 16.29 percentage points. The average (narrow) institutional quality measure also rose sharply. Note that with audit scores from 1 to 4, differences could range from −3 to +3. Finally, the average share of local government spending on capital fell slightly over this time. There was considerable variation across districts for all five channels.

4.1 Step one

Table 2 presents the overall effect of our four alternative RD measures on real per capita GRDP, without instruments in models (1), (2), (3) and (4), and within models (1'), (2'), (3') and (4'). In all results that follow, model (1)/(1') refer to mining's share of GRDP (MINDEP), while models (2)/(2')-(4)/(4') refer to the share of district government revenues from oil/gas (OILGAS-REV), coal (COALREV) or both combined (MINREV), respectively. First-stage IV-GMM regressions are reported in Table S2. Starting with instrument validity tests, Kleibergen-Paap F statistics range from 9.05 for model (4') to 16.08 for model (2'), while OP F statistics range from 4.89 in model (1') to 15.00 in model (2'). With the exception of GRDP mining dependence for OP F statistics, these indicate generally sufficient strength following the rule of thumb of 10.[15] Hansen J statistics for overidentifying restrictions have *P*-values in all models (1')–(4') well above .10. Hausman-type tests of whether each RD measure is exogenous reject this null at the 5 per cent level in models (2')–(4') and narrowly avoid doing so for model (1'). Therefore, we emphasise IV-GMM models for (2')–(4') but OLS for (1).

Moving to results, we confirm the findings of Hilmawan and Clark (2019) for slightly different years that within Indonesia, RD has positively contributed to per capita income. From model (2') a standard deviation (0.0883) increase in the change in oil/gas dependence is associated with a (0.0883*1.119 = 0.0988) 9.88 per cent increase in real per capita income between 2007 and 2015. We find similar positive effects for mining's share of GRDP, or government revenue dependence on oil/gas and coal combined. The sole exception is fiscal dependence on coal revenues, which has no significant effect. Table 2 also indicates baseline 2006 GRDP per capita is robustly negatively associated with subsequent change in income, suggesting convergence between districts.

Our results are similar if we also control for initial 2006 RD. As reported in Table S3, our instruments now show some evidence of weakness for

[14] With 10000 IDR = 0.739 USD at 31 July 2015, this increase would be USD 34 million.

[15] A Kleibergen F statistic of 10 or more is accepted as a benchmark of instrument strength under homoskedasticity (Staiger and Stock 1997), as is an Olea-Pflueger F statistic under heteroscedasticity (Andrews et al. 2019).

Table 2 Resource dependence and real per capita GRDP

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
ΔMining dependence	0.678***	1.539***	-	-	-	-	-	-
	(0.191)	(0.483)	-	-	-	-	-	-
ΔOilGas revenue	-	-	0.038	1.119**	-	-	-	-
	-	-	(0.384)	(0.494)	-	-	-	-
ΔCoal revenue	-	-	-	-	0.672	−0.642	-	-
	-	-	-	-	(0.583)	(0.699)	-	-
ΔMining revenue	-	-	-	-	-	-	0.211	1.032***
	-	-	-	-	-	-	(0.272)	(0.381)
Earthquake	−0.028**	−0.026	−0.029**	−0.028**	−0.027**	−0.032***	−0.029**	−0.022**
	(0.013)	(0.019)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)
ΔLabour force partic.rate	0.226	0.237	0.232	0.322*	0.262	0.196	0.261	0.379**
	(0.174)	(0.174)	(0.166)	(0.176)	(0.187)	(0.182)	(0.171)	(0.155)
Log(GRDP per capita) 2006	−0.116***	−0.099***	−0.136***	−0.076	−0.156***	−0.121***	−0.131***	−0.104***
	(0.031)	(0.037)	(0.033)	(0.047)	(0.033)	(0.037)	(0.030)	(0.034)
Log(Population) 2006	0.011	0.022	0.005	0.026	0.008	0.002	0.008	0.025
	(0.022)	(0.019)	(0.024)	(0.021)	(0.024)	(0.024)	(0.024)	(0.019)
DURBAN	0.049	0.073*	0.041	0.026	0.058	0.026	0.041	0.045
	(0.043)	(0.043)	(0.043)	(0.050)	(0.044)	(0.046)	(0.044)	(0.043)
DJAVA	0.083*	0.140**	0.032	−0.025	0.042	0.027	0.027	−0.009
	(0.047)	(0.064)	(0.043)	(0.042)	(0.042)	(0.042)	(0.042)	(0.039)
Constant	0.723***	0.551***	0.860***	0.542***	0.904***	0.837***	0.826***	0.628***
	(0.138)	(0.175)	(0.166)	(0.168)	(0.160)	(0.162)	(0.151)	(0.140)
Kleibergen-Paap Rank F-stat	-	12.27	-	16.08	-	14.16	-	9.046
Olea-Pflueger (O-P) Effective F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J Statistic *P*-value	-	0.423	-	0.291	-	0.979	-	0.182
Endog *P*-val	-	0.120	-	0.049	-	0.008	-	0.060
Observations	390	390	390	390	390	390	390	390
R-squared	0.156	0.045	0.088	0.031	0.094	0.070	0.091	0.054

Note: Dependent variable is Δlog(real GRDP per capita) between 2007 and 2015. Instruments used are each district's historical resource abundance and change in physical resource production for oil, natural gas and coal. Robust standard errors are in parentheses. *, ** and *** refer to statistical significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively.

analogous models (1’) and (3’) but not (2’) or (4’) and the overidentifying restrictions can be rejected only at the 5 per cent level in model (3’) Persevering with our instruments, RD exogeneity is rejected now only for (3’) such that we take models (1), (2), (3’) and (4) as our preferred specifications. As before, we find that three of four ΔRD measures are significantly (5 per cent level or higher) positively associated with GRDP. Baseline *RD* is not significant for model (1), significant only at the 10 per cent level in (3’) and (4), but significant at the 5 per cent level in (2). Finally, our correlation between initial *RD* and subsequent ΔRD_i ranges from −.36 for GRDP mining dependence, to.40 for coal fiscal revenue dependence, to −.71 for all mining revenue dependence, to −.96 for oil/gas revenue dependence. Thus, aside from oil/gas revenue dependence, the problem that initially high *RD* districts have lower subsequent growth and no room to increase RD seems less evident here. Given that our instruments perform more poorly, we shall proceed without baseline RD for our remaining analysis.

As a second robustness check, we repeat Table 2 using only abundance based instruments. We report this in Table S4. While we cannot always test for overidentifying restrictions (e.g. for coal revenue dependence, where the number of abundance instruments is one), and exogeneity of our RD measure can now be rejected for model (1), our results are otherwise similar.

4.2 Step two

We next test whether RD affects our five candidate mechanisms. Table 3 provides key results for each RD measure, with and without instruments. For brevity, only coefficients on RD and diagnostic tests are shown, with full regressions in Tables S5–S9.

First-stage IV-GMM regression results are as in Step 1, in Table S2. Starting with instrument diagnostic checks, Kleibergen and OP F statistic results are as before, with weakness indicated only by the OP statistic for GRDP mining dependence (1’), and less so the Kleibergen F value for model (4’). Tests of overidentifying restrictions do not reject the null at the 10 per cent level for all RD measures for ΔManufacturing, ΔHigh School Enrolment and three of four RD measures for ΔCapital Spending Share, but do not reject the null only at the 5 per cent level for any of the four RD measures for ΔInstitutional Quality, or for three of four RD measures for ΔAgriculture. This suggests our instruments may be correlated with the structural error terms in institutional quality and agriculture regressions, and thus not be exogenous. With our instruments passing measurable necessary conditions for validity in some models, Hausman tests fail to reject exogeneity of most RD measures in most models, suggesting OLS specifications are preferred. The exception is GRDP dependence on mining, where exogeneity is rejected for manufacturing and high school enrolment or mining revenue dependence for institutional quality. We thus emphasise models (1’), (2), (3) and (4) for manufacturing and high school enrolment, models (1), (2),

Table 3 Resource dependence and five potential causal channels of growth

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
ΔManufacturing output								
ΔMining dependence	0.081	0.319*	-	-	-	-	-	-
	(0.053)	(0.184)	-	-	-	-	-	-
ΔOilGas revenue	-	-	0.378***	0.385**	-	-	-	-
	-	-	(0.119)	(0.167)	-	-	-	-
Δ Coal revenue	-	-	-	-	−0.595***	−0.710*	-	-
	-	-	-	-	(0.209)	(0.367)	-	-
Δ Mining Revenue	-	-	-	-	-	-	0.183**	0.255**
	-	-	-	-	-	-	(0.074)	(0.122)
Kleibergen F	-	12.27	-	16.08	-	14.16	-	9.046
O-P F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J *P*-val	-	0.252	-	0.240	-	0.545	-	0.194
Endog *P*-val	-	0.040	-	0.208	-	0.755	-	0.133
Observations	390	390	390	390	390	390	390	390
R-squared	0.200	0.122	0.227	0.219	0.219	0.218	0.204	0.153
ΔAgricultural output								
ΔMining dependence	0.007	0.033	-	-	-	-	-	-
	(0.008)	(0.027)	-	-	-	-	-	-
ΔOilGas revenue	-	-	0.012	0.033	-	-	-	-
	-	-	(0.017)	(0.025)	-	-	-	-
Δ Coal revenue	-	-	-	-	−0.079***	−0.091**	-	-
	-	-	-	-	(0.020)	(0.043)	-	-
Δ Mining Revenue	-	-	-	-	-	-	−0.010	0.008
	-	-	-	-	-	-	(0.015)	(0.027)
Kleibergen F	-	12.27	-	16.08	-	14.16	-	9.046
O-P F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J *P*-val	-	0.063	-	0.040	-	0.101	-	0.057
Endog *P*-val	-	0.316	-	0.456	-	0.893	-	0.598
Observations	390	390	390	390	390	390	390	390
R-squared	0.402	0.391	0.402	0.400	0.411	0.410	0.402	0.400

Table 3 (*Continued*)

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
ΔNet high school enrolment								
ΔMining dependence	0.119***	0.381***	-	-	-	-	-	-
	(0.044)	(0.119)	-	-	-	-	-	-
ΔOilGas revenue	-	-	0.190***	0.302***	-	-	-	-
	-	-	(0.064)	(0.106)	-	-	-	-
Δ Coal revenue	-	-	-	-	0.102	0.206	-	-
	-	-	-	-	(0.137)	(0.229)	-	-
Δ Mining Revenue	-	-	-	-	-	-	0.198***	0.282***
	-	-	-	-	-	-	(0.060)	(0.099)
Kleibergen F	-	12.27	-	16.08	-	14.16	-	9.046
O-P F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J *P*-val	-	0.377	-	0.278	-	0.794	-	0.376
Endog *P*-val	-	0.053	-	0.304	-	0.598	-	0.507
Observations	390	390	390	390	390	390	390	390
R-squared	0.083	−0.002	0.079	0.074	0.067	0.065	0.082	0.079

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
Δinstitutional quality								
ΔMining dependence	0.700*	2.499***	-	-	-	-	-	-
	(0.404)	(0.889)	-	-	-	-	-	-
ΔOilGas revenue	-	-	0.986	2.195**	-	-	-	-
	-	-	(0.698)	(1.003)	-	-	-	-
Δ Coal revenue	-	-	-	-	2.667***	5.051***	-	-
	-	-	-	-	(0.967)	(1.936)	-	-
Δ Mining revenue	-	-	-	-	-	-	1.583***	3.208***
	-	-	-	-	-	-	(0.585)	(0.629)
Kleibergen F	-	12.27	-	16.08	-	14.16	-	9.046
O-P F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J *P*-val	-	0.067	-	0.098	-	0.073	-	0.062
Endog *P*-val	-	0.168	-	0.211	-	0.195	-	0.073

Table 3 (*Continued*)

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
Observations	390	390	390	390	390	390	390	390
R-squared	0.064	0.013	0.061	0.053	0.066	0.058	0.070	0.055
ΔCapital spending share								
ΔMining Dependence	0.059	−0.066	-	-	-	-	-	-
	(0.042)	(0.140)	-	-	-	-	-	-
ΔOilGas revenue	-	-	−0.069	0.015	-	-	-	-
	-	-	(0.085)	(0.149)	-	-	-	-
Δ Coal revenue	-	-	-	-	0.453**	0.343	-	-
	-	-	-	-	(0.182)	(0.283)	-	-
Δ Mining revenue	-	-	-	-	-	-	0.057	0.001
	-	-	-	-	-	-	(0.082)	(0.128)
Kleibergen F	-	12.27	-	16.08	-	14.16	-	9.046
O-P F-stat	-	4.892	-	14.997	-	11.764	-	10.199
Hansen J *P*-val	-	0.127	-	0.494	-	0.029	-	0.108
Endog *P*-val	-	0.440	-	0.476	-	0.767	-	0.725
Observations	390	390	390	390	390	390	390	390
R-squared	0.038	0.009	0.035	0.031	0.066	0.063	0.034	0.031

Note: Year difference 2007–2015. Instruments used are district historical abundance and change in physical production for the relevant combinations of oil, gas, coal or all three combined. Robust standard errors are in parentheses. *, ** and *** refer to statistical significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively.

(3) and (4) for agriculture and capital spending, and models (1), (2), (3) and (4') for institutional quality.

Moving to results, RD is generally positively associated with three of the five channels investigated. Beginning with education, three of our four preferred RD specifications ((1'), (2) and (4)) are significantly positively associated with high school enrolment rates, with coal revenue dependence (3) also positively signed but insignificant. From (2) for example, a standard deviation (0.088) increase in the change in oil/gas revenue's share of district government budget raises the enrolment rate by (0.088*0.190 = 0.0167) 1.7 percentage points. This result is surprising, given that many 'resource curse' papers finding a negative association with education inputs or outputs, though not unprecedented.[16] Similarly, three of our four preferred RD specifications are significantly positively associated with size of manufacturing and institutional quality, contra Dutch disease or 'rentier state' hypotheses.[17] There is less evidence that RD is significantly associated with the share of government spending on capital, with a significant association (positive) only for coal fiscal dependence.

As with share of fiscal spending on capital, RD is not significantly associated with the size of agricultural output for three of four RD measures. Interestingly, for agriculture as for manufacturing, the outlier is coal fiscal dependence, which is significantly negatively associated with both alternative economic activities. For example, a standard deviation increase in the change in coal's share in district budgets causes agriculture's real GRDP to shrink by (0.034*(−0.079) = −0.0027).27 percentage points, and manufacturing's by (0.158574*(−0.595) = 0.094) 9.4 percentage points. Thus, only for coal fiscal dependence do we find effects in line with a Dutch disease.

To summarise Step 2 results, we find two of four RD measures, GRDP dependence on mining and fiscal dependence on mining revenues, are significantly positively associated with size of manufacturing, high school enrolment rates and with institutional quality, and not associated with size of agriculture or capital spending share. Fiscal dependence on oil/gas is also positively associated with size of manufacturing and high school enrolments but not the other three potential channels. Only fiscal dependence on coal, while significantly positively associated with institutional quality and capital expenditures share, is negatively associated with size of manufacturing and agriculture, as per the Dutch disease.

[16] Kim and Lin (2017) and Farzanegan and Thum (2020) in cross country studies find that non-agricultural primary exports or oil rents as a percentage of GDP raise average years of schooling or spending per student.

[17] Our results are similar if we use ordered probit for the likelihood that districts' scores have improved, stayed the same, or worsened. Our instruments are strong, exogeneity of our RD measures is not rejected for models (1)-(4), and we find RD significantly positively associated with institutional quality at the 1% level for (3) and (4). Model (1) loses its significance at the 10% level, however.

Table 4 Resource dependence, causal channels and real per capita GRDP

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
Mining dependence	0.579***	1.407***	-	-	-	-	-	-
	(0.172)	(0.516)	-	-	-	-	-	-
OilGas revenue	-	-	−0.152	1.044**	-	-	-	-
	-	-	(0.361)	(0.487)	-	-	-	-
Coal revenue	-	-	-	-	0.666	−0.385	-	-
	-	-	-	-	(0.600)	(0.702)	-	-
Mining revenue	-	-	-	-	-	-	0.033	0.926**
	-	-	-	-	-	-	(0.248)	(0.391)
Manufacturing output	0.325	0.120	0.391*	0.075	0.408*	0.333	0.373	0.113
	(0.219)	(0.169)	(0.231)	(0.152)	(0.233)	(0.224)	(0.228)	(0.156)
Agricultural output	1.603***	1.079*	1.774***	1.236**	1.892***	1.647***	1.752***	1.314**
	(0.553)	(0.576)	(0.564)	(0.571)	(0.558)	(0.564)	(0.566)	(0.528)
High school enrolment	0.009	−0.164	0.118	−0.054	0.095	0.125	0.102	−0.058
	(0.147)	(0.162)	(0.142)	(0.150)	(0.147)	(0.146)	(0.141)	(0.146)
institutional quality	0.037***	0.028*	0.045***	0.036**	0.042***	0.046***	0.044***	0.034**
	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.014)
Capital spending share	0.586**	0.352*	0.652**	0.522**	0.613**	0.647***	0.655**	0.467**
	(0.233)	(0.186)	(0.258)	(0.223)	(0.266)	(0.248)	(0.260)	(0.199)
Earthquake	−0.031**	−0.030*	−0.031***	−0.031**	−0.029**	−0.033***	−0.031**	−0.026**
	(0.013)	(0.018)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Dlabforce	0.118	0.130	0.099	0.214	0.141	0.088	0.121	0.241
	(0.177)	(0.169)	(0.170)	(0.176)	(0.187)	(0.182)	(0.177)	(0.157)
Log(GRDP per cap) 2006	−0.171***	−0.138***	−0.205***	−0.119**	−0.214***	−0.181***	−0.193***	−0.149***
	(0.033)	(0.041)	(0.035)	(0.049)	(0.035)	(0.040)	(0.032)	(0.036)
Log(Population) 2006	−0.036	−0.003	−0.048	−0.003	−0.047	−0.039	−0.045	−0.005
	(0.030)	(0.023)	(0.034)	(0.024)	(0.033)	(0.032)	(0.034)	(0.023)
DURBAN	0.118**	0.116**	0.127***	0.085	0.139***	0.115**	0.121**	0.107**
	(0.048)	(0.049)	(0.046)	(0.056)	(0.048)	(0.049)	(0.048)	(0.049)
DJAVA	0.072	0.125*	0.035	−0.019	0.037	0.020	0.028	−0.011
	(0.045)	(0.065)	(0.042)	(0.041)	(0.041)	(0.041)	(0.041)	(0.039)

Table 4 (*Continued*)

Variables	(1) OLS	(1') GMM	(2) OLS	(2') GMM	(3) OLS	(3') GMM	(4) OLS	(4') GMM
Constant	1.109***	0.820***	1.289***	0.800***	1.309***	1.164***	1.239***	0.898***
	(0.225)	(0.219)	(0.267)	(0.226)	(0.257)	(0.261)	(0.254)	(0.195)
Kleibergen-Paap Rank F-stat	-	10.80	-	12.62	-	14.43	-	8.219
Olea-Pflueger (O-P) F-stat	-	4.623	-	13.182	-	11.162	-	8.916
Hansen J *P*-val	-	0.339	-	0.171	-	0.402	-	0.111
Endog *P*-val	-	0.181	-	0.0454	-	0.0704	-	0.0659
Observations	390	390	390	390	390	390	390	390
R-squared	0.218	0.116	0.172	0.098	0.176	0.162	0.171	0.120

Note: Dependent variable Δlog(real GRDP per capita) between 2007 and 2015. Instruments used for RD measures are each district's historical resource abundance and change in physical production for oil, natural gas and coal. Robust standard errors in parentheses. *, ** and *** refer to statistically significant at 10 per cent, 5 per cent and 1 per cent, respectively.

4.3 Step three

Table 4 reports results with the five candidate transmission channels added to Table 2. Regarding instruments, once again Kleibergen-Paap F statistics are above 10 for all but model (4') at 8.22, while OP F statistics indicate weakness for model (1'), and less so (4') at 8.92. Hansen J *P*-values exceed 0.10 in all cases, coming lowest for model (4') at 0.111. With instruments assessed, the exogeneity of our RD measures is rejected at the 0.10 level in models (2) to (4) as before, suggesting specifications (1), (2'), (3') and (4') are preferable. (Our findings generally imply that our RD measures are endogenous in our growth regressions, but not in our causal channel regressions.)

Turning to results, we check whether each candidate channel is positively associated with per capita GRDP in Table 4, and from Table 3 whether it in turn was raised by RD. Growth in real agricultural output, for example, has a significant positive effect on GRDP across all RD measures, but was not itself affected by RD in Table 3. Conversely, growth in manufacturing output is not significantly associated with GRDP in any preferred specification, though in Table 3 it was raised by three of four RD measures. High school enrolment is similarly not significantly associated with GRDP in Table 4. More promisingly, growth in institutional quality is significantly positively associated with GRDP at the 5 per cent level or higher in all four preferred RD specifications. For example, from (2') a standard deviation (1.054) increase in the change in the audit score increases real per capita income by (=1.054*0.036 = 0.038) 3.8 per cent. Given that rising RD was found to increase institutional quality in Table 3 for models (1), (3) and (4'), this suggests that institutional quality may be acting as a causal channel through which RD is raising per capita income in Indonesia. Moving to the last candidate, the share of district public spending on capital is similar to agriculture in being positively associated with GRDP for all preferred RD measures in Table 4, but in Table 3 the only RD measure found to significantly affect this channel was coal revenue dependence (3).

Finally from Table 4, the modest drop in the remaining effects of RD on income compared to Table 2 implies that the portion of RD's effects on income that is being captured by the five causal candidates is limited. For model (1), the RD coefficient falls from 0.678 to 0.579, while for model (2') it falls from 1.114 to 1.044. For model (3'), where neither is significant, the absolute value falls from $|-0.642|$ to $|-0.385|$, while for model (4') it falls from 1.032 to 0.926.

As a robustness check for Step 3, we allow for endogeneity of our potential causal channels along with ΔRD_i without new instruments using Dippel *et al.* (2020) causal mediation analysis. As mentioned, this approach jointly estimates the indirect effect of an ΔRD_i measure on $\Delta LnGRDP_i$ via one causal channel at a time (using only a single abundance instrument), as well as ΔRD_i s direct effect net of that indirect effect, which combine as a total effect. Results are provided in Table S10. Kleibergen-Paap F statistics for instrument strength for ΔRD_i are above 10 for three of four measures (and 8.37 for the fourth). However, the same abundance instrument has far lower Kleibergen-Paap F statistics for each potential causal mechanism, ranging from 0.004 to 5.256 for the first RD measure, 0.063 to 2.607 for the second, 0.018 to 5.562 for the third and 0.317 to 4.502 for the fourth. Causal mediation analysis confirms an overall blessing effect of RD on income, with significant positive total effects for three of four measures (coal dependence again being the exception), and a significant positive direct effect of mining dependence in particular on income net of manufacturing or agricultural output. However, this approach finds no significant indirect effect of any RD measure on income via any of the five potential causal mechanisms. This lack of effect could reflect the weakness of the relevant abundance instrument, or the necessity of considering each causal factor without controlling for the others, but it weakens our confidence in the robustness of the finding that RD has raised incomes in Indonesia by raising the institutional quality of district-level governments.

4.4 A contingent curse?

For brevity, we focus here on our split sample findings, though we find consistent results using an interaction term approach. Tables 5 and 6 provide results using OLS and IV-GMM, respectively. Diagnostic tests for our abundance and production instruments in Table 6 show that OP F statistics range from 10.91 to 162.81 for the 195 stronger institution districts, and well in excess of 10 for all but model (1') for the 195 weaker districts. Hansen J tests yield *P*-values well above 0.10 in all cases. With instruments passing necessary conditions for validity in 7 of 8 cases, RD exogeneity is rejected among stronger institution districts in model (3') and among weaker districts in models (1'), (2') and (4'). We thus take the relevant comparisons to be (1) in Table 5 vs. (1') in Table 6, respectively, and analogously (2) vs (2'), (3') vs. (3) and (4) vs. (4').

These comparisons (or those keeping wholly to OLS or IV-GMM) do not support a contingent curse hypothesis. For two of four RD measures (GRDP dependence and mining revenue dependence), there is a significant positive effect for weaker districts and no effect for stronger districts. For the remaining two RD measures, there is no significant effect in weaker or stronger districts.

We test the robustness of this finding using our broader local governance performance index available only since 2010. Tables S11 and S12 provide analogous regressions to those in Tables 5 and 6, but with all differences between 2011 and 2015, with a 2010 base year. Again beginning with instrument diagnostic tests in Table S12, OP F statistics indicate weakness for six of eight models across stronger and weaker districts, though Hansen *P*-values are well above 0.10 in all models. Persevering with our instruments, exogeneity of RD is rejected for models (1') and (2') for stronger districts, but

Table 5 OLS Effects of resource dependence on districts with stronger and weaker initial institutions in 2006

Variables	Stronger				Weaker			
	Mindep	Oilgasrev	Coalrev	Minrev	Mindep	Oilgasrev	Coalrev	Minrev
ΔMining Dependence	0.062	-	-	-	1.085***	-	-	-
	(0.170)	-	-	-	(0.296)	-	-	-
ΔOilGas revenue	-	0.547	-	-	-	−0.409	-	-
	-	(0.371)	-	-	-	(0.686)	-	-
ΔCoal revenue	-	-	−1.016	-	-	-	0.447	-
	-	-	(1.112)	-	-	-	(0.654)	-
ΔMining revenue	-	-	-	0.488	-	-	-	−0.187
	-	-	-	(0.357)	-	-	-	(0.423)
Earthquake	−0.008	−0.009	−0.009	−0.009	−0.033	−0.050	−0.047	−0.051
	(0.011)	(0.011)	(0.011)	(0.011)	(0.033)	(0.033)	(0.032)	(0.033)
ΔLabour force partic.rate	0.793***	0.914***	0.806***	0.903***	−0.001	−0.137	−0.092	−0.132
	(0.267)	(0.242)	(0.250)	(0.241)	(0.225)	(0.233)	(0.264)	(0.242)
Log(GRDP per capita) 2006	−0.160***	−0.139***	−0.165***	−0.142***	−0.114***	−0.164***	−0.156***	−0.141***
	(0.048)	(0.044)	(0.049)	(0.044)	(0.041)	(0.052)	(0.045)	(0.040)
Log(Population 2006)	0.031	0.032	0.031	0.031	0.005	0.003	0.007	0.005
	(0.029)	(0.029)	(0.029)	(0.029)	(0.032)	(0.035)	(0.035)	(0.035)
DURBAN	0.075	0.058	0.075	0.061	0.100*	0.073	0.077	0.060
	(0.061)	(0.058)	(0.061)	(0.058)	(0.059)	(0.063)	(0.064)	(0.065)
DJAVA	0.099	0.066	0.085	0.074	0.016	−0.018	−0.028	−0.033
	(0.060)	(0.055)	(0.057)	(0.055)	(0.097)	(0.096)	(0.093)	(0.094)
Constant	0.680***	0.620***	0.702***	0.624***	0.765***	1.033***	0.974***	0.944***
	(0.166)	(0.165)	(0.178)	(0.165)	(0.217)	(0.276)	(0.246)	(0.244)
Observations	195	195	195	195	195	195	195	195
R−squared	0.230	0.248	0.231	0.245	0.206	0.073	0.070	0.068

Note: Dependent variable is Δlog(real GRDP per capita) between 2007 and 2015. Stronger and weaker institutions refer to initial level of institutional quality in 2006. Robust standard errors in parentheses. *, ** and *** refer to statistical significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively.

Table 6 IV–GMM Effects of resource dependence on districts with stronger and weaker initial institutions in 2006

Variables	Stronger				Weaker			
	(1') Mindep	(2') Oilgasrev	(3') Coalrev	(4') Minrev	(1') Mindep	(2') Oilgasrev	(3') Coalrev	(4') Minrev
ΔMining dependence	0.346	-	-	-	3.576***	-	-	-
	(0.316)	-	-	-	(1.148)	-	-	-
ΔOilGas revenue	-	0.462	-	-	-	1.574	-	-
	-	(0.291)	-	-	-	(1.079)	-	-
ΔCoal revenue	-	-	0.100	-	-	-	−0.294	-
	-	-	(0.834)	-	-	-	(0.784)	-
ΔMining revenue	-	-	-	0.317	-	-	-	1.333**
	-	-	-	(0.244)	-	-	-	(0.657)
Earthquake	−0.008	−0.008	−0.006	−0.005	0.003	−0.040	−0.052	−0.031
	(0.012)	(0.010)	(0.011)	(0.010)	(0.072)	(0.032)	(0.032)	(0.030)
ΔLabour force partic.rate	0.586**	0.739***	0.767***	0.777***	0.322	0.031	−0.194	0.122
	(0.259)	(0.184)	(0.241)	(0.175)	(0.271)	(0.278)	(0.246)	(0.254)
Log(GRDP per capita) 2006	−0.155***	−0.151***	−0.164***	−0.167***	−0.081	−0.023	−0.130***	−0.077
	(0.041)	(0.045)	(0.047)	(0.036)	(0.054)	(0.094)	(0.050)	(0.050)
Log(Population) 2006	0.035	0.031	0.029	0.035	0.007	0.040	0.011	0.041
	(0.028)	(0.028)	(0.029)	(0.028)	(0.038)	(0.031)	(0.034)	(0.027)
DURBAN	0.095*	0.082	0.084	0.097**	0.197***	0.013	0.062	0.042
	(0.055)	(0.053)	(0.059)	(0.049)	(0.074)	(0.081)	(0.062)	(0.061)
DJAVA	0.107*	0.064	0.103*	0.074	0.134	−0.143	−0.046	−0.116
	(0.056)	(0.049)	(0.054)	(0.049)	(0.141)	(0.094)	(0.092)	(0.085)
Constant	0.628***	0.661***	0.693***	0.680***	0.439	0.328	0.873***	0.482**
	(0.163)	(0.162)	(0.174)	(0.154)	(0.324)	(0.362)	(0.257)	(0.245)
Kleibergen F−stat	22.28	13.80	243.5	14.85	1.021	126.2	17.76	64.89
O−P effective F−stat	15.02	10.91	162.81	12.56	1.296	16.61	13.70	13.73
Hansen J stat, *P*−val	0.596	0.380	0.443	0.603	0.697	0.399	0.402	0.434
Endog *P*−val	0.378	0.445	0.0905	0.279	0.0165	0.0243	0.278	0.0588
Observations	195	195	195	195	195	195	195	195
R−squared	0.208	0.242	0.228	0.237	−0.531	−0.077	0.059	−0.032

not otherwise. We thus take the relevant comparisons for strong vs. weak district coefficients on RD to be (1') on Table S12 vs. (1) on Table S11, and analogously (2') vs. (2), (3) vs. (3) and (4) vs. (4).

Only with the more comprehensive institutional quality measure is there limited evidence for a contingent curse. No RD measure is found to negatively affect income, but mining's share of GRDP has a marginally significant (10 per cent level) positive effect in stronger districts and no effect in weaker ones. Similarly, oil/gas fiscal dependence has a larger positive effect (1.905) in stronger districts than it has in weaker ones (0.197). However, coal revenue dependence has no significant effect in stronger or weaker districts, and overall mining fiscal dependence has a positive effect in weaker districts but no effect in stronger ones.

5. Conclusions

We have examined whether the positive effect of resource dependence (RD) on real per capita income in Indonesia found by Cust and Rusli (2014) and Hilmawan and Clark (2019) can be explained by five candidate causal channels. These candidates have figured prominently in the resource curse/blessing literature, and are RD's effects on 1) the size of the manufacturing or 2) agriculture sectors, 3) education, 4) institutional quality and 5) the proportion of public spending on capital.

Using a three step strategy, we first confirm that RD has been positively associated with income in Indonesia for the years of our study. Using four alternative RD measures and instruments based on historical resource abundance and changes in physical production, we find RD is positively associated with growth for three of four measures. We estimate a standard deviation increase in the change in mining's share of GRDP between 2007 and 2015 would increase real per capita GRDP over that period by 9.4 per cent.

In our second step, we find that most measures of RD positively contribute to the size of manufacturing, high school enrolment rates, and to institutional quality. We find most measures of RD are not significantly associated with share of fiscal spending on capital, nor with the size of agricultural, though with coal fiscal dependence a positive outlier for the former, and a negative outlier for the latter. While there is limited previous research for Indonesia, our positive findings for manufacturing confirm previous descriptive studies by Usui (1997), Asanuma (2008) and Feryawan (2011), and perhaps reflect higher induced demand for resource-related manufactured goods.

Our finding that RD raises high school enrolment rates is unusual, but may reflect resource rents being used to fund increased supply. Similarly, our surprising finding that RD raises district institutional quality might suggest districts are using the additional rents they receive to improve their administrative capacity, perhaps incentivised by responsibilities assigned them under decentralisation (Cust and Poelhekke 2015).

In our third step, we find that while RD increases manufacturing, education enrolment, and institutional quality, only institutional quality is positively associated with economic growth between 2007 and 2015. Specifically, districts that receive a greater share of their fiscal revenues or GRDP share from mining enjoy higher institutional quality as assessed by central government auditors. Whether caused by RD or other factors, this higher institutional quality appears to raise per capita GRDP. Our main approach did not allow, however, for institutional quality (or other potential factors) to be endogenous to growth. Our finding is not robust to using single abundance instruments to jointly address the potential endogeneity of RD and each possible causal factor in turn. This causal mediation analysis does not find that RD works through institutional quality, or any of the five potential causal factors, to raise income. It is hard to know if this discrepancy is because undiagnosed endogeneity of the causal factors in our original Step 3 is creating misleading evidence that institutional quality is a significant mediating variable, or because our abundance measures are poor instruments for our potential causal factors, each considered without controlling for the others. Either way, it is clear our five potential candidates together account for only a small fraction of the positive effect of RD on incomes.

Finally, we do not find support for the 'contingent curse' hypothesis that RD causes growth for districts who already enjoy strong institutions, and not for those who do not.

Our study is limited by being confined to the years after Indonesia's major decentralisation. We thus cannot be sure how much the benefits of RD and its causal channels owe to the particulars of this decentralisation, with its return of resource revenues and public good responsibilities to districts. Nevertheless, for this vast resource-producing developing country, we find RD may be raising per capita income in part by working through funding the improvement of district institutional quality.

Data availability statement

The data that support the findings of this study are available in the supplementary material of this article.

The data underlying this paper can be accessed at [Data S1].

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1 Definitions of variables and data sources.

Table S2 First stage regressions for each rd measure in Table 2 or Table 3.

Table S3 Resource Dependence and real per capita GRDP with RD_{2006} Included.

Table S4 Resource Dependence and real per capita GRDP Using Only Abundance-Based Instruments.

Table S5 Dependent Variables ΔManufacturing output.

Table S6 Dependent variables ΔAgricultural output.

Table S7 Dependent Variable ΔNet Enrolment Ratio for students in high school.

Table S8 Dependent Variable ΔInstitutional Quality.

Table S9 Dependent Variable ΔShare of Public Spending on Capital.

Table S10 Alternative Analysis for Step 3 Using IVMediate

Table S11 FD-OLS Effects of resource dependence on districts with stronger and weaker initial institutions, 2010 base year.

Table S12 IVGMM Effects of resource dependence on districts with stronger and weaker initial institutions, 2010 base year.

Data S1 Data and Stata Regression Command Files.