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DATE OF PHD: **MAY, 2016**

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SUMMARY OF CURRENT RESEARCH ACTIVITY

My research is at the intersection of development and International trade, but my interests extend to environmental economics and the oil curse literature. At the moment, I am currently working on four projects simultaneously with different co-authors.

The first focuses on the differing impacts of democracy on economies depending on their ties to religion. From the literature, democratic dividends accrue to countries which have bound the expansion of freedoms to the secularization of governments. This is inherently different from many Muslim countries with religion at the core of their national identity. In these cases, democratization happens alongside calls to institute, preserve, or expand Islamic Institutions such as Sharia law. Using the unique situation in Nigeria, where half of the country (the Muslim half) after becoming democratic in 1999, pushed for such expansions of Islamic institutions and the other half did not, we examine the role of the interaction between democracy and Islamic institutions, providing insight on what political scientists have termed the fourth wave of democratization, which centers on the Muslim world. Preliminary results show less dividends of democracy accruing to the Muslim half of the country when compared to the non-Muslim half. Some possible explanations could include a significant rise in violence after the elevation of the Sharia courts, a fundamental difference in the quality of institutions between both regions and significant differences in education. Research in this paper is still ongoing as the data collection process at the sub national level is slow going.

The second examines the role of trade and financial openness during and after the recession. While this has been done in the past, the novelty with this study is that we examine the role of openness in taking countries out of the recession given the availability of new data. Thus, we add to the literature by showing that openness, particularly trade openness, switches roles first acting as a curse through which countries are "infected" with the crisis but then, acts as a cure through which countries are delivered from it. Interestingly, we find that the endogenous response of financially open countries who withdrew from the international markets after the onset of the crisis is the reason why findings in the literature show that financial openness exposure was innocuous. We are able to show through a layered counterfactual analysis that should countries have remained just as financially open during the crisis as they had been in 2007, the effects would have been much worse than was observed.

The third paper still in the realm of International trade examines the roles of risk in determining bilateral trade. We pay particular attention to terrorism risk and legal risk, using measures that avoid the thorny issues of reverse causality. We show that these risks have a negative impact on trade, but contribute to the literature more substantially by examining the role of risk in determining a country's place in the global trade network and the formation of trade partner clusters. Results suggest that risk, as measured in this paper, plays an important role in network centrality with higher risk countries being less central in the trade network, ultimately leading to a formation of trade clusters, where similarly risky countries form more

partnerships and trade more with each other while trading less with countries outside their risk buckets. This is even more evident once we control for the presence of natural resources.

The final paper highlights the impact of short and long run water stress on agricultural output, focusing on extreme events. Our analysis includes punctuated dry spell events, longer term droughts, and aridity levels. We also investigate the impact of cumulative water stress and heat stress events. We find that longer run water stress events are damaging to agricultural production, but when simultaneously occurring with heat stress, all water stress events show a greater negative effect on agricultural production than compared to just heat stress alone, sometimes as much as 6 times the negative effect.

There are still plans for a few more projects that are still in their infancy with the barest minimum of data analysis being done. One uses the demonetization in India in November of 2016 as a natural experiment to determine which central bank policy: exchange rate pegging or inflation control, is successful at increasing exports, while the other examines the capital mix (foreign generated versus domestically generated capital) in countries to highlight the impact of specialization in intermediate goods on economic growth. Preliminary results show that countries that complement foreign capital with domestic capital on average have higher output levels and less volatile growth.

SUMMER INSTITUTE SESSION(S) OF INTEREST (IN ORDER OF PREFERENCE)

1. SI2021 Development Economics
2. SI2021 International Trade and Macroeconomics
3. SI2021 Forecasting and Empirical Methods
4. SI2021 Environmental and Energy Economics
5. SI2021 Micro Data and Macro Models

UCHECHUKWU AUGUSTINE JARRETT
Curriculum Vitae
April 2021

Education

2012 to 2016 University of Wisconsin - Milwaukee
Wisconsin. USA.

Ph.D. Economics, May 2016
Dissertation Title: Essays in growth and Development: An International Economics Perspective

2005 - 2009 University of Lagos, Akoka,
Lagos State. Nigeria.

B.Sc. Mathematics & Statistics (1st Class Honors)

Honors and Awards

- College of Business Excellence in Teaching Award, UNL College of Business (2020).
- UNL Parents Recognition Award (2019)
- American Economic Association Summer Program (AEASP), Advanced level Outstanding Teaching Fellow (2016)
- William L. Holahan Prize for Outstanding Teaching by a Graduate Student (2015)
- Member of the winning team in the Nigerian National mathematics competition for University Students (NAMCUS 2010)

Fellowships

- Duke University, Diversity Initiative for Tenure in Economics Fellow (Since 2019)
- University of Nebraska Lincoln, Yeutter Institute for International trade and finance Faculty Fellow (Since 2019)
- University of Nebraska Lincoln, College of Business Seacrest Teaching Fellow (2018, 2019 and 2020)

Research

Publications

Peer reviewed Journals

Mohtadi, H., Ross, M. L., Jarrett, U., & Ruediger, S. (2019). Kleptocracy and tax evasion under resource abundance. *Economics & Politics*. https://doi.org/10.1111/ecpo.12130

Jarrett, U., Mohaddes, K., & Mohtadi, H. (2019). Oil price volatility, financial institutions and economic growth. *Energy Policy*, *126*, 131-144. https://doi.org/10.1016/j.enpol.2018.10.068

Working Papers

"Unmasking the Globalization-Crisis Linkage: A Multi-layered Counterfactual Study" **with Hamid Mohtadi**

"Risky Gravity: Making the case for the role of Risk in Bilateral Trade" **with Hamid Mohtadi**

"The Path from Risk to growth, through Trade" **with Hamid Mohtadi**

Research in Progress

"Heat Waves, Precipitation and Economic Performance: A Global Perspective with Insights for the MENA region" **with Steven Miller and Hamid Mohtadi**

"An Uncertain Path: Nigeria's experience with Shar'ia Law" **with Antu Murshid**

"Economic Outcomes and the evolution of capital-type mix" **with Sujata Saha**

"Inflation targeting or fixed exchange rate regime: Which is better for International trade?"

Presentations

Jarrett, U., Midwest International Economic Development Conference, "Risky Gravity: Making the case for the role of risk in bilateral trade," University of Wisconsin, Madison. (April 26, 2019).

Jarrett, U., Midwest International Economic Development Conference, "Oil price Volatility, Financial Institutions and Economic Growth," University of Minnesota, Minnesota. (April 27, 2018).

Jarrett, U., Midwest Economic Association Conference, "The Role of Risk in Bilateral Trade," Midwest Economic Association, Evanston, Illinois. (March 23, 2018).

Jarrett, U., Midwest International Economic Development Conference, "Transmission of the great recession and the role of openness: A counterfactual diagnosis," University of Wisconsin - Madison and University of Minnesota, Minnesota. (May 7, 2016).

Certification

Survey of International Business. Faculty Development in International Business, Darla Moore School of Business, University of South Carolina. (2018)

Gallup Strengths Certified Coach (2019)

Teaching Experience

University of Nebraska-Lincoln

ECON 215, Statistics, 3 courses.
ECON 321, Introduction to International Economics, 20 courses.
ECON 399, Independent Study, 12 courses.
ECON 421, International Trade, 3 courses.
ECON 422, International Finance, 4 courses.
ECON 423, Economics of the Less Developed Countries, 3 courses.
ECON 822, International Finance (MBA), 4 courses.

Directed Student Learning

Doctorate (outside representative)

Doctorate (outside representative), "Two Essays on US Imports of Olive Oil," Agricultural Economics.
Advised: Abdel Malek Hammami

UCARE: Student Advisor

Shivalingaiah, S.: Impact of demonetization on the Indian economy
Tracey, G.: Reassessing the impact of NAFTA on the United States, Canada and Mexico
Arend, A.: Exploring Foreign Direct Investment as a Mediator between National Culture and Economic Growth
Jindra, M: Exploring Foreign Direct Investment as a Mediator between National Culture and Economic Growth
Paramo, J.: Are there positive externalities for Central and South American countries resulting from increased tension between NAFTA members?
Paramo M.: Are there positive externalities for Central and South American countries resulting from increased tension between NAFTA members?
Volker, T. Impact of mobile money on the Kenyan Economy
Cho, Y. Understanding the effect of crypto currencies on trade flows

First Year Research Experience (FYRE): Faculty Mentor

Condit, C. and Weise, J.

Honors Contracts

Spring 2020: Krause, A.
Spring 2018: Tracey, G.; Gertner, D.; Milius, B.; Albrecht, N.
Fall 2017: Graham, N.
Spring 2017; Vavricek, M.

Independent study

Fall 2020: Aguilar. R.

Summer 2020: Ding, Z., Huang, H., Jiang, S., Ligenza, A.
Spring 2020: Ding, M., Dingbaum, D., Hu, S., Martin, K., Yang, H., Ye, L.
Summer 2019: Press, S., Raj, V.
Fall 2019: Gebbie, K., Li, H., Li, X., Wang, Y.
Spring 2019: Grooms, M., Huang, J., Li, T., Lin, Z., Mohamad, R.
Fall 2018: Tendle, A.
Summer 2018: Dahlin, D.; Gamboa, A.; Wang, C.; Liu, Y.; Wu, X.
Spring 2018: Najjmi, S; Padai, C.; Petersen, A.; Zhao, Y.
Spring 2017: Daniel, R and Wickizer, O.

Senior Thesis Adviser
2021/2022: Cheek, Z.
2018/2019: Tendle, A.; Gandhi, R.; Villota, V.

SERVICE

Department Service

Committee Member, Undergraduate committee. (August 24, 2018 - Present).

College Service

Professor of Practice at Large, General Committee. (August 2020 - Present).

Committee Member, Undergraduate Committee. (August 2018 - Present).

University Service

Committee Member, Academic Standards Committee. (August 15, 2017 - Present).

Media Contributions

Internet

Medium.com. Applying game theory to teaching practices (April 10, 2019).
Harvest Public Media. Interview on tariff war (February 7, 2019).

Newspaper

Omaha World Herald. Commented on the impact of tariffs on the agricultural sector particularly in Nebraska (July 9, 2018).
Suddeutsche Zeiting. Commented on US tariffs on Canadian News paper print (July 2, 2018).
Washington Post. Commented on the effects of US tariffs on Candian Newspaper print on newspaper companies (June 22, 2018).

Radio

NET Radio. Interview on the effects of the Trade war (February 11, 2019).

Work Experience

2016 to date	**Department of Economics** **University of Nebraska, Lincoln** **Assistant Professor of Practice**
Summer 2016	Michigan State University American Economic Association Summer Program 2016 Teaching Fellow
2012 to 2016	**Department of Economics,** **University of Wisconsin-Milwaukee**
2013 - 2016	**Instructor** (Principles of Microeconomics, Intermediate Microeconomics, Economics of personal finance, Introduction to international Economic relations)
2014 to 2016	**Tutor** **Upward bound,** **University of Wisconsin-Milwaukee**
Summer 2015	**Lecturer** **Summer Bridge Program,** **University of Wisconsin-Milwaukee**

Referee Activity

Journal of Economic Behavior and Organization, Journal of International Money and Finance, International Economic Journal, African Development Review, a. Quarterly review of Economics and Finance, Utilities Policy, Middle East Development Journal, Journal of African Business and Journal for the Advancement of Developing Economies.

References

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Oil price volatility, financial institutions and economic growth☆

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ABSTRACT

Theory attributes finance with the ability to both promote growth and reduce output volatility, and therefore increase energy security. But evidence is mixed, partly due to endogeneity effects. For example, financial institutions themselves might be a source of volatility, as the events of 2008 suggest. We address this endogeneity issue by using periods of extreme oil price volatility as a source of nearly *exogenous* volatility, to study the effect of finance. To do this, we develop a quasi-natural experiment and study the effect of the dramatic decline of oil prices in 2014, using a synthetic control methodology. Our hypothesis is that the ability of oil-rich countries to mitigate the effects of this decline rested on the quality of their financial institutions. We focus on 11 oil-rich countries between 2006Q1 and 2016Q4 that had "poor" measures of financial development (treatment group) out of 20 such countries and synthetically create counterfactuals from the remaining (control) group with "superior" financial development. We subject both to the oil price shock of 2014 and find evidence that better financial institutions do indeed reduce output volatility and mitigate its negative effect on growth in the year that showed a sustained decline in oil price. To address any remaining potential endogeneity between oil prices and finance, we use a cross-sectionally augmented autoregressive distributed lag model with data on 30 oil-producing countries over the period 1980–2016, and confirm that the effects of oil volatility on growth is mitigated with better financial institutions. Our results make a strong case for the support of the positive role of financial development in improving energy security and fostering growth.

1. Introduction

Theoretically, institutions of finance are supposed to promote economic growth via better capital allocation, the monitoring and influencing of firms' governance, the pooling of savings, and the promotion of specialization (Levine, 1999, 2005). Theoretical considerations also extend to the contribution of finance to volatility reduction via its ability to allow agents to diversify risk. For example, Acemoglu and Zilibotti (1997) argue that better diversification enables a gradual allocation of funds to their most productive use, with more productive specialization reducing the variability of growth.

But the evidence on whether finance is growth promoting or volatility reducing are mixed. For example, while Levine (1999, 2005) shows that finance is growth promoting, Cecchetti and Kharroubi (2012) illustrate that the advantages of finance in promoting growth exist only up to a certain point beyond which, they become a drag. Evidence on volatility reducing aspects of finance are equally mixed. For example, Braun and Larrain (2005) and Raddatz (2006) find that financial development reduces output volatility, while Easterly et al. (2001) find a U-shaped relationship between volatility and financial sector depth. Denizer et al. (2002) generally supports a negative correlation between financial depth and growth, consumption, and investment volatility, but Acemoglu et al. (2003) and Beck et al. (2001) find that such a relation is not robust. A more recent paper by Dabla-Norris and Srivisal (2013) finds results regarding the volatility effects of finance that echo those found by Cecchetti and Kharroubi (2012) on the growth effects of finance: i.e., financial depth plays a significant role in dampening the volatility of output, consumption, and investment growth, but only up to a certain point. At very high levels, such as those observed in many advanced economies, financial depth amplifies

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consumption and investment volatility.

Most of the studies above are subject to some endogeneity issues that make establishing causality difficult. Consider the financial collapse of 2008 as an example. It is suggested that finance was actually the source of the crisis and its associated volatility. However, if finance also helped to ameliorate further subsequent volatility effects that might have occurred, for example by allowing for greater risk diversification, then causal relation will not be easy to establish. But if we can find an exogenous source of volatility that is independent of finance, then we *can* examine causality.

We find a nearly exogenous source of volatility in oil prices as they heavily impacted oil producing countries. We qualify our source of volatility as "nearly exogenous" because there has been some debate in the literature on the relation between oil and finance. For example, Wen et al. (2012) examine the time-varying relationship between West Texas Intermediate (WTI) prices, S&P 500 returns, and the Chinese stock market indices and find that the dependence between oil shocks and stock markets increases after the 2008 global financial crisis. On the other hand, Fattouh et al. (2013) find no evidence that in general, speculation and financialization of the oil market have driven oil spot prices after 2003, while Irwin and Sanders (2012) show that passive index investment caused a massive bubble in commodity futures prices. Zhang (2017) using a VAR approach, finds "some causality" from Brent prices to stock market (about 23%). Of course, having a stock market react to oil prices or vice versa is different from actual financial development which is the interest of this paper. On this point Ji and Zhang (2018a) provides some suggestive evidence that oil price shocks may have driven the development of the oil future market in China.

As it appears from the above discussion, the issue is less about the exogeneity of oil prices as it is about the exogeneity of financial and stock market variables. However, where some authors find support for the effect of finance on oil prices (e.g, Wen et al., 2002; Irwin and Sanders, 2012) their focus is on short-term price volatilities, rather than on long-term oil price effects. In fact, an extensive study by Mohaddes and Pesaran (2016), using a compact quarterly model of the global economy, formally tests whether oil prices can be treated as weakly exogenous in the country-specific oil supply equations, and finds that they cannot reject this hypothesis for all of the major oil producers, including Saudi Arabia and the United States (see also Cashin et al., 2014).

As for the dependence of financial markets on oil prices, our measure is not one of stock market performance which are subject to the endogeneity discussions above. Rather, we focus on measures that provide long-term institutional support for finance, i.e. "degree of centralization or government control" where the degree of flexibility reflected in a privately controlled financial system is a proxy (or instrument) for the degree of financial depth. In this way, we limit the extent of short-run change in financial measures due to spikes in oil prices decreasing that level of correlation between oil prices and financial depth.[1] Nonetheless, to address any remaining potential endogeneity issues and to see if our findings from our first test, which is a quasi-natural experiment based on the synthetic control method (see below) holds up against any endogeneity issues, we also use a cross-sectionally augmented autoregressive distributed lag (CS-ARDL) approach, which is well known for its ability to address any endogeneity, to test our results and we find them to be consistent.

With our chosen financial depth measure, we then ask what the effect of oil price volatility was on both the growth and the volatility of output among oil producers and whether financial institutions moderated the nature of the impact. This matters not only to oil producers but possibly for global energy security: if better financial management were to moderate the impact of oil price volatility, this could *reduce* reliance on the *quantity* adjustments by oil producers (e.g., OPEC or OPEC+ more recently) to stabilize their revenue stream, implying a more reliable flow of oil and improved energy security for all.

Given the focus on oil producers, the oil price collapse that started from the third quarter of 2014 and that plays a key role in the first part of our paper, is a "negative" volatility whose impact could not have been beneficial to oil producers.[2] Because we use oil prices as our exogenous source of variation and study their effect on oil producing economies, our paper is also related to the oil curse literature, or more broadly, to the natural resource curse literature. Thus, we briefly review the relevant aspects of this literature. First, we note that the prevailing view of the natural resource curse, i.e., the alleged adverse effect of natural resource wealth on income or growth, has been challenged by those that show such an effect depends on the quality of the underlying institutions (Lane and Tornell, 1996; Mehlum et al., 2006; Robinson et al., 2006; Boschini et al., 2007) as well as those who shed doubt on the existence of the curse itself (Alexeev and Conrad, 2009; Arezki et al., 2017; Cavalcanti et al., 2011; Esfahani et al., 2014; Smith, 2015).[3]

Second, we note that in light of these challenges, a new strand of research has emerged that focuses on the *volatility* of resource wealth, instead. For example, Leong and Mohaddes (2011) and El-Anshasy et al. (2015) have shown that resource rent volatility negatively affects economic growth.[4] But here again, the intermediating role of institutions arises. Using the Fraser chain-linked index of institutional quality, Leong and Mohaddes (2011) find that the negative effect of resource volatility on growth is moderated with higher quality institutions. By virtue of its focus on financial institutions, this paper is therefore also related to this last group of studies and is a further refinement of such studies. But because finance plays a particularly direct role in relation to volatility related issues, our focus on financial institutions is a more natural extension of the above studies.

We carry out our analysis in two ways depending on what we mean by oil price volatility. In the first approach, we view volatility as the dramatic drop that oil prices experienced starting from the third quarter of 2014. This allows us to consider this particular event as a quasi-natural experiment. Dividing oil producing countries into those with good financial institutions (control) and those with poor financial institutions (treatment), we study the effect of differences in financial depth across oil rich countries on their ability to deal with this dramatic oil price decline by synthetically constructing our counterfactuals for each treated country using the synthetic control technique originally pioneered by Abadie and Gardeazabal (2003). The advantage of this approach over the prevailing difference-in-difference methodology or its propensity score matching refinement is that the synthetic control approach overcomes the challenge of the selection of an appropriate control group. Such a group may or may not exist even in the absence of

[1] While the long-run impact of oil wealth on such institutions as taxation and transparency has been studied (e.g., Mohtadi, et.al. 2015, 2017), we are not aware of any such long-run studies with respect to financial institutions.

[2] See, for instance, Mohaddes and Raissi (2018) who make this point clear for macro aggregates (such as equity prices, GDP, and inflation) and not only for oil producing, but also for countries with high dependence on major oil producers (such as non-oil producing Middle East and North Africa countries).

[3] For example, Alexeev and Conrad (2009) show that natural resources appear (falsely) to reduce growth rates because they boost base incomes and thus controlling for this effect, uncovers an underlying positive role of natural resources in economic growth. Arezki et al. (2017) use an exogenous instrument from the giant oil field discoveries dataset, to show that in the long-run oil boosts income. Similar conclusions are reached by Smith (2015). Cavalcanti et al. (2011), using the real value of oil production, rent or reserves as a proxy for resource endowment, illustrate that oil abundance has a positive effect on both income levels and economic growth. While they accept that oil rich countries could benefit more from their natural wealth by adopting growth and welfare enhancing policies and institutions, they challenge the common view that oil abundance affects economic growth negatively.

[4] See also Mohaddes and Pesaran (2014).

sampling errors, due to inherent uncertainties in the choice of a suitable control country (Abadie et al., 2010). The synthetic control method constructs a counterfactual that better aligns with the treated country along a variety of factors, reducing the pretreatment differences between the control and treated country.

In the second approach, our measure of oil price volatility is not event-based, but rather, based on the annual standard deviation of monthly oil prices over the period 1980–2016. For this we rely on data for 30 major oil producers and a regression approach using the cross-sectionally augmented autoregressive distributive lag (CS-ARDL) methodology (Cavalcanti et al., 2015; Chudik and Pesaran, 2015; and Chudik et al., 2016) using the pooled mean group (PMG) estimator (Pesaran et al., 1999).

In what follows, Section 2 presents the synthetic control methodology, estimation procedure, and data, while Section 3 discusses the results from this counterfactual synthetic exercise. In Section 4 we re-examine our findings by using the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model to address any remaining endogeneity concerns. We also use this opportunity to extend the scope of our analysis to include more countries over a longer period. Section 5 provides an in depth discussion of the implications of our findings in terms of energy security and finally, Section 6 provides concluding remarks and policy implications.

2. The synthetic control method: methodology, estimation procedure and data

The synthetic control method is a counterfactual approach pioneered by Abadie and Gardeazabal (2003) hence forth known as AG. This is a variation of the difference-in-difference approach, but instead of a control group, determined by pre-intervention propensity matching, a *synthetic control* is constructed using a weighted average of potential controls to obtain the "best fit" that would closely match the treated unit's pretreatment variables. AG use this methodology to study how terrorist activities in the Basque region of Spain post 1960, reduced GDP per capita as compared to a synthetic control composed of other similar regions that were unaffected by the terrorism. An important modification of this methodology is a paper by Singhal and Nilakantan (2016) who study the effect, on economic performance, of counter-insurgency policies in India by comparing the performance of one specific region, Andhra Pradesh, which developed a specialty task force to combat the Naxalite insurgency, with a synthetic control of other similar states which did not have such a specialty task force. In Singhal and Nilakantan (2016), *all* states in India were impacted by the Naxalite insurgency but only Andhra Pradesh developed the task force to fight the insurgency. This contrasts with the approach by AG in which the treatment (terrorism) affected one region but not all.

Our method is more in line with Singhal and Nilakantan (2016) in that fluctuations in the world oil price affect *all* oil producing countries (analogous to terrorism in India), but the differences in the resulting volatility and growth across countries arises due to their *differing* levels of financial development. To estimate possible mitigating impact of financial depth in this framework, the treated (control) countries are oil producers with "low" ("high") levels of financial development.[5] From this we construct a synthetic counterfactual (or control) for each treated country, where both the treated country and its counterfactual are similar in relevant aspects and especially in their dependence on oil (measured by oil to GDP ratios) but differ in their financial depth. A comparison of the predicted "outcome" in the synthetic control with the observed outcome in the treated country will tell us whether or not financial depth mitigates the effects of oil price volatility. The primary outcome variables chosen are output and growth as well as output and growth volatility, as these are the traditional performance metrics, and are the variables also involved in testing the natural resource curse hypothesis. We expect output and growth volatility to be lower and growth and output to be higher in the synthetic controls when compared to their treated counterparts suggesting a positive contribution of financial depth. To test this econometrically, the differences in these measures between the treated country and their synthetic control counterpart are regressed on a dummy variable that represents pre- and post-oil decline with significant results of its coefficients telling a more encompassing story that helps us generalize findings across all treated countries.[6]

2.1. Constructing the synthetic control country

Consider a given set of control and treatment groups. Let $\boldsymbol{W} = (w_1, w_2, ..., w_j)$ be a $(J \times 1)$ vector of non-negative weights, where w_j is the weight applied to control country j in the resulting synthetic control corresponding to a given treatment country (if $w_j = 0$, there is no influence of country j on the synthetic control). Naturally, different vectors of $\boldsymbol{W}$ will generate different synthetic controls. The optimal $\boldsymbol{W}$ is obtained by minimizing the expression,

$$(\boldsymbol{X_1} - \boldsymbol{X_0}\boldsymbol{W})'\boldsymbol{V}(\boldsymbol{X_1} - \boldsymbol{X_0}\boldsymbol{W}) \quad (1)$$

subject to $w_j \geq 0$ *for all* j and $w_1 + w_2 + ... + w_j = 1$, where $\boldsymbol{X_1}$ is a $(K \times 1)$ vector of pretreatment GDP predictors for the treated country; $\boldsymbol{X_0}$ is a $(K \times J)$ matrix of the same K pretreatment GDP predictors for the J possible control countries, $\boldsymbol{V}$ is a diagonal matrix of non-negative components reflecting the importance of different GDP predictors. AG suggests that the optimal choice of $\boldsymbol{V}$ is one where the resulting synthetic control best matches the pretreatment GDP level of the treated country.[7]

The optimal weight vector $\boldsymbol{W}^*$ is applied to the GDP of the control countries to obtain the resulting synthetic control. i.e. if we define $\boldsymbol{Y_1}$ as a $(T \times 1)$ vector of output levels for the treated country and $\boldsymbol{Y_0}$ as a $(T \times J)$ matrix of output levels for the control countries, the synthetic control for the treated country will be the $(T \times 1)$ vector $\boldsymbol{Y_1}^*$, such that

$$\boldsymbol{Y_1^*} = \boldsymbol{Y_0}\boldsymbol{W^*} \quad (2)$$

Given that the weights are derived from the pretreatment period, the differences between the treated country $\boldsymbol{Y_1}$, and its synthetic control $\boldsymbol{Y_1^*}$, should be most prominent in the post treatment period as a result of change in the nature of the relationship between output and its predictors due to the treatment (i.e. if the treatment proves relevant). Thus, the difference between Y_1 and Y_1^* in the post treatment period are attributed to the treatment. The degree of fit of the pretreatment variable of interest (in our case GDP) is what AG refers to as the root mean square prediction error (RMSPE). This is simply the sum of squares of the difference between the resulting synthetic control measures of GDP and the treated country's GDP in the pretreatment period.[8]

[5] The split between "low" and "high" financial development is described in Section 2.2.

[6] See later for expectations and implications of the signs and significance of these coefficients.

[7] To find the optimal vector $\boldsymbol{W}^*$, $\boldsymbol{V}$ is initially assumed to be an identity matrix and an initial $\boldsymbol{W}'$ is calculated. This $\boldsymbol{W}'$ yields the best match to the treated country's GDP measure without taking into account the degree of importance of each of the predictors. Using this initial $\boldsymbol{W}'$, the optimal $\boldsymbol{V}$ matrix is then calculated identifying the degree of importance placed on each predictor. Finally, $\boldsymbol{V}$ is used to calculate the final optimal weight $\boldsymbol{W}^*$. $\boldsymbol{W}^*$ takes the importance of the GDP predictors into account and provides a good fit to the treated country's pre-treatment GDP.

[8] It should be noted that the synthetic control method *does* capture the effect of the 2008 financial crisis in the pretreatment period. This is so since all controls used to create the synthetic control also experienced the same shock and thus so did their resulting synthetic controls which are just the weighted averages of the original controls.

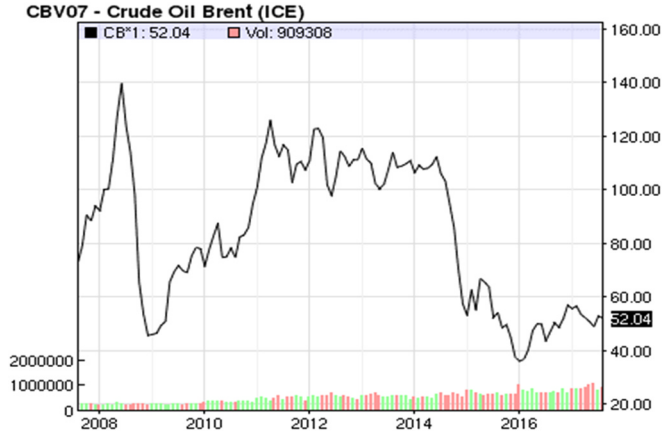


Fig. 1. Monthly oil prices. Source: https://www.nasdaq.com/markets/crude-oil-brent.aspx.

2.2. Estimation procedure and sample selection

As a step towards the goal of this paper we exploit the recent decline in oil prices in the third quarter of 2014 as a source of exogenous variation. As can be seen from Fig. 1, the 2014 decline in the last nine years is second only to the fallout from the 2008 financial crisis (and not by much). Unlike the 2008 decline in which finance was the trigger for the crisis and subsequent reaction of the financial institutions that led to the mitigation of the crisis (Jarrett and Mohtadi, 2017), the 2014 decline has been attributed to a technology shock (shale oil extraction in the United States) and in this case, plausibly exogenous to financial depth.[9] The technological advancements over the last decade have not only reduced the costs associated with the production of unconventional oil, but also made extraction of oil resemble a manufacturing process in which one can adjust production in response to price changes with relative ease. Therefore, one of the implications of the shale oil revolution is that U.S. production can play a significant role in balancing global demand and supply, and this in turn implies that the current low oil price environment could be persistent (see Mohaddes and Raissi, 2018). Moreover, a recent study has also found that output elasticity of unconventional new wells to price changes is 3–4 times conventional wells. This combination produces a floor for the oil prices that may be hard to escape (see, for instance, Bjørnland and Thorsrud, 2016 and Mohaddes and Pesaran, 2017).

To determine the potential mitigating effect of financial depth on countries that suffer a significant deterioration of performance due to the drop in the price of oil, two factors need to be considered: first, paying particular attention to oil rich/dependent countries as this would be the group most impacted by the shock; and the second, sorting the oil rich group into ones with "superior" financial depth and ones without. To accomplish these two goals, we first select countries in the 80th percentile in annual oil value to GDP ratio.[10] These countries comprise both our control and treatment groups. Next, we choose a performance variable. Since all countries are equally exposed to the variations in the oil price, we must find a variable that transmits oil price volatility into country level effects to capture cross-country variations while also reflecting oil price volatility. The most commonly impacted variable is naturally the output level, making GDP an appropriate performance variable to use. The output predictors used to create the synthetic controls by forming the weights that comprise vector $\boldsymbol{V}$ in Eq. (1) include oil-to-GDP ratio, population, capital stock, initial level of output, imports, exports, trade-to-GDP ratios, capital restrictions (measured by the Chinn-Ito, 2006 index) and sovereign wealth funds, specifically, the value of the sovereign wealth fund each country possessed at the beginning of the oil price decline.[11] Finally, we divide the selected countries into two groups; those above-median levels of financial development (Group A), and those below-median (Group B).[12] This cutoff was chosen with the number of countries in mind. If the cut-off is too high or too low, we would either no longer have enough countries in the control group with which to form appropriate synthetic controls or enough of the treated countries with which to make more general statements. Group A countries constitute the *potential* set for constructing the synthetic controls for each country in group B (the treated group).[13]

With these considerations, we have 26 countries with average oil to GDP ratio from 8.9% to 59%, and financial measure split between 16 treated countries in group B and 10 potential control countries in group A. From the selection of treated countries, we drop Egypt, Yemen and Venezuela because their political and social instability in the post-treatment period, would certainly generate higher levels of output volatility that cannot be disentangled from volatility as a result of oil price fluctuation and as such, inclusion of these countries will contaminate our results if left in our sample. We also drop Saudi Arabia given its singular ability to adjust extraction policies to influence changes in oil price which would potentially introduce treatment bias.

In order to highlight the effect of financial depth, measures of financial depth themselves must be omitted from the set of output predictor variables that are used in the synthetic control construction since by design synthetic controls have higher levels of financial development than the treated country.

It is important to note that apart from our proposed indirect effect of financial depth on output through oil price volatility mitigation, there is also the well documented direct effect of financial development on output (see, for instance, Levine, 1999). This implies that we do not expect the pretreatment output levels to be a close match and should differ with varying degrees, depending on how much dispersion there is between financial development measures of the synthetic control and the treated country. Rather, than an obstacle to our analysis, we take advantage of this unique property by developing placebo tests in the following way: we make the erroneous assumption that countries in the control group with high financial development measures (Group A) have poor finances. We then create synthetic controls for each country in group A (one at a time) using the remaining control countries. First, we expect the output levels of both the synthetic control and the

[9] A clear example of this reaction by the financial institutions during the great recession is the increase in bank reserves as well as the reduction in lending activities. No such reaction was observed during the 2014 decline in oil prices making it exogenous to financial depth.

[10] Oil to GDP ratio is from Oil and Gas data (Ross, 2013), available at http://thedata.harvard.edu/dvn/dv/mlross.

[11] The ability of countries to draw on their sovereign wealth funds in order to dampen the negative effects of commodity price volatility is well documented in Mohaddes and Raissi (2017).

[12] The median used for this separation is the median of the average of all financial subset measures in the Fraser chain linked index that measures institutional quality, see Section 2.3. The list of countries in each group is provided in Table 10 in the Appendix.

[13] To further emphasize the effect of financial depth, different cutoffs of financial depth were employed. Countries were split into two groups; one group above the 70th percentile level of financial development (Group A), and the second, having below the 40th percentile level of financial development (Group B) resulting in a sample of 15 countries with 9 treated countries in group B and 6 potential control countries in group A. There was some evidence in support of financial depth alleviating the negative effects of oil price volatility, but the results were mixed. The issue with this approach is the limitation in the number of potential control countries such that adequate synthetic controls may not be possible to construct. This limitation is also the reason why the fits obtained in the main analysis are not as accurate as some others in the literature, where what they study allows them to have more countries in their control "bucket". The results for this analysis are not reported here, but are available from the authors upon request.

"treated" country in the placebo tests to better align due to resulting similar financial measures, i.e. we expect the synthetic controls of our placebo tests to have lower average RMSPE when compared with the average RMSPE of the treated countries. This will add an extra layer to our analysis and to the literature on the finance-growth nexus by showing the degree of importance of financial depth in determining levels of output when these placebo tests are carried out. Secondly, we would expect to see similar fluctuations in output in the pre and post treatment period for both the synthetic control and "treated" country in the placebo tests again as a result of similar financial depth measures. This will serve as verification that results picked up by the main test are valid.

We also rule out Chad from the main analysis due to a comparable lack of pretreatment fit of its synthetic control. While we allow some leeway for the pretreatment fit due to the absence of the financial depth measure in creating the synthetic control, the RMSPE for Chad is 3.5 standard deviations away from the mean of all countries in the treated group which average a RMSPE of 0.29. AG suggests that countries for whom adequate synthetic controls cannot be obtained (very high RMSPE) are outside the convex hull of the potential control countries. To intuit, this would otherwise amount to creating a synthetic control for the United States from countries in Sub-Saharan Africa. We therefore have 12 countries left in the treatment group. Finally, Nigeria is removed from the initial analysis as the country rebased its GDP in 2013 just prior the treatment period under study, thus altering its measure of dependence on oil in the pre and post treatment periods. However, we draw on this particular example to make a separate point in Section 3.2 that ties well with our results while simultaneously providing valuable information about the natural resource curse literature.

2.3. Data

We use quarterly data (between 2006Q1 and 2016Q4), as this allows for more observations especially needed for the post-2014 period given that we only have three annual observations post 2014. Quarterly data is also very useful as it allows us to calculate annual volatility. For a majority of the countries with poor financial measures, quarterly observations on key variables are not reported and as a result, these variables need to be estimated. For the period chosen, quarterly data on imports and exports are the only data points available for all countries in our analysis. We therefore use these variables to generate quarterly output levels. To do so, we first obtain annual measures of import to GDP ratio, and then use the quarterly imports data to generate quarterly output measures for each country. Our assumption is that quarterly ratios remain roughly constant over the quarters within that year. We use this as our primary estimate of quarterly GDP given the relationship between imports and GDP and the well-established literature on marginal propensity to import resulting from changes in GDP (see, for instance, Chang, 1945; Shinohara, 1957; Golub, 1983).

To further validate this as a viable measure, we obtain actual seasonally adjusted quarterly GDP data from 44 countries as well as their corresponding measures of quarterly imports and annual import to GDP ratios. We calculate GDP estimates based on the proposed system above and compare the estimates to the actual quarterly GDP measures. There is an overall correlation coefficient of 0.92, suggesting a significant relationship between the actual and our estimated output data. We also faced similar data restrictions with respect to the predictor variables. To overcome these limitations, we made similar assumptions that the variables remained constant across all quarters for each year, which is not unreasonable as we do not expect significant changes in capital stock and capital restrictions between each quarter of a particular year.

As a measure of financial depth, we turn to the financial components of the Fraser chain linked index of cross-country institutional quality. As a result, our measure of domestic financial depth is the average of the following sub-components of the Fraser chain index defined as follows:

i. ownership of banks (oob) which measures the percentage of bank deposits held in privately owned banks and countries with a higher percentage of these deposits receive a higher "oob" rating;
ii. private sector credit (psc) which measures government borrowing relative to private borrowing with higher government borrowing ratios receiving a lower rating. The assumption here is that greater government borrowing implies more central planning; and
iii. interest rate controls (irc) uses data on credit market controls. Countries where interest rates are determined by the markets, countries with stable monetary policy and reasonable real deposit and lending rate spreads receive higher ratings (Gwartney et al., 2013).

In general, these measures capture the degree of private financial freedom, assigning higher ratings to countries with greater financial freedom (giving them the ability to facilitate growth in their financial infrastructure) and lower ratings to countries with greater government or central control which financial market participants and researchers alike have suggested hampers financial growth. This measure differs from the more traditional indices of financial depth that measure observable outcomes (e.g, stock market indices, actual measures of private sector deposits and private sector lending) but instead capture a measure of the structural framework of the financial sector; its behavior and practices that tend to be stable over time. Therefore, we can make the claim that these countries do not necessarily become decentralized due to oil discoveries keeping our financial measures relatively stable in the pre and post treatment period. This implies that these measures are much less subject to endogeneity as a result of the findings of Beck and Poelhekke (2017) and Zhang (2018) that suggest that oil price shocks can in turn influence the financial depth level since these financial indices are not as affected.

3. Results and interpretation

Table 1 shows the optimal weights assigned to each potential control country. To highlight the effectiveness of the matching process (with the preference slanted towards matching output levels), Table 2 shows the averages of the predictor variables for all treated countries and their corresponding counterfactual synthetic controls. The differences between the synthetic control and the treated group appear small, suggesting that the counterfactual and the treated countries are indeed similar at least with respect to these specific measures.[14] However, given that oil volatility is an ongoing phenomenon, the oil price decline of post-2014 period is not unique but one in the history of oil price volatility in the post-World War two period. As such, our approach does not contain a classic pre-treatment period in which control and treatment countries exhibit identical behavior. Rather, our control and treatment group differ by their financial depth and as such, the analysis we undertake below highlights the consequence of this difference for output by examining the relationship between the treated and control before and after the significant drop in oil prices.

To provide a clearer picture and a conclusion that compares the performance of countries with high financial depth to those with low financial depth, the following regressions are run

$$ratio_output_{i,t} = \alpha_1 + \beta_1 dummy_{i,t} + \varepsilon_{1i,t} \quad (3)$$

$$ratio_growth_{i,t} = \alpha_2 + \beta_2 dummy_{i,t} + \varepsilon_{2i,t} \quad (4)$$

[14] Since we place less emphasis on the fit of the level of the synthetic control and more on the volatility and growth differential, the corresponding graphs for the synthetic and treated countries are not as informative and as such are not reported here but are available upon request from the authors.

Table 1
Optimal weights of potential control countries.

	Brunei	Kuwait	Oman	Qatar	Kazakhstan	Malaysia	Mexico	Norway	Trinidad
Algeria	0	0	0	0.266	0.628	0.009	0	0.097	0
Angola	0	0	0	0.039	0.267	0	0	0.693	0
Azerbaijan	0	0	0	0.244	0	0	0	0.756	0
Cameroon	0	0	0	0.833	0	0	0	0.167	0
Congo$	0	0	0	0.376	0	0	0	0.624	0
Ecuador	0	0	0	0.438	0	0.124	0	0.439	0
Gabon$	0	0	0	0	0	0	0	1	0
Indonesia	0	0	0	0.304	0	0.696	0	0	0
Iran.	0	0.401	0	0.012	0	0.587	0	0	0
Russia$	0	0	0	0.008	0	0.992	0	0	0
UAE	0.457	0	0	0	0.133	0.409	0	0	0.457

Notes: Each ijth cell is the weight assigned to the potential control country j in creating the synthetic control for the treated country i. Numbers sum up horizontally to 1. Each row is therefore the resulting optimal weight vector W* for each treated country i. $ represents countries estimated differently as the resulting Hessian matrix during the minimization process (nested option on stata) was asymmetric and could not be inverted. The non-nested option in stata was thus used to generate the counterfactual for these countries which resulted in less accurate pre-treatment fits.

Table 2
Predictor variable comparison.

	Algeria		Angola		Azerbaijan		Cameroon		Congo$		Ecuador	
	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC
Capital Stock	14.11	13.77	13.30	12.76	11.49	12.46	11.65	13.11	11.03	12.61	13.06	13.10
Imports	23.01	23.66	22.20	22.18	21.33	21.65	20.92	22.42	20.64	21.82	22.29	22.40
Exports	23.47	24.07	23.22	22.82	22.20	22.45	20.84	23.22	21.55	22.62	22.24	23.09
Trade to GDP	0.69	1.35	1.09	1.15	0.84	0.93	0.46	0.82	1.37	0.90	0.61	0.85
GDP 2006: Q1	23.80	23.71	22.54	22.63	21.54	22.28	21.94	22.90	20.34	22.42	22.96	23.02
Oil Value	0.17	0.13	0.47	0.15	0.36	0.19	0.09	0.22	0.47	0.19	0.14	0.19
Ka_open	0.16	0.35	0.02	0.79	0.36	0.80	0.16	0.30	0.16	0.69	0.77	0.60
Population	17.40	16.72	16.86	15.00	16.02	14.71	16.83	16.19	15.21	15.04	16.51	15.77
SWF 2014:Q3	1.52	2.16	0.33	1.01	4.05	2.30	0.00	5.68	0.00	3.06	0.00	3.31
	Gabon$		**Indonesia**		**Iran**		**Russia$**		**UAE**			
	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC		
Capital Stock	11.16	12.20	16.16	14.86	14.97	14.42	15.69	15.52	14.44	14.09		
Imports	20.46	21.32	24.16	24.40	23.51	24.02	24.77	25.15	24.60	23.83		
Exports	21.33	22.13	24.33	24.57	23.88	24.19	25.34	25.04	24.56	24.30		
Trade to GDP	0.88	0.97	0.51	0.66	0.47	0.78	0.50	0.61	1.54	0.90		
GDP 2006: Q1	21.15	22.02	24.69	25.21	24.45	24.73	25.42	26.12	24.78	24.63		
Oil Value	0.38	0.17	0.09	0.12	0.22	0.20	0.15	0.08	0.23	0.22		
Ka_open	0.16	1.00	0.58	0.54	0.40	0.81	0.54	0.69	1.00	0.65		
Population	14.24	14.10	19.30	17.98	18.12	17.10	18.78	18.57	15.84	16.70		
SWF 2014:Q3	0.10	0.90	0.00	2.03	0.48	0.57	0.52	0.07	11.92	7.19		

Notes: The table shows the average estimates of the predictor variables used to determine the optimal weights required to create the counterfactuals for each treated country. The average of all variables for each treated country is reported as well as the average for its corresponding synthetic control. TC represents the data for the treated country and SC represents the data for its corresponding synthetic control. $ represents countries estimated differently as the resulting Hessian matrix during the minimization process (nested option on stata) was asymmetric and could not be inverted. The non-nested option in stata was thus used to generate the counterfactual for these countries which resulted in less accurate pre-treatment fits.

$$diff_output_{i,t} = \alpha_3 + \beta_3 dummy_{i,t} + \varepsilon_{3i,t} \quad (5)$$

$$diff_growth_{i,t} = \alpha_4 + \beta_4 dummy_{i,t} + \varepsilon_{4i,t} \quad (6)$$

Where *ratio_output* (*ratio_growth*) is the ratio of annual output (growth) volatility (treated volatility/control volatility) calculated from the resulting quarterly observations, *diff_output* (*diff_growth*) is the difference in annualized output (growth) between treated and control countries.[15] The dummy variable is zero before 2014 and 1 after 2014. We expect β_1 and β_2 to be positive suggesting that the treated countries showed significantly more volatility than the control post 2014 with respect to output and growth. We also expect β_3 and β_4 to be negative suggesting that the treated countries had significantly lower output and growth post 2014 than their synthetic control.[16]

Table 3 captures the results from Eqs. (3)–(6) above. Columns 1–4 show positive and significant coefficients as expected suggesting that the synthetic controls had less volatility due to their financial depth compared to their treated counterparts and this manifested as higher volatility in both growth and output post 2014. When we exclude the two countries (Cameroon and Indonesia) with oil-to-GDP ratios less than 10%, we observe that the coefficients are larger, giving credence to the idea that the ability of the financial sector to mitigate the negative effects depends on the degree of dependence.[17]

While a majority of the differences in output and growth are negative as was expected, none of them are significant. A possible explanation is that by 2016, the uptick in oil prices may have offset some of the negative effects observed in the 2014/2015 period. This effect

[15] The annual output (growth) volatility data is generated by computing the standard deviation of quarterly output (growth) in a given year. The growth rate of GDP is calculated as the first difference of natural logs of output. Note that the difference measure discussed here is always treated observations – synthetic control observations.

[16] The smaller the difference in output or growth (less positive or more negative), the worse off the treated country is compared to the synthetic control.

[17] This point will be formalized with the case study of Nigeria, see Section 3.2.

Table 3
Annualized regressions with post-treatment years 2014, 2015 and 2016.

	All treated countries				Treated countries with > 10% oil-to-GDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Output Volatility Ratio				
Oil price	1.486**	2.291**	1.486**	2.291**	1.777**	2.736**	1.777**	2.736**
decline	(0.636)	(1.013)	(0.664)	(1.062)	(0.747)	(1.203)	(0.780)	(1.262)
				Growth Volatility Ratio				
Oil price	1.503*	3.303**	1.503*	3.303**	1.767*	3.860**	1.767*	3.860**
decline	(0.796)	(1.385)	(0.832)	(1.452)	(0.953)	(1.646)	(0.995)	(1.727)
				Differences in Output				
Oil price	− 0.0128	− 0.134	− 0.0128	− 0.134	0.0138	− 0.0941	0.0138	− 0.0941
decline	(0.114)	(0.171)	(0.119)	(0.180)	(0.122)	(0.184)	(0.128)	(0.193)
Countries	11	11	11	11	9	9	9	9
Observations	121	121	121	121	99	99	99	99
				Differences in Growth				
Oil price	− 0.111	− 0.0350	− 0.111	− 0.0350	− 0.0894	0.00370	− 0.0894	0.00370
decline	(0.0788)	(0.177)	(0.0827)	(0.186)	(0.0862)	(0.193)	(0.0904)	(0.203)
Countries	11	11	11	11	9	9	9	9
Observations	110	110	110	110	90	90	90	90
Year FE	NO	YES	NO	YES	NO	YES	NO	YES
Country FE	NO	NO	YES	YES	NO	NO	YES	YES

Notes: *,**,*** represent levels of significance at the 10%, 5% and 1% levels respectively. Oil price decline is a dummy variable that represents the cutoff point when the treatment takes place: 0 if before oil price decline and 1 after oil price decline. Output (growth) volatility ratio is annual output (growth) volatility of the treated country divided by the output (growth) volatility of the corresponding synthetic control. For these two measures, a positive estimate suggests that post oil price decline, the treated countries show more volatility than their counterfactual with better financial depth measures (from 0 to 1, ratio increases). Differences in output (growth) is the output (growth) of the treated country minus the output (growth) of the synthetic control. For these measures, a negative estimate suggests that as we move from pre to post oil price decline, output (growth) is lower in the treated country than in their synthetic control suggesting better performance for countries with better financial depth measures (from 0 to 1, the difference gets smaller).

Table 4
Annualized regressions with post-treatment years 2014 and 2015.

	All treated countries				Treated countries with > 10% oil-to-GDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Differences in Output				
Oil price	− 0.0151	− 0.139***	− 0.0151	− 0.139***	− 0.00452	− 0.131**	− 0.00452	− 0.131**
decline	(0.0613)	(0.0485)	(0.0643)	(0.0512)	(0.0707)	(0.0573)	(0.0742)	(0.0604)
Countries	11	11	11	11	9	9	9	9
Observations	110	110	110	110	90	90	90	90
				Differences in Growth				
Oil price	− 0.183***	− 0.179***	− 0.183***	− 0.179***	− 0.173***	− 0.164**	− 0.173***	− 0.164**
decline	(0.0508)	(0.0651)	(0.0537)	(0.0691)	(0.0616)	(0.0719)	(0.0649)	(0.0762)
Countries	11	11	11	11	9	9	9	9
Observations	99	99	99	99	81	81	81	81
Year FE	NO	YES	NO	YES	NO	YES	NO	YES
Country FE	NO	NO	YES	YES	NO	NO	YES	YES

Notes: See Table 3.

should be especially pronounced with respect to the growth rate measures since a lower base value of GDP would exaggerate any increase in subsequent growth. To address this issue, the same regressions are estimated excluding 2016 and the results are summarized in Table 4. Concentrating on 2014 and 2015 only, we see negative and significant differences in output and growth in the post treatment period supporting the point above regarding the 2016 uptick in oil prices. Also, note that the results for growth are even stronger as expected per discussion above.

3.1. Placebo tests

Following the tradition in counterfactual methodologies, we perform placebo tests as a measure of robustness. To do this, we assume that the control countries with superior financial development measures actually have subpar financial measures and re-run the same analysis, one control country at a time. Each time a control country is being "treated", it is removed from the control set.[18]

As hypothesized, the RMSPE in the placebo test is 0.133, slightly less than half of the RMSPE in the treatment group (0.299). This resulting better fit highlights the importance of the contribution of financial depth to output. The second and main point of the placebo tests is to determine if the effect found in the treated tests still persists when treated and synthetic controls have similar financial depth measures. According to our hypothesis, we should expect no discernable

[18] This is in contrast to the methodology suggested by AG. AG uses the idea that if there is no real difference, the treated countries should also be introduced in the "bucket" of control countries used in forming synthetic controls for the placebo tests. Our approach takes things a step further and proves that this need not be done to show that the effect among financially deep countries is negligible. This suggests an even stronger repudiation of arguments against our findings compared to the standard approach by AG.

Table 5
Annualized regressions with post-treatment years being 2014, 2015 and 2016 (placebo).

	All control countries				Control countries with better fits			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Output Volatility Ratio							
Oil price	0.417*	0.245	0.417	0.245	0.530*	0.415	0.530*	0.415
decline	(0.247)	(0.513)	(0.258)	(0.538)	(0.300)	(0.655)	(0.313)	(0.687)
	Growth Volatility Ratio							
Oil price	0.430	1.185	0.430	1.185	− 0.0251	0.340	− 0.0251	0.340
decline	(0.660)	(1.071)	(0.689)	(1.124)	(0.705)	(0.979)	(0.735)	(1.027)
	Differences in Output							
Oil price	0.0321	0.0685	0.0321	0.0685	0.0333	0.165	0.0333	0.165
decline	(0.108)	(0.146)	(0.113)	(0.154)	(0.118)	(0.173)	(0.123)	(0.181)
Countries	9	9	9	9	7	7	7	7
Observations	99	99	99	99	77	77	77	77
	Differences in Growth							
Oil price	0.0339	0.0807	0.0339	0.0807	0.0866	0.209	0.0866	0.209
decline	(0.0682)	(0.244)	(0.0716)	(0.257)	(0.076)	(0.302)	(0.0791)	(0.318)
Countries	9	9	9	9	7	7	7	7
Observations	90	90	90	90	70	70	70	70
Year FE	NO	YES	NO	YES	NO	YES	NO	YES
Country FE	NO	NO	YES	YES	NO	NO	YES	YES

Notes: See Table 3 but note that columns 5–8 in this table excludes control countries with poor fits.

difference in any of our variables before and after the reduction in oil price. In terms of the econometric model adopted in Eqs. (3)–(6) above, we expect much smaller and potentially insignificant coefficients β_1, β_2, β_3 and β_4 when compared to the same estimates in Tables 3 and 4 above.

To this end Table 5 replicates Table 3, from which we can see that the coefficients are far smaller and less significant than in Table 3, thus supporting our main hypothesis that it is indeed the differences in financial depth that account for the differences in Table 3 between the pre and post 2014 periods. Columns 5–8 in Table 5 report the results for those control countries that have much better fits,[19] being in line with the results from columns 1–4. Table 6 replicates the findings in Table 4 for the placebo tests as well. We see that one again, unlike Table 4, all coefficients are far smaller and statistically insignificant; suggesting that the effect of better financial depth is what is driving the results.

3.2. Nigeria the oddity: dependence matters

In this section, which speaks more to the natural resource curse literature, we use the unique circumstances surrounding Nigeria's GDP as an experiment within an experiment to investigate the impact of oil dependence on the ability of the financial sector to mitigate the negative effects of oil price volatility. The premise is simple: Nigeria rebased its GDP measure in 2013 which saw its output grow by about 89% in one year. This revision took the non-oil sectors (mainly telecoms, manufacturing and the prolific entertainment industries) more prominently into account implying a lower dependence on oil in the post-2014 period compared to its pre-treatment period.[20] We stipulate that, if the degree of dependence does not matter, we would expect to see similar results in Nigeria as we have encountered in the treated countries above, where the post-2014 trend indicated higher comparative volatility (i.e. compared to their corresponding synthetic control). However, if dependence matters, we would see that Nigeria (the treatment country) is more volatile in the pre-2014 period than its financially advanced counterfactual and is less so when the degree of dependence on oil is reduced post 2014 after it's GDP has been rebased (despite the negative price shock and the synthetic control having greater financial depth, both of which should have implied even higher volatility for Nigeria post 2014).

Table 7 highlights pre and post-2014 volatility measures as well as output and growth levels for Nigeria. From Table 7, we see that both output and growth volatility for Nigeria in the pre-2014 period was much higher when oil revenues made up a higher percentage of their GDP. In the post 2014 era however, we see that there is no difference in output volatility and an even smaller growth volatility when compared to its synthetic counterfactual. We find no discernable difference in average growth rates as all differences are insignificant but with respect to output, we see no difference in average output in the pre-2014 period,[21] while the post 2014 period shows that Nigeria had higher average output levels when compared with the synthetic control, reflecting the reduced role of oil revenues in GDP. This strongly suggests that the ability of a country's financial sector to mitigate the negative effects of oil price volatility is positively correlated with the degree of dependence on oil, and as such, higher degrees of dependence on oil should be accompanied by higher financial depth.

4. Accounting for potential endogeneities: the panel CS-ARDL model

The results in Section 3 point to a significant effect of financial depth in mitigating oil price volatility, ultimately leading to higher levels of output and growth. While the nature of our measure of finance and the long term time horizon of our study reduce the chances of endogeneities, as we extensively discussed in the introduction, nonetheless, to address remaining concerns about the endogeneity between oil prices and finance (e.g. Zhang, 2017), we re-examine our earlier findings by using the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model.[22] We also use this opportunity to extend

[19] These regressions exclude countries for which the nested option on Stata for synth estimation could not be used, resulting in much less precise fits.

[20] See *Nigeria's GDP Step Change* in The Economist (April 12, 2014). https://www.economist.com/news/finance-and-economics/21600734-revised-figures-show-nigeria-africas-largest-economy-step-change.

[21] This is to be expected given the way in which the counterfactual was created.

[22] While this method is capable of addressing potential endogeneity issues, the drawback of this approach is the loss of sub annual data points for which to calculate annual output and growth volatility. As a result, this approach focuses on the eventual effects of financial mitigation on growth, given historic oil price volatility.

Table 6
Annualized regressions with post-treatment years being 2014 and 2015 (placebo).

	All control countries				Control countries with better fits			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Differences in Output							
Oil price	− 0.00448	− 0.0046	− 0.00448	− 0.0046	− 0.0554	− 0.0119	− 0.0554	− 0.0119
decline	(0.162)	(0.142)	(0.170)	(0.150)	(0.193)	(0.189)	(0.203)	(0.200)
Countries	9	9	9	9	7	7	7	7
Observations	90	90	90	90	70	70	70	70
	Differences in Growth							
Oil price	− 0.00493	0.00298	− 0.00493	0.00298	− 0.00799	0.0200	− 0.00799	0.0200
decline	(0.136)	(0.157)	(0.144)	(0.166)	(0.178)	(0.207)	(0.187)	(0.219)
Countries	9	9	9	9	7	7	7	7
Observations	81	81	81	81	63	63	63	63
Year FE	NO	YES	NO	YES	NO	YES	NO	YES
Country FE	NO	NO	YES	YES	NO	NO	YES	YES

Notes: See Table 3 but note that columns 5–8 in this table excludes control countries with poor fits.

Table 7
Results from the special case of Nigeria.

	Pre 2014: Q3			Post 2014: Q3		
	1	2	3	4	5	6
	TC	SC	TC/SC	TC	SC	TC/SC
Output volatility	0.55	0.18	3.06***	0.11	0.11	1.00
Growth Volatility	0.19	0.14	1.38**	0.08	0.14	0.57*
	TC	SC	TC-SC	TC	SC	TC-SC
Average Output level	24.85	24.86	− 0.01	25.57	25.1	0.47***
Average Growth level	0.05	0.02	0.03	0.03	0.04	− 0.01

Notes: *,**,*** represent levels of significance at the 10%, 5% and 1% levels respectively TC is treated country and SC is the corresponding synthetic control.

the scope of our analysis to include more countries over a longer period of time. We are thus able to focus on four significant (and unusually large) drop in oil prices between 1980 and 2016, particularly 1986, 1998, 2009 and 2015.

4.1. Methodology and estimation procedure

In an analysis such as this where institutional variables are involved, a high degree of persistence in the *level* of these measures is to be expected, rendering analyses that depend on taking a first difference or demeaning less than appropriate. An alternative would be to take five-year averages as is commonly done, but doing so eliminates some variation in other variables of interest such as the growth rate of oil prices and its volatility. The CS-ARDL approach allows us to study the long-run effects of these persistent institutional variables in conjunction with the evolution of the more erratic behavior of oil prices using annual data. Moreover, in a series of papers, Pesaran and Smith (1995), Pesaran (1997), and Pesaran and Shin (1998) show that the traditional ARDL approach can not only be used for long-run analysis, but that it is also valid regardless of whether the regressors are exogenous or endogenous, and whether the underlying variables are *I(0)* or *I(1)*. These features of the panel ARDL approach are appealing in dealing with endogeneity issues. Furthermore, by employing a panel CS-ARDL model, we take into account cross-sectional dependencies in errors due to possible global factors (including the stance of global financial cycle) and/or spillover effects from one country to another which tend to magnify at times of financial crises.[23] We therefore estimate the following equation:

$$\Delta y_{it} = \alpha_i + \sum_{l=1}^{p} \theta_{il} \Delta y_{i,t-l} + \sum_{l=0}^{p} \beta_{il} x_{i,t-l} + \sum_{l=0}^{p} \varphi_{il} w_{i,t-l} + \sum_{l=0}^{p} \delta_l \bar{y}_{t-l} + \sum_{l=0}^{p} \gamma_{il} z_{i,t-l} + \varepsilon_{it}, \quad (7)$$

where, y_{it} is the natural logarithm of real GDP per capita, Δy_{it} is the growth rate of real GDP per capita, and $\bar{y}_t$ is the cross-sectional average of y_{it} at time t, x_{it} is the growth rate of real oil prices ($\Delta poil_{it}$), and w_{it} represents oil price volatility, driven by large price drops. To create this variable we interact realized real oil price growth volatility for year t, $\sigma_{poil,t}$, constructed as the standard deviation of the year-on-year growth rates of the natural logarithm of monthly real oil prices, $poil_{i\tau}$, during months $\tau = 1,\ldots,12$ in year t, with a dummy variable that takes the value of 1 during years of significant oil price drops and 0 otherwise. Therefore, in contrast to most studies in the growth literature, which employ time-invariant measures of volatility, we are able to construct a time-varying measure of oil price volatility. Finally, $\boldsymbol{z}_{it}$ is a vector representing the interaction of the above measure (w_{it}) with the financial variables of interest, i.e. the financial components of the Fraser chain linked index of institutional quality explained in detail in Section 2.3. A comparison of models, one with estimates of w_{it} but without $\boldsymbol{z}_{it}$ and another with $\boldsymbol{z}_{it}$ but without w_{it} should provide evidence of the effect of the financial depth.[24] Comparing the coefficients of w_{it} and $\boldsymbol{z}_{it}$, we expect the coefficients of $\boldsymbol{z}_{it}$ to be smaller so as to illustrate the effect of financial depth in mitigating the effects of negative oil price growth volatility

4.2. Data

We begin with an annual dataset comprised of 194 countries between 1980 and 2016. Note that we must allow for enough lags, p, such the residuals of the error-correction model are serially uncorrelated but not too many lags so that it imposes excessive parameter requirements on the data, i.e. allowing for enough degrees of freedom. Mohaddes and Raissi (2017) suggest capping the lags at 3 and this is the approach that we take. However, to allow for enough lags, sufficient time series observations for each country is needed, we therefore require each country to have at least 25 consecutive observations on y_{it}, x_t, w_{it} and $\boldsymbol{z}_{it}$.[25]

Because of missing observations for some of the countries in case of

[23] See Chudik and Pesaran (2015) for details on cross-sectional adjustment.

[24] Since the only difference between these two specifications is the introduction of finance in the second interaction term $\boldsymbol{z}_{it}$.

[25] Chudik et al. (2017) and Mohaddes and Raissi (2017) suggest the minimum T to be around 25 for each i.

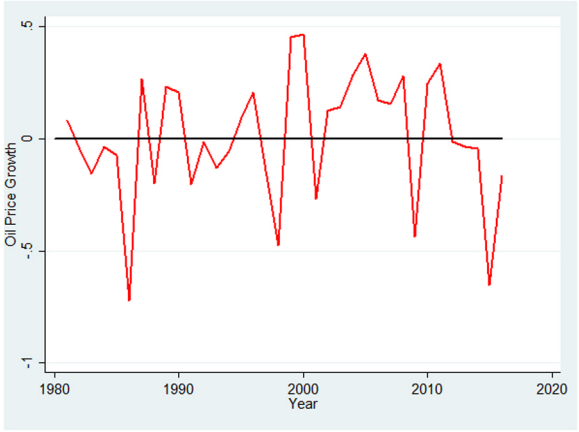


Fig. 2. Oil price growth, 1980–2016. Source: Authors' own calculations based on data from US Department of Energy and OPEC.

the institutional variables,[26] our sample is reduced to 62 countries. Moreover, since we are interested in countries that produce oil, we calculate the average of oil-value-to-GDP ratio for all countries in our dataset over a 30-year period and select only countries above the 50th percentile (which is a cutoff that includes countries that have at least an oil value to GDP of 0.09%). What remains is a sample of 30 oil producers with T greater than 25. Table A3 in the Appendix provides a list of the 30 countries, as well as their average financial measures and the ratio of oil value to GDP.

4.3. The role of financial institutions

Commodity prices are never entirely predictable and oil prices are no exception. However, moderate price fluctuations can be "expected" as the outcome of forecasting models within reasonable confidence bands and internalized by agents' behavior as for example in firms' and investors' hedging strategies. Large shocks that deviate greatly from historical means, however, are often unexpected and this is where we would expect stronger financial institutions to better mitigate the resulting effects. The analogy to bank's expected and unexpected loan default rates illustrates this point: expected loan defaults, those within certain standard deviation of the mean of the probability distribution of default, are considered idiosyncratic risks and allowed for in the loan reserves. However, unexpected defaults, i.e., those exceeding a predetermined standard deviation from the mean, are considered part of systemic risk and only addressed by banks' capital requirements. Under severe downturns as in 2008, banks with low capital were unable to survive the massive effect of default. Now consider Fig. 2 below that shows oil price growth between 1980 and 2016. If we define unexpected shocks as those "out of the norm" when oil price shocks are greater than one standard deviation from the mean, we arrive at the "unexpected oil shocks" in 1986, 1998, 2009 and 2015.[27]

The fact that this approach includes the most recent large oil price drop provide us with a robustness check on the validity of SCM method which also focused on the same period. But since we are now also able to include other periods of large price drop here, our approach in this section goes beyond a robustness check and actually generalizes the hypothesis of the mitigating role of finance to any period where such a shock is experienced.

4.4. Results

Estimating Eq. (7) we present the long-run coefficients of the CS-ARDL regressions in Table 8, where the first three columns indicate that GDP growth is impacted positively and significantly by oil price growth and negatively and significantly by the oil price growth volatility in all three lag specifications. This provides support for the hypothesis that it is not the abundance, but the price volatility of oil that acts to retard long-run growth prospects. The question then is whether financial institutions can dampen this volatility effect? Columns 4–9 of Table 8 presents the results of this analysis.

As the first step, columns 4–6 introduce the measure of "negative oil shocks" which we have denoted as w_{it} in Eq. (7). This measure is constructed by the interaction of oil price growth volatility with a dummy variable which takes the value of 1, when oil price growth is negative *beyond* one standard deviation of the mean, and 0 otherwise, signifying unexpected negative oil price shocks. We see first and foremost that the magnitude of the coefficient of negative oil shocks is about *two and half times larger* than that of oil price growth volatility in columns 1 through 3. This suggests that much of the negative effect of volatility arises from these large (and therefore likely unexpected) shocks, and that the "positive shocks" may have cushioned the overall effect of volatility, given the smaller coefficients in columns 1–3.

Our key results are shown in columns 7–9 of Table 8. Here, we examine the mitigating property of financial institutions in the face of large drops in oil prices. To do this, we interact the financial institutions index with our measure of negative oil shocks. Comparing columns 4–6 to columns 7–9, the strong mitigating role of financial depth in cushioning the effect of the negative oil shock is self-evident: the coefficients of "Finance" when interacted with "Negative Oil Shocks" in columns 7–9, although still negative, are far less than the negative effects of the corresponding coefficients of oil shock but without finance, about one tenth of the latter (i.e., -5.009 vs -0.309; -8.625 vs -0.893; -11.04 vs -0.868). This points to the benefits of strong financial institutions. Notice also that in columns 7–9 the coefficient of "Finance" itself is highly significant and positive. This reinforces the fact that the negative coefficient of the interaction term, comes entirely from the adverse effect of negative oil shock, not financial institutions. The mitigating effect of financial institutions in the presence of unexpected negative shocks echoes our finding of Section 3, where we used the SCM method. In the end however, finance can only cushion the blow, but not reverse it.[28]

5. Energy security and financial institutions

Our counterfactual exercise has so far highlighted the importance of finance in dampening the negative effect of oil price volatility on economic growth, however, our results also have implications in terms of energy security and its impact on development. Although we take a supply-side approach by studying the impact of oil price volatility on oil producers, our results certainly have implications for the net oil importers as well. The latter have often been the principal focus when

[26] While we have annual data on domestic financial institutions from 2000 onward, the data between 1970 and 2000 is reported at five year intervals only. However, since institutional variables change only very gradually over time, we obtain annual series for these variables from 1970 to 2014 by linearly interpolating each institutional variable on a country-by- country basis.

[27] There are also periods that show positive oil price shocks, but we will only focus on the negative unexpected shocks as this is where we believe mitigation of financial institutions is most evident.

[28] In an earlier version of this paper, we verify that the individual components of our finance measure all mitigate the impact of negative oil shocks, with the strongest mitigation effect (measured by the degree of reduction in the size of the negative coefficient) belonging to the ownership of banks measure, followed by the interest rate control and private sector credit (see Jarrett et al., 2018). We also take advantage of the composite nature of the Fraser chain linked index to separate the effect of financial institutions from overall institutional measures and we find that it is the financial measure that is the driving force behind the mitigating effect of the overall variable. Results of these regressions are not reported but are available from the authors upon request.

Table 8
CS-ARDL using PMG: baseline, domestic financial measures and isolating unexpected negative shocks.

	Growth Rates								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oil price Growth	2.398***	1.314*	3.469***	1.283*	− 1.424*	− 1.469	1.358**	− 0.648	− 0.537
	(0.575)	(0.728)	(0.971)	(0.672)	(0.765)	(0.943)	(0.654)	(0.793)	(1.010)
Oil price Growth Volatility	− 2.161**	− 3.71***	− 4.86***						
	(0.984)	(1.088)	(1.445)						
Negative Oil Shocks				− 5.009***	− 8.625***	− 11.04***			
				(1.708)	(1.664)	(2.080)			
Negative Oil Shocks × Finance							− 0.309	− 0.893***	− 0.868***
							(0.200)	(0.230)	(0.295)
Finance							0.546***	0.763***	0.513***
							(0.134)	(0.120)	(0.114)
Error correction	− 0.76***	− 0.81***	− 0.75***	− 0.745***	− 0.815***	− 0.794***	− 0.773***	− 0.837***	− 0.880***
	(0.0457)	(0.0585)	(0.0690)	(0.0452)	(0.0571)	(0.0677)	(0.0438)	(0.0613)	(0.0747)
Countries	30	30	30	30	30	30	30	30	30
Observations	990	960	930	960	930	900	990	960	930

Notes: Regressions are run using the pooled mean group estimator. The ARDL is cross sectionally adjusted using average output, but this variable is not reported. Standard errors in parentheses with *,** and *** representing significance at the 90%, 95% and 99% confidence intervals. Columns 1, 4, and 7 represent an empirical model specification of one lag; columns 2, 5, and 8 have two lags and columns 3, 6, and 9 have three lags. Short-run estimates were included but not reported. Finance is the aggregate measure of financial institutions used in this analysis, which is a combination of bank ownership measures, private sector credit and interest rate controls. Negative oil shocks are constructed by the interaction of oil price growth volatility with a dummy variable which takes the value of 1, when oil price growth is negative *beyond* one standard deviation of the mean, and 0 otherwise, signifying unexpected negative oil price shocks. Comparing columns 4–6 to columns 7–9, the mitigating role of financial depth in cushioning the effect of the negative oil shock is quite evident: The coefficient of Negative Oil Shocks × Finance although still negative, is less than one tenth the of the negative effect of oil shock without finance. This suggests the benefit of strong financial institutions. A version of this table where the level of finance was introduced to columns 4–6 still showed significant reductions in coefficients of the interaction terms suggesting the reduction stems primarily from the interaction between finance and oil price volatility as opposed to just the level of financial depth. Results of this analysis are available from the authors upon request.

discussing energy security which, by definition, is polysemic and can be viewed in different ways depending on the focus of the study (Chester, 2010; Vivoda, 2010). In this section, we highlight some of the pathways through which our findings in this paper connect to and address some of the problems associated with energy security. Ang et al. (2015), in their extensive review of publications on energy security, classify energy security concerns into seven main themes: energy availability, infrastructure, energy prices, societal effects, environment, governance, and energy efficiency. Of these seven themes, we focus on energy availability and energy prices, which 99% and 71% of publications are concerned with respectively, placing these two in the top three of concerns when examining energy security.[29]

In general, energy availability is an energy security concern when one focuses on import disruptions from wars, destabilized regimes, destruction of energy transportation facilities, strikes, and sanctions to name but a few. In addition to this, we posit that import disruptions can also be due to the quantity adjustment mechanism employed by the Organization of the Petroleum Exporting Countries (OPEC) over the last several decades and more recently by OPEC+. It has long been argued, dating back to the first oil crisis of 1973/74, that major oil exporters that heavily depend on oil revenues, set their oil production to achieve a given level of oil revenues, the so-called target revenue model; see, for instance, Bénard (1980), Crémer and Salehi-Isfahani (1980), and Teece (1982).[30] The objective of OPEC, while attempting to stabilize the revenue streams for major oil producing countries, clearly has consequences for oil importers. For example, as we have seen recently, following the US shale oil revolution and the sharp fall in oil prices in 2014, OPEC+ agreed to reduce global oil supply, which in turn played a large role in increasing oil prices by 50% over the last 12 months (also having additional implications for affordability, another dimension of energy security). Given our findings, better financial management of oil price volatility will mean *reduced* reliance on the *quantity* adjustment mechanism, which would in turn, imply a more reliable flow of oil and thus improved energy security for all without compromising economic growth. Note that this will indirectly also address the affordability dimension of energy security as we should see fewer sharp increases in oil prices. The stabilizing effect of better finances on macroeconomic measures (particularly GDP) has the potential to increase energy trade, diversification, and availability and thus overall energy security, through reduction in overall risk.[31]

Now turning our attention to energy prices as an energy security concern, three aspects stand out: absolute price level, price volatility and the degree of competition (Ang et al., 2015). Better financial institutions lead to more efficient allocation of capital resources which in turn provides better technology geared towards cheaper extraction of oil, ultimately leading to lower price levels and increasing competition by increasing the number of energy suppliers (for example fracking in North America).[32] Another aspect of energy security concerns through energy prices is exchange rate fluctuation, which could increase uncertainty given that oil is traded in US dollars, and potentially impact the ability of a net-importer to purchase oil (Ang et al., 2015). Given the well-established relationship between output and exchange rates, the stabilization effect of better finances translates to more stable exchange rates, reducing the associated uncertainty leading to better energy security. Finally, given the results of better mitigation of uncertainty on the supply side, during periods of extreme negative price dips, it is not unreasonable to expect similar mitigating effects of finance on the demand side during extreme price spikes, thus promoting energy security in countries that are most reliant on it.

[29] Infrastructure which deals with the state of facilities which include energy transformation and distribution facilities make up 72% of publication making it the second most important concern, see Ang et al. (2015).

[30] See also Mohaddes (2013) for a short review of the role of OPEC in influencing the oil markets.

[31] The link between lower risk and increase in trade at large has been shown in a recent paper by Jarrett and Mohtadi (2018).

[32] For the role of finance in technological innovation see Laeven et al. (2015). As the US case suggests, such technological innovation may even have a transforming effect, leading from net importer status to net exporter status, if properly harnessed.

6. Conclusions and policy implications

In this paper we have offered a quasi-natural experiment to study the mitigating role of financial depth in the impact of oil price volatility on growth. We investigated this proposition by first using a synthetic control (counterfactual) method to capture the degree to which financial depth mitigates the negative effects of oil volatility, and then correcting for any possible remaining endogeneity issues using panel CS-ARDL regressions, thereby taking into account all three key features of the panel: dynamics, heterogeneity and cross-sectional dependence, a methodological contribution in and of itself.

The counterfactual exercise provided support to the idea that financial depth does indeed mitigate the negative effects oil price volatility and therefore increases energy security. This is evidenced by the fact that the counterfactuals which posit an alternative scenario, where treated countries have higher financial depth measures, showed a significant decrease in output volatility and higher growth rates in 2015. We also found evidence which suggests that better financial depth is required as the degree of dependence on oil increases. Finally, to ensure that any possible endogeneity is not the source of our findings, we verified these results using the CS-ARDL approach and data on 30 oil-producing countries over three decades (1980–2016). More specifically, we illustrated the critical role of financial institutions especially during periods of unexpectedly large negative oil price shocks. In all cases, we also found direct positive contribution of financial depth to growth.

The policy solution we have outlined, i.e., better financial institutions, has a bearing not only for the better management of the impact of this volatility for oil producers, such as those in the Middle East and North Africa as well as the Asian countries ramping up commodity production including those in our sample (Indonesia, Malaysia, Pakistan, Philippines, and Thailand), but also critically for its implications for *improved global energy security* for this vital resource. Evidence suggests that better financial institutions improve macroeconomic stability and decrease reliance on quantity adjustment mechanisms in oil exporting countries, while simultaneously reducing both oil price volatility and oil price levels. These mechanisms have important implications for the availability and pricing of energy (which are important concerns for energy security) without compromising economic growth. In general, the flexibility of a freer financial system allows for faster market adaptation to oil and commodity price fluctuations leading to better allocation of capital and more steady growth.

Appendix A

(See Tables A1–A3)

Table A1
Data sources.

Variables	Sources
Ownership of banks	Fraser chain linked index data set
Private sector credit	Fraser chain linked index data set
Interest rate controls negative	Fraser chain linked index data set
Population	Penn World Tables
Government Consumption	Fraser chain linked index data set
Transfers and subsidies	Fraser chain linked index data set
Judicial independence	Fraser chain linked index data set
Impartial courts	Fraser chain linked index data set
Fraser chain linked Summary Index	Fraser chain linked index data set
Total assets and Liabilities	IMF International Financial Statistics Database
Seasonally adjusted quarterly GDP (for measure verification)	OECD Statistical database
GDP	World Bank World Development Indicator Database
Capital stock at constant 2011 national prices (in mil. 2011US$)	Penn World Tables
Chinn-Ito Dejure measure of financial openness	http://web.pdx.edu/~ito/Chinn-Ito_website.htm
Oil value to GDP ratio	Oil and Gas data Ross (2013) http://thedata.harvard.edu/dvn/dv/mlross
Trade to GDP ratio	World Bank World Development Indicator Database
Import to GDP ratio	World Bank World Development Indicator Database
Oil Price	United States department of energy via quandl.com and OPEC (opec.org)
Exports	IMF International Financial Statistics Database
Imports	IMF International Financial Statistics Database
Sovereign wealth funds	Sovereign wealth funds Institute

Table A2
List of control and treated countries.

Treated Countries	% of oil value to GDP	Control countries	% of oil value to GDP
Angola	59.40%	**Brunei Darussalam**	33.20%
Azerbaijan	43.70%	**Kuwait**	48.20%
Congo, Rep.	59.40%	**Oman**	44.30%
Gabon	45.60%	**Qatar**	37.80%
Algeria	18.50%	**Kazakhstan**	25.30%
Cameroon	9.80%	**Malaysia**	8.50%
Ecuador	15.50%	**Mexico**	8.30%
Indonesia	9.10%	**Norway**	12.40%
Iran, Islamic Rep.	24.90%	**Trinidad and Tobago**	19.10%
Russian Federation	16.50%		
United Arab Emirates	26.01%		

Table A3
List of countries in the CS-ARDL sample.

Country	Finance Measure	percent oil value of GDP
Argentina	6.90	4.37%
Australia	9.63	1.48%
Austria	9.03	0.16%
Benin	8.50	1.40%
Brazil	5.98	1.79%
Canada	9.84	3.44%
Chile	9.01	0.51%
Denmark	9.77	1.26%
Ecuador	8.00	15.46%
Egypt	6.04	14.42%
Ghana	6.79	0.48%
Greece	6.84	0.12%
Guatemala	8.93	0.74%
Hungary	7.98	0.82%
India	6.62	1.52%
Indonesia	7.33	9.13%
Iran	4.78	24.89%
Malaysia	8.60	8.48%
Mexico	8.37	8.29%
Netherlands	9.48	0.14%
New Zealand	9.44	0.57%
Norway	9.49	12.38%
Pakistan	7.29	0.75%
Philippines	8.75	0.20%
Thailand	8.70	0.78%
Tunisia	7.47	6.32%
Turkey	6.63	0.37%
United Kingdom	8.84	1.64%
United States	9.14	1.19%
Venezuela	7.56	28.52%

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