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Macroeconomic Responses to the 2014–2016 Oil Price Decline in Oil-Exporting Economies: A Cross-Country Event Study

A Public-Data Replication and Extension of Grigoli, Herman, and
Swiston (2019)

CERGE-EI

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Research

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Declaration

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3. I agree that this thesis may be used for study and scientific purposes in accordance with the relevant regulations of Charles University.
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In Prague on July 28, 2026.

Nurana Orujova

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Title:

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Abstract:

This thesis investigates why oil-exporting countries experienced different GDP outcomes following oil price shocks. It provides a public-data replication of Grigoli, Herman, and Swiston (2019) for the 2014–2016 oil price decline. It extends their framework by constructing composite resilience measures and applying them to the positive oil-price episode of 2022. Cross-country regressions cover 26 oil-exporting economies and are interpreted as conditional associations. The replication preserves the original coefficient signs, while the composite indices indicate a strong relationship between pre-shock resilience and post-shock performance. For 2022, however, this relationship is weak and unstable, and it disappears completely when developments in 2023 are included. Overall, the evidence demonstrates that resilience is more relevant to reducing losses during adverse episodes than to increasing gains during favorable ones.

Keywords:

oil-price shocks, oil-exporting economies, economic resilience, public-data replication, GDP forecast deviations

Název práce:

Makroekonomické reakce ekonomik vyvážejících ropu na pokles cen ropy v letech 2014–2016: Mezinárodní průřezová eventová studie

Replikace studie Grigoliho, Hermana a Swistona (2019) založená na veřejně dostupných datech a její rozšíření

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Abstrakt:

Tato diplomová práce zkoumá, proč země vyvážející ropu zaznamenaly po cenových šocích na trhu s ropou rozdílný vývoj HDP. Nabízí replikaci studie Grigoliho, Hermana a Swistona (2019) zaměřené na pokles cen ropy v letech 2014–2016, založenou na veřejně dostupných datech. Jejich rámec dále rozšiřuje vytvořením souhrnných ukazatelů odolnosti a jejich aplikací na epizodu růstu cen ropy v roce 2022. Výsledky průřezových regresí pro 26 ekonomik vyvážejících ropu jsou interpretovány jako podmíněné souvislosti. Replikace zachovává znaménka koeficientů z původní studie, zatímco souhrnné indexy ukazují silný vztah mezi odolností před šokem a hospodářským výkonem po šoku. Pro rok 2022 je však tento vztah slabý a nestabilní a při zahrnutí vývoje v roce 2023 se zcela vytrácí. Výsledky celkově ukazují, že odolnost je důležitější pro omezení ztrát během nepříznivých epizod než pro zvýšení přínosů během příznivých epizod.

Klíčová slova:

cenové šoky na trhu s ropou, země vyvážející ropu, ekonomická odolnost, replikace založená na veřejně dostupných datech, odchylky HDP od prognózy

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1 Introduction

1.1 Motivation

Significant fluctuations in oil prices can affect export earnings, government revenue, external liquidity, and domestic demand in oil-exporting economies. Still, the same broad oil-price episode does not necessarily yield the same macroeconomic consequences for oil-exporting countries. After the 2014-2016 oil price decline, some oil exporters reported substantial shortfalls in real GDP relative to pre-decline forecasts for the years ahead. Other countries adjusted to the oil-price decline with considerably smaller losses. This variation in effects represents an important economic puzzle. If countries were affected only in proportion to their economic dependence on oil, the most oil-dependent countries would be expected to experience the lowest outcomes when adjusting. However, the observed differences suggest that exposure alone may not account for the complete vulnerability. The conditions the country had before the oil price fall may also have contributed to the loss of income. Grigoli, Herman, and Swiston (2019) similarly show that the cross-country impact of the 2014–2016 episode was not systematically related to the size of oil exports or to the share of oil in fiscal revenue and economic activity.

Thus, the starting point of this thesis is to distinguish exposure to an external development from the capacity to adjust to it. For an economy that exports most of its oil and oil-related products, a decline in international oil prices may reduce consumption and investment by affecting national income. Additionally, lower commodity prices can tighten external financing conditions by increasing country risk premiums and raising the cost of foreign borrowing. Drechsel and Tenreyro (2018) report that commodity prices may influence not only export income but also the terms on which commodity-dependent economies borrow internationally: higher commodity prices tend to coincide with lower country interest-rate premia,

while lower prices can tighten financing conditions. Furthermore, production and trade structures also matter. Kohn, Leibovici, and Tretvoll (2021) demonstrate that economies that produce and export relatively more commodities are more vulnerable to changes in international relative prices, particularly when their imports are concentrated mainly in manufactured goods. All combined, these mechanisms imply that an oil-price decline can affect exports simultaneously through income, fiscal, trade, and financing channels.

Nevertheless, the strength of these channels is unlikely to be identical across countries. For example, an economy with a more flexible exchange-rate arrangement may be able to accommodate part of the adjustment through relative prices. However, depreciation can also create inflationary and balance-sheet pressures. Therefore, a more diversified export base can provide sources of foreign-exchange earnings beyond the oil sector and reduce the concentration of external income.

When oil revenue declines, governments and the private sector may still need foreign currency to pay for imports, service external debt, and fulfill other international commitments. Therefore, adequate international reserves may allow authorities to cover these financial expenses, limit uncontrolled adjustment, and smooth the transition to a lower level of oil revenue. Likewise, a history of stable inflation may reflect more significant monetary policy credibility and provide more room to stabilize the policy response. Finally, a stronger fiscal position can make it possible to smooth public expenditure rather than impose an immediate contraction when the oil revenue falls. These characteristics do not eliminate an economy's exposure to oil price movements. Nevertheless, they may influence whether a decline in oil income is absorbed gradually or leads to a sharper contraction in domestic activity.

Grigoli et al. (2019) provide a direct model to analyze this question. Using a cross-section of oil-exporting economies, the authors relate GDP performance after the 2014–2016 oil-price decline to five characteristics measured before the episode:

fiscal space, foreign-currency liquidity, export diversification, inflation stability, and exchange-rate flexibility. They report that countries that entered the decline with stronger positions in these five characteristics generally experienced more favorable growth outcomes. The approach of estimating the effect based on a country's preparedness makes this study economically important. Oil dependence reflects the scale of an economy's exposure, but it does not fully capture its ability to respond to changes in oil income.

A country can be highly dependent on oil and still maintain substantial buffers or credible adjustment mechanisms. Conversely, an exporter with weaker policy space may face considerable difficulty even when its oil dependence is less intense. Therefore, the original study presents a useful empirical interpretation of resilience as a combination of structural characteristics, financial buffers, and policy frameworks that exist before the external disturbance occurs.

An essential question is whether the relationship identified by Grigoli et al. can be reproduced when the underlying variables are reconstructed independently from publicly available data. The five resilience measures are not all available in a directly usable and consistently defined form across countries. Their construction requires choices concerning data sources, years, definitions, aggregation, and treatment of missing observations. For instance, reserve adequacy combines reserves with external liabilities, broad money, exports, and exchange-rate classifications. Non-oil exports must be isolated from total exports, while the measurement of fiscal space depends on the government debt and revenue data. All these decisions influence the final variables and the number of countries that can be included in the regression sample. Therefore, public-data replication is not simply a mechanical repetition of the published estimates. The replication examines whether the underlying economic pattern remains evident when the variables are independently reconstructed from transparent, accessible sources. The replication also shows the main differences from the original study. These include a smaller sample and the use of gross government debt relative to revenue rather than net government debt.

The aim is not to question the published results, but to see whether the main relationships can still be found using publicly available data.

The model's relevance also extends beyond the 2014-2016 oil-price episode. In particular, the increase in oil prices during 2022 provides an opportunity to analyze whether the same pre-shock conditions remain explanatory in a later and economically different setting. There is no assumption that the adjustment mechanisms operating during a negative oil-price episode work symmetrically during a positive one. When oil prices decline, lower export and fiscal revenues can make financing constraints binding. Governments and authorities may be forced to use reserves, reduce expenditure, increase borrowing, tighten domestic policies, or permit exchange-rate depreciation. When these conditions are taken into account, fiscal space, external liquidity, and policy credibility can directly affect the severity of the required adjustment. A positive oil-price movement is different. It is true that additional revenue softens some constraints. Still, its effect on real activity depends on how quickly production can respond and how the income is saved, spent, and invested. Recent evidence on commodity-exporting emerging economies indicates that negative commodity-price shocks can produce more abrupt responses in output and investment than positive shocks (Gazzani et al., 2026). This is partly because deteriorating financial conditions amplify downturns. This asymmetry makes the 2022 episode a substantive external-validity test rather than a simple repetition of the original baseline exercises with a different period. At the same time, the 2022 episode cannot be considered as a clean mirror image of the 2014-2016 decline. This is because, during that period, several potential economic disruptions were occurring in the global economy. The IMF described the global economy in 2022 as affected simultaneously by the war, persistent inflation, tighter financial conditions, and the lingering pandemic, while the World Bank reported major war-related disruptions in energy and other commodity markets.

Additionally, the capacity of oil exporters to increase production also differed,

meaning that a rise in the international oil price did not generate the same revenue gain in every country. Because these events also affected economic performance, differences in GDP outcomes cannot be attributed solely to oil price movements or to pre-shock resilience. Therefore, the extension includes COVID-19 exposure and exposure to the war as separate controls rather than treating them as components of the resilience index.

For these reasons, the thesis examines whether pre-shock economic conditions help account for differences in GDP performance across oil exporters during two contrasting oil-price episodes. The first part reconstructs the framework of Grigoli et al. using public data and evaluates whether its five individual relationships remain visible after the 2014–2016 decline. It also considers whether the characteristics provide a clearer signal when combined into broader measures of resilience. The second part analyses performance during and after the positive oil-price episode of 2022, using both the original 2013 conditions and an updated index based on 2019 pre-pandemic fundamentals. The comparison provides evidence on whether the relationship between pre-shock resilience and subsequent economic performance differs across oil-price episodes. It does not aim to identify a pure structural oil-price shock, nor does it estimate the causal effect of any individual policy characteristic. Instead, the analysis examines whether the relationships observed during the 2014–2016 oil-price decline are also present during the positive oil-price episode of 2022, which occurred under very different global economic conditions.

1.2 Research Focus and Empirical Approach

This section presents the main questions addressed in the thesis and summarizes the empirical approach used to analyze them. The central replication question is whether exchange-rate flexibility, non-oil export capacity, reserve adequacy, inflation stability, and fiscal space are associated with GDP performance following

the 2014–2016 oil-price decline. Then, the thesis extends the original framework by examining whether these characteristics are more informative when combined into broader measures of resilience. It then applies the same framework to the positive oil-price episode of 2022, considering both the immediate 2022 GDP outcome and cumulative performance through 2023. For the later episode, the analysis compares the original 2013 resilience conditions with updated measures based on 2019 pre-pandemic fundamentals.

The empirical analysis begins with a sample of 26 oil-exporting countries, whereas the preferred replication regressions use a common sample of 23 countries with complete necessary data. Economic performance after the 2014–2016 decline is measured primarily by the deviation of realized real GDP from the pre-shock forecast path. An alternative outcome compares average real GDP growth before and after the decline. The five pre-shock characteristics are examined separately. Additionally, they are combined into a standardized resilience index and a median-based count of favorable conditions. The later extension uses GDP forecast deviations for 2022 and 2023 and includes separate controls for major pandemic- and war-related disruptions. The estimates are interpreted as conditional cross-country associations rather than causal effects.

1.3 Contributions

This thesis makes three main contributions. First, it provides an independent replication of Grigoli et al. (2019) using publicly available data. The replicated estimates are presented alongside the original study results, which allows the signs, magnitudes, and statistical precision of the coefficients to be compared directly. This exercise shows whether the main economic relationships remain visible when the original framework is reconstructed with alternative public sources. The thesis also repeats the analysis using the realized slowdown in GDP growth. This alternative outcome does not rely on the accuracy of the pre-shock GDP forecast;

therefore, it provides an additional test of the original relationships.

Second, the thesis extends the original model by combining the five pre-shock characteristics into two broader measures of resilience. Firstly, the standardized resilience index gives equal weight to exchange-rate flexibility, non-oil exports, reserve adequacy, inflation stability, and fiscal space. Second, the median-based resilience count offers a simpler measure by recording the number of favorable pre-shock conditions that each sample country satisfies. These measures examine whether the five characteristics are more informative when combined into dimensions of a country's adjustment capacity than when considered separately. The third contribution is an external-validity exercise based on the positive oil-price episode of 2022. The analysis considers GDP performance in 2022 and through 2023. It compares the original 2013 resilience conditions with an updated index based on 2019 pre-pandemic fundamentals. It includes separate controls for COVID-19 mortality, Russia's distinct position, and pre-war trade exposure to Russia and Ukraine. The results are also repeated after excluding Russia from the sample. This extension examines whether a framework associated with economic performance during an adverse oil-price decline remains significant during a later positive episode.

2 Literature Review

The macroeconomic consequences of oil-price fluctuations depend on several factors, including the underlying source of price change, the degree of commodity dependence of the country, the financial and policy environment before the shock, and the sign of the shock itself. These factors play a particularly important role in oil-exporting economies. A decline in oil prices directly reduces export and fiscal revenues; however, exchange-rate adjustment, access to external finance, reserve holdings, the credibility of monetary policy, the composition of exports, and the government’s capacity to smooth expenditure can amplify or moderate the final effect. By contrast, economies may respond differently to an oil-price increase because financial constraints, fiscal decisions, and domestic absorption may operate differently during economic booms and downturns (Drechsel & Tenreyro, 2018; Gazzani et al., 2026; Grigoli et al., 2019).

This literature review develops the necessary conceptual basis to analyze such cross-country heterogeneity. Section 2.1 discusses the determination and identification of oil-price shocks. Section 2.2 reviews the transmission of commodity-price shocks in oil-exporting economies. Section 2.3 discusses Grigoli et al. (2019), the main study replicated in this thesis. Section 2.4 investigates five pre-shock dimensions that can influence countries’ resilience: exchange-rate flexibility, export diversification, reserve adequacy, inflation stability and fiscal space. Section 2.5 considers shock asymmetry and external validity, thereby motivating the thesis’s comparison of the 2014–2016 negative oil-price shock with the positive 2022 oil-price shock.

2.1 Oil-price determination and identification

The main point is that an observed change in the price of oil should not automatically be considered an exogenous oil-supply disturbance. Production disruptions,

shifts in global economic activity, or oil-market-specific demand developments can cause oil price changes. The origins of an oil shock matter because shocks associated with expanding global demand affect oil exporters differently from those associated with supply shortages or changes in precautionary demand (Kilian, 2009; Kilian & Murphy, 2014). Therefore, it is crucial in the literature to identify the underlying reason for the price change rather than treating every decimal-point difference in oil prices as equivalent. This thesis has been constructed around that idea; therefore, the empirical exercises do not seek to estimate a structural model of global oil price determination. Instead, the analysis studies cross-country differences in economic performance around two major oil-price episodes: the 2014–2016 price decline and the price increase in 2022 following Russia’s full-scale invasion of Ukraine. These two episodes are treated as common external shocks to oil-exporting countries. The analysis then examines whether differences in countries’ pre-shock conditions help explain their later GDP performance. Therefore, the empirical approach is closer to a cross-sectional event study and an external validity exercise than to structural identification of the global oil shock itself.

In this sense, Kilian (2009) provides the main framework to analyze the source of a price change. The author separates oil-price fluctuations into three structural shocks. First, an oil-supply shock reflects an unexpected change in global oil production. Second, a global aggregate-demand shock arises from changes in the global business cycle and affects the demand for oil and other industrial commodities. Third, an oil-market-specific demand shock mainly reflects changes in precautionary demand caused by uncertainty about future oil supply. Kilian (2009) reports that demand shocks explain more of the historical oil-price variation than unexpected disruptions to oil production. Therefore, the economic effects of an oil-price change mainly depend on its origin: whether it is an oil-supply shock, a global aggregate-demand shock, or an oil-market-specific demand shock. This means that two similar oil-price changes may have different economic effects if they arise from different shocks (Kilian, 2009).

In addition, Kilian and Murphy (2012) claim that the conclusions drawn from structural oil-market models also depend on how the shocks are identified. The authors find that sign restrictions alone can produce several different models with different conclusions about the importance of supply and demand shocks. To narrow these results, they add reasonable limits on the short-run oil-supply elasticity. These additional restrictions support the conclusion that demand shocks often play a larger role in oil-price movements than supply shocks (Kilian & Murphy, 2012).

Similarly, Kilian and Murphy (2014) extend this analysis by incorporating crude oil inventories into the model. The authors separate three types of shocks: flow supply, flow demand, and speculative demand. Flow supply refers to current oil production, while flow demand refers to current oil consumption that is driven by global economic activity. Speculative demand refers to demand for oil inventories driven by expectations about future supply and demand. For instance, if market participants expect an oil shortage, they may increase demand for oil inventories, and this can raise the current oil price even before oil production changes. Kilian and Murphy (2014) find that the 2003–2008 oil-price increase was mainly driven by stronger global oil consumption, rather than by speculation or unexpected supply shortages. However, speculative-demand shocks played a more important role in some earlier oil-price episodes (Kilian & Murphy, 2014).

Baumeister and Kilian (2016a) bring these results together and claim that oil-price fluctuations usually reflect a combination of supply, demand, and expectation shocks. The authors also distinguish an oil-price change from an oil-price shock, which means that an oil-price shock is the unexpected part of the observed price movement. Therefore, the size of an oil-price shock depends on the expectation used as the benchmark. This further shows why an observed change in oil prices cannot be interpreted without considering the cause and expectation. This framework is directly relevant to the 2014–2016 episode studied in the thesis. Baumeister and Kilian (2016b) find that the decline in oil prices during the second

half of 2014 did not result from one single shock. More than half of the decline between June and December was predictable using information available in June 2014. The predictable part of this decline reflected earlier adverse global-demand shocks, positive oil-supply shocks, and changes in expected production. The remaining part of the decline reflected a reduction in storage demand in July and an unexpected weakening of the global economy in December. The authors find no evidence that positive oil-supply shocks after June 2014 or the November OPEC announcement alone explain the decline (Baumeister & Kilian, 2016b).

Therefore, the 2014–2016 oil-price decline should be viewed as a broad adverse external shock for oil exporters rather than a pure supply shock (Baumeister & Kilian, 2016b). The present thesis does not estimate a structural model of the global oil market or separate the exact contribution of each global shock. Instead, it examines why GDP performance differed among oil-exporting countries that faced the same broad oil-price decline. The analysis tests whether differences in pre-shock policy frameworks, structural characteristics and financial buffers help explain these outcomes.

Similarly, the same distinction is important for the 2022 extension. The rise in oil prices occurred during the recovery from the COVID-19 pandemic and around Russia’s full-scale invasion of Ukraine (World Bank, 2022). It should not be treated as the exact opposite of a single negative shock in 2014. The extension instead tests whether the pre-shock resilience framework also predicts GDP performance during a later positive oil-price episode. Therefore, COVID exposure and exposure to the war are included as separate controls.

2.2 Macroeconomic transmission in commodity-exporting economies

A broad literature indicates that commodity-price changes are a major source of business-cycle volatility in countries that depend heavily on commodity production and exports. These fluctuations affect the economy through several channels. On the one hand, higher commodity prices increase the value of domestic production and exports. They also increase national income and government revenue, which can boost consumption and investment. Higher commodity prices may also improve external financing conditions as lenders may view the country as more creditworthy. On the other hand, lower commodity prices can reverse these effects. They can reduce export income, worsen the terms of trade, and tighten borrowing conditions (Drechsel & Tenreyro, 2018; Grigoli et al., 2019).

Drechsel and Tenreyro (2018) provide a useful framework to analyze these effects in depth. The authors build a small-open-economy model, in which commodity prices influence economic activity through two channels: the value of commodity production and the cost of external borrowing. Higher commodity prices increase the value of production and reduce the country's interest-rate spread. In their application to Argentina, these two channels jointly raise GDP, consumption, and investment, while the trade balance declines as domestic expenditure increases. The authors report that commodity-price shocks explain about 38 percent of fluctuations in Argentina's output growth after 1950, with larger contributions to consumption and investment volatility (Drechsel & Tenreyro, 2018).

The financing channel is especially relevant for this thesis. When oil prices fall, sovereign spreads may rise, and access to external credit may weaken. This can amplify the loss of export income by reducing investment and forcing cuts in domestic expenditure. The effect of an oil-price decline may therefore depend not only on a country's exposure to oil exports, but also on its balance sheet and

its ability to manage tighter external financing conditions (Drechsel & Tenreyro, 2018).

Moreover, Kohn et al. (2021) focus on a different mechanism. The authors study the structure of production and trade with their multi-sector small-open-economy model, which distinguishes commodities, manufactures, and non-tradable goods. The structure of trade differs across these two groups of economies. While emerging economies often export commodities and import manufactures, developed economies usually have more balanced trade flows across sectors. As a result, the goods that emerging economies produce differ from the goods that they consume. This makes emerging economies more exposed to international commodity-price fluctuations (Kohn et al., 2021).

Kohn et al. (2021) report that differences in production and trade patterns explain 30–39 percent of the difference in GDP volatility between emerging and developed economies. In their study, commodity-price shocks explain 26.1 percent of the variance in real GDP in emerging economies, while in developed economies, the value is 10.7 percent.

The above-mentioned findings support the role of non-oil exports in this thesis. An economy with a broader export base has a wider range of foreign-exchange earnings. Therefore, in this thesis, the non-oil-export variable captures the degree of export concentration, rather than trade openness alone. A higher non-oil export share means that a smaller share of foreign-exchange earnings depends directly on oil. Kohn et al. (2021) also report that the composition of trade matters: economies with large commodity export surpluses and manufacturing trade deficits are more exposed to commodity-price fluctuations.

Merener and Steglich (2018) provide similar evidence on diversification. The authors study 56 commodity-producing countries and report that countries specializing in a single commodity experience higher output-value volatility than more diversified economies. Between 1987 and 2006, specialized producers had

average output-value volatility of 27 percent, while producers of three or more commodities had average volatility of 12.7 percent. However, the benefits of diversification became smaller between 2007 and 2012. During this period, commodity prices moved more closely together. Therefore, diversification reduces commodity risk, but it does not remove it completely. When different commodity prices are highly correlated, the effect of diversification becomes weaker (Merener & Steglich, 2018). This evidence supports the use of non-oil exports in this study. However, the measure used here is broader than the measure in Merener and Steglich (2018). The thesis does not specifically measure diversification across different commodities. Instead, it measures exports outside crude oil, including other goods and services. Therefore, the variable captures the relative size of the non-oil tradable sector.

Moreover, Blanchard and Riggi (2013) show that the effects of oil-price changes can also differ across periods. The authors study why oil-price increases had smaller effects on output and inflation after the mid-1980s than in the 1970s. The study argues that lower wage indexation and stronger monetary-policy credibility changed the transmission of oil-price shocks. Their analysis focuses on advanced oil-importing economies; however, it shows that the effects of oil-price movements depend on the policy and institutional environment. Additionally, the relationship between oil prices and economic performance may change over time (Blanchard & Riggi, 2013).

In addition, Gazzani et al. (2026) report that positive and negative commodity-price shocks may have different effects. Specifically, the authors claim that negative shocks reduce output and investment more quickly than positive shocks increase them. They explain this asymmetry mainly through financial conditions. When commodity prices fall, export income declines and the country becomes a riskier borrower. Negative commodity-price shocks raise country spreads, which measure the additional interest rate that the country pays above a safer international benchmark. As a result, external borrowing becomes more expensive.

At the same time, net capital inflows decline, reducing the amount of foreign financing available to the country. In this case, firms and governments may need to reduce investment and domestic expenditure, thereby strengthening the initial effect of the commodity-price decline. By contrast, positive shocks do not produce an equally strong improvement in spreads and capital inflows. This asymmetry explains why negative shocks have faster and more severe effects than positive shocks (Gazzani et al., 2026). This study is discussed in detail in Section 2.5. Its findings support the view that commodity-price booms and commodity-price declines are not exact opposites (Gazzani et al., 2026).

Furthermore, Barrot et al. (2018) study how global demand, supply, monetary, and commodity shocks affect GDP in developing economies. The authors also examine whether these effects depend on trade openness, financial openness, and commodity specialization. Their approach separates the external shock from the country characteristics that shape its transmission. They report that domestic shocks explain most GDP fluctuations, but the contribution of external shocks has increased over time. More importantly for this thesis, commodity-intensive economies are more vulnerable not only to commodity shocks but also to other global disturbances. This supports the view that commodity specialization increases an economy's wider exposure to external economic conditions (Barrot et al., 2018).

All these findings complement Drechsel and Tenreyro (2018) and Kohn et al. (2021). They also support the use of non-oil exports in the present thesis. A larger share of non-oil exports indicates a broader export structure and less direct dependence on oil revenues. However, Barrot et al. (2018) measure commodity specialization differently. Their study supports the economic reasoning behind the thesis variable rather than its exact construction.

Overall, the literature shows that commodity-price shocks affect economies through export income, production, domestic expenditure, trade and external financing.

It also explains why the same oil-price shock can lead to different GDP outcomes across countries. Countries differ in export concentration, borrowing conditions and adjustment capacity; therefore, these differences are central to the empirical analysis in this thesis.

2.3 Grigoli et al. (2019) and the resilience of oil exporters

Grigoli et al. (2019) provide the main study on which the present thesis builds. While much of the oil-price literature examines the average effects of oil-price shocks over time, the authors focus on why the same 2014–2016 oil-price decline produced different economic outcomes across oil-exporting countries. Their main contribution is to shift attention from the degree of oil dependence alone to the economic conditions that countries had before the shock. In this way, the study asks the broader question of why some commodity-exporting economies are more resilient than others.

The authors find that oil exporters with stronger fiscal positions, larger foreign-currency liquidity buffers, more diversified export structures, greater price stability, and more flexible exchange-rate regimes generally performed better after the oil-price decline. Together, these pre-shock conditions account for a substantial share of the differences in economic performance among oil-exporting countries. By contrast, the impact of the shock was not strongly related to the size of oil exports or the share of oil in fiscal revenue and economic activity. These findings suggest that vulnerability to an oil-price decline depends not only on a country's exposure to oil, but also on its capacity to adjust when oil income falls. Therefore, Grigoli et al. (2019) provide the five-dimensional resilience framework that organizes the remaining literature and the empirical analysis in this thesis.

This framework provides the basis for the five dimensions examined in the following

section. Each dimension represents a different channel through which pre-shock conditions may influence the transmission of an oil-price decline. The broader literature on exchange-rate adjustment, export diversification, external liquidity, inflation stability and fiscal space is therefore reviewed separately below.

2.4 Pre-shock policy frameworks, structural characteristics and financial buffers

The literature on commodity-exporting and emerging economies suggests that vulnerability to an external shock has several dimensions. No single policy variable fully describes whether a country is well positioned to absorb a large movement in its export price. The methodology replicated in this thesis summarizes resilience using five pre-shock dimensions: exchange-rate flexibility, the non-oil export share, reserve adequacy, inflation stability and fiscal space.

2.4.1 Exchange-rate flexibility

A flexible exchange rate can operate as a relative-price adjustment mechanism after an external real shock. When export prices decline, nominal depreciation can lower domestic costs relative to foreign prices, thereby supporting the non-oil tradable sector. Under a fixed or rigid exchange-rate arrangement, this adjustment cannot occur through the exchange rate. Instead, wages, prices, employment, or domestic expenditure may need to decline. As wages and prices often adjust slowly, the decline in output may become more extensive (Levy-Yeyati & Sturzenegger, 2003).

Levy-Yeyati and Sturzenegger (2003) study the relationship between exchange-rate regimes and growth and output volatility. The authors use a de facto classification based on the actual behavior of exchange rates and foreign reserves. They find that

less flexible regimes are associated with slower growth and higher output volatility for developing countries. However, they do not find the same relationship for industrial economies. Additionally, the authors claim that rigid regimes can make adjustment to real shocks more difficult and may require higher interest rates to maintain the fixed exchange-rate commitment (Levy-Yeyati & Sturzenegger, 2003).

All the above-mentioned evidence supports the inclusion of an exchange-rate flexibility variable in the empirical analysis as a potential dimension of pre-shock resilience. However, it does not establish that flexible regimes always insulate commodity exporters from every type of shock. Additionally, their results describe the general relationship between exchange-rate regimes and economic performance over a long period of time. The authors do not directly measure countries' responses to a specific commodity-price episode (Levy-Yeyati & Sturzenegger, 2003).

Conversely, Gazzani et al. (2026) provide a different result. They study positive and negative commodity-terms-of-trade shocks and find that differences between fixed and flexible exchange-rate regimes do not explain the stronger effects of negative shocks relative to positive shocks. Instead, the authors argue that tighter financial conditions after negative shocks are the main source of this asymmetry (Gazzani et al., 2026).

These findings do not necessarily conflict with those of Levy-Yeyati and Sturzenegger (2003). Exchange-rate flexibility may help economies adjust to real shocks in general, even if it does not explain the different effects of positive and negative shocks in a specific sample. Therefore, in this thesis, exchange-rate flexibility is treated as a possible shock-absorption mechanism. It should not be interpreted as a guarantee of resilience or as a policy variable with an independent causal effect.

2.4.2 Export diversification

The export structure determines how strongly a commodity-producing economy is exposed to oil-price changes. When a large share of exports is accounted for by oil, an oil-price fall causes a substantial decline in export revenue. A larger non-oil tradable sector can reduce this dependence and provide alternative sources of foreign-exchange income. Kohn et al. (2021) indicate that the composition of trade affects how an economy responds to commodity-price fluctuations. Emerging economies that export commodities and import manufactured goods are more exposed than economies with more balanced trade flows across sectors. Their results support the view that export diversification can reduce the transmission of commodity-price shocks to domestic income and expenditure (Kohn et al., 2021).

Similarly, Merener and Steglich (2018) provide evidence on the benefits of diversification. They find that commodity producers with more diversified production experience lower volatility in the value of their output. However, these benefits become smaller when the prices of different commodities move together. Therefore, diversification reduces concentration risk; however, it cannot fully protect an economy from a common global commodity shock (Merener & Steglich, 2018).

In this thesis, non-oil exports as a percentage of GDP are used as an indicator of structural diversification. A higher value suggests that the economy has a greater capacity to generate export revenue outside the oil sector. Therefore, the variable in this study should be interpreted as a structural characteristic rather than as a short-term policy instrument.

2.4.3 Reserve adequacy

International reserves provide governments and central banks with liquid foreign-currency resources. They can be used when export revenues decline, capital inflows fall, or demand for foreign currency increases. However, the value of reserves

depends not only on their size but also on the potential financial pressures facing the economy (Jeanne & Rancière, 2011; Obstfeld et al., 2010).

Jeanne and Rancière (2011) view reserves as insurance against sudden stops in capital inflows. When external borrowing becomes unavailable, reserves can help support consumption and reduce the costs associated with the financial shock. The amount of reserves a country should hold depends on the likelihood of a sudden stop, the potential damage it could cause, and the opportunity cost of holding liquid foreign assets (Jeanne & Rancière, 2011).

Obstfeld et al. (2010) argue that reserves may also protect the domestic financial system. During a financial crisis, a central bank may face capital outflows while residents also attempt to convert their domestic assets into foreign currency. Therefore, reserve needs may depend on financial openness, the size of the domestic financial system, and the exchange-rate regime (Obstfeld et al., 2010).

Bems and de Carvalho Filho (2011) provide a similar argument for exporters of exhaustible resources. As commodity income is highly uncertain, these economies have a strong reason to accumulate foreign assets as precautionary savings. This motive becomes stronger when resource revenue represents a large share of national income (Bems & de Carvalho Filho, 2011).

Together, these studies show that reserve adequacy should be assessed relative to possible sources of foreign-currency pressure. This supports using a broader reserve-adequacy measure rather than a simple reserves-to-GDP ratio. The exact construction of this measure is explained in the data and methodology chapter (Bems & de Carvalho Filho, 2011; Jeanne & Rancière, 2011; Obstfeld et al., 2010).

2.4.4 Inflation stability and monetary-policy credibility

Inflation volatility provides information about the stability of the domestic macroeconomic environment. A country entering an external shock with high and unstable

inflation may have less capacity to support economic activity or allow the exchange rate to depreciate without causing additional inflation (Fraga et al., 2004).

Fraga et al. (2004) demonstrate that emerging economies face more difficult monetary-policy trade-offs than advanced economies. Emerging countries are often exposed to larger external shocks, weaker policy credibility, and a stronger effect of exchange-rate changes on domestic prices (Fraga et al., 2004). As a result, currency depreciation may increase inflation and inflation expectations. The central bank may then need to raise interest rates even when economic activity is already weak.

The authors also argue that limited credibility increases the output cost of reducing inflation and contributes to greater volatility in inflation, output and interest rates. Their findings support the use of pre-shock inflation volatility as an indicator of the constraints facing monetary policy (Fraga et al., 2004).

Additionally, Blanchard and Riggi (2013) provide more limited supporting evidence. They find that after the mid-1980s, several factors helped reduce the effects of oil-price increases, including better-anchored inflation expectations, stronger monetary-policy credibility, and lower wage indexation. Their study mainly analyzes oil-importing economies; however, it shows that inflation institutions can influence the transmission of oil-price shocks (Blanchard & Riggi, 2013).

The inflation-volatility variable used in this thesis is not a direct measure of central-bank credibility or monetary-policy quality. It is instead a broad proxy for nominal stability before the shock.

2.4.5 Fiscal space and expenditure smoothing

Oil-price shocks can have major fiscal effects because governments often receive a large share of oil income through taxes, royalties, or ownership of oil production. When oil revenue declines, a government with limited fiscal space may need

to decrease public consumption and investment during the downturn. In this context, van der Ploeg and Venables (2011) examine how resource-rich developing economies should use temporary windfall revenues. Governments may use windfall revenues for current consumption, debt reduction, domestic investment, or the accumulation of foreign assets. Van der Ploeg and Venables (2011) argue that saving the entire windfall abroad may not always be optimal. In capital-scarce countries with high borrowing costs, using part of the revenue to reduce public debt or finance productive domestic investment may yield greater long-term benefits. Additionally, their analysis shows that accumulating foreign assets is not the only way to achieve responsible resource management. The appropriate use of a windfall depends on the country's debt position, development needs and expected returns to domestic investment (van der Ploeg & Venables, 2011).

Arezki and Brückner (2012) claim that political and institutional conditions also influence the use of commodity windfalls. In less polarized countries, positive commodity-price shocks are more likely to improve net foreign asset positions, whereas in highly polarized countries, similar windfalls are more likely to increase government consumption and corruption while reducing net foreign assets. Therefore, it can be concluded that favorable commodity prices do not automatically create fiscal buffers (Arezki & Brückner, 2012).

These findings suggest that countries facing the same oil-price shock may enter the next downturn with completely different fiscal positions, depending on how resource revenues are managed (Arezki & Brückner, 2012; van der Ploeg & Venables, 2011).

Céspedes and Velasco (2014) investigate whether fiscal policy in commodity-producing countries changed across different commodity booms. They find that fiscal policy was often procyclical during the commodity booms of the 1970s and early 1980s, as governments expanded expenditure and saved relatively little of the additional revenue. However, during the more recent boom, revenues rose strongly

while expenditure increased more slowly, which led to greater fiscal saving in many countries. The authors associate this change with improvements in institutional quality and the use of fiscal rules. Their results demonstrate that commodity windfalls do not automatically create fiscal space; the outcome depends on whether governments save part of the additional revenue or allow expenditure to rise with commodity prices (Céspedes & Velasco, 2014).

In this thesis, the fiscal variable is intended to capture the government’s capacity to absorb revenue losses and maintain expenditure. The literature supports the general importance of fiscal space, but it does not identify one perfect empirical measure. Therefore, the choice and construction of the fiscal-space measures, including the differences between net government debt, gross government debt, and the reserves-based proxy, are discussed in detail in the data and methodology chapters.

2.4.6 Interpretation of the five-dimensional framework

The resilience model includes five different economic dimensions. Exchange-rate flexibility may support relative-price adjustment. Non-oil exports measure structural diversification. Reserves provide access to external liquidity. Inflation stability reflects the constraints facing monetary policy. Fiscal space captures the government’s ability to smooth expenditure. The composite resilience index is best understood as a summary of pre-shock economic conditions rather than as a structural measure of resilience. Examining the individual components remains important because a weak overall index result may mask differences among the underlying mechanisms (Grigoli et al., 2019).

2.5 Shock asymmetry and external validity

In the literature, many studies use linear models in which positive and negative commodity-price shocks are assumed to have effects of similar size but opposite direction. However, this assumption may be too restrictive. For example, financial constraints may become binding during downturns but remain unimportant during booms. Governments may be forced to reduce expenditure when revenues fall, while a positive windfall can be used in several different ways. Therefore, positive and negative shocks may affect the economy through different mechanisms (Gazzani et al., 2026).

Gazzani et al. (2026) provide direct evidence of this asymmetry. The authors use non-linear panel local projections for commodity-exporting emerging economies. They find that negative commodity-price shocks reduce output and investment more quickly than positive shocks increase them. Similarly, negative shocks raise sovereign spreads, reduce net capital inflows, and increase the probability of a sudden stop. Positive shocks do not produce equally significant improvements in these financial variables. The authors explain that tighter financial conditions are the main reason for stronger effects of negative shocks. When commodity prices fall, weaker export revenues may lower creditworthiness and restrict access to external finance. This intensifies the initial decline in income and investment (Gazzani et al., 2026).

Gazzani et al. (2026) also find that the exchange-rate regime and the fiscal-policy response do not explain the difference between positive and negative impulse responses. This does not necessarily mean that exchange-rate flexibility or fiscal space are irrelevant to economic performance. It means these variables are not the primary explanation for the asymmetry observed in their sample (Gazzani et al., 2026).

The literature on resource windfalls also suggests that positive shocks can result in more varied outcomes. First, van der Ploeg and Venables (2011) show that

additional resource revenue can be used for consumption, debt reduction, public investment, private capital formation, or foreign asset accumulation. Therefore, a positive shock may expand the available policy choices rather than creating a single main adjustment path (van der Ploeg & Venables, 2011).

Arezki and Brückner (2012) show that these choices depend partly on political institutions. Some countries save windfall revenues, while others increase government consumption and enter the following period with weaker external positions. Similarly, Bems and de Carvalho Filho (2011) show that resource-exporting countries may save part of a positive income shock because of uncertainty about future commodity prices (Arezki & Brückner, 2012; Bems & de Carvalho Filho, 2011).

These findings are important for the empirical extension in this thesis. The original resilience framework was designed around the negative oil-price episode of 2014–2016 (Grigoli et al., 2019). Additionally, the extension examines whether the same pre-shock characteristics also predict economic performance around the positive oil-price episode of 2022. This exercise tests the external validity of the model rather than repeating the original analysis with a later year. A variable that helps a country avoid forced adjustment during a downturn may not determine how additional income is used during a boom. Thus, the relationship found during a negative shock may be weaker or different during a positive episode.

The 2022 episode also occurred in a more complex economic environment. Countries were affected differently by the recovery from the COVID-19 pandemic and by their exposure to the Russia–Ukraine war (World Bank, 2022). These factors are treated separately in the empirical analysis to avoid altering the meaning of the resilience index.

Replication and external validation answer different questions. Replication asks whether the original result can be reproduced using the stated methodology and reconstructed data. External validation asks whether the same relationship continues to hold in another period or under a different type of shock. A result

may be reproducible in its original setting but have limited predictive power in a later and economically different episode.

Overall, the literature supports three conclusions. First, commodity-price shocks affect exporters through export income, domestic expenditure, and external financing. Second, pre-shock structural and policy conditions may influence the size of these effects. Third, positive and negative shocks should not necessarily be expected to produce opposite but otherwise identical responses. These conclusions motivate both the replication of the 2014–2016 exercise and its extension to the positive oil-price episode of 2022.

3 Replication and Extension of Grigoli et al. (2019)

3.1 Original Study: Data and Methodology

3.1.1 Country sample and data

Grigoli et al. (2019) provide the baseline study replicated in this thesis. Their analysis provides the original country sample, variable definitions, and empirical framework used as the starting point for the replication. The authors examine the cross-country effects of the 2014–2016 oil-price decline using a sample of economies in which oil exports were sufficiently important for the price decline to have a major influence on overall economic performance. The authors begin with a broader group of 44 countries exporting at least 50,000 barrels of oil per day. Within this group, the ratio of oil exports to GDP in 2013 varied from 0.8 to 95 percent. To maintain a clear focus on oil-dependent economies, the authors define their core sample as countries in which oil exports exceeded 8 percent of GDP in 2013 (Grigoli et al., 2019).

Grigoli et al. (2019) also test their findings using broader country samples, but the present thesis focuses on the authors' 26-country core sample. The resulting core sample contains 26 countries: Algeria, Angola, Azerbaijan, Bahrain, Brunei Darussalam, Cameroon, Chad, Colombia, the Republic of Congo, Ecuador, Equatorial Guinea, Gabon, Kazakhstan, Kuwait, Malaysia, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, Timor-Leste, Trinidad and Tobago, Turkmenistan, the United Arab Emirates, and Venezuela. Iran and Iraq are excluded from the core sample because their economic performance was strongly affected by increases in oil production that had not been projected in 2014. South Sudan and Yemen are

excluded because armed conflict represented an important additional influence on economic activity. Libya and Syria are excluded from all of the authors' analyses because of data limitations (Grigoli et al., 2019).

3.1.2 Outcome and explanatory variables

The main dependent variable measures the difference between the realized path of real GDP and the path forecast before the oil-price decline. The authors use real GDP data from the IMF's *World Economic Outlook* database. The Fall 2014 WEO vintage provides the pre-shock forecast, while the Spring 2017 vintage provides the subsequently reported outcome. For each country, real GDP in 2015 or 2016 is normalized by real GDP in 2013 in the corresponding WEO vintage. The dependent variable is the difference between the normalized realized path and the normalized forecast path, expressed in percentage points. A negative value indicates that real economic activity was lower than expected before the shock. Conversely, a more positive value indicates a smaller adverse effect. The authors focus on the cumulative GDP deviation through 2016 because oil prices remained low and the broader economic effects of the shock were likely to appear with a delay. The deviation through 2015 and the Spring 2014 forecast vintage are used as robustness alternatives (Grigoli et al., 2019).

The paper also considers two outcomes that do not depend directly on the accuracy of the pre-shock forecast. The first is the slowdown in total real GDP growth, defined as the compound growth rate of real GDP during 2015–2016 minus the compound growth rate during 2011–2014. The second applies the same calculation to non-oil real GDP. The non-oil growth measure is intended to capture the effect of the oil-price decline on activity outside the oil sector. Both measures are obtained from the WEO database. The authors report that they do not construct a forecast-deviation measure for non-oil real GDP because forecasts are unavailable for a sufficiently large number of countries (Grigoli et al., 2019).

The preferred baseline specification uses the 2016 real GDP forecast deviation as the dependent variable and includes five indicators of pre-shock economic conditions as explanatory variables. These variables are measured mainly in 2013 to capture the economic conditions in place before oil prices began to decline (Grigoli et al., 2019).

First, exchange-rate flexibility is based on the IMF’s *Annual Report on Exchange Arrangements and Exchange Restrictions*. The authors use the de facto exchange-rate regime in 2013 and assign a value of 1 to floating and freely floating regimes. Stabilized arrangements, conventional pegs, currency boards, and officially dollarized economies receive a value of -1 , while all other arrangements receive a value of 0. A higher value therefore represents greater exchange-rate flexibility (Grigoli et al., 2019).

Second, non-oil exports are measured as a percentage of GDP, using data from the WEO and IMF Article IV staff reports. The preferred specification uses the 2013 value, while the authors examine averages over 2011–2013 and 2012–2013 as robustness measures. The authors use this variable as an indicator of economic diversification, representing the size of the non-oil export sector. The paper reports the source and the final ratio but does not provide a separate country-level construction formula for the underlying non-oil export series (Grigoli et al., 2019).

Third, reserve adequacy is measured as reserve assets relative to an IMF reserve-adequacy metric and is expressed as a percentage of that benchmark. The data are taken from the WEO and IMF Article IV staff reports. For economies with fixed exchange-rate regimes, the metric is defined as 20 percent of portfolio and other investment liabilities, 10 percent of broad money, and 10 percent of exports. For economies with flexible regimes, the corresponding weights are 15, 5, and 5 percent. The preferred regression uses the 2013 value, while the authors also consider averages over 2011–2013 and 2012–2013 (Grigoli et al., 2019).

Fourth, inflation volatility is constructed from WEO data and measures the three-

year standard deviation of the percentage change in the consumer price index. Therefore, the baseline value reflects the history of inflation variation before the shock. In the robustness specifications using multi-year averages of the other regressors, the inflation-volatility measure remains unchanged because it already summarizes inflation outcomes over 2011–2013 (Grigoli et al., 2019).

Finally, net government debt is measured as a percentage of government revenue. This variable is constructed using the WEO and the External Wealth of Nations database. The measure is defined as gross government debt minus gross assets, divided by government revenue. The preferred specification uses the 2013 value, while the robustness analysis also considers averages over 2011–2013 and 2012–2013. Dividing net government debt by revenue shows the size of the government’s debt position relative to the revenue available to finance it (Grigoli et al., 2019).

The next section explains which of the original data could be reconstructed for the present thesis and where alternative public sources or proxy variables were required.

3.1.3 Empirical specification

Grigoli et al. (2019) use a cross-sectional event-study design to examine why the 2014–2016 decline in oil prices produced different economic outcomes across oil-exporting countries. The oil-price decline is treated as a common external shock to oil-dependent economies, and the cross-country analysis tests whether countries with stronger pre-shock economic conditions achieved better real GDP performance afterward. Each country contributes one observation to the regression.

The explanatory variables are measured before the oil-price decline so that they reflect the conditions in place before the shock rather than subsequent policy responses. This allows the study to test whether stronger pre-shock economic conditions were associated with better subsequent real GDP performance.

The design does not identify causal effects. Exchange-rate regimes, reserve accumulation, export diversification, inflation outcomes, and fiscal positions are not randomly assigned. They may reflect broader institutional, political, historical, and structural differences across countries. The estimates therefore show cross-country associations between pre-shock fundamentals and subsequent economic performance. However, they do not establish that changes in any single policy variable caused the observed outcomes.

The authors' preferred empirical specification relates the 2016 real GDP forecast deviation to five measures of pre-shock economic conditions:

$$\begin{aligned} \text{GDPDev}_{i,2016} = & \alpha + \beta_1 \text{ERFlex}_{i,2013} + \beta_2 \text{NonOilExports}_{i,2013} \\ & + \beta_3 \text{ReserveAdequacy}_{i,2013} + \beta_4 \text{InflationVolatility}_{i,2011-2013} \\ & + \beta_5 \text{NetDebtPctRevenue}_{i,2013} + \varepsilon_i. \end{aligned} \tag{3.1}$$

The dependent variable, $\text{GDPDev}_{i,2016}$, is the percentage-point difference between the realized cumulative real GDP path from 2013 to 2016 and the corresponding path forecast before the oil-price decline. Higher values indicate stronger performance relative to the pre-shock forecast.

$\text{ERFlex}_{i,2013}$ is the exchange-rate flexibility measure. A one-unit increase represents movement toward a more flexible exchange-rate arrangement. The expected sign of β_1 is positive because greater exchange-rate flexibility may allow relative-price adjustment to occur through depreciation rather than entirely through reserve losses, domestic expenditure compression, or lower output.

$\text{NonOilExports}_{i,2013}$ measures non-oil exports as a percentage of GDP. The expected sign of β_2 is positive because a larger non-oil export sector indicates greater diversification and a broader source of foreign-currency earnings when oil revenue declines. The coefficient measures the change in the GDP forecast deviation associated with a one-percentage-point increase in non-oil exports relative to GDP,

holding the other variables constant.

$\text{ReserveAdequacy}_{i,2013}$ measures foreign-exchange reserves relative to the IMF reserve-adequacy metric. The expected sign of β_3 is positive because larger external liquidity buffers may allow countries to smooth adjustment during the shock. The coefficient represents the change in the GDP forecast deviation associated with a one-percentage-point increase in reserve adequacy.

$\text{InflationVolatility}_{i,2011-2013}$ is the standard deviation of annual CPI inflation before the oil-price decline. The expected sign of β_4 is negative. Greater pre-shock inflation volatility may indicate weaker monetary credibility and less scope for countercyclical monetary policy. The coefficient measures the change in the GDP deviation associated with a one-percentage-point increase in the standard deviation of annual inflation.

$\text{NetDebtPctRevenue}_{i,2013}$ measures net government debt relative to government revenue. The expected sign of β_5 is negative because a larger net debt burden indicates less fiscal space to smooth expenditure after the decline in oil revenue.

The constant, α , represents the predicted GDP deviation when all explanatory variables equal zero. The error term, ε_i , captures unobserved country characteristics, measurement error, and country-specific developments not included in the model. The authors estimate the equation using ordinary least squares on their 26-country core sample. They report standard errors that are robust to heteroskedasticity and adjusted for the small sample.

3.2 Public-Data Replication

The replication preserves the authors' cross-sectional design, outcome definition, measurement timing, and five-dimensional framework. However, as explained in this section, an exact reconstruction is not possible because some of the country-level series used by the authors are not publicly available.

The first difference concerns the data sources. The thesis relies on publicly available and reproducible datasets. This requires combining data from the WEO, AREAER, External Wealth of Nations, World Development Indicators, UN Comtrade, UNCTAD, and BACI rather than using the authors' original country-level data.

The second difference concerns sample coverage. The original baseline regression includes 26 countries, whereas the preferred replication includes 23 because the non-oil-export measure is unavailable for Equatorial Guinea, Turkmenistan, and Timor-Leste. Several explanatory variables are also reconstructed from public sources. These differences are documented in detail in Section 3.2.

The main methodological difference concerns fiscal space. Because the original net-government-debt measure could not be reproduced for a sufficiently large sample, the preferred replication uses gross government debt relative to revenue. A gross-debt-minus-reserves measure is examined as an alternative specification.

All thesis regressions are estimated in Stata using heteroskedasticity-robust standard errors. Differences between the original and replicated coefficients may therefore reflect changes in the sample, the construction of the variables, and the fiscal measure used.

An exact replication of every variable used by Grigoli et al. (2019) was not possible because several of the country-level series employed in the original study are not publicly available in a consistent and downloadable form. In particular, the authors combine information from the IMF's *World Economic Outlook*, IMF Article IV staff reports, the External Wealth of Nations database, and other IMF sources when constructing non-oil exports, reserve adequacy, and net government debt. Although the paper reports the broad definitions and principal sources, the complete underlying country-level series and all source substitutions are not provided in detail. Therefore, this thesis follows the original economic definitions and timing as closely as possible while replacing unavailable data with transparent

public-data alternatives.

The real GDP forecast deviation, the realized GDP growth slowdown, the exchange-rate classification, and inflation volatility can be reconstructed closely from the public sources used by the authors. By contrast, non-oil exports and reserve adequacy were rebuilt from their underlying components. The fiscal variable requires a more substantial substitution because a directly comparable measure of net government debt is available for too few countries. All substitutions are documented below, including the original units, transformations, source order, and treatment of missing values.

This thesis uses the same 26-country core sample as Grigoli et al. (2019). However, the preferred baseline regression contains 23 countries because the preferred non-oil-export measure is unavailable for Equatorial Guinea, Turkmenistan, and Timor-Leste. Equatorial Guinea lacks the required 2013 services-export observation. Turkmenistan lacks services-export observations for 2011–2013 and the broad-money data required for reserve adequacy. For Timor-Leste, the preferred non-oil-export measure is unavailable in the final dataset. Missing observations are retained as missing and are not replaced with zero.

3.2.1 Real GDP forecast deviation

The principal dependent variable is the deviation of realized real GDP performance through 2016 from the path forecast before the sustained decline in oil prices. The construction uses the IMF WEO indicator for real GDP levels at constant prices ($NGDP_R$). Thus, it measures changes in the volume of economic activity rather than changes in nominal GDP caused by inflation, exchange-rate movements, or changes in the GDP deflator.

The pre-shock forecast is taken from the October 2014 WEO vintage. The subsequently reported real GDP path is taken from the April 2017 WEO vintage. The calculation uses 2013 as the base year and 2016 as the endpoint. Because

the WEO may revise the historical level of real GDP across vintages, each path is normalized using the 2013 real GDP value reported in the same vintage. For country i , the dependent variable is constructed as follows:

$$\text{GDPDev}_{i,2016} = 100 \left[\frac{\text{RGDP}_{i,2016}^{2017}}{\text{RGDP}_{i,2013}^{2017}} - \frac{\text{RGDP}_{i,2016}^{2014}}{\text{RGDP}_{i,2013}^{2014}} \right]. \quad (3.2)$$

The superscript identifies the WEO vintage, while the subscripts identify the country and calendar year. Thus, $\text{RGDP}_{i,2013}^{2017}$ and $\text{RGDP}_{i,2013}^{2014}$ refer to real GDP for the same country and year, but as reported in the WEO vintages in April 2017 and October 2014, respectively. These values may differ because historical national-accounts data can be revised and constant-price series may be rebased between WEO publications. Therefore, each GDP path is normalized by the 2013 value reported in the same vintage. This prevents differences in the scale or historical level of the two series from being interpreted as differences in cumulative real GDP growth.

The first ratio represents the realized 2016 real GDP level relative to its 2013 level, based on the April 2017 vintage. The second ratio represents the corresponding path forecast in October 2014. Subtracting the two ratios produces the percentage-point difference between the realized and forecast normalized real GDP paths. A positive value indicates that the realized real GDP path was stronger than forecast in October 2014. Conversely, a negative value indicates real economic activity fell below the pre-shock forecast. For example, a value of -3 means that the realized normalized real GDP path through 2016 was approximately 3 percentage points below the normalized path forecast before the oil-price decline. Therefore, higher or less negative values are interpreted as better economic performance relative to the pre-shock forecast. The real GDP forecast deviation variable is available for all 26 countries.

3.2.2 Realized GDP growth slowdown

The realized GDP growth slowdown provides an alternative outcome that does not depend on the accuracy of the October 2014 forecast. It compares average annual real GDP growth during the shock period with that before the shock. The calculation uses constant-price real GDP levels from the April 2017 WEO vintage.

The pre-shock period covers growth during 2011–2014. The compound annual growth rate is calculated from the 2010 and 2014 real GDP levels:

$$g_{i,2011-2014} = 100 \left[\left(\frac{\text{RGDP}_{i,2014}^{2017}}{\text{RGDP}_{i,2010}^{2017}} \right)^{1/4} - 1 \right]. \quad (3.3)$$

Using 2010 as the initial level is necessary because the four annual growth observations for 2011, 2012, 2013, and 2014 jointly describe the change from the end of 2010 to the end of 2014.

The shock-period growth rate covers 2015–2016 and is calculated as

$$g_{i,2015-2016} = 100 \left[\left(\frac{\text{RGDP}_{i,2016}^{2017}}{\text{RGDP}_{i,2014}^{2017}} \right)^{1/2} - 1 \right]. \quad (3.4)$$

The final variable is

$$\text{GrowthSlowdown}_i = g_{i,2015-2016} - g_{i,2011-2014}. \quad (3.5)$$

The measure is expressed in percentage points of average annual real GDP growth. A negative value indicates that average annual growth was lower during 2015–2016 than during 2011–2014. Thus, a more negative value indicates a larger slowdown in average annual growth following the oil-price decline. A positive value indicates that annual growth accelerated relative to the pre-shock period.

The total real GDP growth slowdown is reconstructed for all 26 sample countries, following Grigoli et al. (2019). The corresponding non-oil real GDP exercise is not

reproduced because consistent public data on non-oil real GDP are unavailable for a sufficiently large number of countries in the sample.

3.2.3 Exchange-rate flexibility

Exchange-rate flexibility is reconstructed from the de facto exchange-rate arrangements reported in the IMF's 2013 *Annual Report on Exchange Arrangements and Exchange Restrictions*. The variable is constructed according to Grigoli et al. (2019).

In general, floating and freely floating arrangements receive a value of 1. Fixed or highly constrained arrangements receive a value of -1 . This category includes conventional pegs, stabilized arrangements, currency-board arrangements, and economies with no separate legal tender or official dollarization. All remaining arrangements receive a value of 0. These include crawl-like and other managed arrangements that provide some scope for exchange-rate movement but are not classified as floating.

Thus, a higher value indicates greater nominal exchange-rate flexibility:

$$\text{ERFlex}_i = \begin{cases} 1, & \text{floating or freely floating,} \\ 0, & \text{intermediate or managed arrangement,} \\ -1, & \text{fixed, pegged, or stabilized arrangement.} \end{cases} \quad (3.6)$$

The exchange-rate flexibility variable enters the regression directly. The same AREAER regime classification determines whether a country receives the flexible-regime or nonflexible-regime weights in the reserve-adequacy calculation. Countries classified as floating or freely floating receive the lower flexible-regime reserve weights, while countries coded 0 or -1 receive the nonfloating weights. Based on the 2013 AREAER classification, Colombia and Norway receive the flexible-regime weights in the reserve-adequacy calculation.

3.2.4 Non-oil exports

Non-oil exports are reconstructed by combining merchandise exports, services exports, and crude-oil exports. All three components are first expressed in individual current US dollars. The variable is then divided by nominal GDP measured at current prices and in current US dollars:

$$\text{NonOilExportsUSD}_{it} = \text{MerchandiseExportsUSD}_{it} + \text{ServicesExportsUSD}_{it} - \text{CrudeOilExportsUSD}_{it} \quad (3.7)$$

and

$$\text{NonOilExportsPctGDP}_{it} = 100 \left[\frac{\text{NonOilExportsUSD}_{it}}{\text{NominalGDPUSD}_{it}} \right]. \quad (3.8)$$

Merchandise exports are obtained from the World Bank’s World Development Indicators using indicator `TX.VAL.MRCH.CD.WT`. This series is reported in individual current US dollars; therefore, the data do not require a monetary unit conversion. Nominal GDP is also expressed in current US dollars. It is used only as the denominator of this export-share variable; constant-price real GDP is used for the dependent variables described above.

Services exports are obtained primarily from UN Comtrade’s annual trade-in-services data. The data refer to exports to the world under the EB02 classification, code 200, and the reported `primaryValue` is treated as current US dollars. Where a comparable UN Comtrade observation is unavailable, the corresponding WDI services-export series is considered as a secondary source. This secondary source provides the missing 2011 value for Trinidad and Tobago but does not provide consistent substitutes for Equatorial Guinea or Turkmenistan. Missing services values are not treated as zero.

Crude oil is defined using HS code 270900, which covers crude petroleum oils

and oils obtained from bituminous minerals. These data are obtained from UN Comtrade where available. The values are reported in individual current US dollars, so no further unit conversion is required. Where direct export data are unavailable, crude-oil exports are reconstructed using BACI mirror-import data. This approach uses the value of crude oil that partner countries report importing from each exporting country for which a direct report is missing. For a given exporting country and year, all bilateral import observations for crude oil under HS 270900 are summed across partner countries. Because BACI reports trade values in thousands of current US dollars, the resulting total is multiplied by 1,000 to obtain current US dollars.

$$\text{BACICrudeOil}_{it} = \sum_j v_{ijt}, \quad (3.9)$$

where j indexes the importing partner. The resulting total is converted from thousands of US dollars to individual US dollars:

$$\text{CrudeOilExportsUSD}_{it}^{BACI} = 1,000 \times \sum_j v_{ijt}. \quad (3.10)$$

BACI mirror trade is used only where a direct export report is unavailable. No crude-oil-export observations remain missing after applying this source hierarchy.

The preferred baseline uses the 2013 non-oil-export share. A robustness specification uses the average for 2012–2013. The 2012–2013 average is calculated only when both annual observations are available, while the 2011–2013 average requires observations for all three years. The preferred 2013 measure is unavailable for Equatorial Guinea, Turkmenistan, and Timor-Leste. Equatorial Guinea lacks the required 2013 services-export observation. Turkmenistan lacks comparable services-export data for all three years. For Timor-Leste, the preferred non-oil-export measure could not be constructed from the available public data. Therefore, these sample countries are excluded from the preferred baseline regression.

The resulting measure should be interpreted as a transparent proxy for the size of the non-oil tradable sector. As only crude oil under HS 270900 is subtracted, the measure may still include natural gas, refined petroleum products, and other hydrocarbon-related exports.

3.2.5 Reserve adequacy

The reserve-adequacy series used by Grigoli et al. (2019) is not publicly available for the full sample. Therefore, this variable is reconstructed from its underlying components. The final indicator compares foreign-exchange reserves excluding gold with a weighted benchmark based on external liabilities, broad money, and exports of goods and services.

The numerator is foreign-exchange reserves excluding gold from the External Wealth of Nations database. The series is reported in current US dollar millions. Gold is excluded because the measure is intended to capture liquid foreign-currency assets that can be used directly to meet balance-of-payments and foreign-currency financing needs.

The first denominator component is external financial liabilities. External liabilities are also obtained from the External Wealth of Nations database and are constructed as

$$L_{it} = \text{PortfolioEquityLiabilities}_{it} + \text{PortfolioDebtLiabilities}_{it} + \text{OtherInvestmentLiabilities}_{it}. \quad (3.11)$$

External liabilities include portfolio equity, portfolio debt, and other investment liabilities, while foreign direct investment and financial-derivative liabilities are excluded. Reported zero values are retained as valid observations, while blank observations are treated as missing.

The second denominator component is broad money. Broad money is obtained

from the World Development Indicators using indicator `FM.LBL.BMNY.GD.ZS`, and is initially reported as a percentage of GDP.

The variable is converted into current US dollar millions using nominal GDP from the External Wealth of Nations database so that it is expressed in the same monetary units as reserves and external liabilities:

$$B_{it} = \frac{\text{BroadMoneyPctGDP}_{it}}{100} \times \text{GDPUSDm}_{it}. \quad (3.12)$$

The third component of the reserve-adequacy benchmark is exports of goods and services. The main exports-to-GDP series is obtained from UNCTADstat. Where the principal exports-to-GDP series is unavailable, including for Nigeria and Trinidad and Tobago, the export share is reconstructed from current-dollar merchandise exports, services exports, and nominal GDP:

$$\text{ExportsPctGDP}_{it} = 100 \left[\frac{\text{GoodsExportsUSD}_{it} + \text{ServicesExportsUSD}_{it}}{\text{NominalGDPUSD}_{it}} \right]. \quad (3.13)$$

The resulting percentage is converted into current US dollar millions:

$$X_{it} = \frac{\text{ExportsPctGDP}_{it}}{100} \times \text{GDPUSDm}_{it}. \quad (3.14)$$

Reserves, external liabilities, broad money, and exports are expressed in current US dollar millions before they are combined to construct the reserve-adequacy benchmark.

For countries with floating or freely floating exchange-rate regimes, the reconstructed benchmark is

$$\text{ReserveMetric}_{it}^{Flex} = 0.15L_{it} + 0.05B_{it} + 0.05X_{it}. \quad (3.15)$$

For all other exchange-rate arrangements, the benchmark is

$$\text{ReserveMetric}_{it}^{Nonflex} = 0.20L_{it} + 0.10B_{it} + 0.10X_{it}. \quad (3.16)$$

Flexible exchange-rate regimes receive lower weights because exchange-rate adjustment can absorb part of the external pressure that would otherwise require the use of reserves. Under the 2013 AREAER classification, Colombia and Norway receive the flexible-regime weights.

The final variable is:

$$\text{ReserveAdequacy}_{it} = 100 \left[\frac{\text{FXReservesExGold}_{it}}{\text{ReserveMetric}_{it}} \right]. \quad (3.17)$$

The measure is expressed as a percentage of the reconstructed reserve-adequacy benchmark. A value of 100 indicates that reserves equal the benchmark. A value above 100 percent means that reserves exceed the calculated benchmark, whereas a value below 100 percent means that they do not fully meet it.

The preferred baseline uses the 2013 ratio. The 2012–2013 and 2011–2013 alternatives are constructed by calculating reserve adequacy separately for every year and then averaging the annual ratios. The underlying components are not averaged before the ratio is calculated. Turkmenistan is missing because broad-money data are unavailable for the required period.

3.2.6 Inflation volatility

Inflation volatility is constructed from the IMF WEO indicator PCPIPCH, which measures the annual percentage change in the consumer price index. The construction uses annual inflation rates for 2011, 2012, and 2013. It does not use the CPI price-level index.

For country i , average inflation over the three years is

$$\bar{\pi}_i = \frac{\pi_{i,2011} + \pi_{i,2012} + \pi_{i,2013}}{3}. \quad (3.18)$$

Inflation volatility is the sample standard deviation of the three annual inflation rates:

$$\text{InflationVolatility}_i = \sqrt{\frac{\sum_{t=2011}^{2013} (\pi_{it} - \bar{\pi}_i)^2}{3 - 1}}. \quad (3.19)$$

The denominator is $(3 - 1)$ because the variable is calculated as a sample standard deviation. All three annual inflation observations are required; if any observation is missing, the standard deviation is not calculated. The variable is measured in percentage points of annual CPI inflation. A higher value indicates greater variation in inflation before the oil-price shock and weaker price stability.

3.2.7 Fiscal-space measures

The fiscal part of the replication distinguishes among three different concepts: the net government debt measure used by Grigoli et al. (2019), the gross-debt-to-revenue measure used in the preferred thesis specification, and the gross-debt-minus-reserves approximation used as an alternative.

Original net government debt relative to revenue Grigoli et al. (2019) use net government debt as a percentage of government revenue. Conceptually, net government debt deducts relevant government financial assets from gross government liabilities, but the complete underlying country-level construction cannot be reproduced from publicly available data.

A direct WEO net government debt series was considered a possible replication measure; however, it was available for only 12 of the 26 countries. This coverage is too limited for the principal five-variable regression. Therefore, the direct WEO

net-debt series is also not used in the preferred analysis.

Preferred gross government debt relative to revenue The preferred thesis fiscal variable is general government gross debt relative to general government revenue:

$$\text{GrossDebtPctRevenue}_{i,2013} = 100 \left[\frac{\text{GGXWDG}_{i,2013}}{\text{GGR}_{i,2013}} \right], \quad (3.20)$$

where **GGXWDG** is general government gross debt and **GGR** is general government revenue from the WEO.

Both series are reported in the same national-currency units. Therefore, no exchange-rate conversion is required because the units cancel when the ratio is calculated. The resulting variable is expressed as a percentage of government revenue. For example, a value of 150 means that gross government debt is equivalent to 150 percent of annual government revenue.

Gross government debt relative to revenue provides consistent coverage across the replication sample. Nonetheless, unlike the original net-debt measure, it does not account for government financial assets. Therefore, it should be interpreted as an alternative indicator of fiscal space rather than an exact substitute of the original variable.

The variable measures the debt burden relative to the government's revenue base, without assuming the availability of central-bank or other public-sector assets. This measure is used in the preferred baseline regression, the realized GDP growth-slowdown regression, and the 2013 composite resilience index. In the composite index, its sign is reversed because higher debt indicates weaker fiscal space.

Gross debt minus foreign-exchange reserves relative to revenue As an alternative, the thesis constructs a reserves-based approximation of net government

debt:

$$\text{NetDebtProxy}_{i,2013} = 100 \left[\frac{\text{GrossGovernmentDebt}_{i,2013} - \text{FXReservesExGold}_{i,2013}}{\text{GovernmentRevenue}_{i,2013}} \right]. \quad (3.21)$$

The gross-debt and revenue series are taken from the WEO. Foreign-exchange reserves excluding gold are obtained from the External Wealth of Nations database. Because the reserve series is reported in current US-dollar millions while the WEO fiscal series is reported in national-currency units, reserves are first converted into national currency using the corresponding IMF national-currency-per-US-dollar exchange rate.

Then, the converted value must be rescaled to the same unit used by the WEO fiscal series before it is subtracted from gross debt. After the numerator components are all expressed in the same currency and scale, the result is divided by government revenue. This alternative measure subtracts foreign-exchange reserves from gross government debt before dividing by government revenue. It is conceptually closer to net debt than the gross debt measure. However, it does not account for other government financial assets and treats central bank reserves as part of the consolidated public sector balance sheet. Therefore, it is used as an alternative specification rather than as the preferred fiscal-space measure.

The gross-debt-minus-reserves proxy is used only in the alternative fiscal specification. Instead, the preferred baseline regression and the 2013 composite resilience index use gross government debt relative to revenue. In the composite index, the sign of this measure is reversed because higher debt indicates weaker fiscal space.

3.2.8 Replication equations

The preferred replication equation is

$$\begin{aligned}
\text{GDPDev}_{i,2016} = & \alpha + \beta_1 \text{ERFlex}_{i,2013} + \beta_2 \text{NonOilExports}_{i,2013} \\
& + \beta_3 \text{ReserveAdequacy}_{i,2013} + \beta_4 \text{InflationVolatility}_{i,2011-2013} \\
& + \beta_5 \text{GrossDebtPctRevenue}_{i,2013} + \varepsilon_i.
\end{aligned} \tag{3.22}$$

The preferred specification uses gross government debt relative to government revenue as the fiscal variable and is estimated on the 23-country complete-case sample. The alternative fiscal specification retains the same dependent and explanatory variables but replaces gross government debt relative to revenue with the gross-debt-minus-reserves proxy. This tests whether the results are sensitive to the choice of fiscal-space measure.

The realized GDP growth-slowdown regression uses the same explanatory variables as the preferred specification but replaces the 2016 GDP forecast deviation with the realized growth-slowdown measure:

$$\begin{aligned}
\text{GrowthSlowdown}_i = & \alpha + \beta_1 \text{ERFlex}_{i,2013} + \beta_2 \text{NonOilExports}_{i,2013} \\
& + \beta_3 \text{ReserveAdequacy}_{i,2013} + \beta_4 \text{InflationVolatility}_{i,2011-2013} \\
& + \beta_5 \text{GrossDebtPctRevenue}_{i,2013} + \varepsilon_i.
\end{aligned} \tag{3.23}$$

This exercise reproduces the authors' alternative total real GDP outcome. Additional robustness specifications replace the 2013 values of non-oil exports and reserve adequacy with their pre-shock averages. All thesis regressions use heteroskedasticity-robust standard errors.

3.2.9 Sample coverage

Table 3.1 summarizes the country coverage of the replication and composite-resilience exercises.

Table 3.1 Sample coverage for the replication and composite-resilience exercises

Exercise	Observations	Main exclusions
Original country sample	26	None.
Preferred baseline replication	23	Equatorial Guinea, Turkmenistan, and Timor-Leste because the preferred non-oil-export measure is unavailable.
2013 standardized resilience index and median-based count	23	Same complete-case restrictions as the preferred baseline.

Notes: WEO denotes the IMF *World Economic Outlook*; AREAER denotes the IMF *Annual Report on Exchange Arrangements and Exchange Restrictions*; WDI denotes the World Development Indicators; EWN denotes the External Wealth of Nations database; and BACI denotes the CEPII international trade database.

3.3 Replication Results

3.3.1 Descriptive patterns

The preferred replication sample contains 23 countries and displays substantial variation in economic performance. The mean deviation of the 2016 GDP forecast is approximately -8.27 percentage points, with observations ranging from about -26.52 to 0.66 . Therefore, most oil exporters performed below the real GDP paths forecast before the oil-price decline, although the extent of the forecast disappointment varied across countries.

The explanatory variables also vary widely within the sample. Reserve adequacy ranges from approximately 15 to 790 percent of the reconstructed benchmark. There are also substantial differences in non-oil exports, inflation volatility, exchange-rate arrangements, and government debt relative to revenue. This variation allows the analysis to examine whether economic conditions observed before

the shock are associated with subsequent GDP performance.

Table 3.2 Descriptive statistics for the 2014–2016 replication sample

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
2016 GDP forecast deviation	23	-8.271	7.720	-26.522	0.662
Real GDP growth slowdown	23	-3.297	3.150	-14.055	0.820
Exchange-rate flexibility	23	-0.609	0.656	-1.000	1.000
Non-oil exports (% of GDP)	23	29.095	25.113	2.753	88.436
Reserve adequacy (% of metric)	23	164.275	201.016	14.869	790.062
Inflation volatility	23	1.895	2.072	0.149	10.164
Gross government debt (% of revenue)	23	80.698	66.172	4.565	237.384
Standardized 2013 resilience index	23	0.000	1.000	-3.241	1.494
Median-based resilience count	23	2.217	1.126	0.000	4.000

The table reports descriptive statistics for the common 23-country complete-case sample used in the preferred replication and composite-resilience exercises. The

2016 GDP forecast deviation is measured in percentage points relative to the October 2014 WEO forecast. The real GDP growth slowdown is average annual real GDP growth during 2015–2016 minus average annual growth during 2011–2014. The standardized resilience index has mean zero and standard deviation one by construction. The median-based resilience count records the number of favorable pre-shock conditions and has a theoretical range from zero to five.

3.3.2 Baseline forecast-deviation results

Table 3.3 presents the original baseline estimate reported by Grigoli et al. (2019) together with the preferred public-data replication and two alternative thesis specifications. The preferred regression uses the 2013 explanatory variables and gross government debt relative to government revenue. The alternative specifications use the gross-debt-minus-reserves proxy and the 2012–2013 averages of non-oil exports and reserve adequacy.

Table 3.3 Original and replicated baseline results

	Original study	Thesis replication		
	(1) GHS (2019) core sample	(2) Preferred baseline	(3) Net-debt proxy	(4) 2012–2013 averages of exports and reserves
Exchange-rate flexibility	2.948*** (0.975)	3.382* (1.903)	3.274* (1.733)	3.315* (1.814)
Non-oil exports (% of GDP)	0.147** (0.056)	0.100 (0.079)	0.088 (0.062)	0.109 (0.075)
Reserve adequacy (% of metric)	0.007*** (0.001)	0.008* (0.004)	0.001 (0.014)	0.008* (0.004)
Inflation volatility	-1.614** (0.666)	-1.195 (0.825)	-1.101 (0.815)	-1.152 (0.809)
Fiscal variable used	Net government debt	Gross government debt	Gross debt minus reserves	Gross government debt
Fiscal coefficient	-0.002*** (0.000)	-0.012 (0.033)	-0.020 (0.040)	-0.014 (0.033)
Constant	-8.271*** (1.965)	-7.144** (3.032)	-6.782* (3.429)	-7.408** (2.932)
Observations	26	23	23	23
R^2	0.581	0.418	0.422	0.430

Notes: The dependent variable is the percentage-point difference between realized cumulative real GDP growth from 2013 to 2016 and the cumulative growth path forecast in the October 2014 World Economic Outlook. Column (1) reproduces Grigoli et al. (2019), Table 2, column (1). Columns (2)–(4) report the thesis estimates. Column (2) uses gross government debt relative to revenue. Column (3) uses gross government debt minus foreign-exchange reserves relative to revenue. Column (4) uses 2012–2013 averages for non-oil exports and reserve adequacy. Standard errors are reported in parentheses. The original study reports heteroskedasticity- and small-sample-robust standard errors; the thesis regressions use heteroskedasticity-robust standard errors. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

All five coefficients in the preferred replication have the same sign as those reported in the original study. To be exact, exchange-rate flexibility, non-oil exports, and reserve adequacy enter positively, while inflation volatility and gross government debt relative to revenue enter negatively.

Exchange-rate flexibility has a coefficient of 3.382 and is statistically significant at the 10 percent level. Reserve adequacy also enters positively and is significant at the 10 percent level, with a coefficient of 0.008. The coefficients on non-oil exports, inflation volatility, and gross government debt have the expected signs but are not statistically significant.

The preferred specification contains 23 observations and has an R^2 of 0.418. Therefore, the five explanatory variables account for approximately 42 percent of the observed cross-country variation in the 2016 GDP forecast deviation.

The alternative specifications produce similar results. Replacing gross government debt with the gross-debt-minus-reserves proxy leaves the signs of all coefficients unchanged and raises the R^2 only slightly, from 0.418 to 0.422. Using the 2012–2013 averages of non-oil exports and reserve adequacy also preserves the main coefficient pattern and produces an R^2 of 0.430. Therefore, the baseline findings are not highly sensitive to either of these alternative constructions.

3.3.3 Comparison with the original baseline estimates

The replication reproduces the qualitative pattern of the original results, although it does not have the same statistical significance levels. The exchange-rate coefficient is 3.382 in the thesis and 2.948 in the original study, while the reserve-adequacy coefficients are 0.008 and 0.007, respectively. The non-oil-export coefficient is somewhat smaller in the replication, at 0.100 compared with 0.147, and inflation volatility remains negative in both regressions. In the original core-sample specification, all five explanatory variables are statistically significant. In the preferred replication, only exchange-rate flexibility and reserve adequacy are

significant, both at the 10 percent level. The replication also has a lower R^2 , at 0.418 compared with 0.581. These differences may reflect the smaller estimation sample, the reconstruction of several variables from public sources, and the use of gross rather than net government debt. Nevertheless, the stability of the coefficient signs and the close agreement between the exchange-rate and reserve-adequacy estimates indicate that the main economic pattern is broadly reproduced in this thesis using the public-data sample.

3.3.4 Realized GDP growth-slowdown results

Table 3.4 compares the original and replicated regressions using the realized real GDP growth slowdown. This measure compares actual GDP growth before and during the oil-price decline, so it does not rely on the October 2014 forecast.

Likewise, the coefficient pattern is again similar across the two studies. Exchange-rate flexibility enters positively in both regressions, with a coefficient of 0.854 in the thesis and 0.792 in the original study; however, neither estimate is statistically significant.

Non-oil exports also enter positively. The thesis coefficient is 0.0388 and statistically significant at the 10 percent level, compared with the original coefficient of 0.053, which is significant at the 5 percent level.

The strongest replicated result concerns inflation volatility. Its coefficient is -0.914 in the thesis and -1.065 in the original study, and both estimates are statistically significant at the 1 percent level. The close values and statistical significance indicate that the negative association between pre-shock inflation instability and subsequent growth performance is well reproduced in the thesis.

Reserve adequacy is positive in both regressions, although only the original coefficient is statistically significant. The fiscal coefficients are also negative in both specifications. Still, their magnitudes are not directly comparable because

Table 3.4 Original and replicated results using the real GDP growth slowdown

	Original study	Thesis replication
	(1) GHS (2019) core sample	(2) Public-data replication
Exchange-rate flexibility	0.792 (0.574)	0.854 (0.643)
Non-oil exports, 2013 (% of GDP)	0.053** (0.024)	0.0388* (0.0209)
Reserve adequacy, 2013	0.003*** (0.001)	0.0039 (0.0030)
Inflation volatility	-1.065*** (0.364)	-0.914*** (0.291)
Net government debt (% of revenue)	-0.000* (0.000)	—
Gross government debt (% of revenue)	—	-0.0053 (0.0083)
Constant	-3.043** (1.087)	-2.391** (0.898)
Observations	26	23
R^2	0.529	0.741

Notes: The dependent variable is average annual real GDP growth during 2015–2016 minus average annual real GDP growth during 2011–2014. Column (1) reports the original core-sample estimate, and column (2) reports the public-data replication. Standard errors are reported in parentheses. The original study reports heteroskedasticity- and small-sample-robust standard errors; the thesis regression uses heteroskedasticity-robust standard errors. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

the original study uses net government debt relative to revenue, while this thesis uses gross government debt relative to revenue. The thesis regression has an R^2 of 0.741, compared with 0.529 in the original study. This difference should be interpreted cautiously because the regressions use different samples and fiscal measures. The main result is that the estimated relationships have similar signs and magnitudes, particularly for inflation volatility and non-oil exports.

3.4 Composite Measures of Pre-Shock Resilience

3.4.1 Construction of the composite measures

The five explanatory variables are combined into a composite resilience index using the common complete-case sample of 23 countries. This ensures that each country's index is constructed from the same set of components.

Each component j is standardized as

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}, \quad (3.24)$$

where $\bar{x}_j$ and s_j are the sample mean and standard deviation of component j . Exchange-rate flexibility, non-oil exports, and reserve adequacy enter with positive signs. Inflation volatility and gross government debt relative to revenue enter with reversed signs because higher values indicate weaker resilience.

The initial composite is calculated as:

$$\text{ResilienceRaw}_{i,2013} = \frac{1}{5} \left[z(\text{ERFlex}_i) + z(\text{NonOilExports}_i) + z(\text{ReserveAdequacy}_i) - z(\text{InflationVolatility}_i) - z(\text{GrossDebtPctRevenue}_i) \right]. \quad (3.25)$$

Each component therefore receives an equal weight. The resulting composite is

standardized again:

$$\text{ResilienceIndex}_{i,2013} = \frac{\text{ResilienceRaw}_{i,2013} - \overline{\text{ResilienceRaw}_{2013}}}{s(\text{ResilienceRaw}_{2013})}. \quad (3.26)$$

The final standardized index has a mean of zero and a standard deviation of one within the construction sample, with higher values indicating stronger pre-shock resilience.

As a complementary measure, the thesis constructs a median-based resilience count using the same 23-country sample. A country receives one point when its exchange-rate flexibility, non-oil export share, or reserve adequacy is strictly above the corresponding sample median. It also receives one point when its inflation volatility or gross government debt relative to revenue is strictly below the sample median. The resulting measure ranges from zero to five, with higher values indicating a larger number of favorable pre-shock characteristics. Gross government debt relative to revenue is used so that the count is consistent with the preferred standardized index.

The standardized index enters the regression as

$$\text{GDPDev}_{i,2016} = \alpha + \theta \text{ResilienceIndex}_{i,2013} + \varepsilon_i. \quad (3.27)$$

The coefficient θ measures the percentage-point difference in the 2016 GDP forecast deviation associated with a one-standard-deviation increase in the resilience index.

These composite measures are extensions of the original study. Grigoli et al. (2019) include the five indicators separately but do not combine them into a standardized index or a median-based count.

3.4.2 Composite-resilience results

Table 3.5 presents the results for the standardized resilience index and the median-based resilience count. Both measures combine the five pre-shock characteristics, but they use different aggregation procedures.

Table 3.5 Composite resilience and the 2016 GDP forecast deviation

	(1) Standardized index	(2) Median-based count
Resilience measure	4.750*** (1.016)	3.821** (1.616)
Constant	-8.271*** (1.299)	-16.743*** (3.839)
Observations	23	23
R^2	0.379	0.311

Notes: The dependent variable is the 2016 GDP forecast deviation. Column (1) uses the standardized continuous 2013 resilience index. Column (2) uses the number of components on the favorable side of the sample median. A country receives one point for exchange-rate flexibility, non-oil exports, or reserve adequacy strictly above the sample median, and one point for inflation volatility or gross government debt relative to revenue strictly below the sample median. The theoretical range is zero to five; the observed range is zero to four. Both regressions use the same 23-country complete-case sample. Heteroskedasticity-robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

The standardized index has a coefficient of 4.750, a robust standard error of 1.016, and a p -value below 0.001. The regression contains 23 observations and has an R^2 of 0.379. Because the index has a standard deviation of one, the coefficient indicates that a one-standard-deviation increase in measured pre-shock resilience is associated with an approximately 4.75 percentage-point more favorable GDP forecast deviation.

This magnitude is substantial relative to the sample mean deviation of approximately -8.27 percentage points. The index alone also explains nearly 38 percent of the observed cross-country variation, compared with approximately 42 percent when the five components are entered separately.

The median-based count produces the same qualitative conclusion. Its coefficient

is 3.821, with a robust standard error of 1.616 and a p -value of 0.028. A condition is favorable when exchange-rate flexibility, non-oil exports, or reserve adequacy is above the sample median, or when inflation volatility or gross government debt relative to revenue is below the sample median. Each additional favorable pre-shock characteristic is associated with an approximately 3.82 percentage-point more favorable GDP forecast deviation. The count alone explains approximately 31 percent of the cross-country variation. Most countries satisfy two or three of the five favorable conditions, while no country satisfies all five.

The consistency of the standardized-index and median-count results strengthens the composite finding. The standardized index reflects how far each country is from the sample average, while the median count only shows whether each characteristic is relatively favorable. Since both measures yield similar results, the finding is unlikely to be driven solely by extreme values or by the index's standardization.

3.5 Summary and Interpretation

The public-data replication reproduces the signs of the five relationships reported by Grigoli et al. (2019), although fewer individual coefficients are statistically significant. In the GDP forecast-deviation specification, exchange-rate flexibility and reserve adequacy provide the clearest individual results. Both variables have positive coefficients and are statistically significant at the 10 percent level.

The realized growth-slowdown regression emphasizes relatively different dimensions of resilience. Inflation volatility has a negative and statistically significant coefficient, while non-oil exports have a positive coefficient that is statistically significant at the 10 percent level. The signs of all five explanatory variables remain consistent across the forecast-deviation and growth-slowdown regressions. This similarity indicates that the general pattern is not entirely dependent on the

accuracy of the October 2014 GDP forecast.

Both composite resilience measures are strongly associated with GDP performance during the adverse 2014–2016 oil-price episode. A one-standard-deviation increase in the standardized index is associated with an approximately 4.75 percentage-point more favorable GDP deviation. Additionally, each additional favorable condition in the median-based count is associated with an approximately 3.82 percentage-point more favorable GDP deviation. These results suggest that no single pre-shock condition determines resilience. Instead, countries appear to perform better when several favorable characteristics are present simultaneously, including stronger policy frameworks, greater economic diversification, and larger fiscal and external buffers.

Nevertheless, the replication results should be interpreted with caution. The preferred thesis sample contains fewer countries than the original study, and several variables are reconstructed from public sources or replaced with transparent proxy measurements. These differences may reduce statistical precision and contribute to differences in coefficient significance. Therefore, the replication broadly reproduces the economic pattern reported by Grigoli et al. (2019), but it does not reproduce every original level of statistical significance.

4 Application to the 2022 Oil-Price Shock

4.1 Motivation and Hypotheses

The application to the positive oil-price episode of 2022 examines whether the role of pre-shock resilience differs between positive and negative oil-price movements. The replication results indicate that stronger pre-shock resilience was associated with more favorable GDP performance during the 2014–2016 oil-price decline. However, this finding does not determine the expected relationship during a positive episode. The economic interpretation of resilience creates three hypotheses concerning the sign of the resilience coefficient in the 2022 application.

Hypothesis 1: Resilience matters primarily during adverse shocks Pre-shock resilience may have no systematic relationship with GDP performance during a favorable oil-price episode. The five resilience components were originally selected to capture countries' capacity to absorb a decline in oil revenue and the resulting fiscal, external, and financial pressures. When oil prices rise, these constraints are relaxed rather than intensified. Based on this interpretation, resilience should matter little for the GDP response to the favorable episode, and the expected coefficient on the resilience index is zero.

Hypothesis 2: Resilience represents stabilization capacity Pre-shock resilience may be negatively associated with GDP performance during a favorable oil-price episode. If resilience reflects the ability to stabilize the economy, more resilient countries may smooth both positive and negative shocks. They may save a larger share of the additional oil revenue, reduce public debt, or limit a rapid expansion in domestic expenditure. Therefore, these countries would experience

smaller losses during adverse episodes, but also a smaller immediate positive response during favorable episodes. Under this interpretation, the expected coefficient on the resilience index is negative.

Hypothesis 3: Resilience represents efficient shock accommodation

Pre-shock resilience may be positively associated with GDP performance during a favorable oil-price episode. Countries with stronger fiscal positions, extensive external liquidity and more stable macroeconomic conditions may be better able to convert additional oil income into real economic activity. Under this interpretation, resilient countries can limit losses during adverse episodes while retaining more of the benefits of favorable episodes. Therefore, the expected coefficient on the resilience index is positive.

The three hypotheses analyze the role of resilience in three different ways. The first implies that resilience is valuable mainly during adverse shocks. The second hypothesis treats resilience as a stabilizing mechanism that dampens economic responses in both directions. The third treats resilience as a broader capacity to manage shocks effectively, meaning it produces favorable outcomes during both negative and positive episodes.

The relatively short duration of the 2022 oil price increase also has temporal significance for the analysis. If resilience affects the immediate absorption or use of the additional oil revenue, any relationship may be more observable in the 2022 GDP deviation than in cumulative performance through 2023. The 2023 outcome reflects a longer period during which oil prices, global financial conditions, the effects of the pandemic and the war, and domestic policy preferences developed.

4.2 Empirical Methodology

The application retains the cross-sectional design used in the replication but changes the outcome period, the forecast vintage, and the treatment of contemporaneous disruptions. It estimates the same general relationship for the 2022 and 2023 GDP forecast deviations and compares the original 2013 resilience index with an updated index based on 2019 pre-pandemic fundamentals.

The positive-shock extension tests whether the resilience index is associated with real GDP performance during the 2022 oil-price episode. The analysis uses the 2022 and 2023 GDP forecast deviations described in Section 4.3.

For outcome year h , where $h \in \{2022, 2023\}$, the initial specification is

$$\text{GDPDev}_{i,h} = \alpha_{h,k} + \theta_{h,k} \text{ResilienceIndex}_{i,k} + \varepsilon_{i,h}, \quad (4.1)$$

where $k \in \{2013, 2019\}$ identifies the resilience-index year. The 2013 index provides an out-of-sample test of the original pre-shock conditions, while the 2019 index uses information measured closer to the 2022 episode. A positive value of $\theta_{h,k}$ indicates that stronger measured resilience is associated with better GDP performance relative to the October 2021 forecast.

The conditional specification adds COVID-19 exposure and a Russia indicator:

$$\begin{aligned} \text{GDPDev}_{i,h} = & \alpha_{h,k} + \theta_{h,k} \text{ResilienceIndex}_{i,k} + \gamma_h \text{COVIDExposure}_{i,2022} \\ & + \delta_h \text{Russia}_i + \varepsilon_{i,h}. \end{aligned} \quad (4.2)$$

The Russia indicator equals one for Russia and zero for all other countries. The same regressions are then estimated after excluding Russia to assess whether this observation drives the results.

A separate specification replaces the Russia indicator with the continuous 2021 trade-exposure measure:

$$\begin{aligned} \text{GDPDev}_{i,h} = & \alpha_{h,k} + \theta_{h,k} \text{ResilienceIndex}_{i,k} + \gamma_h \text{COVIDExposure}_{i,2022} \\ & + \lambda_h \text{WarTradeExposure}_{i,2021} + \varepsilon_{i,h}. \end{aligned} \quad (4.3)$$

Russia is excluded from this specification for the reason explained in Section 4.3.5. The estimation samples and country exclusions are summarized in Section 4.3.6. The estimation samples and country exclusions are summarized in Section 4.3.7. These regressions are interpreted as tests of external validity. They examine whether the relationship observed during the 2014–2016 negative oil-price episode also appears during the later positive episode, without assigning a causal interpretation to the estimated coefficients.

4.2.1 Estimation and limitations

All equations are estimated using ordinary least squares. The thesis reports heteroskedasticity-robust standard errors because the variance of the regression error may differ substantially across countries with different sizes, income levels, economic structures, and degrees of oil dependence.

The small number of observations is the main statistical limitation. The preferred replication includes 23 countries, while the positive-shock specifications include between 20 and 24 countries. With samples of this size, adding even a small number of controls reduces the remaining degrees of freedom. As a result, the coefficient estimates may have large standard errors, and conventional significance tests may have limited power.

Because the sample is small, the results may be sensitive to individual country observations. This is especially important for variables such as reserve adequacy,

COVID-19 mortality, and trade exposure, which vary considerably across countries. The Russia indicator and Russia-exclusion exercises address one clear case, although other observations may also affect the estimates.

The regressions do not establish causal effects. The explanatory variables may be correlated with omitted factors such as institutional quality, political stability, income per capita, governance, production capacity, financial development, geographical position, or the management of earlier oil revenues. These characteristics may affect both the pre-shock indicators and subsequent GDP performance.

The GDP forecast deviations may also reflect country-specific developments unrelated to oil prices. Political instability, domestic conflict, changes in oil production, sanctions, investment projects, natural disasters, and revisions to national accounts may affect the dependent variable.

Finally, the 2022 episode is especially difficult to isolate because it was a compound macroeconomic event. The increase in oil prices coincided with the recovery from COVID-19, Russia’s full-scale invasion of Ukraine, sanctions, supply-chain disruptions, high global inflation, changes in monetary policy, and differences in countries’ oil-production capacity. The COVID-19 and war-exposure controls therefore capture only selected aspects of this environment.

For these reasons, the results are interpreted as conditional cross-country associations. The analysis provides evidence on replication and external validity, but it does not identify the causal effect of resilience or isolate a purely exogenous oil-price shock.

4.3 Data and Sample

This section explains the newly constructed and updated variables for the 2022 oil-price extension. Variables that follow the same definitions as the replication measures in Section 3.2 are described only in terms of their updated years, data

vintages, and sample coverage.

4.3.1 Real GDP deviation in 2022

The 2022 real GDP deviation is constructed using the same method as the 2016 outcome described in Section 3.2.1. Constant-price real GDP is obtained from the IMF *World Economic Outlook*. The October 2021 WEO provides the pre-shock forecast, while the April 2024 WEO provides the subsequently reported real GDP values. The calculation uses 2021 as the base year and 2022 as the endpoint:

$$\text{GDPDev}_{i,2022} = 100 \left[\frac{\text{RGDP}_{i,2022}^{2024}}{\text{RGDP}_{i,2021}^{2024}} - \frac{\text{RGDP}_{i,2022}^{2021}}{\text{RGDP}_{i,2021}^{2021}} \right]. \quad (4.4)$$

A positive value indicates that the realized real GDP path was stronger than forecast in October 2021, while a negative value indicates that it fell below the forecast path.

4.3.2 Real GDP deviation in 2023

The 2023 real GDP deviation applies the same construction to the cumulative real GDP path between 2021 and 2023. The October 2021 WEO again provides the forecast, and the April 2024 WEO provides the subsequently reported values:

$$\text{GDPDev}_{i,2023} = 100 \left[\frac{\text{RGDP}_{i,2023}^{2024}}{\text{RGDP}_{i,2021}^{2024}} - \frac{\text{RGDP}_{i,2023}^{2021}}{\text{RGDP}_{i,2021}^{2021}} \right]. \quad (4.5)$$

Higher values indicate stronger economic performance relative to the October 2021 forecast. A corresponding realized growth-slowdown measure is not constructed for the 2022 episode. A comparison between growth before and after the oil-price increase would be heavily influenced by the exceptional contraction and rebound associated with the COVID-19 pandemic. The resulting measure would therefore be difficult to interpret as a response to the oil-price shock.

The preferred construction uses 2021 as the base year because it compares the realized post-shock path with the forecast immediately preceding the 2022 oil-price increase. Using 2020 would incorporate differences in the initial pandemic contraction and the subsequent recovery into the dependent variable. A 2020-base version is therefore treated as a robustness exercise rather than as the preferred outcome.

4.3.3 Updated 2019 resilience components

The updated resilience index captures the economic conditions prevailing in 2019, the last complete year before the COVID-19 pandemic. Its five components follow the definitions used in the 2013 index, except that the underlying data are updated where possible.

Exchange-rate flexibility Exchange-rate flexibility is updated using the 2019 AREAER classification. The coding follows the same procedure as for the 2013 measure: floating and freely floating arrangements receive a value of 1, fixed or highly constrained arrangements receive a value of -1 , and intermediate arrangements receive a value of 0. The 2019 classification is also used to assign the flexible- and nonflexible-regime weights in the updated reserve-adequacy measure.

Non-oil exports Non-oil exports are measured as a percentage of nominal GDP in 2019. The definition and source hierarchy are the same as those described in Section 3.2.4, using updated merchandise-export, services-export, crude-oil-export, and nominal-GDP observations for 2019.

Reserve adequacy Reserve adequacy is reconstructed using 2019 foreign-exchange reserves, external liabilities, broad money, and exports of goods and services. Foreign-exchange reserves and liabilities are obtained from the External

Wealth of Nations database, while broad money is obtained from the World Development Indicators. The formula and regime-dependent weights are unchanged from Section 3.2.5. The 2019 AREAER classification determines which reserve weights are applied.

Inflation volatility Updated inflation volatility is calculated as the sample standard deviation of annual CPI inflation in 2017, 2018, and 2019. Annual inflation is obtained from the October 2021 WEO using indicator PCPIPCH. The definition is identical to the earlier measure, but the three-year period is updated.

Fiscal space The updated fiscal variable is general government gross debt relative to general government revenue in 2019. Both series are obtained from the October 2021 WEO. This is the same fiscal measure used in the preferred 2013 index. The gross-debt-minus-reserves proxy is not used in the updated index.

The updated index is constructed for 24 countries. Turkmenistan and Venezuela are excluded because missing broad-money data prevent the construction of their 2019 reserve-adequacy measures.

4.3.4 COVID-19 exposure

COVID-19 exposure is measured using deaths reported to the World Health Organization during calendar year 2022. Reported deaths are divided by the country’s 2022 population from the World Development Indicators and multiplied by 100,000:

$$\text{COVIDExposure}_{i,2022} = 100,000 \left[\frac{\text{COVIDDeaths}_{i,2022}^{\text{WHO}}}{\text{Population}_{i,2022}^{\text{WDI}}} \right]. \quad (4.6)$$

The variable is included as a separate exposure control because the pandemic was a contemporaneous shock rather than a pre-existing component of economic

resilience. It should be interpreted cautiously because reported deaths may differ across countries because of differences in testing, death certification, and reporting capacity.

4.3.5 War exposure

War exposure is addressed in three ways. First, a Russia indicator is included to account for Russia’s direct involvement in the war and its distinct exposure to sanctions and trade restrictions. Second, the regressions are repeated after excluding Russia to examine whether the results are driven by this observation. Third, a continuous measure is constructed using bilateral merchandise trade with Russia and Ukraine in 2021:

$$\text{WarTradeExposure}_{i,2021} = 100 \left[\frac{X_{i,\text{RUS}} + M_{i,\text{RUS}} + X_{i,\text{UKR}} + M_{i,\text{UKR}}}{\text{NominalGDP}_{i,2021}} \right]. \quad (4.7)$$

The numerator includes exports to Russia, imports from Russia, exports to Ukraine, and imports from Ukraine, summed across all HS products in the 2021 BACI data. Trade values and nominal GDP are expressed in current US dollars. Russia is excluded from regressions using this measure because trade between Russia and itself is not comparable with the bilateral exposure of other countries.

4.3.6 Descriptive patterns

The positive-shock outcomes show a different pattern. The mean 2022 GDP forecast deviation is 1.165 percentage points, indicating that the available countries performed above the October 2021 forecast on average during the immediate shock year. However, observations range from -4.149 to 8.872 , with a standard deviation of 2.714 percentage points. Therefore, the positive average may conceal substantial cross-country heterogeneity.

By 2023, the mean forecast deviation falls to -0.093 percentage points, which is close to zero. The observations range from -5.275 to 5.351 , with a standard deviation of 2.834. The near-zero average is consistent with the possibility that any benefits of higher oil prices were offset by the continuing effects of COVID-19 and the war in Ukraine. Thus, the outcome should be interpreted as the net result of several overlapping shocks rather than as a direct measure of the oil-price effect. Reported COVID-19 mortality and pre-war trade exposure are also highly dispersed. COVID-19 mortality averages 14.391 deaths per 100,000 inhabitants, with a standard deviation of 26.898 and a maximum of 114.145. Merchandise trade with Russia and Ukraine averages 1.751 percent of GDP, with a standard deviation of 3.366 and a maximum of 13.725 percent of GDP.

Table 4.1 reports descriptive statistics for the positive oil-price extension.

Table 4.1 Descriptive statistics for the positive oil-price extension

Variable	<i>N</i>	Mean	Std. dev.	Minimum	Maximum
2022 real GDP forecast deviation	24	1.165	2.714	-4.149	8.872
2023 real GDP forecast deviation	25	-0.093	2.834	-5.275	5.351
2013 resilience index	23	0.000	1.000	-3.241	1.494
2019 resilience index	24	0.000	1.000	-2.309	1.740
COVID-19 deaths per 100,000	25	14.391	26.898	0.063	114.145
2021 Russia–Ukraine trade exposure (% of GDP)	25	1.751	3.366	0.000	13.725

The 2022 and 2023 GDP forecast deviations measure the percentage-point differences between realized and forecast cumulative real GDP growth from the 2021 base year to the indicated final year. Both resilience indices are standardized to have mean zero and standard deviation one in their respective construction samples. Trade exposure is measured as 2021 merchandise trade with Russia and Ukraine as a percentage of 2021 nominal GDP.

4.3.7 Sample coverage

Table 4.2 summarizes the country coverage of the 2022 application.

Table 4.2 Sample coverage for the 2022 oil-price application

Exercise	Observations	Main exclusions
2019 resilience-index construction	24	Turkmenistan and Venezuela because 2019 reserve adequacy cannot be constructed.
2022 GDP-deviation outcome	24	Brunei Darussalam and Venezuela because the required WEO real GDP observations are unavailable.
2022 regression with the 2013 index	21	Intersection of the 2013-index and 2022-outcome samples.
2022 regression with the 2019 index	23	Intersection of the 2019-index and 2022-outcome samples.
2022 trade-exposure regression with the 2013 index	20	Complete-case sample excluding Russia.
2022 trade-exposure regression with the 2019 index	22	Complete-case sample excluding Russia.
2023 GDP-deviation outcome	25	Venezuela because the required WEO real GDP observation is unavailable.
2023 regression with the 2013 index	22	Intersection of the 2013-index and available 2023-outcome samples.
2023 regression with the 2019 index	24	Intersection of the 2019-index and available 2023-outcome samples.
2023 trade-exposure regression with the 2013 index	21	Complete-case sample excluding Russia.
2023 trade-exposure regression with the 2019 index	23	Complete-case sample excluding Russia.

Notes: WEO denotes the IMF *World Economic Outlook*; AREAER denotes the IMF *Annual Report on Exchange Arrangements and Exchange Restrictions*; WDI denotes the World Development Indicators; EWN denotes the External Wealth of Nations database; WHO denotes the World Health Organization; and BACI denotes the CEPII international trade database.

4.4 Results for 2022 and 2023

Table 4.3 presents the results for the 2022 and 2023 GDP forecast deviations in the same format. Panel A reports the immediate 2022 outcome, while Panel B

reports cumulative performance through 2023. Columns (1)–(4) use the original 2013 resilience index, and columns (5)–(8) use the updated 2019 resilience index. Within each group, the first column includes only the resilience index, the second adds COVID-19 mortality, the third adds both COVID-19 mortality and a Russia indicator, and the fourth excludes Russia from the estimation sample.

Table 4.3 Pre-shock resilience and GDP forecast deviations in 2022 and 2023

	2013 resilience index				2019 resilience index			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index only	+ COVID-19	+ COVID-19 and Russia	Russia excluded	Index only	+ COVID-19	+ COVID-19 and Russia	Russia excluded
<i>Panel A: 2022 GDP forecast deviation</i>								
2013 resilience index	0.346 (0.495)	0.781* (0.394)	0.805* (0.404)	0.805* (0.394)	–	–	–	–
2019 resilience index	–	–	–	–	-0.294 (0.530)	0.270 (0.403)	0.506 (0.380)	0.506 (0.371)
COVID-19 deaths per 100,000	–	-0.051*** (0.010)	-0.042*** (0.009)	-0.042*** (0.009)	–	-0.055*** (0.011)	-0.048*** (0.010)	-0.048*** (0.009)
Russia indicator	–	–	-3.387*** (0.506)	–	–	–	-4.038*** (0.679)	–
Russia excluded	No	No	No	Yes	No	No	No	Yes
Observations	21	21	21	20	23	23	23	22
R^2	0.013	0.431	0.527	0.368	0.012	0.292	0.368	0.235
<i>Panel B: 2023 GDP forecast deviation</i>								
2013 resilience index	-0.304 (0.980)	0.053 (0.939)	0.055 (0.965)	0.055 (0.943)	–	–	–	–
2019 resilience index	–	–	–	–	-0.501 (0.525)	-0.063 (0.541)	-0.044 (0.603)	-0.044 (0.590)
COVID-19 deaths per 100,000	–	-0.042*** (0.012)	-0.041*** (0.013)	-0.041*** (0.012)	–	-0.043*** (0.013)	-0.043*** (0.012)	-0.043*** (0.012)
Russia indicator	–	–	-0.402 (0.563)	–	–	–	-0.344 (1.073)	–
Russia excluded	No	No	No	Yes	No	No	No	Yes
Observations	22	22	22	21	24	24	24	23
R^2	0.007	0.189	0.190	0.162	0.033	0.191	0.192	0.163

Notes: The dependent variable in Panel A is the percentage-point deviation of cumulative real GDP growth in 2022 from the October 2021 WEO forecast, using 2021 as the base year. The dependent variable in Panel B is the corresponding cumulative deviation through 2023. The resilience indices are standardized to have mean zero and standard deviation one in their respective construction samples. COVID-19 exposure is measured by reported deaths per 100,000 inhabitants in 2022. Columns (3) and (7) include a Russia indicator, while columns (4) and (8) exclude Russia from the estimation sample. Heteroskedasticity-robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

In Panel A, the unconditional coefficient on the 2013 resilience index is 0.346 and is not statistically significant. After COVID-19 mortality is added, the coefficient

increases to 0.781 and becomes significant at the 10 percent level. Including the Russia indicator produces a coefficient of 0.805, which remains significant at the 10 percent level. The estimate is unchanged to three decimal places when Russia is excluded, although the robust standard error changes slightly.

These results provide limited evidence of a positive short-run relationship between the 2013 resilience index and the 2022 GDP deviation after accounting for COVID-19 exposure. However, the evidence is statistically weak and is based on a small sample. COVID-19 mortality enters negatively and is statistically significant in all conditional specifications. The Russia indicator is also negative and statistically significant, indicating that Russia experienced an unusually weak 2022 forecast deviation relative to the remaining countries after controlling for resilience and COVID-19 mortality.

The 2019 index provides less support for a short-run resilience relationship. Its unconditional coefficient is -0.294 and is not statistically significant. After COVID-19 mortality is included, the coefficient becomes positive but remains statistically insignificant across the conditional specifications. Therefore, the positive conditional relationship found for the 2013 index is not reproduced when the updated 2019 fundamentals are used.

Panel B shows that neither resilience index is significantly associated with the cumulative GDP forecast deviation through 2023. The unconditional coefficient on the 2013 index is -0.304 . It moves close to zero after COVID-19 mortality is included and remains close to zero when the Russia indicator is added or Russia is excluded. The unconditional coefficient on the 2019 index is -0.501 and is also statistically insignificant. After COVID-19 mortality is included, this coefficient also moves close to zero.

COVID-19 mortality remains negative and statistically significant across all conditional 2023 specifications. By contrast, the Russia indicator is not statistically significant for the 2023 outcome. Excluding Russia leaves the resilience and

COVID-19 coefficients almost unchanged.

Overall, the comparison indicates that the limited positive association between resilience and GDP performance is concentrated in the immediate 2022 outcome and in specifications using the original 2013 index. The association does not persist through 2023 and is not reproduced by the updated 2019 index. The estimates should therefore be interpreted as evidence of a weak and specification-dependent short-run relationship rather than a stable association across index vintages and outcome horizons.

One possible interpretation of the stronger performance of the 2013 index is that the variables identified by Grigoli et al. (2019) capture structural dimensions of adjustment capacity that were particularly relevant to the 2014–2016 episode and may remain persistent across countries. By contrast, updating the same components to 2019 preserves the formal construction of the index but does not necessarily reproduce the same underlying measure of resilience with equal accuracy.

This result illustrates both a strength and a limitation of the original framework. Its strength is that the selected fundamentals appear to capture economically meaningful differences in countries' capacity to adjust. Its limitation is that their empirical performance may depend partly on the episode in which the variables were originally identified. The framework therefore cannot be assumed to retain the same explanatory power when it is mechanically updated and applied to a different oil-price episode.

Therefore, the 2022 GDP deviation captures a period when the favorable oil price movement was strongest, whereas the cumulative 2023 outcome includes a period when the initial price increase had already weakened. This offers one possible explanation for the positive conditional relationship with the 2013 resilience index in the 2022 results and its disappearance when performance is measured through 2023. Resilience may have influenced countries' capacity to absorb or use the

initial increase in oil income, but it did not determine their subsequent GDP paths after the additional revenue weakened. This interpretation remains tentative because the 2023 outcome also incorporates continuing effects of the pandemic, the war, inflation, tighter global financial conditions, and country-specific policy responses.

4.5 Robustness to Pre-War Trade Exposure

Table 4.4 examines whether the results are sensitive to pre-war merchandise trade exposure to Russia and Ukraine. Panel A reports the 2022 outcome, while Panel B reports the 2023 outcome. Russia is excluded from all specifications because trade between Russia and itself is not comparable with the bilateral exposure of the remaining countries. Within each index and outcome pair, the models with and without the trade-exposure control are estimated on identical samples.

For the 2022 outcome, adding trade exposure changes the 2013-index coefficient only slightly, from 0.805 to 0.801. The trade-exposure coefficient is -0.049 , with a robust standard error of 0.122, and is not statistically significant. In the 2019-index sample, the resilience coefficient changes from 0.506 to 0.544. The trade-exposure coefficient is -0.113 , with a robust standard error of 0.133, and is also not statistically significant.

In the 2013-index sample for 2023, adding trade exposure changes the resilience coefficient only slightly, from 0.055 to 0.092. The trade-exposure coefficient is -0.142 , with a robust standard error of 0.148, and is not statistically significant.

In the 2019-index sample for 2023, the resilience coefficient changes from -0.044 to 0.052. The trade coefficient is -0.157 , with a robust standard error of 0.149, and is also not statistically significant.

Adding trade exposure modestly increases R^2 in all comparisons but does not change the main findings. The resilience coefficients retain the same broad inter-

Table 4.4 Robustness to pre-war trade exposure to Russia and Ukraine

	2013 resilience index		2019 resilience index	
	(1) No trade control	(2) + trade control	(3) No trade control	(4) + trade control
<i>Panel A: 2022 GDP forecast deviation</i>				
2013 resilience index	0.805* (0.394)	0.801* (0.409)	—	—
2019 resilience index	—	—	0.506 (0.371)	0.544 (0.387)
COVID-19 deaths per 100,000	— 0.042*** (0.009)	— 0.042*** (0.009)	— 0.048*** (0.009)	— 0.049*** (0.010)
2021 Russia–Ukraine trade exposure (% of GDP)	—	—0.049 (0.122)	—	—0.113 (0.133)
Observations	20	20	22	22
R^2	0.368	0.374	0.235	0.254
<i>Panel B: 2023 GDP forecast deviation</i>				
2013 resilience index	0.055 (0.943)	0.092 (0.949)	—	—
2019 resilience index	—	—	—0.044 (0.590)	0.052 (0.619)
COVID-19 deaths per 100,000	— 0.041*** (0.012)	— 0.043*** (0.013)	— 0.043*** (0.012)	— 0.045*** (0.013)
2021 Russia–Ukraine trade exposure (% of GDP)	—	—0.142 (0.148)	—	—0.157 (0.149)
Observations	21	21	23	23
R^2	0.162	0.197	0.163	0.201

Notes: The dependent variable in Panel A is the percentage-point deviation of cumulative real GDP growth in 2022 from the October 2021 WEO forecast, using 2021 as the base year. The dependent variable in Panel B is the corresponding cumulative deviation through 2023. Russia is excluded from all regressions. Trade exposure is measured as merchandise trade with Russia and Ukraine in 2021 as a percentage of 2021 nominal GDP. COVID-19 exposure is measured by reported deaths per 100,000 inhabitants in 2022. Columns (1) and (2) use the 2013 resilience index, while columns (3) and (4) use the updated 2019 resilience index. Within each index and outcome pair, models with and without the trade-exposure control are estimated on identical samples. Heteroskedasticity-robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

pretation, while COVID-19 mortality remains negative and statistically significant. This suggests that omitting this measure of pre-war bilateral trade exposure does not explain the weak resilience results in the positive-shock application.

4.6 Summary and Interpretation

The findings for the positive oil-price episode are less consistent than those obtained for the adverse 2014–2016 episode. The 2013 index is positively associated with the immediate 2022 outcome after adjustment for the controls, although the result is only marginally significant. No statistically significant relationship is found when the updated 2019 index is used in the regression.

The positive association is also limited to the short-run 2022 outcome. Neither the 2013 nor the 2019 index is statistically associated with cumulative GDP performance through 2023. This pattern is consistent with the possibility that pre-shock resilience mattered more for the immediate absorption of the temporary oil-revenue increase than for the subsequent medium-term GDP path. However, this interpretation remains tentative because the 2022 episode coincided with several major global and country-specific disruptions.

COVID-19 mortality is the most stable correlate in the positive-shock extension. Russia also experienced an unusually weak GDP deviation in 2022, while its position is not statistically unusual in the 2023 regressions. Greater trade exposure to Russia and Ukraine is associated with a lower GDP deviation, but the relationship is not statistically significant and does not materially change the resilience coefficients.

The comparison of the 2013 and 2019 indices also raises an external-validity issue. The original components may capture meaningful and persistent dimensions of resilience, but their empirical performance may partly reflect the particular episode in which they were identified. Mechanically updating the same components does

not guarantee that the resulting index measures the same underlying adjustment capacity with equal accuracy.

Overall, the results are most consistent with Hypothesis 1, which predicts no systematic relationship between pre-shock resilience and GDP performance during a favorable oil-price episode. The resilience coefficient is statistically insignificant in most specifications, especially when the updated 2019 index is used and when economic performance is measured through 2023. This pattern does not necessarily prove that resilience has no role during positive oil-price episodes. Still, it indicates that any relationship is not stable across index vintages, controls, and outcome periods.

The estimation results provide little support for Hypothesis 2. If resilience primarily represented stabilization capacity, the coefficients would be expected to be consistently negative because more resilient countries would smooth the positive windfall and would experience a smaller immediate growth. However, the estimated coefficients are not systematically negative and become positive in the conditional 2022 specifications.

Hypothesis 3 receives only limited support. In the 2022 regressions using the original 2013 index, the resilience coefficient is positive and marginally significant when controlling for COVID-19 exposure. This result is consistent with the possibility that more resilient countries were better able to benefit from the favorable oil-price movement in the short run. However, the relationship is not the same when the updated 2019 index is used, and it disappears when GDP performance is measured through 2023. Therefore, the evidence suggests that any positive association between resilience and performance during a favorable episode was weak, sensitive to index construction, and concentrated in the immediate 2022 outcome.

All in all, the results indicate that the resilience framework is strongly associated with performance during the adverse 2014–2016 episode, while the evidence is

weaker and more specification-dependent during the positive 2022 episode. This suggests that the role of pre-shock resilience may itself be asymmetric across negative and positive oil-price episodes. The estimates remain conditional cross-country associations and should not be interpreted as causal effects.

5 Discussion and Conclusion

This thesis analyzed whether differences in pre-shock economic conditions help explain differences in GDP outcomes among oil-exporting countries following major oil price shocks. It first replicated the framework of Grigoli et al. (2019) for the 2014–2016 oil-price decline using independently reconstructed public data. It then extended the analysis by combining the five pre-shock indicators into broader measures of resilience and applying the framework to the positive oil-price episode of 2022.

The public-data replication broadly confirms the main economic pattern reported in the original study. All five explanatory variables enter with the expected signs, although some coefficients are less statistically significant than in the published results. Exchange-rate flexibility and reserve adequacy provide the clearest evidence in the GDP forecast-deviation regression. At the same time, inflation stability and non-oil exports are more visible in the realized growth-slowdown exercise. The consistency of the coefficient signs across the two outcomes suggests that the general result is not driven only by the October 2014 GDP forecast.

The composite measures provide stronger evidence than the individual indicators. The results indicate that countries with more favorable pre-shock conditions experienced smaller GDP shortfalls after the 2014–2016 decline. This result appears both when the five components are combined into a standardized index and when resilience is measured as the number of favorable conditions. The similarity between the two approaches suggests that resilience is better understood as a combination of economic characteristics rather than as the result of a single dominant policy variable.

Furthermore, extending the thesis to the positive 2022 episode produces a different outcome. The original 2013 index is positively associated with the immediate 2022

GDP outcome after accounting for COVID-19 exposure. The updated 2019 index does not show the same relationship. In addition, neither the 2013 nor the 2019 index is significantly associated with GDP performance through 2023. Including controls for Russia does not change this conclusion.

In general, these findings are most consistent with Hypothesis 1. Pre-shock resilience seems to be more important when countries face a decline in oil income compared to when higher oil prices ease fiscal and external pressures. The results provide little support for Hypothesis 2 and only limited support for Hypothesis 3. Overall, the evidence is most consistent with Hypothesis 1: resilience has no stable relationship with GDP performance during the favorable oil-price episode.

The contrast between the two oil-price episodes suggests that the role of resilience may itself be asymmetric. During an adverse shock, countries may be forced to draw on reserves, reduce expenditure, borrow additional funds, or adjust through the exchange rate. In such cases, stronger initial conditions can directly smooth the adjustment. A positive oil-price movement creates a broader range of possible responses. Additional revenue may be spent, saved, invested, or used to consolidate debt. Therefore, pre-shock resilience does not necessarily determine how much of the favorable movement is reflected in real GDP.

However, several limitations remain. The number of sample countries is small, and some variables are reconstructed from multiple public sources to address missing data. Gross government debt relative to revenue is used instead of the original net-debt measure. Furthermore, the non-oil export variable may still include some hydrocarbon-related products. The 2022 episode is also challenging to isolate because it overlapped with the recovery from COVID-19, the war in Ukraine, inflation, sanctions, changes in oil production, and tighter global financial conditions. Finally, it should be considered that the regressions identify conditional cross-country associations rather than causal effects.

Overall, the thesis demonstrates that pre-shock economic conditions are closely

related to performance during the adverse 2014–2016 oil-price decline. The same relationship is much weaker during the favorable 2022 oil-price episode. Therefore, resilience appears to be most valuable as protection against economic downside risk. Stronger buffers, greater diversification, macroeconomic stability, fiscal space, and more flexible policy frameworks can decrease vulnerability when oil income falls; still, they do not guarantee stronger GDP growth when oil prices rise.

Závěr v češtině

Tato práce analyzovala, zda rozdíly v ekonomických podmínkách před šokem pomáhají vysvětlit rozdíly ve vývoji HDP mezi zeměmi vyvážejícími ropu po významných cenových šocích na trhu s ropou. Nejprve replikovala metodologický rámec Grigoliho et al. (2019) pro pokles cen ropy v letech 2014–2016 s využitím nezávisle rekonstruovaných veřejných dat. Následně spojila pět ukazatelů před šokem do širších měřítek odolnosti a rozšířila tento rámec na období růstu cen ropy v roce 2022.

Replikace obecně potvrzuje hlavní ekonomický vzorec původní studie. Všech pět proměnných má očekávaná znaménka, ačkoli některé koeficienty jsou méně statisticky významné. Flexibilita měnového kurzu, přiměřenost rezerv, cenová stabilita a neropný vývoz poskytují nejvýraznější výsledky napříč oběma ukazateli vývoje HDP. Kompozitní ukazatele poskytují silnější výsledky a naznačují, že země s příznivějšími podmínkami před šokem zaznamenaly po poklesu cen ropy v letech 2014–2016 menší propady HDP.

Naproti tomu odolnost nevykazuje stabilní vztah s vývojem HDP během příznivého období roku 2022, zejména při hodnocení výsledků do roku 2023. Tato zjištění jsou nejvíce v souladu s Hypotézou 1 a naznačují, že odolnost je důležitější při poklesu příjmů z ropy než v situaci, kdy vyšší ceny ropy zmírňují fiskální a vnější tlaky.

Analýza je omezena malým vzorkem, rekonstruovanými proměnnými, alternativním měřením dluhu a souběhem období roku 2022 s oživením po pandemii COVID-19, válkou na Ukrajině, inflací, sankcemi a změnami globálních finančních podmínek. Celkově se zdá, že odolnost před šokem je nejcennější jako ochrana před rizikem hospodářského poklesu, nezaručuje však vyšší růst HDP při růstu cen ropy.

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List of Abbreviations

AREAER	Annual Report on Exchange Arrangements and Exchange Restrictions
BACI	Base pour l'Analyse du Commerce International
COVID-19	Coronavirus disease 2019
CPI	Consumer Price Index
EIA	U.S. Energy Information Administration
EWN	External Wealth of Nations
GDP	Gross Domestic Product
GHS	Grigoli, Herman, and Swiston
HS	Harmonized System
IMF	International Monetary Fund
OLS	Ordinary Least Squares
OPEC	Organization of the Petroleum Exporting Countries
RGDP	Real Gross Domestic Product
UNCTAD	United Nations Conference on Trade and Development
USD	United States dollar
VAR	Vector Autoregression
WDI	World Development Indicators
WEO	World Economic Outlook
WHO	World Health Organization