Master's Thesis of Economics

Long-run impact of innovation on resource-dependence and economic growth in the context of Resource curse and Middle-income trap

- A panel cointegration approach -

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Abstract

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The ubiquity of innovation-growth literature has created an impression of having found a universal panacea for stagnant economic growth problem. Nevertheless, majority of the research proves the point by referring to East Asian countries, which are, probably, the sole group of countries that succeeded in overcoming middle-income trap by innovating. Such situation around innovation-growth research has created a gap for further investigation, which leaves the issue of resource-dependent states unresolved. Specifically, this paper demonstrates that a considerable share of countries that fall into the middle-income trap are resource exporters, which could mean that Resource curse, a common problem facing developing resource countries, is a determining factor for economic growth of these countries.

Current paper, thus, tries to combine the issues of Resource Curse stemming from resource-overabundance and Middle-income trap to reassess innovation's positive impact on economic growth. To diverge from the 'well-behaving' country analysis, this paper will utilize data on 24 relatively underrepresented upper-middle-income countries including Central Asian, Western Asian, Southeast Asian states, etc. as some of them are representative of both Middle-income trap and Resource curse.

An intrinsically time-series approach, panel cointegration, will be used in this endeavor. In contrast to abundant cross-sectional comparison literature, this method will help one to identify long-run relationship and its direction of causality between main variables. The analysis will begin by taking a stance on Resource curse debate and identify whether its proxy, resource dependence, is a determinant of economic growth. One will, then, identify whether innovation might have a mitigating effect on Resource curse, as measured by resource dependence. A proper robustness check using various model specifications will support the empirical evidence that Resource curse is detrimental to economic growth and that innovation, indeed, has a mitigating effect on resource-dependence. As a result, innovation's positive effect on overcoming Resource curse and Middle-income trap will be stated based on the empirical analysis robust to unobserved heterogeneity and serial correlation.

Key words: innovation, resource dependence, resource curse, middle-income trap, panel cointegration, error-correction model.

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I. Introduction

1. Current state of resource trade

Decades after the creation of steam engine and subsequent industrial inventions, countries have been constantly increasing their industrial production and shifting from agriculture and resource extraction towards manufacturing sectors. Still, historical evidence demonstrates that natural resource extraction, especially that of oil, has been steadily increasing up to the last decades. For example, world oil production nearly doubled between 1965 and 1980, with a continuous rise by 30% more up until 2010 (Ruta & Venables, 2012). International oil trade has followed a similar pattern with its share in total world trade rising to around 66% in 2010. Interestingly, a driver for resource trade has been rise of emerging economies' industrial production, which spurred an upsurge in the demand side of resource trade. Case in point, there was an increase in import of natural resources in China (by 30%), Singapore (by 22%), South Korea (by 17%) and India (by 25%) since 2000 (Ruta & Venables, 2012).

Though it is true that leading natural resource exporters include both advanced economies, such as US and Canada, and developing countries (like Africa, Middle East, CIS), there is still a clear distinction in the level of dependence of an economy on resources. For instance, share of resource exports in total exports in less diversified developing economies spikes to 70%, while it does not reach 20% in developed natural resource exporters (Ruta & Venables, 2012). This lack of export diversification, thus, has been referred to as a leading source of economic stagnation in developing resource exporter countries. Importantly, resource abundance and resource-dependence, meaning over-exporting resources compared to other products, has broadly been identified in the literature as strong factors dragging countries into either so-called 'Resource curse' or middle-income trap, the former meaning that countries with abundant resources experience slower growth compared to non-resource countries (Auty, 1993), and the latter meaning that countries stagnate at the level of 20-30% of US's GDP per capita (Lee, 2013b).

2. Resource curse

There is a plethora of literature discussing economic stagnation or slowdown of developing resource exporters. Following Sachs and Warner (1995), majority of papers uses so-called Resource curse as a broader term to define a tendency of resource-abundant countries to experience downturns in economic growth and manufacturing exports, the latter also referred to as Dutch disease. Similarly, resource abundance has been linked to volatility in output growth (Poelhekke & van der Ploeg, 2009) and commodity price dependence (Ruta & Venables, 2012) resulting in instability of economic development.

However, there is no agreement upon a point that a country rich in natural resources would be better off without them (Badeeb, Leen & Clark, 2017). Despite negative theoretical evidence for Resource curse, there is also counter-evidence from both advanced and developing countries which managed to overcome severe economic slowdown. Famous examples of these countries include US, Canada, Sweden, Australia, Botswana, Chile, Indonesia, etc. It is important to note which factors contributed to these countries' steady growth despite resource abundance, which will be discussed in more details in the literature review. Generally, though, Resource curse remains a ubiquitous problem for a large number of developing countries at different levels of growth.

3. Resource curse and Middle-income trap

Intuitively, an interesting parallel can be made between Resource curse and widely-discussed Middle-Income trap, which refers to economic stagnation of developing countries at around 20-30% of US GDP per capita level (Lee, 2013b). An empirical evidence based on 14 countries from this paper's sample (Figure 1) shows that more than half of them are trapped in the middle-income trap (Azerbaijan, Bulgaria, Belarus, Colombia, Costa-Rica, Iran, Malaysia, etc.)

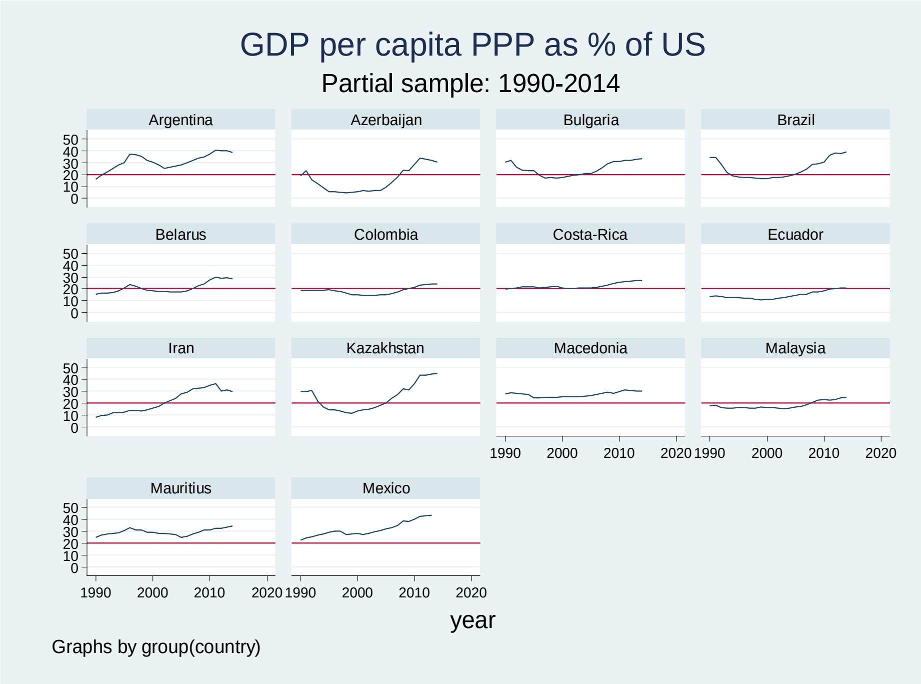

Figure 1. Middle-income trap in a sample of 14 countries.

Source: Prepared by the author using World Bank Database.

At the same time, Figure 2, outlining the leading natural resource exporters among developing countries demonstrates that there is a clear overlap between country's resource export orientation and falling into middle-income trap. This is evident from examples of Malaysia, Argentina, Iran, Colombia, Ecuador, Belarus, Azerbaijan. Similarly, a stagnating pattern can be witnessed in Kazakhstan, Argentina and Brazil, despite higher levels of development in preceding periods.

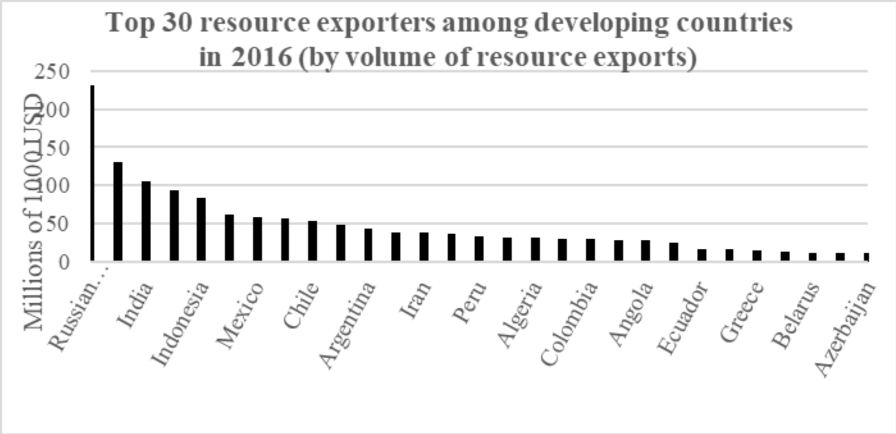

Figure 2. Top 30 natural resource exporters among developing countries by volume of resource exports.

Source: Prepared by the author using Chatham House resource trade database.

Hence, it is possible that by considering Resource curse, one might explain country's stagnation in the middle-income trap in case of resource-rich states. Although this seems to be an obviously negative factor for economic growth, one of main questions of this paper will be to try to restate the argument for Resource curse's negative impact on economic growth, because, given the empirical evidence, this relationship is not universally negative. Still, if one can make an argument for existence of a negative relationship between resource-dependence of a country, which is a proxy for Resource curse, and economic growth, then one further needs to look for possible solutions for this overarching problem.

4. Innovation as a remedy to Resource curse

Among numerous factors, innovation has by far been one of the most widely discussed remedies for middle-income trap. Still, the ubiquity of innovation-growth literature has created an impression of having found a universal panacea for stagnant economic growth problem. Nevertheless, majority of research papers prove the point through the analysis of the so-called Asian tigers, or East Asian countries, as these are, probably, the sole group of countries, which succeeded in overcoming the middle-income trap by innovating. Such situation around innovation-growth research has created a gap for further investigation, which I try to fill with this research.

5. Contribution and innovativeness

More specifically, this paper diverges from majority of literature to include evidence from regions previously underrepresented in the literature and having a certain characteristic (resource dependence), but whose development paths might add some relevant variables into identifying the determinants of economic growth. By doing this, the gap in the research will be filled by also considering innovation's effect on growth channeling through Resource curse prism, i.e. by answering the question whether innovation's ability to stimulate growth is a sole prerogative of industrialized countries, or is it an important factor for resource exporters as well.

An underlining question, then, is whether innovation is a relevant variable not only for economic growth, but also for mitigating the negative consequences of Resource curse, i.e. for decreasing the resource-dependence of a country. This paper will, therefore, try to contribute to literature on both Resource curse and Innovation by assessing the long-run cointegrating relationship between innovation and resource-dependence, and see whether a possibly soothing effect of innovation could be channeled further to economic growth. For this purpose, one first needs to prove the existence of resource-dependence's negative effect on economic growth. Then, an analysis of innovation's negative effect on resource-dependence would come as a solution to the problem of slow economic growth. Thus, such chain-relationship analysis will provide a full-scale understanding of a specific channel of innovation's positive effect on economic growth through Resource curse mitigation.

From theoretical point, this paper will contribute to the literature on Resource curse by not only stating its existence and debating the existing theories, but also by seeking a solution to the problem. Indeed, literature is abundant in discussing factors that might help a country overcome Resource curse, such as trade openness, institutional quality, etc., but there is a very limited range of research considering innovation as a possible remedy. From empirical point, a key variation of this research from existing literature lies in its intrinsically time series focus. Rather than conducting a mere cross-country comparison, this paper also considers the dynamic long-run relationships and variables' time series properties that will complement cross-country comparison. In this endeavor, a panel cointegration approach has been the most compelling technique so far. It will allow one to test the relationship between main variables of focus regardless of possible heterogeneity, omitted variable problem and cross-sectional dependence. Then, as a result of empirical test, one may conclude whether innovation, indeed, is one of determinants of resource-dependence and, further, economic growth, or the other way around.

6. Structure of the paper

This paper will be organized as follows. Section II will discuss existing literature on Resource curse, innovation and economic growth. Then, in Section III, utilizing both, literature and empirical data, one may form a theoretical argument of the paper and its main hypotheses. Section IV will outline theoretical foundations of panel cointegration approach by discussing its four-step process and then, Section V will discuss the specifics of data and variables used in testing. Afterwards, in Section VI, one may proceed to depiction of results of empirical tests, which will be organized by two broad hypotheses. After outlining results for all steps of the tests, a proper robustness check is provided in Section VII, which is followed by a discussion of results and limitations of research. The paper will terminate by making broader concluding remarks and possible policy implications in Section IX.

II. Literature review

The following literature review will be structured to begin with general research on Resource curse and debate over its negative effect on economic growth.

It will, then, continue by discussing factors intervening within the resource-economic growth relationship that are widely discussed solutions for Resource curse. Following, literature on innovation's effect on economic growth will be provided as representation for innovation's undebatable facilitating effect on economies. Finally, papers on innovation's specific applicability to Resource curse problem will terminate the discussion on relevant literature before moving on to building new theoretical argument.

1. Are resources a curse or a blessing?

Representatives of traditional school of thought in resource literature including Sachs and Warner (1995) and others has advocated that resource rich economies demonstrate slower growth patterns, which deteriorates with falling manufacturing exports as opposed to mineral exports. Similarly, Poelhekke and van der Ploeg (2009) also claimed that natural resource abundance depresses economic growth both directly and through the channel of volatility of unanticipated output growth.

However, an alternative view held by Badeeb et al. (2017) and Arezki and van der Ploeg (2007), suggests that it is misleading to conclude that natural resources are intrinsically and ultimately harmful to growth, as none of researchers so far provided an evidence that a country is well off without resources. Specifically, detrimental effect of resources on growth might be overestimated in econometric analyses, because as macroeconomic-type research they are prone to omitted variable bias and heterogeneity problems.

Similarly, according to Lin et al (2011), resource-abundance can be turned to a blessing provided that a country utilizes its resources endowment as comparative advantage to the fullest. This may require strong management of resource revenues to channel them to more productive sectors at the middle-income trap stage, thus facilitating structural transformation. Still, Lin et al (2011) also point out that Resource curse will still take place if governments blindly instill industrial policies without fully utilizing current comparative advantage before shifting their economies to manufacturing sectors, which would also require enormous capital inflows.

2. Why is Resource curse not a universal problem?

In a similar manner, Acemoglu and Robinson (2012) demonstrate, based on cases of Australia, Chile, Norway, Botswana and United States as opposed to Cameroon, that falling into resource curse is conditional upon poor institutional quality and the former countries managed to overcome the curse while Cameroon fell into this trap due to its weak institutions. This popular view is supported by Stiglitz (2005), who provides two contrasting cases to conclude that government effectiveness is important in determining resource curse. Specifically, he notices that several decades ago Indonesia and Nigeria, and Sierra Leone and Botswana started out at similar income levels and were all resource abundant. However, later on Indonesia and Botswana diverged considerably from Nigeria and Sierra Leone (almost 4 times in income terms), because the latter group struggled with civil unrest during the period. However, Lee and Kim (2009) emphasize that institutions are only significant to economic growth in case of lower- and lower-middle income countries. This is evident from their observation that upper-middle income and high-income countries have similar levels of institutional quality, meaning this factor is not a determining one for overcoming middle-income trap, a term applicable to upper-middle-income countries.

A second widely discussed possible factor for success of some resource countries in overcoming the Resource curse is trade openness. According to Martin (2005), there might still be an increase in productivity and manufacturing exports when policies encourage export activities among firms. Importantly, author points out that firms are more prone to greater technical change when they expand internationally, rather than being part of a restricted market. Arezki and van der Ploeg (2007), too, argue that countries with less restrictive trade policies tend to overcome Resource curse's negative consequences and can even turn their resource-orientation into a blessing. Still, according to Lee and Ramanayake (2015), trade openness may not always have a curing effect on economy unless there is a simultaneous export growth in a developing country.

3. Can innovation cure Resource curse and middle-income trap?

Literature on resource curse, though, is currently shifting its focus from merely stating the negative impact of the curse to trying to propose policies to avoid or negate the externalities from resources (Badeeb, 2017). Majority, nevertheless, only limits their focus to discussing institutional quality and trade openness as important factors in resource economies. Unfortunately, one important factor is often underlooked in the literature – innovation, which might be a source of overcoming Resource curse or at least decreasing its extent.

Innovation literature is abundant in economic growth implications. For instance, Lee (2013b) writes on technological innovation's beneficial effect on catching-up with forerunner countries. Europe 2020 strategy report (European Commission, 2017), has also advocated innovation as an important driver of economies, which would increase local firms' competitiveness worldwide, create jobs and contribute to sustainable economic development. The latter point was first suggested by Schumpeter (1970), where he explained conceptually how R&D activities might facilitate economic development by producing innovative ideas and processes by utilizing human capital (Erdil Sahin, 2015). This paper laid the foundation for further emphasis on the literature on innovation's positive impact on economic growth, which will help one build theoretical foundations of current paper.

Numerous other authors have argued for innovation's positive effect on growth, and most of them succeeded in proving the point using various empirical techniques and samples. Due to broad coverage of innovation literature, I will outline the main arguments and results in the following Table 1.

Table 1. Existing literature on innovation's effect on economic growth.

Author(s)	Method	Sample, period	Results
Park (1995)	OLS, Fixed effect, Random effect	10 OECD countries, 1970-1987	Private sector R&D expenditure spillover facilitates local factor productivity, while public sector R&D has international positive spillover.
Freire-Serén (1999)	Fixed effect	21 OECD countries, 1965-1990	1% increase in R&D expenditure is proven to increase real GDP by 0.08%.
Ulku (2004)	Fixed-effects and Arellano-Bond GMM estimators	20 OECD and 10 non-OECD, 1981-1997	Both samples yielded positive and significant relationship between R&D, innovation (patent applications) and GDP per capita.
Bozkurt (2015)	Johansen cointegration and VECM	Turkey, 1998-2013	There is a cointegration between R&D and GDP, but only uni-directional causality from GDP to R&D.
Gocer (2013)	Panel cointegration test, Panel AMG method	11 developing Asian countries, 1996-2012	R&D expenditures increase high-tech exports, communication technology exports and economic growth.
Lee and Kim (2009)	Panel fixed effect, GMM, Cross-sectional equation	Developing countries, 1965-2002	Institutions and secondary education matters for increasing economic growth in lower and lower-middle income countries, while technological development (R&D) and tertiary education are important for upper-middle and high-income income countries.

There is, still, a very limited range of literature applying innovation as an instrument of overcoming Resource curse in particular. Among them, Al Sabah (2014) suggests that it is possible to mitigate the extent of resource dependence by incentivizing firms to engage in more technologically innovative activities, which would make exports more productive and institutions more transparent, thus facilitating economic growth. Although Al Sabah (2014) provides a strong theoretical foundation for the argument for innovation's ability to decrease resource dependence, his paper lacks empirical evidence for the argument. Similar argument for innovation is made by Wright and Czelusta (2004), who once again drew upon examples of US, Australia and Sweden and claimed that these countries succeeded in utilizing their advanced technologies to promote growth even though these are the leading resource-exporting economies.

4. Conclusion from the literature

Based on existing literature on Resource curse, innovation and economic growth, one can conclude that Resource curse argument is still a controversial question and there is no clear consensus on its negative effect on economic growth. Unlike Resource curse question, literature is abundant in evidence for innovation's positive impact on economic growth broadly, which allows one to use these findings unquestionably for the purpose of current analysis. Therefore, the paper will further assume that innovation can directly improve economic development. However, there is no clear answer to whether this effect might be channeled through Resource curse prism, i.e. that there is a clear curing effect of innovation on resource dependence that would then facilitate growth. These open questions from the literature, thus, will contribute to the foundations of the main hypotheses of the paper.

It is important to note from the literature that there are various possible factors that might increase or decrease the possibility of a country to fall into Resource curse, like institutions, trade openness, etc., but, for reasons of theoretical novelty, innovation is the most attractive factor, as it has a very limited coverage in natural resource literature.

III. Theory and hypotheses development

Given a limited coverage of innovation-resource dependence relationship in the existing literature, innovation's mitigating effect will be also traced from available country data. Thus, theory building in this paper will also be based on empirical observations rather than solely relying on previous literature.

1. Evidence for existence/absence of Resource curse problem

First, one needs to take a stance on the controversial relationship between resource dependence (representing Resource curse) and Economic growth. Based on data from Malaysia and Mauritius presented below, there is, indeed, a detrimental effect of resource dependence on growth, which supports a popular claim in the literature (see Figure 3 and 4).[①]

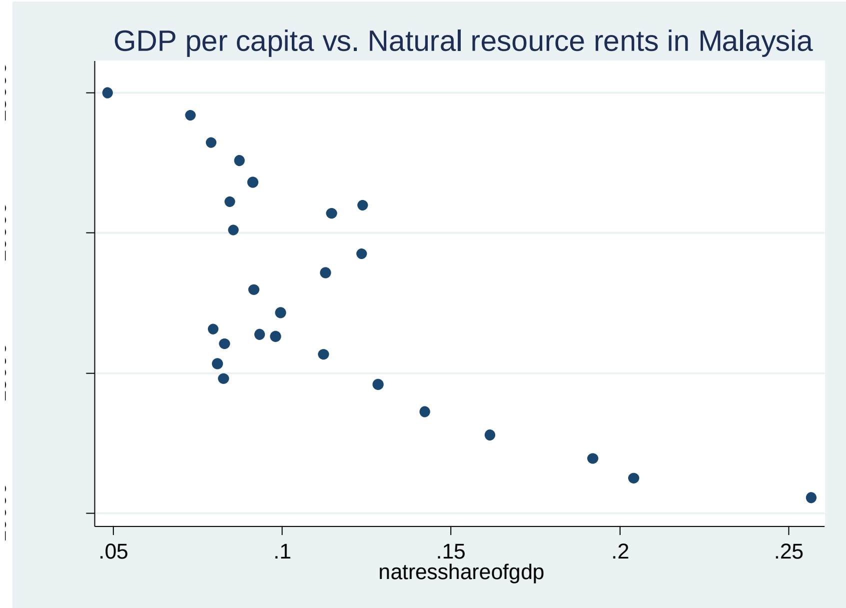

Figure 3. Resource curse evidence from Malaysia.

① Natural resource rents share in GDP is used to indicate resource-dependence on these graphs and further in the paper. The detailed discussion on definition and calculations of this indicator will be provided in the Data and Methodology section later.

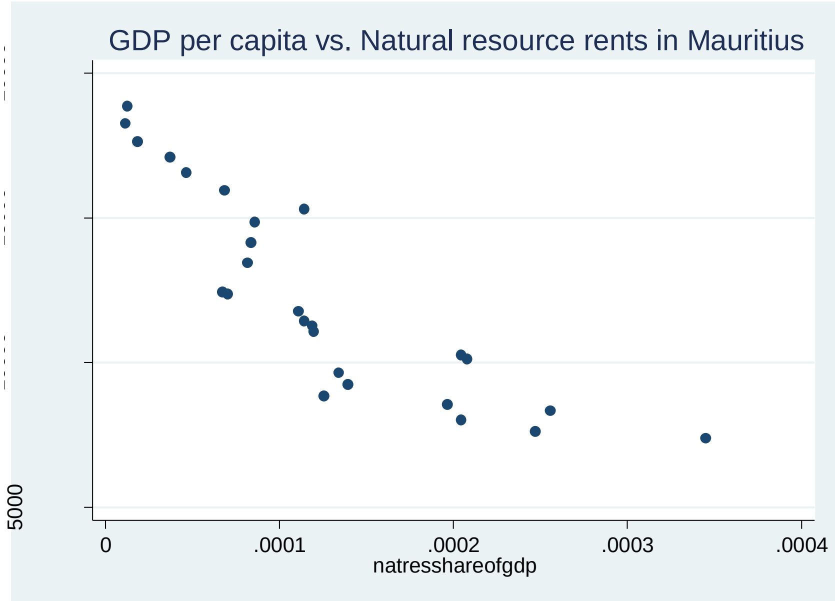

Figure 4. Resource curse evidence from Mauritius.

Source: Prepared by the author utilizing the World Bank data.

Following a similar argument, it is also worth looking at Figure 5, which clearly demonstrates differences in resource rents of lower-middle, upper-middle income and high-income countries. Apparently, there is only a slight divergence between lower-middle and upper-middle income data, which means that resource rents are not a determining factor at lower levels of economic development. On the other hand, in line with this paper's focus on middle-income trap, resource rents tend to become considerably lower at every point in time in high-income countries. This allows one to accept that Resource curse is, indeed, an important problem to solve by a country at upper-middle income stage to move further into high-income group.

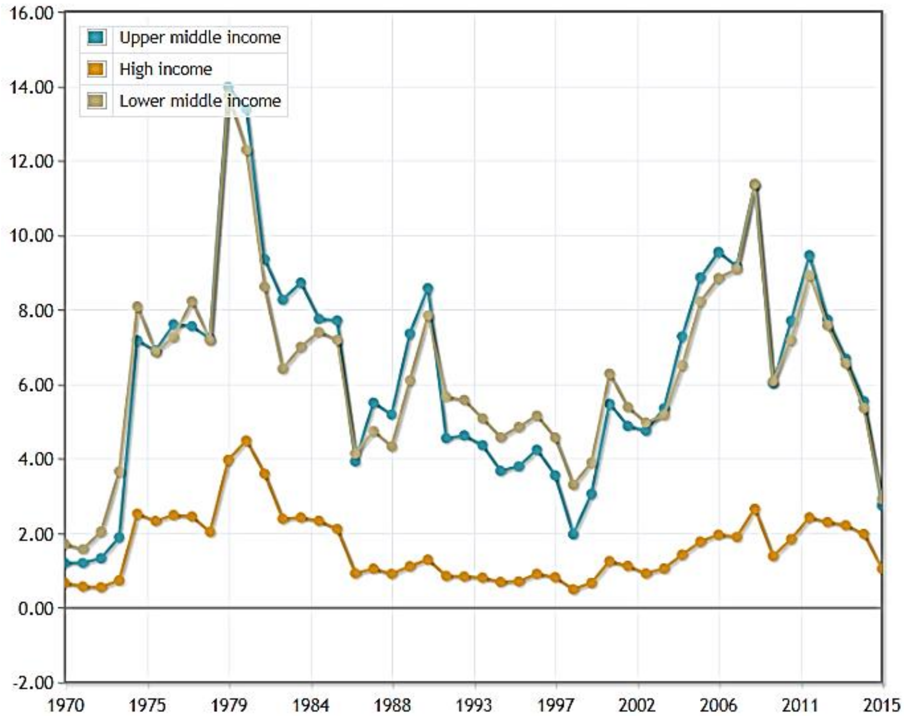

Figure 5. Total natural resource rents as % of GDP (from top to bottom – upper-middle income and lower-middle income, high income).

Source: indexmundi.com using World Bank WDI.

On the other hand, other countries from the same sample, such as Thailand and general sample, demonstrate that there is no clear-cut pattern of relationship, or even a positive one, between resource dependence and economic growth (Figures 6 and 7). Thus, similar to literature, empirical data does not demonstrate an undebatable Resource curse issue, which means this requires a rigorous econometrical proof.

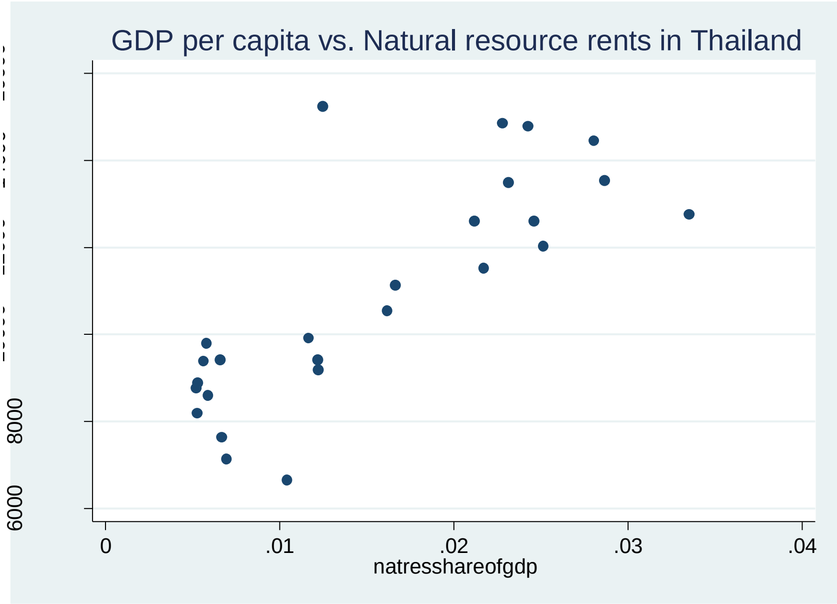

Figure 6. Evidence against Resource curse from Thailand.

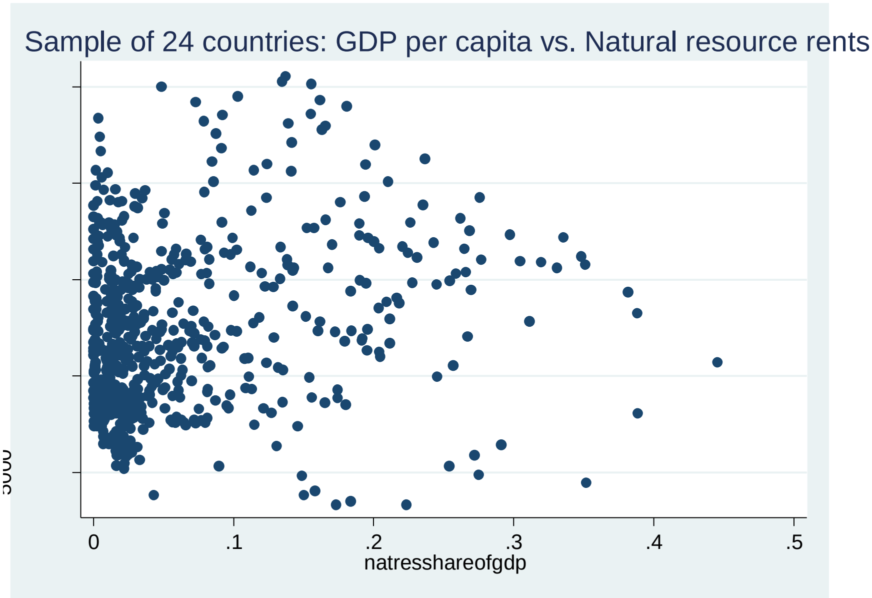

Figure 7. Evidence against Resource curse argument from overall sample of countries (unclear pattern).

Source: Prepared by the author utilizing the World Bank data.

Based on data observation made above, a proper empirical analysis needs to be conducted to identify: first, true sign of relationship between resource dependence and economic growth in the long-run and, second, the direction of this relationship (whether there is uni- or bi-directional long-run causality). Hence, the first hypothesis (and its extension) would be:

H1a: There is a negative long-run relationship between Resource dependence and Economic growth.

H1b: There is a uni-directional long-run causality running from Resource dependence to Economic Growth.

2. Evidence for innovation's effect on resource dependence

Moving on to solving the problem of stagnated economic growth from Resource curse, one might witness how innovation can be a useful exogenous factor affecting Resource curse. For instance, Figure 8 demonstrates an example of Kazakhstan, and more specifically the evolution of R&D/GDP ratio (lower line) versus Resource-dependence (ratio of resource exports to total exports). It is apparent from the figure that, excluding the world crisis of 2007-2009 (where both variables moved in a similar manner due to common exogenous factors), two series have opposite movement at almost every point in time. Representing resource dependence with resource export share in total exports is an extra empirical observation, but throughout this paper one will use another indicator, natural resource rents as a share of GDP. The figure still suggests that there is a negative relationship between innovation and resource-dependence at least in this panel of countries, but possibly worldwide as well.

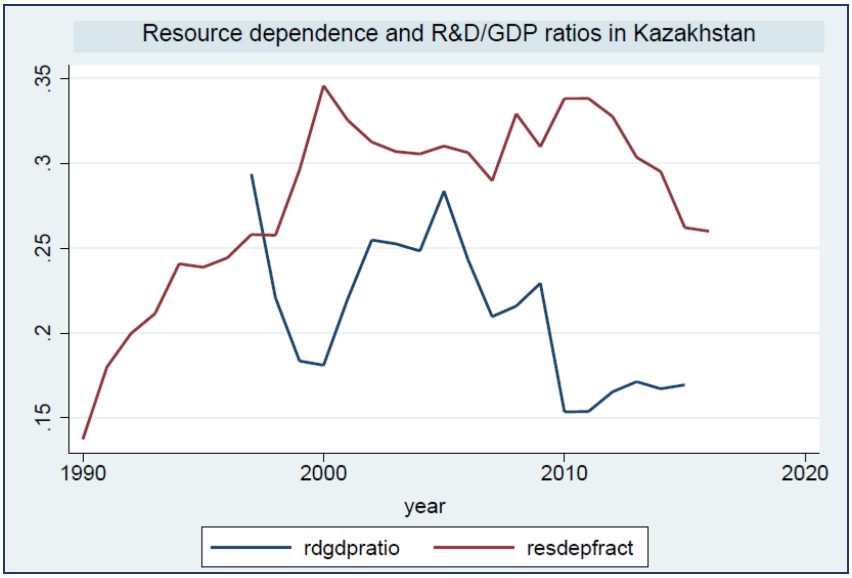

Figure 8. Resource dependence vs. Innovation in Kazakhstan.

Unfortunately, it is challenging to demonstrate a clear relationship between natural resource rent indicator and innovation due to low variability of R&D/GDP ratio for majority of the countries, which makes the relationship invisible even at logarithm levels of resource dependence. Therefore, this paper will proceed with the empirical analysis, which would help one shed light on existence of econometric relationship otherwise invisible in the data.

Based on empirical data one may theorize that innovation, through the channels of increased transparency and engaging in more productive export activities by the firms, has a decreasing effect on resource dependence. More specifically, Maican et al (2017) have found that R&D investment is especially facilitating for export demand in high-technology, because this sector's elasticity of productivity is higher than in low-technology sectors (like crude resource extraction). Thus, by replacing larger share of output revenue with high-technology ones would automatically decrease resource rents as a share of GDP. Overall, due to fixed endowment of resources, supply of natural resources will not change by itself, but its share in total income may be affected by other sectors. On the other hand, after analyzing African countries' cases, Lee et al. (2015) posit that moving from crude oil extraction to refining is a step forward, using medium short-cycle technologies. This might suggest that innovation can directly affect resource sector's rent levels, because unlike crude resource extraction, refining has its costs and is more prone to competitive forces and decreases in abnormal profits (exactly what is meant by resource rents), a positive change for growth. Hence it is possible to hypothesize the following:

H2a: There is a negative long-run relationship between innovation and resource-dependence.

In terms of direction of causality, the following extension outlines the possibility of using innovation as a tool to affect resource dependence without suffering from reverse causality:

H2b: There is a uni-directional long-run causality running from innovation to resource dependence.

3. A note on innovation's effect on economic growth and a theoretical summary.

This paper will continue without restating innovation's positive impact on economic growth, as the literature is abundant enough in this field and one may accept this relationship as proven. But generally, knowing that innovation has positive impact on economic growth would complete the circular relationship chart below (Figure 9) and this paper will contribute by proving two remaining hypotheses to ensure the channeling impact of innovation, rather than simply a direct one.

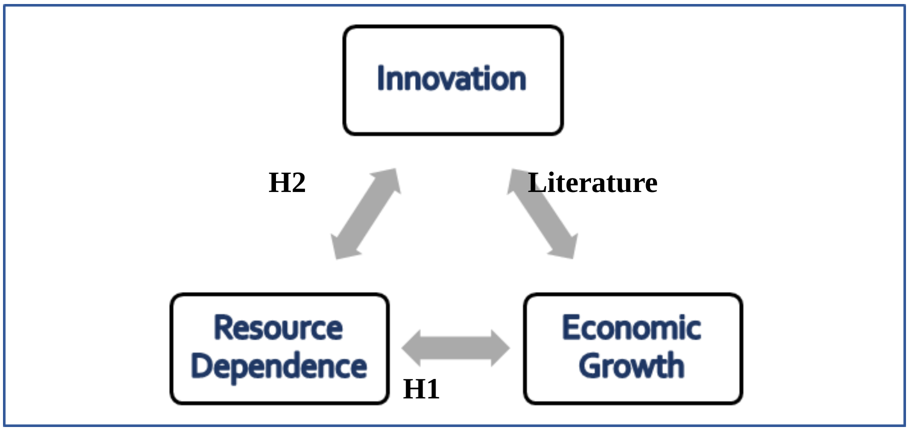

Figure 9. Summary of main hypotheses.

IV. Data and indicators

To test the abovementioned hypotheses as robustly as possible, data used for Panel cointegration empirical analysis has to follow several specific characteristics.

First, it requires one to use a panel cross-country data, and in this paper, I will utilize a panel of 24 (N) upper-middle income countries, including those from relatively underrepresented regions, which are Central Asia, Western Asia, Southeast Asia and Latin America, etc. (see Appendices for a full list and classification of countries by region and by extent of resource dependence). Second, panel cointegration analysis requires long time spans. Thus, a period of 26 years, from 1990 to 2016 (T), will be used, but this period may be further shortened for some parts of analysis due to missing values problem and consequently its inappropriateness for those parts. In general, Panel cointegration analysis has mostly been used with time series datasets, but recently has been applied to panel datasets, which tends to increase the extent of question that one can now discuss given the wide availability of panel data on country level. Despite a relatively short time span and number of cross-sections, panel data analysis will not suffer as much from this as would Fixed effect or GMM estimators, due to its good small sample properties (Bun & Windmeijer, 2010), as the latter two are heavily reliable on large cross-sectional dimension (N).

A third condition requires all variables to be non-stationary processes, because to ensure cointegration, a linear combination of non-stationary variables should become a stationary process (based on macroeconomic theory). This is a convenient requirement, as majority of macroeconomic variables (a focus of this paper, too) tend to be unit root processes. I will first list the variables of interest in this section and in the next section will conduct panel unit root tests to assess whether they are, indeed, non-stationary. It is worth noting that, even though panel cointegration approach does not have a conventional classification of dependent and independent variables (as cointegration is the goal), I will divide variables in a traditional manner, because analysis will not stop at finding cointegration, but will proceed to find direction and signs of relationship.

More specifically, I will treat the economic growth and resource dependence variables as dependent in hypotheses 1 and 2 respectively, because resource dependence and innovation are treated as exogenous variables in those hypotheses. Below one can find a table (Table 2) of all variables used in the analysis, including control variables.

Table 2. Description and sources of the variable indicators

Variable	Definition	Source
GDP per capita PPP	GDP per capita PPP (constant 2011 international $)	Penn World Table 9.0
GDP PPP	GDP PPP (constant 2011 international $))	PWT9.0
R&D expenditure	Research and Development expenditure as a percentage of GDP	WDI
Resource-dependence	Total natural resource rents as a percentage of GDP: difference between the price of a commodity and the average cost of producing it (abnormal profit)	WDI
GDP as % of US's	Ratio of GDP per capita, PPP (constant 2011 international $) over that of US	WDI
Trade openness	Sum of exports and imports a percentage of GDP	WDI
Population growth	Annual growth rate of population (%)	WDI
Investment	Gross fixed capital formation (% of GDP)	WDI
Secondary enrollment	Gross enrollment ratio, secondary, both sexes (%)	WDI
Institutional quality	Estimate of government effectiveness	World Governance Indicators (WB)
Government expenditure	General government final consumption expenditure(% of GDP)	WDI
Medium-high-tech.exports	Medium and high-technology exports as percentage of total manufacturing exports	WDI
FDI	Foreign direct investment as a percentage of GDP	WDI

Important to note on the measure of resource dependence, a controversial debate might occur on its alternative indicators. Following Sachs and Warner (1995) and De Rosa and Iootty (2012), majority of papers measure resource-dependence by fuel exports as a percentage of GDP, underlying assumption being that fuel exporting countries are historically more prone to relying on resource exports as their main economic driver. However, this is a crude measure of resource dependence, because it is limited to only one type of natural resource. Another attractive alternative to this relatively crude measure comes from an indicator developed by Hailu and Kipgen (2015), called EDI (Extractives dependence index). The index consists of 3 indicators:

"a) the share of export earnings from extractives in total export earnings; b) the share of revenue from extractives in total fiscal revenue; and c) extractives

industry value added in GDP"(Hailu & Kipgen, 2015, p.3).

However, the time span of the index currently covers data up to 2010, which would substantially decrease the power of the panel cointegration test. Therefore, this measure can be utilized later if data on more recent periods becomes available.

Based on limited availability of indicators of resource dependence, the focus of this paper will be on an innovative way to measure resource dependence, total natural resources rents. This measure, suggested by World Bank Development Indicators based on Lange et al (2010), is *"the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents"* (World Bank, 2011). In this definition, 'rent' refers to economic rent, i.e. revenues above the cost of extracting the resources. These are calculated by the World Bank by:

"taking the difference between the price of a commodity and the average cost of producing it. This is done by estimating the world price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs (including a normal return on capital). These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product (GDP)." (World Bank, 2011)

The relevance of this measure to Resource curse discussion can be traced intuitively from the fact that it represents contribution of natural resources to economic output. It is a good measure of resource dependence because it shows that there is lack of production, as rents occur in natural resource sectors because nothing is being produced. Alternatively, in case of healthy production, competition drives abnormal profits (rents) to zero, leading to sustainable and productive economic development. Thus, increased rents that are not reinvested into more productive sectors and capital demonstrate boundedness(dependence) of an economy by resource revenues from its endowments and means borrowing against its future stock (World Bank, 2011).

There are numerous variations of indicators of economic growth variable in the literature, but for the purposes of this paper one will focus on GDP constant PPP and GDP per capita constant PPP retrieved from Penn World Table 9.0. Both measures will be used for this empirical analysis, provided that they pass the Panel unit root tests and are eventually non-stationary variables.

Turning to the measure of innovation, it is measured by a conventional R&D/GDP ratio indicator, which demonstrates the input to innovation, a reason why it is often criticized as not conveying the true extent of innovational output (Castellaci and Natera, 2013). Indeed, not all firms that invest in R&D eventually end up with technological innovations. In this line, Lee (2013a) argues that mere public R&D spending and tax incentivizing might not be as effective as promoting more R&D capability among firms, i.e. encouraging firms to engage in more R&D transferring activities from research institutes and in public-private R&D partnerships. However, due to controversies present in the literature on measuring innovation as well as lack of plausibly widely-available alternative, I will continue with R&D/GDP ratio indicator further throughout the analysis.

A set of control variables for second hypothesis on resource dependence includes institutional quality (measured by government effectiveness index) and trade openness, which are widely connected in the literature to Resource curse, including Acemoglu and Robinson (2012) paper. For economic growth variable in hypothesis 1, I follow convention in the literature and macroeconomic theory to include trade openness, investment (gross capital formation), government spending, population growth and human capital (secondary enrollment), as well as adding medium-high-technology exports, inflation and FDI as alternatives in robustness checks. Below one can find a table of summary statistics for available data, where it is, unfortunately, clear that the main variable innovation lacks full data for a whole period and has a low variation compared to other main variables, which are current limitations of the paper (see Table 3). Nevertheless, one may still proceed with econometric analysis despite this observation to see if it affects the results considerably or not. Importantly, while conducting Panel cointegration analysis, a maximum of only seven explanatory variables can be included in the model, which is a restriction made by Pedroni (1999). For this reason, a more rigorous robustness check will help one to confirm results using various combinations of control variables.

Table 3. Descriptive statistics for a set of variables.

Variable	Obs.	Mean	Median	Std. Dev.	Min	Max
GDP constant PPP	600	449115.7	173446.7	631467.1	9822.835	3447919
GDP per capita PPP	641	12458.17	11989.86	4432.288	3319.77	25668.88
R&D/GDP ratio	383	0.4776	0.4177	0.301	0.0515	1.298
Resource rents share	614	6.4115	2.7829	7.928	0.000	44.557
Government effectiveness	432	-0.154	-0.129	0.5322	-1.3348	1.267
Government spending	638	14.39	13.72	3.6514	2.976	30.124
Inflation	557	64.399	11.837	343.22	-1.538	7481.66
Gross capital formation	638	22.363	21.263	6.16	5.385	57.709
Trade openness	638	76.019	66.599	40.39	13.75	220.41
Med-high-tech exp	558	0.333	0.3178	0.1952	0.029	0.801
Secondary enrollment	512	80.327	83.22	17.05	28.505	129.0
Population growth	648	0.989	1.249	0.958	-2.171	2.824
FDI	624	3.637	2.539	4.90	-0.876	55.076

V. Empirical analysis (theoretical background).

In general, working with panel data tends to bring numerous concerns, such as unobserved heterogeneity, cross-sectional dependence and serial correlation. In addition, it is usually advisable to work with larger panel datasets to achieve more robust results (as in Fixed effect and GMM), which restricts the ability of authors to make innovative theoretical contributions considerably. Considering these overarching challenges, new generation of empirical techniques, including Panel cointegration approach, allows one to shed light on previously underdiscussed issues, because it allows cross-sectional dependence and omitted variables in the analysis.

The benefits of Panel cointegration procedure over conventional panel data techniques such as Fixed effect, pooled OLS, Random effect, GMM lie in its good small sample property (and also for samples with equal N and T, which is almost the case in this paper), independence of asymptotic characteristics. As Pedroni (1999) points out, the advantage of non-stationary methods (like Panel cointegration, FMOLS, VECM used in this paper) is that they overcome two main heterogeneity types that exist in most analyses: fixed effects and differences in short-run responses of cross-sections to deviations.

Panel cointegration approach used in this paper consists of four steps, because in order to come up with reliable evidence for long-run relationship data needs to satisfy several characteristics. As a result, a test robust to slope heterogeneity, small sample size distortions and omitted variable bias is an output.

First step in the process, Panel unit root tests, requires a dependent variable and, for better results, all other relevant variables to demonstrate non-stationarity, meaning the data contains unit root. The reason for this lies in macroeconomic theory, which states that a linear combination of non-stationary variables turns out to be stationary, a core assumption of the next step, cointegration testing. Second, having evidence of non-stationarity of data, one may proceed to panel cointegration test, which would identify the existence and the number of cointegrating relationships. However, before conducting Johansen cointegration test, one needs to identify the optimal lag criteria and prove that variables are I(1). Then, the third step, Group-mean Fully-Modified OLS (FMOLS) would provide long-run coefficients of the cointegrating relationship. The last step – Vector Error-Correction Model (VECM) - will assess both short- and long-run relationships and, most importantly, it will demonstrate an evidence of uni- or bi-directional causality. Detailed assumptions and the results of each step of panel cointegration analysis are provided in the following sub-sections.

1. Panel Unit Root Tests (PURTs)

Following the majority of panel cointegration literature, I utilize four different panel unit root tests, one of which is, actually, a test for cross-sectional dependence. All tests generally assess the following unit root equation:

$$y_{it} = X_{it}\delta_i + \rho_i y_{it-1} + \epsilon_{it} \quad \textbf{(1)}$$

where i=1, 2…N are cross-sections and t=1, 2…T are time periods, X_{it} is a vector of exogenous variables, ρ_i - autoregressive coefficients, ϵ_{it} - error terms. $|\rho_i| = 1$ means y_i contains unit root, while $|\rho_i| < 1$ means y_i is stationary.

The first test is called after Levin, Lin and Chu (2002), shortly LLC, and it assumes a common unit root process across all cross-sections. That is, $\rho_i = \rho$ is the main underlying assumption. LLC uses an ADF regression equation:

$$\Delta y_{it} = d_{it}\delta_i + \rho y_{it-1} + \sum_{j=1}^{k_i} \varphi_{it}\Delta y_{it-j} + \epsilon_{it} \quad \textbf{(2)}$$

where Δ stands for first-difference, k_i is a lag, d_{it} is vector of deterministic variables. The null hypothesis of the test is:

H_0: $\rho = 0$ $(all\ time\ series\ contain\ a\ unit\ root)$, while the alternative is:

H_1: $\rho = \rho_i < 0 (none\ contains\ a\ unit\ root)$.

Alternatively, the second test by Im, Pesaran and Shin (2003) allows the unit root process to vary across cross-sections. It assesses the same equation (but changed ρ into ρ_i) as LLC, but with slightly modified null and alternative hypotheses:

H_0:$\rho_i = 0$ for all i;

H_1:$a\ non-zero\ fraction\ N_1\ of\ processes\ is\ stationary$.

Im et al. (2003) note that for consistency of their panel unit root test, they assume that N_1 is nonzero and approaches a fixed value 0<b<1. However, it is possible that both first-generation panel unit root tests fail to provide reliable results, which happens in case of cross-sectional dependence. This problem may arise from an omitted common stationary or non-stationary factor, such as world crisis, oil prices, or regional events/characteristics, that would affect all or a group of cross-sections simultaneously through spatial spillover effects (Breitug and Pesaran, 2005). Intuitively, it is very likely that macroeconomic variables of focus will exhibit cross-sectional dependence. Therefore, it is necessary to first conduct a test for cross-sectional dependence (CD test) proposed by Pesaran (2004) to check if the errors of cross-sectional terms are independent through the following estimation equation:

$$\mathbf{CD} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \qquad \mathbf{(3)}$$

where $\hat{\rho}_{ij}$-s are correlation coefficients between cross-sections and where the null and alternative hypotheses are respectively:

$$H_0: \hat{\rho}_{ij} = 0; \ H_1: \hat{\rho}_{ij} \neq 0.$$

Provided that the CD test yields rejection of null hypothesis, i.e. presence of cross-sectional dependence is confirmed, one should be cautious in using LLC and IPS tests and rather switch to Pesaran (2007) test. Pesaran (2007) also uses standard ADF regression, but adds cross-sectional averages of lagged levels and first-differences of individual variables. This gives a cross-sectionally augmented ADF statistics, or CADF, whose power remains in presence of panel with 1) similar orders of magnitude of N and T; 2) small values of N and T as evident from Monte Carlo experiments and 3) serial correlation (Pesaran, 2007).

Pesaran (2007) test estimates the following CADF equation that accounts for serial correlation:

$$\Delta y_{it} = a_i + b_i y_{it-1} + c_i \overline{y_{it-1}} + \sum_{j=0}^{p} d_{ij} \Delta \overline{y_{t-j}} + \sum_{j=1}^{p} \delta_{ij} \Delta y_{it-j} + \varepsilon_{it} \quad \mathbf{(4)}$$

The null hypothesis is based on OLS estimate of b_i, and like in LLC and IPS, assumes non-stationarity (b_i=0), while alternative hypothesis assumes stationarity ($b_i \neq 0$).

2. Panel Cointegration Test

Broadly speaking, panel cointegration test developed by Johansen (1991,1995) checks for existence of one or more cointegrating vectors between variables of focus. It uses the following restricted VAR, or error correction estimation equation to obtain the residuals:

$$\Delta y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \Pi y_{t-1} + \varepsilon_t \qquad \textbf{(5)}$$

where y_t is a vector of variables of interest, μ is constant term, Γ and Π are coefficient matrices. This equation differs from VAR by including a (t-1) variable lag separately in the equation, which is called an error correction term. Here one is interested in the rank of Π, which will equal the number of cointegrating relationships.

For this purpose, after running this VEC model, one may use its residuals for further identifying the trace and maximum eigenvalue statistics, i.e. two likelihood estimators, to see how many and which cointegrating relationships exist between variables. The first, trace statistic, is estimated by the following equation:

$$Trace = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i) \qquad \textbf{(6)}$$

This test hypothesized that the rank of Π is < or = r cointegrating vectors. The second test, the maximum eigenvalue statistic, assesses the hypothesis of exactly r cointegrating vectors in y_t and computed by:

$$\lambda max = -T ln(1-\lambda_i) \qquad \textbf{(7)}$$

For proceeding with the next step in econometric analysis, though, one also needs identification procedure to explicitly confirm which equation will be estimated further, because GFMOLS assumes that all variables in the model are endogenous. More specifically, second part of Johansen estimation output, that has normalized cointegrating coefficients, will specify which equation is a cointegrating vector and which variable is on right- and left-hand side of the equation. Then, one can construct a GFMOLS equation to assess this relationship's coefficients.

3. Group-mean Fully Modified OLS (FMOLS)

Having confirmed the existence of panel cointegration, the next step, Group-mean FMOLS (Fully Modified OLS) by Pedroni (2001) is used to estimate the coefficients of long-run relationship. The general estimating equation is:

$$y_{it} = \alpha_i + \beta x_{it} + \epsilon_{it},$$

$$x_{it} = x_{it-1} + e_{it} \quad \textbf{(8)}$$

where y is either *Resource Dependence* or *Economic Growth*, x includes main variable *Innovation/Resource dependence* and the control variables and estimator of interest is $\hat{\beta}$. In Group-mean FMOLS, though, heterogenous cointegrating vector is assumed, i.e. β_i (Pedroni, 2001). For the resource dependence case, the control variable is institutional quality, while for economic growth they are Government spending and Trade Openness.

Specifically, Pedroni (1995) and Phillips and Moon (1999) devised a fully-modified OLS estimator for time-series homogenous cointegration vectors to make it account for endogenous regressors and long-run correlation of error terms (e_{it} and ϵ_{it} in equation 7) with innovation of regressors (Breitug & Pesaran, 2005). Group-mean FMOLS (a panel version of FMOLS) proposed by Pedroni (2001), in turn, improves on power of FMOLS estimator by taking the averages of time-series FMOLS estimators from all cross-sections. Traditionally, papers on non-stationary estimation stop after unit root and cointegration testing, but with broader availability of data and innovative methods like FMOLS, one can now proceed to analyze in-depth the signs and the dynamics of the relationships. The advantages of GFMOLS over traditional OLS, Dynamic OLS and pooled FMOLS include a fast convergence rate of $T\sqrt{N}$ (rather than traditional $\sqrt{N}$) meaning it has a good small sample power, robustness to endogeneity problem (Pedroni, 2001).

4. Vector error-correction model (VECM)

Given that the long-run relationship and its coefficients are obtained from Johansen cointegration and GFMOLS, one may proceed to the final step, Panel VECM (Vector Error-Correction Model) developed by Pesaran et al. (1999). It is different from a conventional error-correction model in constructing a multiple-equation model based on restricted VAR.

Evidence of existence of cointegration, though, cannot tell us if only one variable affects the other or the reverse effect is also true. Therefore, VECM will identify whether the relationship is one-way or two-way in both short-run and long-run. Technically, VECM estimates the following equation:

$$\Delta z_{it} = \delta_i \hat{\epsilon}_{it-1} + \sum_{j=1}^{p} \Theta_{ij} \Delta z_{it-j} + \alpha_i + \xi_{it} \qquad \textbf{(9)}$$

where $z_{it} = \begin{pmatrix} res\_depend \\ r\&d/gdpratio \\ \vdots \end{pmatrix}$ and $\hat{\epsilon}_{it-1}$ is estimated error-correction term from previous FMOLS regression. For the long-run case, one is interested in this error-correction term’s coefficients, as it demonstrates how one variable responds to deviations in the long-run relationship from previous year (long-run causality). Thus, null hypothesis 1 is $H_0: \delta_{1i} = 0$. For the purposes of this analysis, ECT coefficient must be in the range [-1, 0] and significant to confirm long-run error correction. For the short-run causality, respectively, null hypothesis 2 is that each term in the Θ_{ij} cross-correlation matrix is zero (absence of short-run causality) and alternative hypothesis states the existence of short-run Granger causality. The results of panel cointegration analysis on two main hypotheses is presented in the preceding sections below.

VI. Results of empirical analysis

1. Panel Unit Root Tests for all variables

Having briefly discussed the theoretical foundations of panel unit root tests, one can witness their results for all the variables of interest as seen in Table 4 below.

Table 4. Panel Unit Root Test results

Tests / Var.	LLC	IPS	Pesaran (2007)			LLC	IPS	Pesaran (2007)			Pesaran (2004)
			lags=0	lags=1	lags=2			lags=0	lags=1	lags=2	
	With intercept					With intercept and trend					
GDP constant PPP	7.25 (1.000)	11.02 (1.000)	0.40 (0.657)	-1.86 (0.031) *	-2.89 (0.002) **	-2.39 (0.008) **	2.45 (0.993)	2.56 (0.995)	-1.13 (0.129)	-1.67 (0.048) *	73.36 (0.000)**
GDP per capita PPP	4.69 (1.000)	8.47 (1.00)	-1.76 (0.039) *	-3.16 (0.001) **	-1.95 (0.026) *	-2.11 (0.018) *	0.16 (0.564)	4.21 (1.000)	1.58 (0.942)	2.69 (0.996)	76.22 (0.000)**
R&D expenditure	1.31 (0.905)	3.04 (0.998)	0.34 (0.631)	NA	NA	-1.79 (0.04)*	0.57 (0.715)	2.03 (0.979)	NA	NA	0.83 (0.408)
Resource-dependence	-4.70 (0.000) **	-3.86 (0.000) **	-4.39 (0.000) **	-3.73 (0.000) **	-0.77 (0.219)	-3.08 (0.001) **	-3.07 (0.001) **	-1.96 (0.025) *	-2.67 (0.004) **	0.62 (0.732)	23.24 (0.000)**
Trade openness	-1.04 (0.148)	-1.27 (0.101)	-1.17 (0.121)	-2.57 (0.005) **	-0.95 (0.171)	0.29 (0.613)	1.29 (0.901)	-1.03 (0.151)	-2.08 (0.019) *	0.78 (0.784)	14.77 (0.000)**
Population growth	-0.31 (0.377)	0.78 (0.783)	-1.19 (0.117)	-0.62 (0.267)	0.65 (0.742)	-11.60 (0.000) **	-13.98 (0.000) **	0.39 (0.655)	-8.68 (0.000) **	2.92 (0.998)	18.4 (0.000)**
Investment	-1.57 (0.057)	-2.44 (0.007) **	0.34 (0.632)	-0.51 (0.305)	0.05 (0.520)	-0.34 (0.367)	-0.88 (0.188)	1.03 (0.849)	0.59 (0.723)	1.25 (0.896)	0.87 (0.385)
Secondary enrollment	0.04 (0.516)	1.38 (0.916)	NA	NA	NA	2.22 (0.986)	0.96 (0.832)	NA	NA	NA	NA
Institutional quality	-1.60 (0.054)	0.44 (0.669)	0.67 (0.750)	1.31 (0.906)	2.30 (0.989)	-0.06 (0.476)	1.78 (0.962)	1.21 (0.888)	0.98 (0.836)	3.69 (1.000)	-1.87 (0.061)
Government expenditure	-1.91 (0.028) *	-1.96 (0.024) *	-1.41 (0.079)	-0.20 (0.419)	0.11 (0.543)	-1.78 (0.038) *	-2.62 (0.004) **	-2.27 (0.012) *	-1.63 (0.051)	-1.89 (0.029) *	0.86 (0.391)
CPI (inflation)	2.793 (0.997)	5.777 (1.000)	-0.98 (0.164)	-0.98 (0.164)	-1.21 (0.114)	7.064 (1.000)	8.25 (1.000)	2.16 (0.985)	0.65 (0.743)	1.08 (0.860)	44.49 (0.000)**
Medium &high-tech	-3.666 (0.000) **	-2.479 (0.007) **	-1.55 (0.060)	-1.19 (0.117)	1.54 (0.938)	-3.414 (0.000) **	-1.773 (0.038) *	0.02 (0.507)	1.43 (0.924)	3.71 (1.000)	7.33 (0.000)**

** - 0.01, * - 0.5.
Null hypothesis: non-stationarity
Automatic lag selection
NA – not available due to missing values and inability to conduct test.
Shaded regions demonstrate stationarity risk.

It is important to first look at the CD test results (Pesaran(2004)), which demonstrates evidence of cross-sectional dependence in most of the variables. Therefore, it is worth focusing on the results of Pesaran (2007) rather than LLC and IPS results for the most part. Both Pesaran (2007) and LLC and IPS support non-stationarity, as null hypothesis could not be rejected in majority of cases. There is, still, a limited evidence for strong non-stationarity in cases of several variables, GDP constant PPP, Resource dependence, Population growth and Medium-high tech exports, which is why one can conduct Pesaran (2007) test for longer lags and see that (Table 5), indeed, these variables converge to becoming non-stationary over larger lags. We will proceed further given these results, because, according to Pesaran (2007), in presence of cross-sectional dependence and serial correlation, all tests tend to over-reject the null of non-stationarity. As a result of panel unit root tests, thus, one may conclude non-stationarity of data and may proceed to the panel cointegration test. Gengenbach, Palm and Urbain (2008) also solve the issue of serial correlation by adding more lads in the tests, which makes it more probable that a series is non-stationary.

Table 5. Pesaran (2007) test for chosen variables.

	GDP constant PPP		**Resource dependence**		**Medium-High-tech exports**		**Population growth**	
Lags	With int.	With int. and trend	With int.	With int. and trend	With int.	With int. and trend	With int.	With int. and trend
0	0.40 (0.657)	2.56 (0.995)	-4.23 (0.000)**	-1.96 (0.025)*	-1.55 (0.060)	0.02 (0.507)	-0.31 (0.378)	0.59 (0.725)
1	-1.86 (0.031)*	-1.13 (0.129)	-3.68 (0.000)**	-2.67 (0.004)**	-1.19 (0.117)	1.43 (0.924)	-4.53 (0.000)**	-10.78 (0.000)**
2	-2.89 (0.002)**	-1.67 (0.048)*	-0.76 (0.223)	0.62 (0.732)	1.54 (0.938)	3.71 (1.000)	0.62 (0.732)	3.03 (0.999)
3	0.72 (0.764)	-0.13 (0.450)	-0.49 (0.311)	1.89 (0.971)	1.39 (0.918)	3.59 (1.000)	-0.53 (0.298)	-0.40 (0.343)
4	1.87 (0.969)	0.66 (0.745)	-0.29 (0.388)	1.26 (0.896)	2.81 (0.997)	5.28 (1.000)	2.09 (0.982)	2.29 (0.989)
5	-0.56 (0.289)	-0.73 (0.234)	2.38 (0.991)	2.87 (0.998)	NA	NA	2.39 (0.991)	2.88 (0.998)

** - 0.01, * - 0.5.
Null hypothesis: non-stationarity
Automatic lag selection
NA – not available due to missing values and inability to conduct test.

Based on the evidence that variables of focus are non-stationary, one may further conduct remaining steps, which will be classified into two parts: Resource curse hypothesis and Innovation hypothesis. Still, despite having proven non-stationarity at levels, in order to run Johansen cointegration test one also needs evidence that variables are I(1), i.e. prove that variables become stationary at first differences. Thus, an additional procedure will be conducted for main variables for two equations, and the results are presented below according to hypotheses 1 and 2 (see Appendix 3 for summary of unit root test outputs).

Table 6: Summary of proof of I(1) variables unit root tests.

	Variable	Level	First-difference	Conclusion
H1	GDP per capita	Non-stationary	stationary	I(1)
	Government spending	Non-stationary	stationary	I(1)
	Trade Openness	Non-stationary	stationary	I(1)
	Natural resource rents (also in H2)	Non-stationary	stationary	I(1)
H2	R&D/GDP ratio	Non-stationary	stationary	I(1)
	Institutional quality	Non-stationary	stationary	I(1)

Given the results of the panel unit roots test extensions, one can proceed to assessing two hypotheses starting with Johansen cointegration testing. The following sections of results will be groups according to two hypotheses.

2. Resource Dependence-Economic Growth Equation

i. Panel cointegration test

For the purposes of conducting robust cointegration test, one needs, first, to identify the optimal lag interval for Johansen and VECM tests. This process is conducted using five common lag selection criteria, including sequential modified LR test statistic, final prediction error, Akaike information criterion, Schwarz information criterion and Hannan-Quinn information criterion. The results for both hypotheses are presented in Appendix 4, and they demonstrate that for Hypothesis 1 (Resource curse) optimal lag interval is 3, while for Hypothesis 2(Innovation) optimal lag interval is 2. We, then, will use the abovementioned results further in our cointegration and error-correction models.

Beginning with Resource curse argument, one may identify if there is any evidence of cointegration between resource dependence, economic growth, trade openness and government spending. GDP per capita PPP was chosen (over GDP constant PPP) and used further to represent economic growth due to its undoubtable non-stationarity characteristics in PURTs. Below one can find the output of first part of Johansen test, where results are divided according to Trace and Maximum Eigenvalue statistics.

Figure 10. Johansen cointegration test results for Hypothesis 1.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 crit.value	Prob. **
r=0*	0.11487	87.9835	47.8561	0.0000
r≤1	0.03633	25.2637	29.7971	0.1522
r≤2	0.01186	6.2420	15.4947	0.6669
r≤3	0.00021	0.1073	3.8415	0.7432
Trace test indicates 1 cointegrating eqn. at 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max. eigen. Statistic	0.05 crit.value	Prob. **
r=0*	0.11487	62.7198	27.5843	0.0000
r≤1	0.03633	19.0216	21.1316	0.0962
r≤2	0.01186	6.1347	14.2646	0.5960
r≤3	0.00021	0.1073	3.8415	0.7432
Maximum eigenvalue test indicates 1 cointegrating eqn. at 0.05 level				
* denotes rejection of hypothesis at 0.05 level				
** MacKinnon-Haug-Michelis (1999) p-values				

* Variables: GDP per capita, Natural resource rents, Trade Openness, Government Spending.
* Lag interval = 3, Number of observations=514 (period is 1994-2015)

According to both statistics, there is a presence of cointegration among four variables and both statistics demonstrate that there is one cointegrating vector. To identify which vector is cointegrating vector and to see if GDP per capita is the variable on the left-hand side of the equation, second part of Johansen test is presented below and demonstrates normalized cointegrating coefficients.

Equation 10: Cointegrating equation with normalized cointegrating coefficients (standard errors in parentheses):

$$gdppercap = -1842.6natresrents - 357.9tradeopen - 4410.9govspend$$

$$(373.745) \qquad (68.5718) \qquad (823.946) \quad (1)$$

From the figure above, it is clear that cointegrating relationship is the equation for GDP per capita PPP, and not the other variables. Therefore, given this result, one can further assess this vector's long-run coefficients using GFMOLS.

ii. GFMOLS

Given that cointegration exists in Johansen test above, GFMOLS is conducted to come up with long-run coefficients of cointegrating relationship based on residuals from previous cointegration regression. Table 7 represents that there is a significant negative relationship between resource dependence and economic growth, supporting the claim that Resource curse, indeed, negatively affects economic growth. Next section will go even further to assess the direction of causality by VECM method.

Table 7. Results for GFMOLS for Resource dependence – Economic growth equation

Depend. Var.	**Economic Growth (GDP per capita PPP)**	
Specification	No trend	With trend
Resource dependence	-13722.67 (0.000)**	-28037.18 (0.000)**
Trade Openness	58.58 (0.000)**	32.48 (0.006)**
Gov. spending	405.0 (0.000)**	553.78 (0.000)**

** - 0.01, * - 0.5.
p-value in ()
lag length is automatically selected by AIC criterion.
null hypothesis: no relationship, coefficient is zero.

According to GFMOLS results, the Hypothesis 1 is supported, i.e. there is a long-run negative and significant cointegrating relationship from Resource dependence to Economic Growth. Similarly, a traditional notion of trade openness' effect on economic growth is supported and demonstrates that more open countries tend to grow in the long-run. It might seem counter-intuitive to obtain positive coefficient of Government spending, but it could be due to the fact that for developing countries, growing government may be beneficial because it would increase institutional quality of the country, or the funds may flow to healthcare, social care systems, etc.

As a result of GFMOLS estimation, I managed to identify the coefficients of long-run cointegrating relationship. As a final step in this analysis, one needs to further assess long-run dynamics of this cointegrating relationship with error-correction model.

iii. VECM

Provided with the of Johansen cointegration and GFMOLS results, one can freely test whether cointegrating vector dynamics affect economic growth through time and how fast economic growth adjusts in future periods from changes in equilibrium today. Based on Johansen cointegration, the vector error-correction model of focus with single cointegrating vector and 3 lags will be as follows:

D(GDPPERCAPITA) = C(1)*(GDPPERCAPITA(-1) + 1842.57247541*NATRESRENTS(-1)+357.911850457*TRADEOPEN(-1) + 4410.99116224*GOVSPEND(-1) - 116040.356544)+C(2)*D(GDPPERCAPITA(-1))+ C(3)*D(GDPPERCAPITA(-2)) + C(4)*D(GDPPERCAPITA(-3)) + C(5)*D(NATRESRENTS(-1))+ C(6)*D(NATRESRENTS(-2))+ C(7)*D(NATRESRENTS(-3)) + C(8)*D(TRADEOPEN(-1)) + C(9)*D(TRADEOPEN(-2)) + C(10)*D(TRADEOPEN(-3))+ C(11)*D(GOVSPEND(-1)) + C(12)*D(GOVSPEND(-2))+ C(13)*D(GOVSPEND(-3)) + C(14) (10)

where first expression in brackets(bold) represents error-correction term, i.e. the cointegrating vector relationship considering deviation in the previous period. Respectively, C(1) is the long-run Error-correction coefficient (speed of adjustment), while other C() coefficients represent short-run dynamic relationships.

To prove existence of long-run Granger causality, ECT term has to be negative and its absolute value has to be in [0,1] range and significant. To assess the long-run coefficient C(1) in details, equation 10-th coefficients' p-values are checked with Least squares regression (Figure 12 below):

Figure 11. Panel least squares estimation of coefficients of VECM.

—	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.002822	0.001044	2.703722	0.0071
C(2)	0.325506	0.044906	7.248627	0.0000
C(3)	-0.048388	0.045345	-1.067103	0.2864
C(4)	0.157076	0.042000	3.739916	0.0002
C(5)	23.33360	8.988249	2.596012	0.0097
C(6)	19.65184	8.610518	2.282306	0.0229
C(7)	17.22374	8.583465	2.006618	0.0453
C(8)	1.661421	2.673788	0.621374	0.5346
C(9)	-1.111480	2.237677	-0.496712	0.6196
C(10)	1.728976	2.214652	0.780699	0.4353
C(11)	-8.229470	16.05833	-0.512474	0.6085
C(12)	-29.59804	15.52455	-1.906531	0.0571
C(13)	24.38472	14.70925	1.657781	0.0980
C(14)	191.8022	27.59075	6.951687	0.0000

The results above demonstrate that ECT coefficient is positive and significant, i.e it is not between [-1,0], which means that there is not long-run Granger causality on Economic growth. To check for short-run causality, I conduct additional Wald test for specific restrictions on Natural resource rents' effect on GDP per capita (coefficients of focus are C(5), C(6) and C(7) in equation 10 above. Wald test results are presented below:

Figure 12. Wald test for coefficients of Natural resource rents.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.955329	(3, 524)	0.0083
Chi-square	11.86599	3	0.0079

Null Hypothesis: C(5)=C(6)=C(7)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	23.33360	8.988249
C(6)	19.65184	8.610518
C(7)	17.22374	8.583465

Restrictions are linear in coefficients.

The output shows that null hypothesis of no relationship is rejected, according to p-values that are significant. Thus, one can conclude that there is a short-run Granger causality from resource dependence to economic growth. Interestingly, results of VECM demonstrate that rather than being long-run, the dynamics of cointegrating relationship are short-run, which partially support the main hypothesis. This can, on the other hand, be explained by the frequency of data (yearly) and the length of period of focus, which is short. Due to these factors, it is possible that long-run effect might not be represented by this data, while it is intuitive that there is more pronounced short-run yearly effect.

Overall, as a result of four-step analysis, one managed to prove that 1) cointegration between resource dependence and economic growth exists; 2) there is a negative significant relationship between the two variables, as proposed by majority of theoretical literature; 3) there is a uni-directional long-run Granger causality on economic growth, but not the other way around (from single cointegrating vector); and 4) there is only short-run effect of Resource curse on country's economy, but no long-run effect.

3. Innovation-Resource Dependence Equation

Moving on to the main contribution of this paper, given the non-stationarity and I(1) nature of main variables, one may proceed to assess whether innovation affects resource dependence or not (Hypothesis 2). This results section will follow a similar structure to previous section.

i. Panel cointegration test

Similar to previous section, before conducting Johansen cointegration test, we ran a lag selection process and identified that optimal lag interval is 2(see Appendix 4 for details). The results of Johansen (1991,1995) cointegration test for innovation, resource dependence and institutional quality equation are provided in the figure below:

Figure 13. Johansen cointegration test result for Hypothesis 2.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 crit.value	Prob. **
r=0*	0.1134	32.4257	29.7971	0.0243
r≤1	0.0411	11.0071	15.4947	0.2111
r≤2	0.0197	3.5399	3.8415	0.0599
Trace test indicates 1 cointegrating eqn. at 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max. eigen. Statistic	0.05 crit.value	Prob. **
r=0*	0.1134	21.4187	21.1316	0.0456
r≤1	0.0411	7.4671	14.2646	0.4355
r≤2	0.0197	3.5399	3.8415	0.0599
Maximum eigenvalue test indicates 1 cointegrating eqn. at 0.05 level				
* denotes rejection of hypothesis at 0.05 level				
** MacKinnon-Haug-Michelis (1999) p-values				

* Variables: Natural resource rents, R&D/GDP ratio, Government effectiveness.
* Lag interval = 2, Number of observations=178(period is 1999-2015)

The output above demonstrates support for claim that cointegration exists. Once again, according to Trace and Maximum eigenvalue statistics, there is only one cointegrating vector between these three variables. Moving forward, a second part of Johansen test will show which exact equation entails this single cointegrating relationship.

Equation 11: Cointegrating equation with normalized cointegrating coefficients (standard errors in parentheses):

$$natresrents = -\underset{(88.8624)}{11.3}rdgdpratio - \underset{(42.9127)}{189.9}goveffectiveness \qquad \textbf{(11)}$$

According to the second part of Johansen test, the cointegrating relationship runs from innovation and government effectiveness on resource dependence (left-hand side), which is a single cointegrating vector to be assessed further. It can be represented by the following equation (which is a VAR equation) for clarity:

Nat.res.rents = C(1)*Nat.res.rents(-1)+C(2)*Nat.res.rents(-2)+C(3)*rdgdpratio(-1)+C(4)*rdgdpratio(-2)+C(5)*goveffect(-1)+C(6)*goveffect(-2)+C(7) (12)

Given this result, one may proceed to GFMOLS and assess this vector's long-run coefficients.

ii. GFMOLS

Running GFMOLS on Innovation-Resource dependence equation yields supportive results and supports Hypothesis 2 as evident from Table 10 below.

Table 8. Group-mean FMOLS results for Innovation-Resource Dependence equation.

Depend. Var.	**Resource Dependence**	
Specification	No trend	With trend
R&D/GDP ratio	-196.6 (0.000)**	-71.54 (0.000)**
Institutional quality	-3.90 (0.000)**	-0.45 (0.599)
Num. of observ.	214	214

** - 0.01, * - 0.5.
p-value in ()
null hypothesis: no relationship, coefficient is zero.
Control variables: fdi, tradeopen, govspend, grosscapform.
R&D/GDP is in ratio terms, while resource dependence is in %.

The results in Table 10 clearly support this paper's claim for innovation's mitigating effect on resource-dependence (Hypothesis 2), as the coefficient for R&D/GDP ratio on natural resource rents share is negative and significant for both trend and no-trend specifications. Results for Institutional quality's effect on resource dependence also support claims from literature that institutions help to overcome Resource curse, but only without trend specification.

Following the favorable regression results, one may proceed to assess the long-run dynamics with VECM in the next section.

iii. VECM

Provided with cointegrating vector specification and that there is only one vector, one may construct error-correction model using this vector. The following equation (12) demonstrates the VECM model of interest, where relationship is channeled towards Natural resource rents from other variables of focus. As before, main focus for identifying long-run causality is on C(1) coefficient, called speed of adjustment coefficient in front of error correction term(cointegrating vector in previous period) in bold. Other coefficients in front of lags of main variables represent short-run causality.

D(NATRESRENTSTOGDPPERC) = C(1)*(NATRESRENTSTOGDPPERC(-1) - 28.4459419716*RDGDPRATIO(-1) + 824.545021367*GOVEFFECT(-1) + 77.554258994) + C(2)*D(NATRESRENTSTOGDPPERC(-1)) + C(3)*D(NATRESRENTSTOGDPPERC(-2)) + C(4)*D(RDGDPRATIO(-1)) + C(5)*D(RDGDPRATIO(-2)) + C(6)*D(GOVEFFECT(-1)) + C(7)*D(GOVEFFECT(-2)) + C(8) + C(9)*FDI + C(10)*TRADEOPEN + C(11)*GOVSPEND. (13)

Running Panel least squares regression on this equation yield the following output:

Figure 14. Panel least squares results for coefficients of VECM.

—	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.001091	0.000456	-2.392006	0.0178
C(2)	-0.149207	0.067816	-2.200186	0.0290
C(3)	-0.331332	0.062708	-5.283741	0.0000
C(4)	-1.053220	2.985309	-0.352801	0.7246
C(5)	2.746971	2.696139	1.018854	0.3096
C(6)	-0.692885	1.633248	-0.424238	0.6719
C(7)	-1.815772	1.663911	-1.091268	0.2766
C(8)	1.051534	1.096963	0.958586	0.3390
C(9)	0.040778	0.028366	1.437594	0.1523
C(10)	0.001993	0.005546	0.359345	0.7198
C(11)	-0.088689	0.062662	-1.415365	0.1587

Supportive of hypothesis 2's claim, C(1) coefficient is significant at 5% level (p-value = 0.0178) and it lies within [-1,0] interval. This supports that there is, indeed, a long-run causality from innovation and institutional quality on resource dependence. Specifically, it tells that there is 0.11 percent adjustment of natural resource rents in this period from previous period's changes to equilibrium relationship. Though this adjustment speed seems to be very slow in economic terms, it is intuitive that resource-dependent economy will find it extremely challenging to abandon its resource-orientation until it exhausts its stock of natural resource to the fullest. Similarly, this speed supports theoretical argument that for resource-exporting countries it is more difficult to innovate, as opposed to industrialized countries that do not have this easy and attractive source of income (where country does not have to produce anything).

Moving forward to short-run causality, below is the result of Wald test specifically for coefficients of innovation, C(4) and C(5):

Figure 15. Wald test for coefficients of innovation.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	0.626683	(2, 183)	0.5355
Chi-square	1.253366	2	0.5344

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-1.053220	2.985309
C(5)	2.746971	2.696139

According to Wald test results, the null hypothesis of no short-run causality is not rejected, meaning that there is no short-run Granger causality from innovation to resource dependence.

To sum up, results for Innovation and Resource Dependence VECM equation demonstrate that there is a unilateral negative (from GFMOLS) long-run causality (significant at 5% level) from R&D/GDP ratio to Resource rents, which fully supports Hypothesis 2. There is also no evidence of reverse long-run causality to innovation (as there is only one cointegrating vector), showing that this variable is exogenously affecting the relationship. In the short-run, however, causality is not supported by empirical test, but it may also make economic sense, as was discussed before: for innovation to make impact on resource orientation of a country, it requires longer period of time until stock of natural resources is fully or mostly exhausted.

To summarize the results of the whole analysis for Hypothesis 2 on Innovation-Resource dependence relationship, one may definitely accept that 1) there is a significant cointegrating relationship; 2) there is a negative and significant (as suggested) long-run relationship; and 3) there is a uni-directional long-run causality on resource dependence. These findings, in turn, combined with ones in sections on

Hypothesis 1, allow us to confirm, that there might be an effect of innovation on economic growth, eventually, channeled through its effect on resource dependence. However, to prove this empirical result one must conduct a proper robustness check to see if the relationships still exist in different model specifications, which is done in the next section.

VII. Robustness Check

1. Resource dependence – Economic growth equation

First, the robustness check for Hypothesis 1 will be done for GFMOLS, which will be followed by robustness check on Hypothesis 2 in the next section.

According to Table 13, out of 16 model specifications, 12 models confirm negative long-run relationship at 1% significance level, while 2 more models provide support on 5% significance level. Apparently, the negative relationship between resource dependence and economic growth remains significant even in the presence of various intervening factors.

Table 9. Group-mean FMOLS Robustness Check for Resource Dependence-Economic Growth.

Model specif.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Res. depend	-12550.1 (0.001)**	-7293.3 (0.028)*	-7922.8 (0.000)**	-14189.5 (0.000)**	-11924.9 (0.000)**	-6494.8 (0.000)**	-9210.0 (0.069)	-7790.5 (0.068)
Secondary Enrollm.		116.24 (0.000)**				179.04 (0.000)**	56.79 (0.000)**	103.2 (0.000)**
Population Growth			-2666.8 (0.000)**			-4479.6 (0.000)**		
Inflation				24.54 (0.038)*			60.7 (0.000)**	
Gov.spend					-7.36 (0.849)			-167.6 (0.012)*
Trade Openness	-2.01 (0.886)	-14.03 (0.262)	4.52 (0.635)	-46.73 (0.000)**	-15.1 (0.064)	-8.78 (0.421)	-35.3 (0.000)**	-13.86 (0.295)
FDI	438.98 (0.000)**	240.3 (0.022)*	439.3 (0.000)**	414.4 (0.000)**	281.58 (0.000)**	230.77 (0.000)**	170.1 (0.036)*	390.1 (0.000)**
Institutional quality	3594.53 (0.000)**	2556.3 (0.000)**	1693.6 (0.000)**	2811.5 (0.000)**	1864.1 (0.000)**	1238.6 (0.001)**	2916.4 (0.000)**	1847.8 (0.000)**
Obser-s	333	247	333	300	333	247	223	247

Model specifications	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Resource dependence	-8071.5 (0.000)**	-7916.5 (0.000)**	-12360.3 (0.001)**	-8413.5 (0.000)**	-11191.5 (0.018)*	-8698.2 (0.000)**	-8159.6 (0.000)**	-8330.1 (0.001)**
Secondary Enrollment					33.72 (0.025)*	68.12 (0.000)**	58.1 (0.000)**	8.93 (0.439)
Population Growth	-344.8 (0.521)	-3582.3 (0.000)**		-2126.2 (0.000)**		-3308.7 (0.000)**	-5996.2 (0.000)**	-3488.9 (0.000)**
Inflation(CPI)	30.81 (0.004)**		40.66 (0.001)**	23.8 (0.001)**	62.28 (0.000)**	22.8 (0.129)		14.5 (0.242)
Government spending		-100.6 (0.004)**	-138.6 (0.003)**	-217.4 (0.000)**	-64.11 (0.294)		-155.0 (0.004)**	-188.8 (0.000)**
Trade Openness	-22.53 (0.035)*	-11.82 (0.135)	-52.95 (0.000)**	-23.88 (0.000)**	-63.06 (0.000)**	-24.5 (0.323)	-10.99 (0.338)	-34.92 (0.006)**
FDI	349.9 (0.000)**	320.4 (0.000)**	319.7 (0.001)**	273.2 (0.000)**	304.2 (0.000)**	177.85 (0.001)**	323.6 (0.000)**	306.5 (0.000)**
Institutional quality	960.2 (0.002)**	1570.5 (0.000)**	1175.3 (0.000)**	900.98 (0.000)**	1998.4 (0.000)**	1651.6 (0.000)**	1063.7 (0.000)**	1352.4 (0.000**)
Number of observations	300	333	300	300	216	216	233	216

Overall, a robustness check for Hypothesis 1 has yielded strong support for previous empirical analysis and confirmed negative coefficients of cointegrating relationships in the resource dependence-economic growth equation. The following section provides a similar robustness check for Hypothesis 2.

2. Innovation-Resource Dependence Equation

Following a similar procedure we run the GFMOLS robustness check on Hypothesis 2, where 10 out of 18 model specifications confirm negative relationship at 1% level, while 3 more specifications confirming it at 5% level. This is, once again, a strong support for previous GFMOLS results.

Table 10. Group-mean FMOLS Robustness Check for Innovation-Resource Dependence.

Model specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Innovation	0.95 (0.670)	-11.18 (0.000)**	-10.24 (0.001)**	-22.67 (0.011)*	-12.45 (0.037)*	-10.23 (0.000)**	-3.90 (0.007)**	-1.04 (0.457)	-8.72 (0.000)**
Secondary Enrollment				-0.14 (0.019)*	-0.07 (0.354)	-0.29 (0.000)**	-0.13 (0.002)**	-0.11 (0.007)**	-0.08 (0.069)
FDI								-0.09 (0.065)	0.03 (0.489)
Investment									
GDP per capita			-3.63 (0.891)				0.0002 (0.036)*	0.001 (0.001)**	
Trade Openness		0.15 (0.000)**	0.13 (0.000)**		0.22 (0.000)**	0.13 (0.000)**	0.15 (0.000)**	0.11 (0.000)**	0.15 (0.000)**
Institutional Quality	1.01 (0.358)	0.47 (0.453)	1.61 (0.075)	2.05 (0.366)		-2.92 (0.001)**	-1.01 (0.132)	1.65 (0.060)	-0.92 (0.195)
Number of countries	236	230	230	171	253	167	152	146	152

Model specifications	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Innovation	-11.12 (0.000)**	-9.68 (0.000)**	-94.5 (0.000)**	-5.88 (0.027)*	-6.22 (0.000)**	-2.21 (0.103)	-1.32 (0.529)	-4.82 (0.000)**	-4.98 (0.035)*
Secondary Enrollment					-0.02 (0.643)	-0.15 (0.006)**	-0.11 (0.203)	-0.06 (0.338)	
FDI	-0.26 (0.080)	-0.24 (0.129)	-51.49 (0.000)**				-0.13 (0.073)	0.04 (0.469)	0.001 (0.997)
Investment			10.67 (0.000)**	-0.06 (0.217)	0.03 (0.386)	-0.02 (0.673)	-0.06 (0.377)	-0.01 (0.850)	0.012 (0.859)
GDP per capita		-0.0003 (0.337)	-0.02 (0.000)**	-7.61 (0.759)		0.0002 (0.159)	0.0002 (0.007)**		
Trade Openness	0.14 (0.000)**	0.14 (0.000)**	-6.96 (0.000)**	0.19 (0.000)**	0.18 (0.000)**	0.14 (0.000)**	0.15 (0.000)**	0.16 (0.000)**	0.23 (0.000)**
Institutional Quality	1.68 (0.002)**	1.23 (0.326)	-7.11 (0.000)**	2.25 (0.000)**	-1.19 (0.056)	-0.05 (0.939)	3.34 (0.012)*	-0.57 (0.508)	1.09 (0.028)*
Number of countries	230	220	214	220	152	146	132	146	220

To conclude, a proper robustness check for Hypothesis 2 has yielded support for previous results in GFMOLS, regardless of variations and number of variables included in the model. Therefore, one may claim that there is a strongly persistent negative cointegrating relationship between innovation and resource dependence.

As a last step in the whole empirical analysis, robustness check concludes that the four-step Panel cointegration relationship is, indeed, reliable and yields support for main hypotheses of the paper which are based on literature and data observations. Below is a summary of robustness check, to visualize to which extent the empirical test results were supported. Table 16 demonstrates number of model specifications, out of total number, which passed the robustness check.

Table 11. Summary of robustness checks.

	GFMOLS	
	Strong support	**Weak support**
H1	12 / 16	2 /16
H2	10 / 18	3 / 18

VIII. Discussion and Limitations

As a result of four-step empirical analysis and subsequent robustness checks, this paper's main arguments for existence of Resource curse's negative effect on growth and innovation's possibly curing effect on Resource curse are confirmed. The results of empirical testing on two main hypotheses are outlined in Table 12 below.

Table 12. Summary of empirical results on two main hypotheses.

Hypotheses (equations)	**Johansen cointegration**	**GFMOLS**	**VECM**
H1: Resource dependence-economic growth	Cointegrated (1 vector)	Negative, significant (at 1% level)	LR: No causality SR: Uni-directional causality → Economic growth
H2: Innovation-resource dependence	Cointegrated (1 vector)	Negative, significant (at 1% level)	LR: Uni-directional causality →Res.dependence SR: No causality

Still, due to complications in working with panel datasets on macroeconomic level, as well as engaging in a sophisticated Panel cointegration approach, this paper might have several limitations.

First, evident from table of descriptive statistics, a dataset is not balanced, i.e. the main indicator, R&D/GDP ratio suffers from man missing values. Therefore, there might be a considerable variation in results, if another indicator of innovation is included or missing data is filled in manually or using imputation methods, which might be an improvement of the paper later.

Second, VECM could also suffer from missing values and demonstrate different results given a different time-structure, i.e. if the period length is quarterly, rather than yearly. For more reliable long-run results, a longer and more structural breaks-proof time structure needs to be adopted, if the data on such period structure is available.

Third, it is compelling to expand on this paper by combining resource dependence and innovation in one vector to assess their mixed effect on economic growth as opposed to their proven individual effects, but for reasons of econometric complication, this question is left for further extensions.

Finally, despite good small sample properties of empirical tests in the process, increasing the sample size would be valuable addition to the analysis. Especially, increasing time span may allow one to include more lags in the regressions, as the analysis is originally shown to perform well in time-series datasets.

Currently, though, these limitations will be outlined and taken into consideration, but they do not seriously hurt he results and contribution of this paper. The author will respond to these limitations and improve on empirical procedures further, provided the presence of more encompassing dataset and more comprehensible econometric technique. For now, therefore, one may proceed to make some concluding remarks of this paper and outline some possible implications of the results.

IX. Conclusion and policy implications

Key focus of this paper was to determine the existence of long-run equilibrium relationship between Resource-Dependence and Economic growth, as well as between Innovation and Resource dependence in the context of 24 upper-middle-income developing countries for a period 1990-2016.

Having checked the data for compatibility by conducting panel unit root and panel cointegration tests, we traced the long-run relationship using Group-mean FMOLS method by Pedroni (2001). The results indicate an evidence of negative relationship between Resource Dependence and Economic growth, while also confirming negative relationship between Innovation and Resource dependence.

Specifically, according to coefficients in GFMOLS, a 1% increase in Natural resource rents share in GDP leads to 13722.8 US dollars decrease in GDP per capita PPP. Though suspiciously escalated, this effect's existence and persistence is of no doubt after conducting a robustness check, but a more refined empirical data analysis is needed to completely rule out overestimation and errors. Though, based on these results, there is a strong detrimental effect of Resource curse on economic growth, meaning it is, indeed, a very important factor that may explain why some countries fall into a Middle-Income trap. Looking at VECM results also shows that, Resource curse directly affects economic growth in the short-run, rather than in long-run, meaning there is a relatively immediate stagnation resulting from country's increased focus on resource extraction.

Similarly, a 1% increase in R&D/GDP ratio decreases the share of natural resource rents in GDP by 1.96 %. This effect is relatively weak, but it still demonstrates the power of innovation as a tool to overcome negative consequences of resource overdependence, i.e. Resource curse. Also, the result of GFMOLS can be explained by VECM results, which tells that there is a long-run causality towards resource dependence. Once again, both long-run coefficient of GFMOLS and ECT coefficient demonstrate that it takes longer time for a country to abandon a share of its resource profits if it innovates today, which is, clearly, the case in most resource-exporting countries who are reluctant to change their established economic orientations.

These two effects, combined into one system of chained effects, represent a model for policymakers in resource-rich countries to consider when contemplating ways of combating Middle-income trap. Oftentimes, both in literature and on government levels, experts tend to try to blindly replicate the experience of advanced economies. This approach is favorable for catching-up with developed countries, but not all the specifics of developed countries may be applied to developing ones. Keeping that in mind, current paper has made an important first step, often skipped in policy-design, of assessing whether a factor that helped advanced economies to grow (innovation) is also binding when we consider specific type of economies, not industrialized, but resource-reliant. The analysis has confirmed that innovation is equally important for resource countries as it is for industrialized ones, which allows policymakers to facilitate R&D activity by incentivizing firms to engage in R&D, and by increasing country's R&D capability. Knowing this goal allows governments to also engage in improving human capital's absorptive capacity (Navaretti and Tarr (2000)) to be compatible with innovative orientation of a country, increasing FDI to allow entry of more productive businesses and finally, providing enough protection for intellectual property rights (Martin, 2005). Importantly, though, policymakers might not witness immediate effect from innovation, as evident from its long-run causality on resource dependence, which might seem as a weakness of innovation as policy tool. However, once effect on resource dependence is done, further impact on economic growth will take place in shorter periods and benefit the country faster. Hence, as a whole, this chained effect is, indeed, a long-run change, but it is definitely a worthy economic endeavour.

Another important takeaway from current analysis is that presence of cross-sectional dependence may be used by policymakers for facilitating growth. For instance, several countries in this sample, Central Asian, Southeast Asian states and Turkey, will all be affected by a common "One belt, One road" initiative, which will allow innovation spillover from China to these countries. In case of resource countries, this will result in growth of more productive innovative sectors, such as medium and high-technology, that will eventually constitute larger revenue shares in GDP and replace part of Resource rents share in national income.

Despite several technical misspecification issues and data limitations, this paper managed to support the theorization on innovation's mitigating effect on Resource curse. And, more broadly, the end result of this effect may be overcoming the Middle-income trap, which is strongly connected to Resource curse in resource countries.

To conclude, thus, this paper's use of a robust empirical technique and an underrepresented and resource-oriented sample of countries as opposed to ubiquitous focus in literature on "well-behaving" advanced states ensures the legitimacy of its results for use in further research and policymaking. Still, the research would benefit from additional analysis on several questions: trade variables' (such as Trade Openness, FDI) effect on Resource curse as alternative means of mitigation to innovation, institutional (structural transformation through use of resource revenues) change argument's assessment following Lin (2011), exchange rate undervaluation's effect on Resource curse and economic growth as a variable alternative. These extensions will, thus, be made by the author depending on data availability and compatibility.

X. Appendices

Appendix 1: List of countries in a sample.

Region	Countries
Latin America	Argentina, Ecuador, Brazil, Colombia, Paraguay, Peru, Venezuela
Central Asia	Kazakhstan
Western Asia	Azerbaijan, Iran, Turkey
Southeast Asia	Malaysia, Thailand
Europe	Belarus, Bulgaria, Macedonia, Romania, Russia, Serbia
Central America	Costa Rica, Mexico, Panama
Africa	Mauritius, South Africa

Appendix 2: Classification of resource dependent countries in a sample (natural resource rents as percentage of GDP).

	2000	2005	2010
Azerbaijan	35.21	38.87	30.47
Iran	31.14	33.12	22.63
Kazakhstan	24.55	27.68	21.03
Venezuela	18.37	25.41	10.21
Russian Federation	21.66	19.35	13.90
Ecuador	14.56	16.53	10.87
Malaysia	9.80	11.28	8.45
Colombia	5.08	6.10	6.27
Mexico	3.28	5.69	4.85
Peru	1.90	5.67	11.10
Argentina	2.10	5.44	3.14
South Africa	2.89	4.78	7.66
Brazil	2.45	4.75	4.45
Romania	3.60	2.35	1.49
Thailand	1.22	2.17	2.31
Macedonia	0.58	2.07	4.73
Paraguay	1.58	1.92	2.64
Belarus	2.47	1.83	1.41
Bulgaria	1.36	1.75	2.52
Serbia	2.03	1.43	2.28
Costa Rica	1.02	0.97	1.65
Turkey	0.23	0.29	0.56
Panama	0.11	0.10	0.26
Mauritius	0.01	0.01	0.01

Appendix 3: Unit root tests on levels and first-differences for specific variables used in hypotheses 1 and 2:

Variable	Level				First-difference			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
Gdppercap	2.094 (0.982)	5.389 (1.000)	16.44 (1.000)	5.97 (1.000)	-2.323 (0.010)**	-3.23 (0.001)**	72.34 (0.013)*	211.3 (0.000)**
Natresrents	-0.778 (0.219)	-0.838 (0.201)	38.454 (0.836)	94.389 (0.001)**	5.304 (1.000)	-4.52 (0.000)**	90.51 (0.000)**	502.98 (0.000)**
Tradeopen	-1.121 (0.131)	-1.403 (0.081)	56.794 (0.180)	92.72 (0.001)**	-0.058 (0.477)	-7.111 (0.000)**	137.9 (0.000)**	485.7 (0.000)**
Govespend	-0.167 (0.434)	-1.39 (0.082)	73.74 (0.01)**	93.489 (0.001)**)	0.155 (0.562)	-6.77 (0.000)**	130.1 (0.000)**	446.7 (0.000)**
Rdgdpratio	1.71 (0.956)	2.165 (0.985)	25.55 (0.963)	33.42 (0.759)	4.82 (1.000)	-2.69 (0.004)**	58.39 (0.006)**	197.4 (0.000)**
Goveffect	-1.12 (0.132)	-0.47 (0.318)	45.64 (0.487)	63.20 (0.05)*	2.599 (0.995)	-4.083 (0.000)**	83.97 (0.001)**	346.46 (0.000)**

*null hypothesis: non-stationary, contains unit root.
*lag length =3 according to Information criteria.
*() indicate p-values.
*LLC tends to demonstrate counter-results for first-differences, but one can disregard them, because LLC assumer common unit root, which is often not the case in macroeconomic variables.

Appendix 4: Lag selection results for Hypotheses 1 and 2.

Hypothesis 1(Resource Dependence-Economic growth):

VAR Lag Order Selection Criteria
Endogenous variables: GDPPERCAPITAPPP NATRESRENTSTOGDPPERC TRADEOPEN GOVSP...
Exogenous variables: C
Date: 05/30/18 Time: 23:00
Sample: 1990 2016
Included observations: 538

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-11305.59	NA	2.13e+13	42.04310	42.07498	42.05557
1	-8350.569	5855.121	3.84e+08	31.11736	31.27676	31.17971
2	-8264.664	168.9375	2.96e+08	30.85749	31.14441	30.96972
3	-8194.054	137.8066*	2.42e+08*	30.65448*	31.06892*	30.81659*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

*Result: majority of criteria choose lag length of 3.

Hypothesis 2 (Innovation-Resource dependence):

VAR Lag Order Selection Criteria
Endogenous variables: NATRESRENTSTOGDPPERC RDGDPRATIO GOVEFFECT
Exogenous variables: C
Date: 05/30/18 Time: 23:24
Sample: 1990 2016
Included observations: 137

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-602.5998	NA	1.387138	8.840873	8.904814	8.866857
1	-23.73535	1123.927	0.000338	0.521684	0.777449*	0.625621*
2	-14.14471	18.20122*	0.000335*	0.513061*	0.960650	0.694950
3	-9.432833	8.735889	0.000357	0.575662	1.215074	0.835503
4	-6.536952	5.242179	0.000391	0.664773	1.496008	1.002567
5	-1.910639	8.172027	0.000417	0.728622	1.751681	1.144369

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

*Result: majority of criteria choose lag length of 2.

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XII. Abstract (in Korean)

어디에서나 흔히 볼 수 있는 혁신 성장에 대한 연구는 정체된 경제 성장 문제에 대한 보편적 만병 통치 약을 찾았다는 인상을 주었다. 그럼에도 불구하고, 이 연구의 대부분은 혁신을 통해 중진국 함정을 극복한 유일한 그룹인 동 아시아 국가들을 언급함으로써 이 점을 입증하고 있다. 혁신 성장 연구와 관련된 그러한 상황은 추가적인 조사를 위한 간격을 만들어 냈고, 이는 자원 의존적인 국가들의 문제를 해결되지 않은 채로 두었다. 특히, 이 논문은 중진국 함정에 걸린 국가들의 상당 부분이 자원 수출자들인데 이는 자원 개발 도상국들이 직면하고 있는 공통된 문제인 자원 저주가 이들 국가의 경제 성장 결정 요인이라는 것을 보여준다.

그러므로 현 논문은 혁신이 경제 성장에 미치는 긍정적인 영향을 재평가 하기 위해 자원 과잉과 중진국 함정에서 기인한 자원 과잉 문제들을 결합하려고 한다. 혁신을 통하여 성장한 국가 분석에서 벗어나기 위해, 본 논문은 중진국 함정과 자원의 저주를 대표하는 중앙 아시아, 동남 아시아, 동남 아시아 24개 국가 데이터를 분석한다.

본질적으로 시계열 접근법인 패널 공적분 방법이 본 논문에 사용된다. 기존의 문헌과 다르게, 이 방법은 주요 변수들 간의 장기적 관계와 그 인과 관계 방향을 확인하는 데 도움이 된다. 본 분석은 자원의 저주

를 정의하고 자원 의존이 경제 성장의 결정 요인인지 여부를 확인하는 것으로 시작된다. 그리고 자원 의존성으로 측정하였을 때, 혁신이 자원의 저주에 완화 효과를 미칠 수 있는지 확인한다. 다양한 모델 사양을 사용하는 적절한 강인성 점검은 자원 저주가 경제 성장에 해로우며, 실제로 혁신이 완화 효과를 가지고 있다는 경험적 증거를 뒷받침한다. 자원 의존적인 결과적으로, 자원의 저주 및 중진국 함정 극복에 미치는 혁신의 긍정적 영향은 관찰되지 않는 이질성과 직렬 상관 관계에 대한 견실한 경험적 분석에 기초하여 명시된다.

주요어: 혁신, 자원 의존성, 자원의 저주, 중진국 함정, 패널 공적분, 오차교정모형

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