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Inflation-at-Risk in the Middle East and Central Asia

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ABSTRACT: This paper investigates inflation risks for 12 Middle East and Central Asia countries, with an equal share of commodities exporters and importers. The empirical strategy leverages the recent developments in the estimation of macroeconomic risks and uses a semi-parametric approach that balances well flexibility and robustness for density projections. The paper uncovers interesting features of inflation dynamics in the region, including the role of backward versus forward-looking drivers, non-linearities, and heterogeneous and delayed exchange rate pass-through. The results have important implications for the conduct of monetary policy and central bank communication in the Middle East and Central Asia and emerging markets in general.

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WORKING PAPERS

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Prepared by Maximilien Queyranne, Romain Lafarguette, and Kubi Johnson [1]

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Contents

Glossary

2Q	Two-Quarter
4Q	Four-Quarter
CPI	Consumer Price Index
EME	Emerging Market Economy
GaR	Growth-at-Risk
HAC	Heteroskedasticity and autocorrelation consistent
IaR	Inflation-at-Risk
IMF	International Monetary Fund
ME&CA	Middle East and Central Asia
OE	Oil exporter
OI	Oil importer
UAE	United Arab Emirates
VaR	Value-at-Risk

Executive Summary

Following the COVID-19 shock, price pressures have intensified in most countries as demand recovered from the pandemic, supply chain distortions persisted, and commodity prices surged (IMF, 2021). Headline inflation has spiked, while core inflation – the change in the prices of goods and services excluding food and energy - has started to rise as well. In the Middle East and Central Asia (ME&CA) region, inflation rates have also surged since mid-2020, driven mostly by external factors, particularly international food prices (IMF, 2022). The war in Ukraine has triggered a further increase in commodity prices, that has translated into higher inflation.

In this context, central banks need to assess upside risks to their baseline inflation forecasts. Since at least the 1980s, economists have recognized the important effects that uncertainty and risks can have on economic decisions. Following the pandemic, price pressures have been higher and more persistent than forecasted by most central banks, pointing to a tendency to underestimate upside tail risks. In that context, gauging the balance of risks to the baseline inflation forecasts and identifying key drivers of inflation dynamics have become critical to navigate the considerable uncertainty surrounding the outlook for price movements. While central banks in advanced economies are increasingly incorporating risks into their inflation forecasts (pioneered by the Bank of England inflation fan charts at the end of the 1990s, see for instance Britton et al. 1998), most central banks in emerging markets focus only on central inflation projections for their policy making.

Against this background, this paper addresses a few key questions: what are the main drivers of core inflation in the ME&CA countries? Has the distribution of core inflation outcomes varied across time in the region? How central banks can better deal with inflation risks, especially upside ones, when making monetary policy decisions and communicating risks to baseline forecasts? Given recent price hikes, what are the main risks for inflation outcomes in the ME&CA region?

To answer these questions, this paper first estimates the mean of future core inflation outcomes for a set of ME&CA countries, conditional on a set of contemporaneous variables, and shows the heterogeneity of inflation drivers at different horizons (two-quarter-ahead (2Q-ahead) and four-quarter-ahead (4Q-ahead)). The model relies on an augmented a Phillips Curve, which features a series of domestic and external macroeconomic variables that can affect core inflation (current core inflation, output gap, inflation expectations, commodity prices, and the exchange rate), a measure of the underlying trend in inflation that is less volatile than the consumer price index (CPI) ans is generally a better gauge of long-term inflation expectations. The Phillips Curve is estimated via panel OLS and the core inflation is regressed on the domestic and external macroeconomic variables of each country. We find that current inflation is the main explanatory variable of future 2Q-ahead core inflation across our sample, pointing to significant inertia in price setting, while inflation expectations have a stronger effect on 4Q-ahead core inflation. Commodity prices are also large determinants of future inflation, while the exchange rate is more muted given that some countries in the sample have a fixed exchange rate. We also find that the domestic output gap has limited explanatory power on future core inflation across our sample, pointing to limited short-term trade-off between employment and inflation in the regio Second, we estimate the entire distribution of future possible core inflation outcomes rather than just the point (baseline) forecast. We use the semi-parametric density estimation strategy used in the IMF Growth-at-Risk (GaR) model (Prasad and al., 2019, and Lafarguette, 2019) to project the future dynamic of core inflation. We estimate quantile regression to gauge the relative importance of current macro-financial regressors on 2Q-ahead and 4Q-ahead core inflation at different points in the sample. We focus our analysis on the right tail of the distribution to capture upside risks, i.e. high inflation. Typically, in most countries, the explanatory power of the model is maximized on the right-tail of the inflation distribution: while low and average inflation dynamics can be driven by many factors – including seasonal ones – high inflation has a limited set of clearly identified drivers, each with a substantial impact. For 2Q-ahead inflation, current core inflation has the strongest impact when inflation is high, suggesting a high-degree of persistence. This underscores the importance of keeping inflation low and stable to prevent self-reinforcing inflation dynamics. Exchange rate and commodity prices have a smaller effect than current core inflation on 2Q-ahead inflation, although their relative impact is magnified at the right tail of the inflation distribution compared to the central and lower quantiles. For 4Q-ahead core inflation, inflation expectations play a larger role in explaining inflation outcomes, and the transmission of commodity prices and exchange rate depreciation is more pronounced than in the short run (see Caselli and Roitman 2016 for a thorough analysis of exchange rate pass-through in emerging markets).

Third, to analyze the evolution of future inflation risks across time, we fit parametric distributions to the estimated inflation quantiles at three points in time: in the middle of our sample period (end-2014), at end-2019 to measure inflation dynamics prior to the COVID-19 shock, and at end-2021, to determine whether right tail risks increased recently along with higher headline inflation. We find that in most ME&CA countries, core inflation distributions shifted to the left and became centered around lower levels of inflation from 2014-2019 when considering 4Q-ahead inflation. More recently, however, the distribution of future core inflation outcomes has moved to the right in most countries, especially for 4Q-ahead core inflation. The surge in commodity prices had not yet fully passed through to core inflation at end-2021 in most countries, but future core inflation outcomes have become more volatile and more skewed to the right.

Finally, our model captures nonlinearities and provides a forward-looking approach to mitigate inflation risks and avoid a de-anchoring of inflation expectations. Central banks could leverage this Value-at-Risk (VaR) approach to better communicate risks to the outlook and the baseline.

The paper is organized as follows. Section I reviews the literature on inflation-at-risk. Section II presents some stylized facts on inflation developments in the ME&CA region discusses the data and empirical approach. Section IIII presents the results. And Section IV discusses policy implications and concludes.

Literature Review

Adrian and al. (2019) were the first to transpose the Value-at-Risk (concept extensively used in finance) to macroeconomic forecasting, to project the conditional distribution of future real GDP growth as a function of current macro-financial conditions. Adrian and al. propose a convenient approach to project the density of future real GDP growth, appropriate even with a limited data sample.[1] Their method relies on a two-step semi-parametric approach: first, future GDP growth is regressed on a set of current macro-financial indicators, using quantile regressions. Second, the authors fit a continuous t-skew distribution on the conditional quantiles estimated in step 1. Adrian and al. (2019) find significant non-linearities across quantiles, with lower quantiles of the GDP distribution exhibiting strong variation as a function of current financial conditions, while the upper quantiles being stable over time. Their results suggest a strong predictive power of financial conditions to signal crisis time, while macro-financial linkages play a lesser role on the upper quantiles of the GDP distribution.

Building on this GaR model, a recent and growing literature aims at estimating inflation-at-risk to better capture the inflation outlook beyond point-forecasts. Lopez-Alido and al. (2020) investigate the tail risks to the inflation outlook in the United States from the 1970s, using quantile regressions. The baseline quantile regression model is an augmented Phillips Curve model with five main dependent variables that capture price persistence (lagged average inflation), forward-looking price setting (long-term inflation expectations), labor slack (the unemployment gap), variation in relative prices (quarterly change in relative import prices), and financial conditions (credit spreads). The paper finds that the muted response of the conditional mean of inflation to economic conditions masks ample variability in the conditional predictive distribution of inflation and that tight financial conditions carry substantial downside inflation risks.

Banerjee and al. (2020) extend the quantile regression methods used by Adrian et al (2019) to investigate inflation risks in a panel of advanced and emerging market economies (EMEs).[2] Their paper uses quantile panel regressions with fixed effects to estimate the conditional quantiles of the four-quarter-ahead headline inflation rate. Then, they fit a continuous skewed t-distribution on the discrete conditional quantiles set. The quantile regressions specification also features an open-economy Phillips Curve, capturing output (through either real GDP growth or the output gap), current inflation, the exchange rate (change in the nominal effective exchange rate or the US dollar), and the change in oil price in domestic currency. The specification also includes a measure of financial conditions in the estimated Phillips curves (the realized volatility in equity returns). The authors find that upside inflation risks have generally declined over time, reflecting successful disinflationary processes and the adoption of inflation targeting regimes. They also show significant non-linearities in emerging market economies, with large exchange rate depreciations associated with upside inflation risks, while tightening financial conditions increase both up- and downside inflation risks.

Beyond VaR analysis, a large literature analyzes how uncertainty and risks may affect central bank's monetary policy decisions and whether they should adopt a more risk-based approach when setting their main policy rates. Evans and others (2015) show that the Federal Reserve has taken uncertainty into account in setting its policy rate and recommend a "risk management approach" that requires policy to be formulated considering the

[1] While most density-based models used in finance such as copulas or kernels rely on data sampled at high frequency, most macroeconomic variables are only available at quarterly frequency.

[2] ME&CA countries are not included in the EMEs panel, which comprises of Korea, Mexico, Poland, and Turkey.

dispersion of shocks around their means. They also show that risk management is a long-standing practice in the conduct of monetary policy in the United States, using a narrative study of Federal Reserve communications and estimated policy reaction functions.

Empirical Strategy

We study a sample of 12 EMEs in the ME&CA, which includes six OIs (Armenia, Egypt, Jordan, Morocco, Pakistan, and Tunisia) and six OEs (Algeria, Bahrain, Iran, Kazakhstan, Oman, and UAE) for which data is available. All data used is quarterly and covers on average 45 quarters. Shorter period is used for five countries in our sample (Armenia, Bahrain, Iran, Tunisia, and UAE), due to data limitations. The countries and data sources used in each case are described in Appendix I.

First, this paper estimates the relationship between key domestic and external factors and future price developments, as primarily measured by the 2Q-ahead core inflation. While we also estimate this relationship for the 4Q-ahead core inflation, we focus on 2Q-ahead inflation to ensure enough observations to estimate quantile regressions. We present in appendix a series of robustness checks related to the projection of 4Q-ahead core inflation.

We use core inflation as it is less volatile than the overall consumer price index (CPI), in line with the approach used in IMF (2021). Given data limitations and various methodologies used to compute core inflation across countries in our sample, we extend the approach used in IMF (2022) to compute core inflation by excluding food prices (food and non-alcoholic beverages) and energy prices (housing, water, electricity, gas and other fuels) from CPI. This approximation to core inflation implies that for food, we include elements that are non-volatile or are administered, and for energy, that exclude fuels used in transport. However, it is reasonable as all components have the same trend and as a more precise definition of core inflation in a selected number of countries display the same trend and limited differences overall (IMF, 2022).

Our estimates of core inflation show that Egypt and Iran have experience larger upside inflation shocks, driven by a large depreciation of their national currency in 2016 and 2018, respectively (Figures 1 and 2). In addition, international sanctions are another large driver of inflation in Iran. A nominal depreciation of the Algerian dinar in 2015 also led to a pick-up in inflation, but the impact was significantly lower than in Egypt and Iran. Most countries have managed to broadly maintain core inflation around five percent throughout the 2010s, and a few countries experienced near zero (Armenia and Morocco) or even negative core inflation during several consecutive quarters (Bahrain, Oman, and UAE).

Figure 1. Derived Core Inflation, Oil Exporters

(year-over-year)

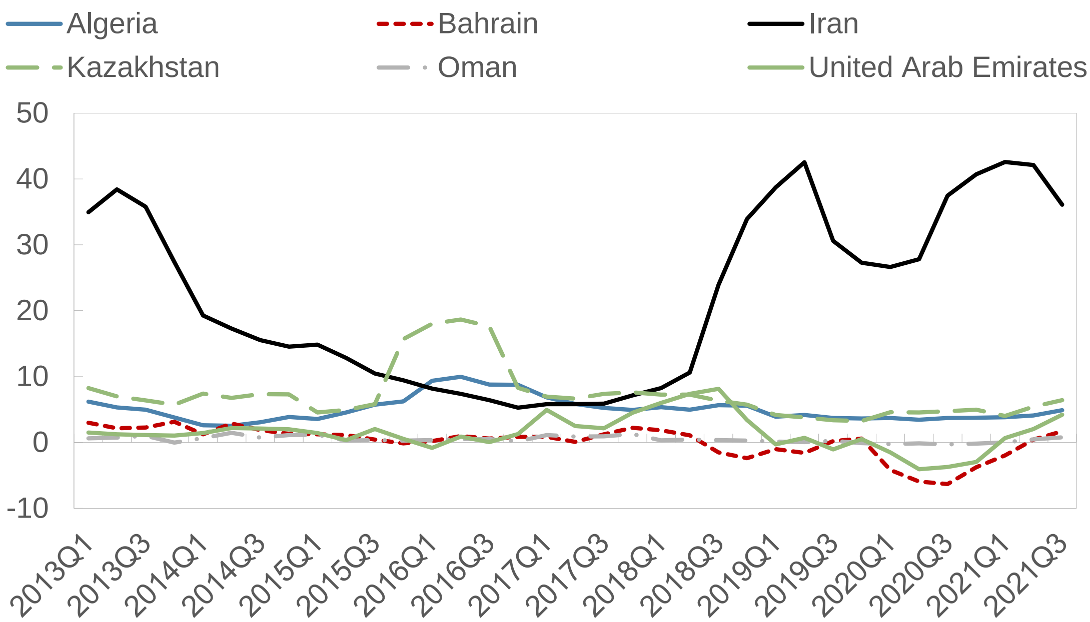
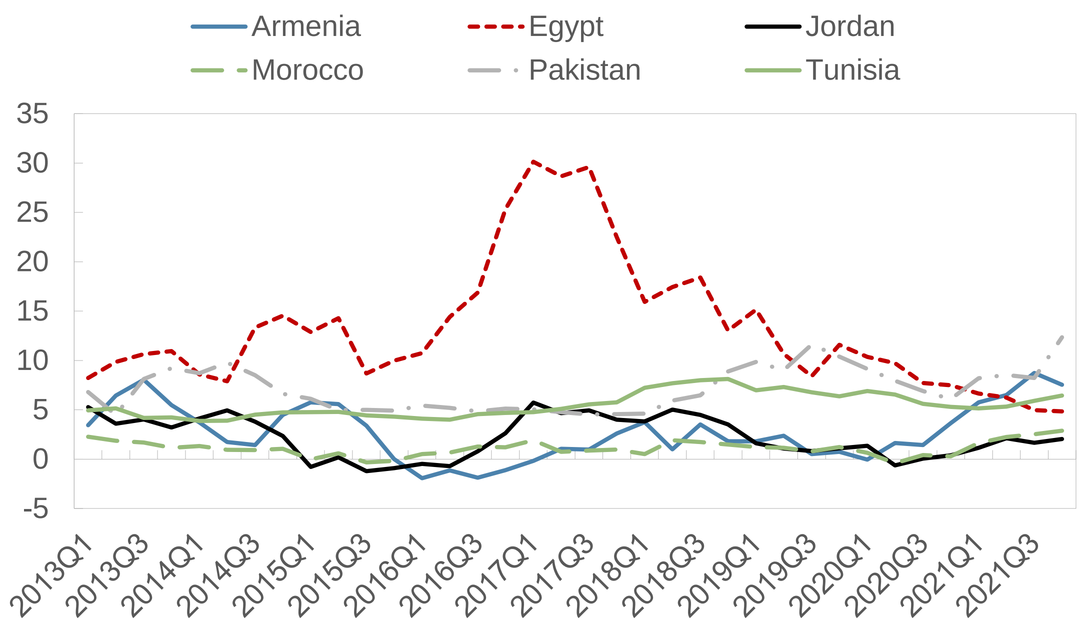


Figure 2. Derived Core Inflation, Oil Importers

(year-over-year)



Following Banerjee and al. (2020), we model an augmented Phillips curve with open economy variables as key drivers of future 2Q-ahead (and 4Q-ahead) core inflation for each country in our sample, with fixed effects, as follows:

$$\pi^{*}_{i,t+2} = \alpha + \beta_{\gamma}\gamma_{i,t} + \beta_{\Pi}\pi^{*}_{i,t} + \beta_{\Pi^{e}}\pi^{LTE}_{i,t} + \beta_{n}\Delta neer_{i,t} + \beta_{p}\Delta P^{*}_{i,t} + FE$$

where *i* indexes the country, *t* the quarterly time period. *Y*, *π*, and *neer* denote the output gap (or industrial production),[3] current core prices, and the nominal effective exchange rate, respectively. As in IMF (2021), the output gap is the difference between the actual and potential output in percent of potential output, where potential is estimated as a Hodrick-Prescot-filtered underlying trend of output. Current core prices are estimated using the methodology described above. *P* captures commodity price pressures using the Goldman Sachs Commodity Price Index.[4] In addition, we use a proxy of inflation expectations (π^{LTE}), measured by the five-year ahead forecast for CPI inflation from the IMF's World Economic outlook, as in IMF (2021).[5] All variables (both the dependent and regressors, except the output gap) are normalized using z-score for comparability. *FE* (fixed effects) captures unobserved, time-invariant heterogeneity across countries.

We also run country-by-country regressions with heteroskedasticity and autocorrelation consistent (HAC) standard errors, without fixed effects, as this differencing strategy is not well suited for nonlinear operators such as quantiles (see Abrevaya and Dahl, 2008). As described in Prasad and al. (2019), although each quantile regression is linear, the relationship between the regressors and future core inflation is based on quantile regressions that capture different slopes at different points on the future core inflation distribution. Therefore, we use these country-by-country results in the quantile regressions and to provide higher tolerance given the limited number of observations for each country, we start with a confidence interval of 20 percent and note significance at 10 percent and 5 percent levels.

Second, this paper uses the semi-parametric density estimation strategy used in the IMF GaR model (Prasad and al., 2019) by using quantile regressions to estimate the potentially nonlinear relationship between the above-mentioned macroeconomic regressors and quantiles of future core inflation. The quantile regression takes the following specification:

$$\pi^{*q}_{i,t+2} = \alpha^{q} + \beta^{q}_{\gamma}\gamma_{i,t} + \beta^{q}_{\pi}\pi^{*}_{i,t} + \beta^{q}_{\pi^{e}}\pi^{LTE}_{i,t} + \beta^{q}_{n}\Delta neer_{i,t} + \beta^{q}_{p}\Delta P^{*}_{i,t} + \varepsilon^{q}_{t+2}$$

where *i* indexes the country, *t* the quarterly time period. The dependent variable $\pi^{*q}_{i,t+2}$ represents future core inflation 2Q-ahead for quantile q, with q ϵ {0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9}; $\Delta\gamma_{,t}, \pi^{*}_{i,t}, \pi^{LTE}_{i,t}, \Delta neer_{i,t}, \Delta P^{*}_{i,t},$ are the main regressors from the augmented Philips curve with their associated quantile coefficients β^{q}; and α^{q} and ε^{q}_{t+2} denote a constant term and the residual, respectively. As described in the Technical Appendix of Prasad and al. (2019), the quantile regressions are estimated at different points of the distribution of $\pi^{*q}_{i,t+2}$, and each coefficient β^{q} represents the marginal contribution of an average change of the regressor to the variation in the quantile *q* of the future core inflation distribution.

Then, we fit a continuous future core inflation distribution for each country. A continuous distribution fit is helpful to obtain a complete picture of the inflation risks and to compute the associated risk metrics, such as Value-at-

[3] The nonoil output gap was also tested but did not provide strong results across our sample.

[4] Following Banerjee (2020), we also tried our regression with the change in oil prices in domestic currency and found limited statistical significance and high p values across most countries. This may reflect the prevalence of energy subsidies across countries in our sample that limit pass-through of oil prices to domestic prices.

[5] Inflation expectations are derived from IMF desk projections as more specific measures of inflation expectations are not available in most countries in our sample. As in IMF (2022), inflation forecasts are an annual average produced twice a year which have been linearly interpolated at quarterly frequency.

Risk (VaR) or the expected shortfall. We follow the t-skew parametric fit approach available in the IMF GaR tool developed by Lafarguette (2019). The choice of the t-skew family has been popularized in finance (see Adcock et al. (2015) for a review) and has been increasingly used in macroeconomics. T-skew distributions feature interesting properties (asymmetry, fat tails, etc.) in a relatively parsimonious framework with closed-form expressions (see Azzalini and Capitanio (1994) for a full-fledged presentation of the t-skew distribution). The t-skew distribution also encompasses more common and simpler distributions, such as the t and the Gaussian distributions, which can be obtained as special cases of the t-skew. The distribution fit is done on the discrete, empirical cumulative distribution function (CDF) represented by the set of the conditional quantiles estimated from the quantile regressions. The fit is done via minimizing the Euclidean distance between the empirical quantiles and the theoretical quantiles of a t-skew distribution. Before proceeding to the distance minimization, we uncross – if necessary - the estimated conditional quantiles using the approach of Chernozhukov et al. (2014). Quantiles crossing is a common problem in quantile regressions projections, and even more when the accuracy of the quantile regression estimator is dampened by small and potentially noisy sample, as it is the case when working on emerging markets.

The distribution fit features a standard optimization on the three parameters of the t-skew (the location, scale and skewness), using the Basin-hopping algorithm in Python scipy package (see Virtanen et al. (2020)).

$$loc, scale, skew = argmin[\sum_{q}\{tsk.quantile(q, loc, scale, skew) - \hat{Q}[\pi_{i,t+2}^{*q}]\}^2]$$

Where $tsk.\ quantile\ (q,\ loc,\ scale,\ skew)$ represents the quantile q of the t-skew distribution with parameters (loc, scale, and skew) and $\hat{Q}\left[\pi_{i,t+2}^{*q}\right]$ the conditional quantiles estimated from the quantile regressions.

The future core inflation distributions are projected at three points in time over the sample period for each country to provide an assessment of the dynamic of downside and upside risks to core inflation: (i) at the mid-range of our sample period (2014 Q4) and in order to provide a sufficient number of observations, (ii) the last quarter before the pandemic shock (2019 Q4), and (iii) at the latest available datapoint (2021 Q3 for most countries).

Empirical Results

Benchmark Regressions

Overall, the panel regression with a fixed effect displays stronger explanatory power for future core inflation at 2Q-ahead than at 4Q-ahead (Table 1). This may be explained by strong price control mechanisms across our sample, given the prevalence of administered food prices (especially in Gulf Cooperation Council countries) and of energy subsidies that limit the pass-through of food and commodity prices in the short term (IMF, 2022).

At 2Q-ahead, current core inflation shows the largest coefficient and is statistically significant at the 1 percent significance level, while inflation expectations display both lower coefficient and statistical significance. This dominance of backward-looking inflation points to significant inertia in price setting in the near term across our sample. However, we find that our backward-looking measure of inflation has lower explanatory power on future 4Q-ahead core inflation, as the inertia in price setting process may gradually dissipate overtime. On the contrary, our measure of forward-looking inflation (inflation expectations) displays stronger coefficients and the expected positive sign more frequently after four quarters. These results are in line with IMF (2022) which finds that long-term inflation expectations play a prominent role in explaining inflation dynamics. In this context, firmly anchoring inflation expectations is critical to control inflation in the long run. The exchange rate is statistically significant at the 1 percent significance level at both horizons, with larger coefficient for 4Q-ahead core inflation. The output gap and commodity prices have lower statistical significance overall.

Table 1. Panel OLS Results for Two-Quarter-Ahead and Four-Quarter-Ahead Core Inflation

VARIABLES	2Q-ahead Core Inflation	4Q-ahead Core Inflation
Core Inflation	0.705***	0.276***
	(0.0391)	(0.0518)
Inflation Expectations	0.157**	0.337***
	(0.0715)	(0.0939)
Output Gap	-0.0364**	0.00103
	(0.0175)	(0.0236)
Exchange Rate	0.000138***	0.000412***
	(5.33e-05)	(7.10e-05)
Commodities	0.303*	-0.0690
	(0.180)	(0.257)
Constant	1.057***	1.588***
	(0.340)	(0.463)
No. of Observations	563	543
R-squared	0.530	0.209
Number of countries	12	12

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The country-by-country regressions also show that core inflation has the largest effect on future 2Q-ahead core inflation in most countries and is broadly comparable between OEs and OIs on average, with a one standard deviation in current core inflation displaying positive coefficients on future conditional prices as expected (Table 2). . These results are statistically significant at the 5 percent level for most countries.

The effect of forward-looking inflation, proxied by inflation expectations, is more muted, with coefficients in OEs showing the expected sign, and being larger and more statistically significant (except for Algeria and UAE) than in OIs. Commodity prices is also associated with future core inflation across most of our sample and display the expected positive sign across all countries except for Morocco (where it is not statistically significant also). Excluding countries with a hard peg (Bahrain, Oman, and UAE), exchange rate depreciation leads to inflationary pressures in most countries as shown by the expected positive sign, with results statistically significant at the 5 percent level for most countries.[6] Finally, the output gap displays limited explanatory power and statistical significance, and points to limited trade-off between employment and inflation in the short run.

[6] For Morocco and Pakistan, the estimates for the exchange rate impact are affected by the switch between fixed and more flexible regimes throughout the sample.

These results are in line with those of IMF (2022), in which the output gap and domestic settings do not appear to be statistically significant determinants of inflation in the
Phillips curve estimation These findings may reflect endogeneity issues in the Phillips curve estimates though, illustrating the empirical disconnect between inflation and output gap (McLeay and Tenreyro, 2019).

Table 2. OLS Results for Two-Quarter-Ahead Core Inflation

	Algeria	Armenia	Bahrain	Egypt	Iran	Jordan	Kazakhstan	Morocco	Oman	Pakistan	Tunisia	UAE
Core Inflation	0.5484882***	0.3917983***	0.6480722***	0.7745444***	0.5593244***	0.007603	0.3149312*	0.3860771***	0.9694680***	0.4991866***	0.8048432***	0.1328181
	0	0	0	0	0	0.98	0.13	0.02	0	0	0	0.75
Inflation Expectations	-0.1338905***	-0.1442462	0.3563832***	0.1085599	0.3697853***	0.1604563**	0.3115067***	-0.10321	-0.2563387***	-0.0364403	-0.091736	0.2306435
	0.03	0.63	0.04	0.34	0.02	0.07	0	0.47	0.02	0.77	0.58	0.23
Output Gap	0.0002068	-0.0035088***	-0.0005673	-0.0090838***	-0.0092800***		-0.0028306**	0.0003902	-0.0000045		0.0005924***	-0.0007922*
	0.52	0	0.23	0.01	0		0.06	0.66	0.81		0.01	0.12
Exchange Rate	0.6720595***	0.4279073***	0	0.2007331***	-0.1186085	0.1083524	0.1331126	-0.5173027***		0.2832547***	0.0418578	
	0	0.04	.	0.03	0.33	0.32	0.54	0		0	0.54	
Commodities	0.2753082*	0.6108352***	0.4904718***	0.0118776	0.3872235*	0.4384844**	0.0397668	-0.110635	0.0788986*	0.4857176***	0.2530964***	1.4169374**
	0.18	0	0.01	0.89	0.15	0.1	0.79	0.54	0.19	0	0.01	0.1
Industrial Production						0.0000015***				0.0001132		
						0.05				0.82		
Constant	-0.0642106	0.0694959	0.0647431	-0.1451195	-0.0592226	0.0118039	-0.0525447	0.1439207	0.1496935**	0.1422644*	0.2423468**	0.587969
	0.57	0.7	0.64	0.22	0.76	0.94	0.53	0.32	0.05	0.17	0.1	0.27
No. of Obs.	41	42	41	50	37	58	70	46	59	48	40	30
R-Squared	0.75	0.45	0.53	0.66	0.73	0.28	0.42	0.36	0.83	0.59	0.81	0.38
BIC	82.07	105.54	104.43	112.57	79.16	170.27	185.02	133.97	82.73	117.33	64.92	99.15

* p<0.2 ** p<0.1 *** p<0.05. HAC Standard Errors used.

Appendix 2 presents the results of the country-by-country regression for 4Q-ahead core inflation. Commodities have a slightly stronger effect on 4Q-ahead core inflation in some OEs (Algeria, Bahrain, Iran, and Bahrain) and OIs (Armenia, Pakistan, and Tunisia), pointing to the gradual transmission of commodity prices to core inflation. Our results for 4Q-ahead core inflation are broadly similar for the output gap and the exchange rate, the former displaying very small coefficients and the latter having marginally larger effect.

Quantile Regressions

The quantile regressions' results for 2Q-ahead core inflation are presented in the following heatmaps for each variable separately (Figure 3). In addition, Appendix III presents our detailed quantile regressions results by countries. Quantile regressions allow to identify potential nonlinearities, with the impact of regressors varying across the quantiles of the distribution of the dependent variable. Overall, variables have more explanatory power in the right tail of the distribution – i.e for high inflation -, except in five countries (Armenia, Iran, Jordan, Morocco, and Pakistan).

Consistent with the OLS results, current core inflation displays the higher coefficients and significant nonlinearities across quantiles. Overall, our backward-looking inflation variable has a strong impact at the center and right tail of the distribution with four countries showing larger effect when inflation is high, especially among OEs (Algeria, Kazakhstan, and Oman) and Egypt. In five countries, current core inflation has more impact around the middle of the distribution (Iran, UAE, Armenia, Jordan and Tunisia). Given that current core inflation is an important determinant of future inflation, keeping inflation low and stable is critical to avoid self-reinforcing inflation dynamics.

Inflation expectations also have more impact on the right tail of the distribution for most countries in our sample and are especially strong in Armenia and Iran. These results indicate that high past inflation experiences tend to shift the distribution to the upside and generate significant upside risks. In Bahrain and UAE, inflation expectations have a larger significance in the left tail of the distribution, likely pointing to their dominant role in explaining the long periods of near zero and negative core inflation in these two countries.

Commodity prices affect more strongly the right tail of the distribution both in OEs and OIs. The effects are particularly large in Iran and UAE, and to a lesser extent in Bahrain. Our results differ from Banerjee and al. (2020) which find that the impact of commodities is broadly linear across quantiles in EMEs. These differences may be explained by the composition of our sample in which energy exports and imports are larger as a share of GDP in Korea, Mexico, Poland, and Turkey.

The exchange rate has also more effect on the right tail of the distribution in four countries (Algeria, Egypt, Jordan, and Pakistan). And in Armenia, the impact of the exchange rate on future core inflation is strong from the mean to the right tail of the distribution. Overall, this points to the reinforcing channel of foreign exchange depreciation on inflation dynamics, especially at the right tail of the distribution. These findings are in line with Banerjee and al (2020) which shows that depreciations increase upside inflation risk in selected EMEs. Finally, our results also show that the domestic output gap has no impact across quantiles, in line with our findings from the OLS regression.

Figure 3. Two-Quarter-Ahead Core Inflation - Quantile Coefficients by Regressor[7]

Current Core Inflation

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	0.603	0.411	0.335	0.528	0.621	0.620	0.668	0.506	0.637
Armenia	0.378	0.411	0.417	0.396	0.518	0.464	0.432	0.422	0.324
Bahrain	1.035	0.437	0.559	0.606	0.626	0.543	0.508	0.706	0.582
Egypt	0.395	0.406	0.547	0.619	0.564	0.697	0.837	0.824	0.964
Iran	0.519	0.453	0.693	0.870	0.838	0.934	0.800	0.701	0.326
Jordan	0.318	0.289	0.290	0.226	0.346	0.321	0.217	0.319	0.310
Kazakhstan	0.332	0.275	0.400	0.410	0.578	0.647	0.646	0.631	1.003
Morocco	0.718	0.589	0.530	0.538	0.394	0.180	0.245	0.147	0.525
Oman	0.831	0.798	0.815	0.869	0.890	0.913	0.970	1.056	1.376
Pakistan	0.596	0.545	0.442	0.587	0.531	0.519	0.422	0.523	0.260
Tunisia	0.816	0.780	0.780	0.776	0.845	0.884	0.860	0.835	0.877
United Arab Emirates	-0.144	-0.316	-0.332	0.060	0.041	0.198	-0.076	0.181	-0.261
Country Average	*0.533*	*0.423*	*0.456*	*0.541*	*0.566*	*0.577*	*0.544*	*0.571*	*0.577*

Less Inflationary *More Inflationary*

Inflation Expectations

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	-0.042	-0.044	-0.067	-0.103	-0.12	-0.122	-0.128	-0.168	-0.191
Armenia	-0.145	-0.366	-0.315	-0.004	0.066	0.097	0.168	0.377	0.822
Bahrain	0.573	0.352	0.311	0.357	0.317	0.328	0.178	0.235	0.203
Egypt	0.036	0.027	0.007	0.145	0.137	0.13	0.241	0.167	0.161
Iran	0.303	0.354	0.339	0.373	0.376	0.342	0.41	0.4	0.81
Jordan	0.139	-0.011	0.093	0.188	0.128	0.098	0.07	0.168	0.159
Kazakhstan	0.153	0.229	0.204	0.169	0.103	0.159	0.179	0.278	0.301
Morocco	-0.068	-0.057	-0.11	-0.223	-0.176	-0.096	0.174	0.223	0.377
Oman	-0.197	-0.19	-0.17	-0.181	-0.152	-0.132	-0.131	-0.31	-0.303
Pakistan	-0.255	-0.128	-0.045	-0.12	-0.112	-0.073	0.036	0.442	0.388
Tunisia	-0.607	-0.516	-0.63	-0.573	-0.154	-0.345	-0.405	-0.343	-0.548
United Arab Emirates	0.429	0.401	0.434	0.316	0.209	0.247	0.287	0.254	0.217
Country Average	*0.027*	*0.004*	*0.004*	*0.029*	*0.052*	*0.053*	*0.090*	*0.144*	*0.200*

[7] For a given variable, the heat maps below show the coefficients for each country at different quantiles. Except for the output gap, the variables are all standardized; this means the coefficient equals the size of the standard deviation movement in 2Q-ahead core inflation associated with a one standard deviation movement in the variable shown.

Figure 3. Two-Quarter-Ahead Core Inflation - Quantile Coefficients by Regressor (Continued)

Output Gap

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	-0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001
Armenia	0.000	-0.003	-0.003	-0.002	-0.003	-0.004	-0.004	-0.004	-0.005
Bahrain	-0.002	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001
Egypt	-0.002	-0.003	-0.002	-0.005	-0.006	-0.007	-0.009	-0.010	-0.012
Iran	-0.006	-0.005	-0.010	-0.014	-0.014	-0.015	-0.015	-0.012	-0.017
Jordan 1/	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kazakhstan	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.004
Morocco	-0.001	-0.001	0.000	0.000	-0.001	-0.001	0.000	-0.003	-0.002
Oman	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pakistan 1/	0.000	0.001	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001
Tunisia	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001
United Arab Emirates	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.003
Country Aveage	*-0.001*	*-0.001*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.003*	*-0.004*

1/ Industrial production used instead of GDP

Exchange Rate[1/]

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	0.648	0.611	0.513	0.48	0.473	0.504	0.525	0.826	0.763
Armenia	-0.388	-0.171	0.006	0.733	0.491	0.732	0.753	0.656	0.455
Egypt	0.118	0.361	0.221	0.188	0.348	0.271	0.18	0.224	0.1
Iran	-0.014	-0.135	-0.068	-0.114	-0.142	-0.24	-0.288	-0.468	-0.098
Jordan	0.066	0.102	0.083	0.056	0.14	0.107	0.162	0.178	0.321
Kazakhstan	-0.087	-0.08	-0.233	-0.227	-0.124	-0.022	0.129	0.057	-0.416
Morocco	-0.363	-0.319	-0.46	-0.589	-0.609	-0.645	-0.88	-0.729	-0.743
Pakistan	0.146	0.261	0.284	0.35	0.329	0.286	0.328	0.475	0.591
Tunisia	0.183	0.154	0.169	0.176	-0.03	-0.059	-0.06	-0.065	0.012
Country Aveage	*0.034*	*0.087*	*0.057*	*0.117*	*0.097*	*0.104*	*0.094*	*0.128*	*0.109*

1/ Increase in the exchange rate translates to a depreciation. Bahrain, Oman, and the United Arab Emirates are excluded because they have fixed exchange rates.

Figure 3. Two-Quarter-Ahead Core Inflation - Quantile Coefficients by Regressor (Continued)

Commodity Prices

	Quantiles								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
Algeria	0.268	0.341	0.177	0.224	0.217	0.301	0.283	0.327	0.357
Armenia	0.22	0.486	0.471	0.519	0.484	0.753	0.808	0.722	0.323
Bahrain	0.871	-0.08	0.279	0.377	0.382	0.479	0.454	0.576	0.705
Egypt	-0.052	-0.017	0.03	-0.073	-0.006	-0.012	0.061	0.037	0.049
Iran	0.377	0.287	0.563	0.785	0.813	1.021	1.122	1.068	1.234
Jordan	0.413	0.39	0.296	0.316	0.321	0.305	0.194	0.119	0.116
Kazakhstan	0.144	0.142	0.022	0.012	0.024	0.041	0.107	0.109	-0.615
Morocco	-0.234	-0.257	-0.318	-0.336	-0.211	-0.16	-0.359	-0.13	-0.426
Oman	0.122	0.102	0.09	0.063	0.033	0.044	-0.002	0.021	0.191
Pakistan	0.078	0.149	0.407	0.414	0.551	0.493	0.444	0.309	0.397
Tunisia	0.062	0.169	0.127	0.138	0.262	0.195	0.269	0.299	0.499
United Arab Emirates	1.171	1.632	1.705	1.484	1.226	1.944	3.507	3.609	4.826
Country Average	*0.287*	*0.279*	*0.321*	*0.327*	*0.341*	*0.450*	*0.574*	*0.589*	*0.638*

Quantile regressions' results for 4Q-ahead core inflation are presented in Appendix IV (heatmaps) and V (detailed results by country). Coefficients for current core inflation are weaker across quantiles for all countries relative to 2Q-ahead, and the effect on the right tail of the future core inflation distribution is also less pronounced. Only four countries display large coefficients across all quantiles, of which two OEs (Bahrain and Oman) and two OIs (Egypt and Tunisia). Inflation expectations have larger effect on the middle range of the quantiles (from 20 to 70 quantiles) both in most OEs and OIs, which confirms that longer run inflation is more influenced by forward-looking inflation than backward-looking inflation.

Commodity prices display on average larger coefficients at the right tail of the distribution, may be pointing to a larger pass through to domestic prices in a context of high inflation. Across quantiles, the impact of the exchange rate appears also larger than for 2Q-ahead, especially in the right tail of the distribution, revealing the long-lasting effect of exchange rate depreciation on prices. Finally, the relationship between the output gap and 4Q-ahead core inflation is as weak as for 2Q-ahead core inflation.

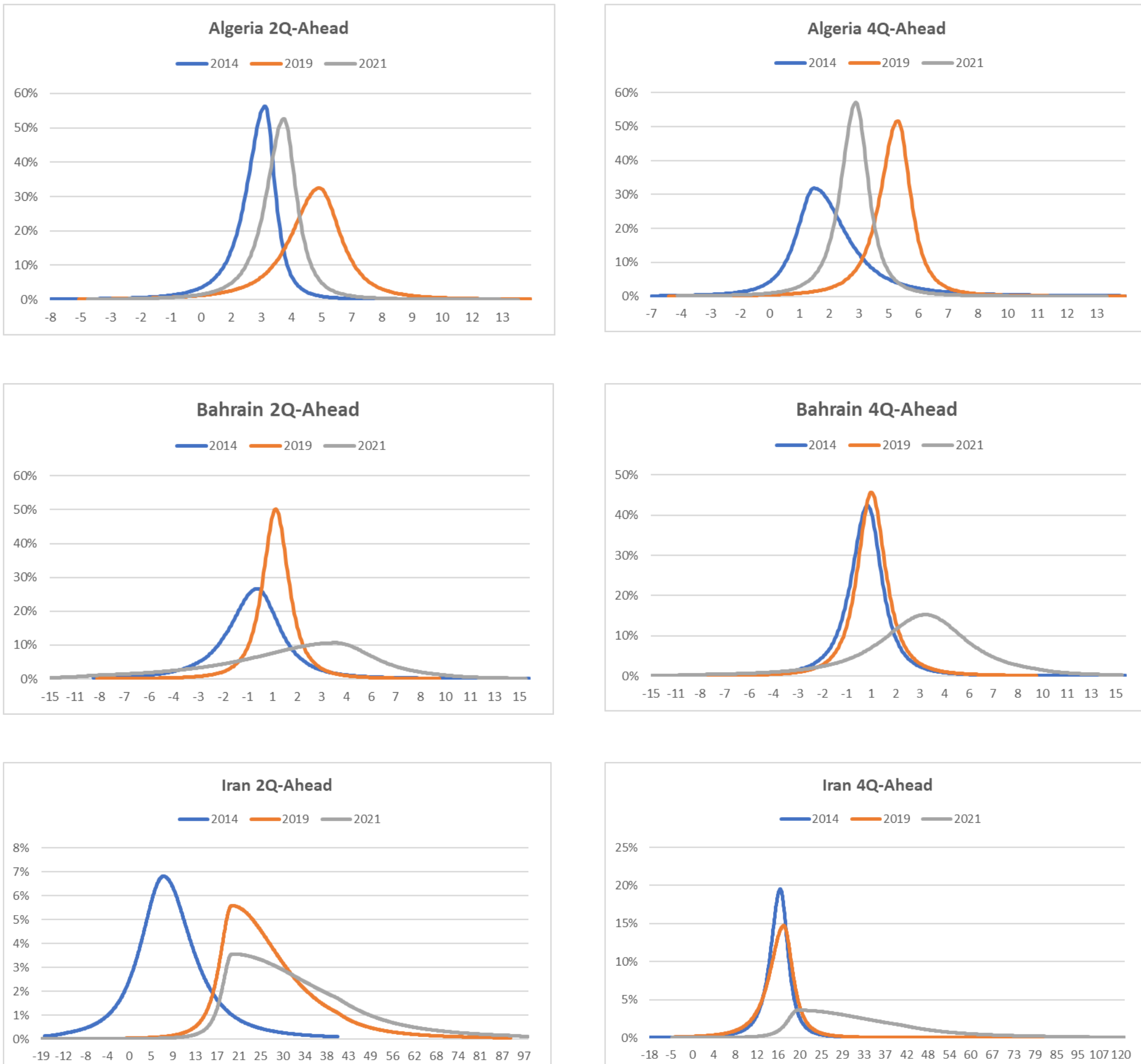
Distributions of Future Inflation

Figures 4 and 5 present the distributions of 2Q-ahead and 4Q-ahead core inflation in 2014, 2019 and 2021 for OEs and OIs, respectively. The location of the distributions of 2Q-ahead and 4Q-ahead core inflation has evolved significantly during the sample period. From 2014-2019, the distributions of conditional core inflation outcomes have moved to the left in most countries for 4Q-ahead core inflation. The picture is more balanced when looking at 2Q-ahead core inflation, especially for oil importing countries.

Since the pandemic shock, it appears that higher headline inflation had not yet transmitted fully into our core inflation measures at end-2021. For 2Q-ahead core inflation, four countries experienced a leftward shift since end-2019, of which two OEs (Algeria and UAE), and two OIs (Pakistan and Tunisia), while the location remains broadly unchanged in four other countries, mostly OEs (Iran, Kazakhstan, and Oman). However, three OIs have experienced a rightward shift (Armenia, Egypt, and Jordan). Finally, Morocco and Oman’s central banks have broadly succeeded in maintaining their distributions centered around low levels of inflation throughout the sample period. For 4Q-ahead core inflation, more countries have experienced a rightward shift that may reflect increased risks of higher inflation levels.

In addition, most countries have experienced a change in the skewness of their distribution, which measures the asymmetry around the mean. Distributions have become positively skewed overtime in most countries relative to both 2014 and 2019, indicating that upside risks have become more prominent. This is observed both for 2Q-ahead and 4Q-ahead core inflation. The kurtosis, which is a measure of how fat the tails of the future core inflation distributions are relative to a normal distribution, has also increased across countries overtime, especially among OEs, showing that inflation tail risks have become more prominent. Finally, the variance of the distribution, as measured by the dispersion of the distribution around the mean, has also widened in most OEs and OIs, especially between 2014 and 2019. Over the recent period, the variance has increased more for 2Q-ahead core inflation than 4Q-ahead core inflation. Overall, future core inflation outcomes have become more volatile and have tilted to the right tail of the distribution throughout the period, especially in OEs.

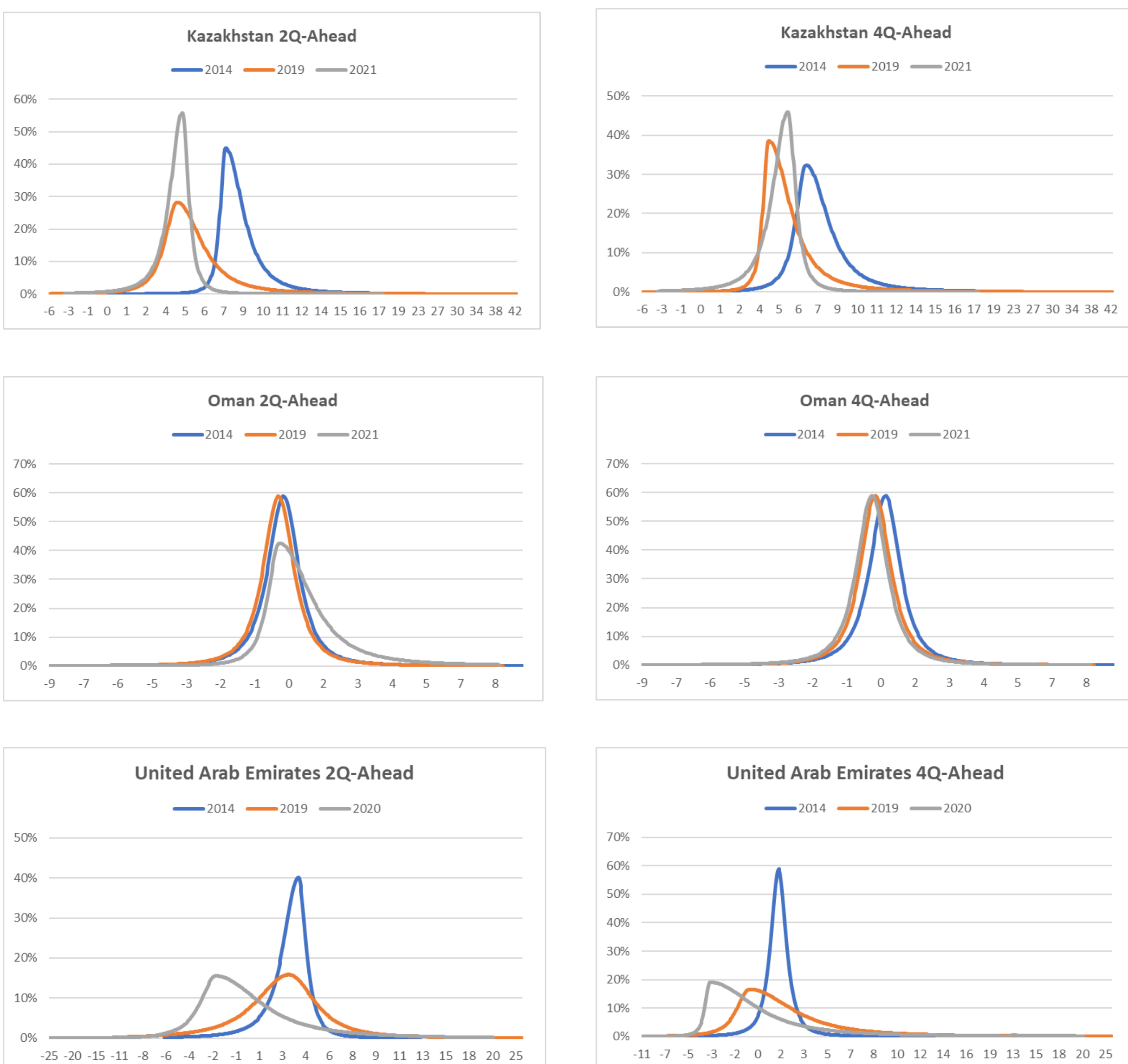
Figure 4. Oil Exporters: 2Q and 4Q-Ahead Core Inflation Distribution 1/



Source: IMF staff calculations

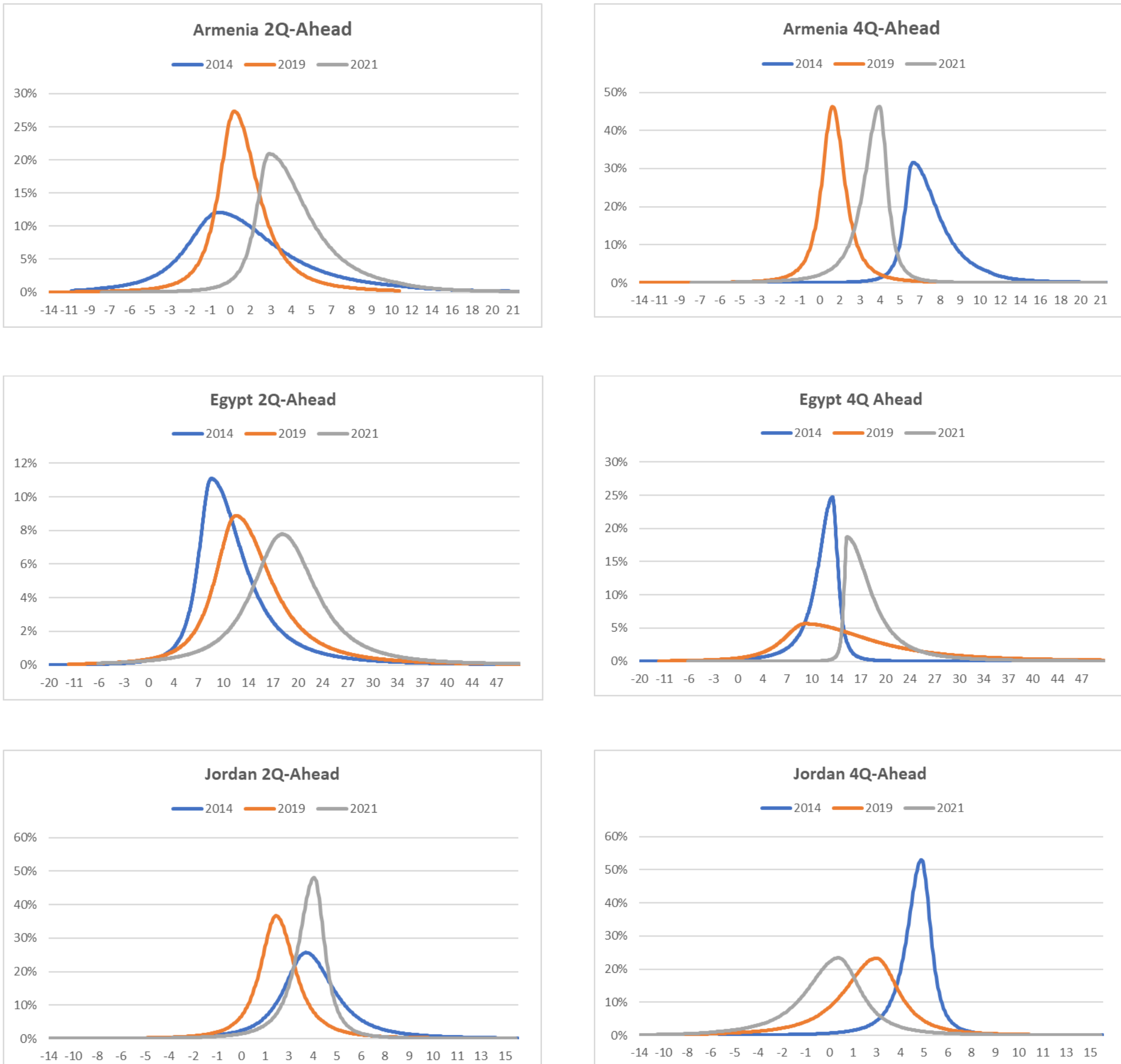
1/ Each curve represents the complete distribution of the 2Q-ahead (4Q-ahead) core inflation conditional on the state of macroeconomic variables at the end of a given year.

Figure 4. Oil Exporters: 2Q and 4Q-Ahead Core Inflation Distribution (Continued)



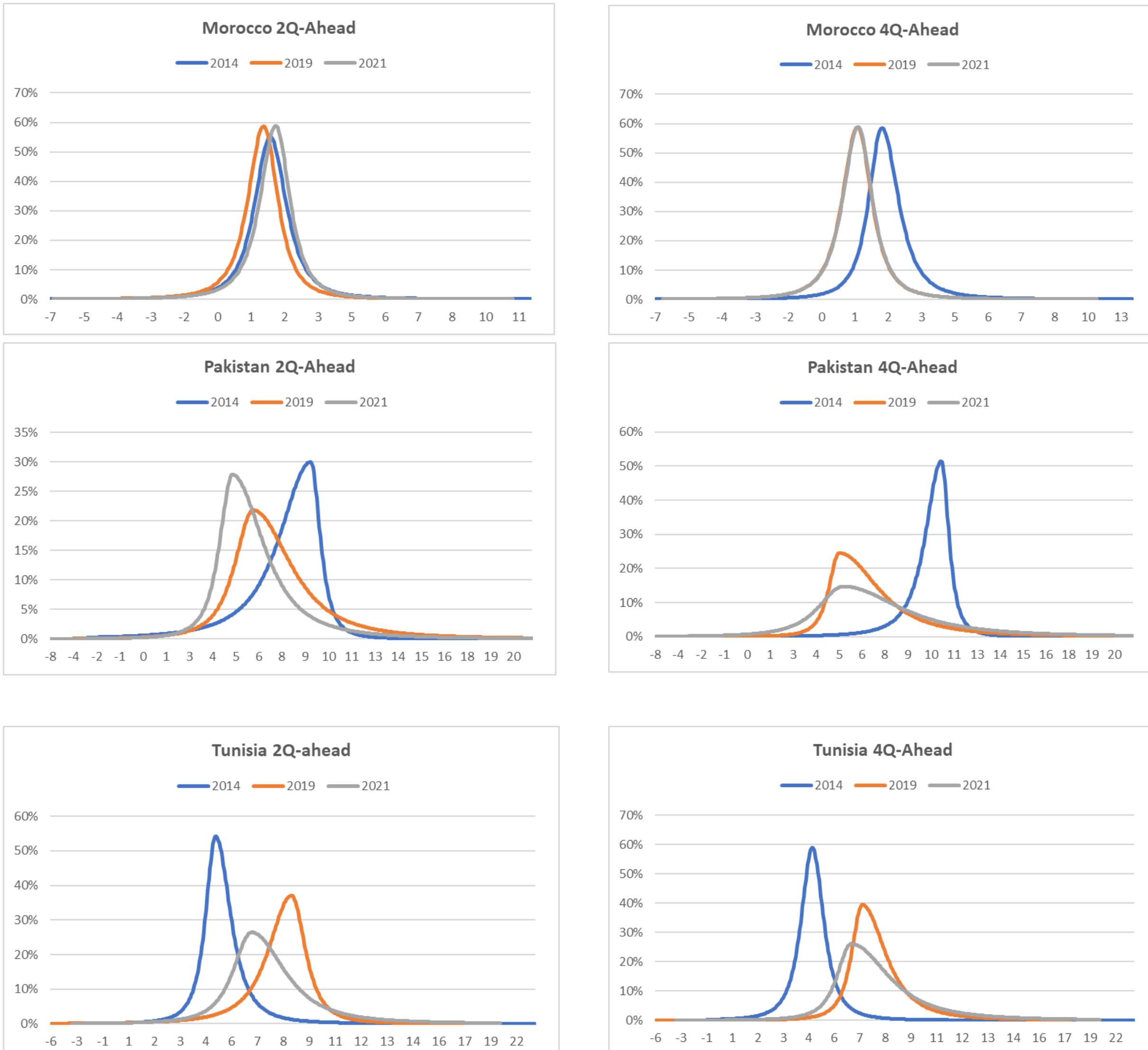
Source: IMF staff calculations

Figure 5. Oil Importers: 2Q and 4Q-Quarters-Ahead Core Inflation Distribution



Source: IMF staff calculations

Figure 5. Oil Importers: 2Q and 4Q-Ahead Core Inflation Distribution (Continued)



Source: IMF staff calculations

Conclusions and Policy Implications

Our paper extends the inflation-at risk approach recently developed in the literature to the ME&CA region. Four main conclusions can be drawn from our results:

- The impact of key drivers of inflation may vary overtime, with current levels of core inflation having a larger effect on future conditional core inflation at two quarters ahead, and inflation expectations at four quarters ahead.
- The factors that drive future core inflation are likely to have nonlinear effects at different levels of inflation. In particular, current core inflation level and inflation expectations tend to have a larger impact at the center and right tail of the distribution. Exchange rate depreciation and commodity prices also have a larger impact in the right tail of the distribution, albeit smaller than our backward and forward-looking inflation variables.
- The transmission of commodity prices to core inflation takes time, in a context where price control mechanisms are pervasive in the region, and is stronger when inflation levels are high. Similarly, the exchange rate has long lasting impact on core inflation, especially in the right tail of the distribution.
- Recently, the relatively limited pass-through of higher headline inflation to core inflation has masked more prominent upside risks and more volatile future inflation outcomes. The point (baseline) forecast of future inflation is therefore insufficient to spot inflation risks accurately and design an appropriate monetary policy.

In that context, central banks in the ME&CA could give more attention to inflation risks, especially upside ones. The balance between dowside and updside risks around the baseline forecast greatly matters for monetary policy decision. For example, nonlinear effects may become pronounced and not be fully captured by the core linear model and would need to be incorporated in the forecasting process. This would help reduce the likelihood of persistent and costly deviations from target by acting early on before upside risks materialize. Therefore, more attention and information on risks would help diminish those very risks when central banks make policy decision.

Central banks could decide on their inflation risk tolerance based on the VaR approach presented in this paper. As conditional inflation is forecasted, the inflation-at-risk model would provide a forward-looking approach to mitigate risks. By capturing nonlinearities, it could alleviate shocks and help avoid sudden shifts in inflation expectations. For countries in the sample that don’t have a pegged exchange rate, once the future conditional distribution is projected, central banks could decide how much of the tail risk it would reduce for example by increasing its policy rate in case of significant updside risk. In that case, the central bank might even want to overshoot – i.e. increasing the policy rate substantially – in order to firmly anchor expectations. To inform its decision, central banks could determine thresholds as a value-at-risk of conditional inflation distributions forecasted based on an inflation-at-risk model (e.g. 90 percent, 95 percent, etc.).

In addition, central banks in the region could better communicate risks to their baseline forecast. In an uncertain environment, communicating only about point forecasts might give a wrong impression and endanger the credibility of the central bank. Already, some central banks in the ME&CA communicate risks in a qualitative manner taking into account the exchange rate, commodity prices, and inflation expectations (Pakistan), or the balance of risks to the outlook (Morocco). In addition, Morocco’s central bank BAM publishes fan charts showing probability bands for CPI (and real GDP) over 8 quarters and Pakistan’s Monetary Policy

Committee generally provides an inflation range forecast (2 percentage points amplitude) rather than a point forecast.

By communicating on future inflation risks, central banks would be able to rationalize their monetary policy and steer agents' behavior more efficiently. This emphasis on alternative outcomes can also be helpful in explaining subsequent developments that do not match the assumptions in the baseline forecast. However, central banks should communicate in a clear and transparent way, as risks projections might be more complex to grasp for economic agents and could ultimately undermine confidence.

Already, most inflation-targeting central banks complement their main scenario with alternative scenarios in their monetary policy report, accompanied by a discussion of their main drivers. Alternative scenarios are a way to reveal both the central bank expectations about the future and the monetary policy reaction function. Appropriately constructed and communicated, alternative scenarios can contribute to making monetary policy more predictable. In some cases, central banks also discuss what these downside scenarios imply for the future course of policy. Such exercises can convey to the public a sense of how a central bank will react to unexpected developments.

Beyond the scenario-based approach, central banks in the ME&CA could better communicate risks to the outlook and the baseline, drawing from the VaR approach. They could reveal whether the balance of risks is tilted to the downside or the upside and identify the main factors driving its baseline scenario, given the full distribution of future conditional inflation. This would help communicate uncertainties around the baseline to observers and support market participants to improve their views on future inflation and internalize central bank monetary policy guidance.

Appendix I. Data Sources

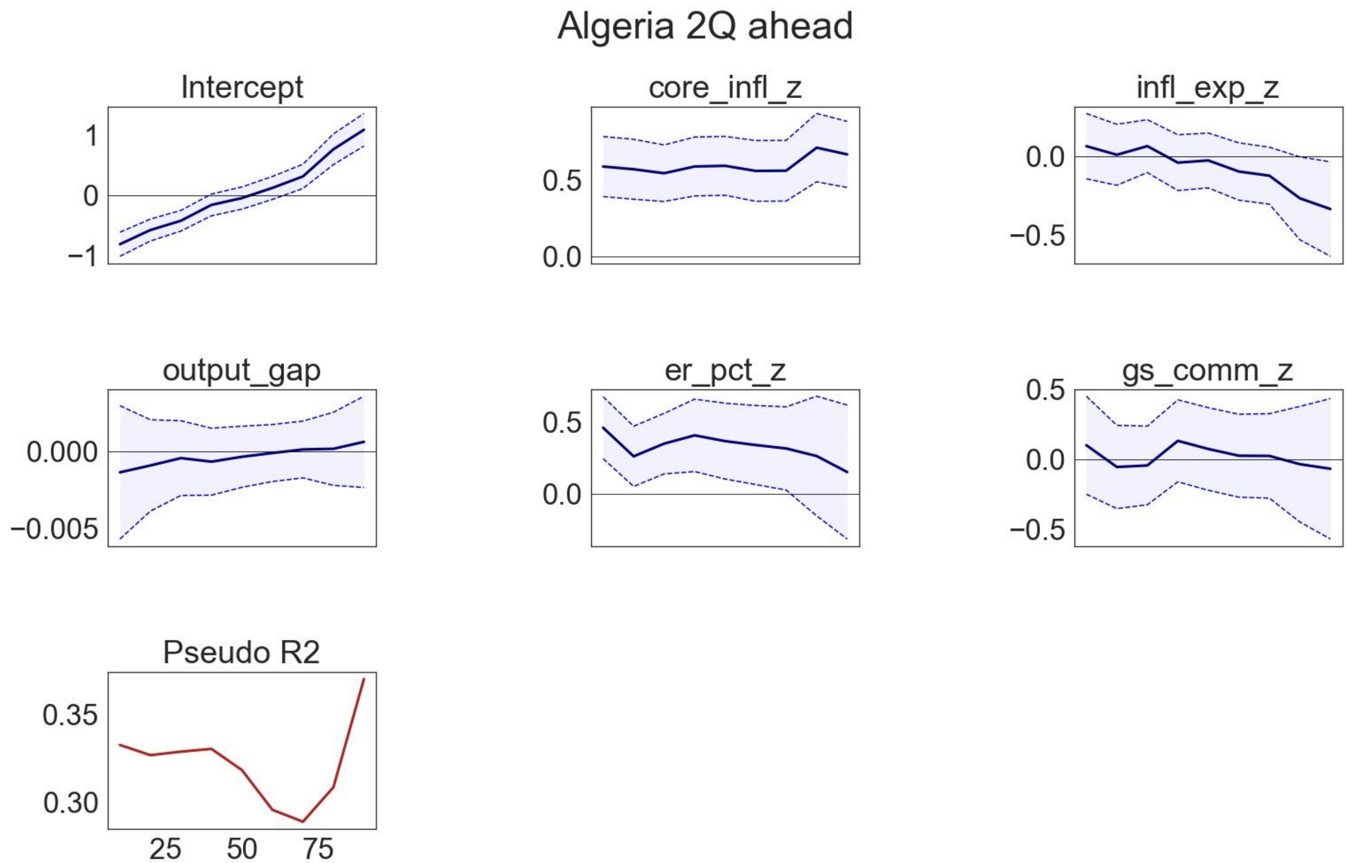
Variable	Definition	Sources
Core Inflation	Z-score of year over year change in core inflation	IMF MCD Regional Studies Division
Output gap	Percent difference between nominal and potential GDP growth. Potential GDP growth calculated using a Hodrick-Prescott Filter	CEIC Data
Industrial Production	Substitute for output gap. Percent difference between nominal and potential industrial production. Potential calculated using a Hodrick-Prescott Filter	Haver Analytics
Nominal Effective Exchange Rate	Z-score of year over year change in nominal effective exchange rate	IMF International Financial Statistics
Commodity Price Index	Z-score of year over year change in Goldman Sachs Global Commodity Price Index.	Bloomberg
Inflation Expectations	Z-score of 5-year ahead forecast of IMF CPI forecast	IMF World Economic Outlook

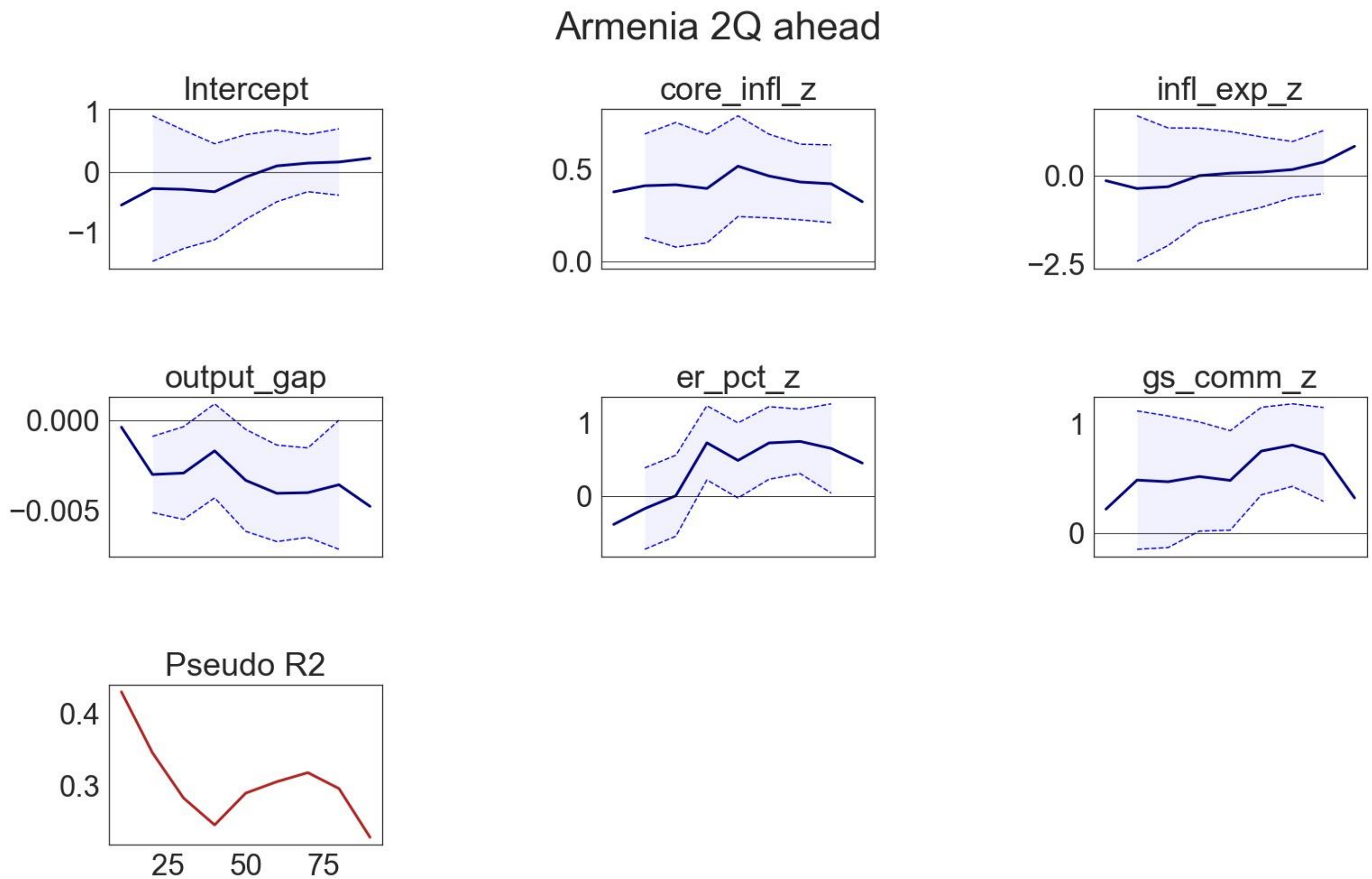
Appendix II. OLS Results for Four-Quarter-Ahead Core Inflation

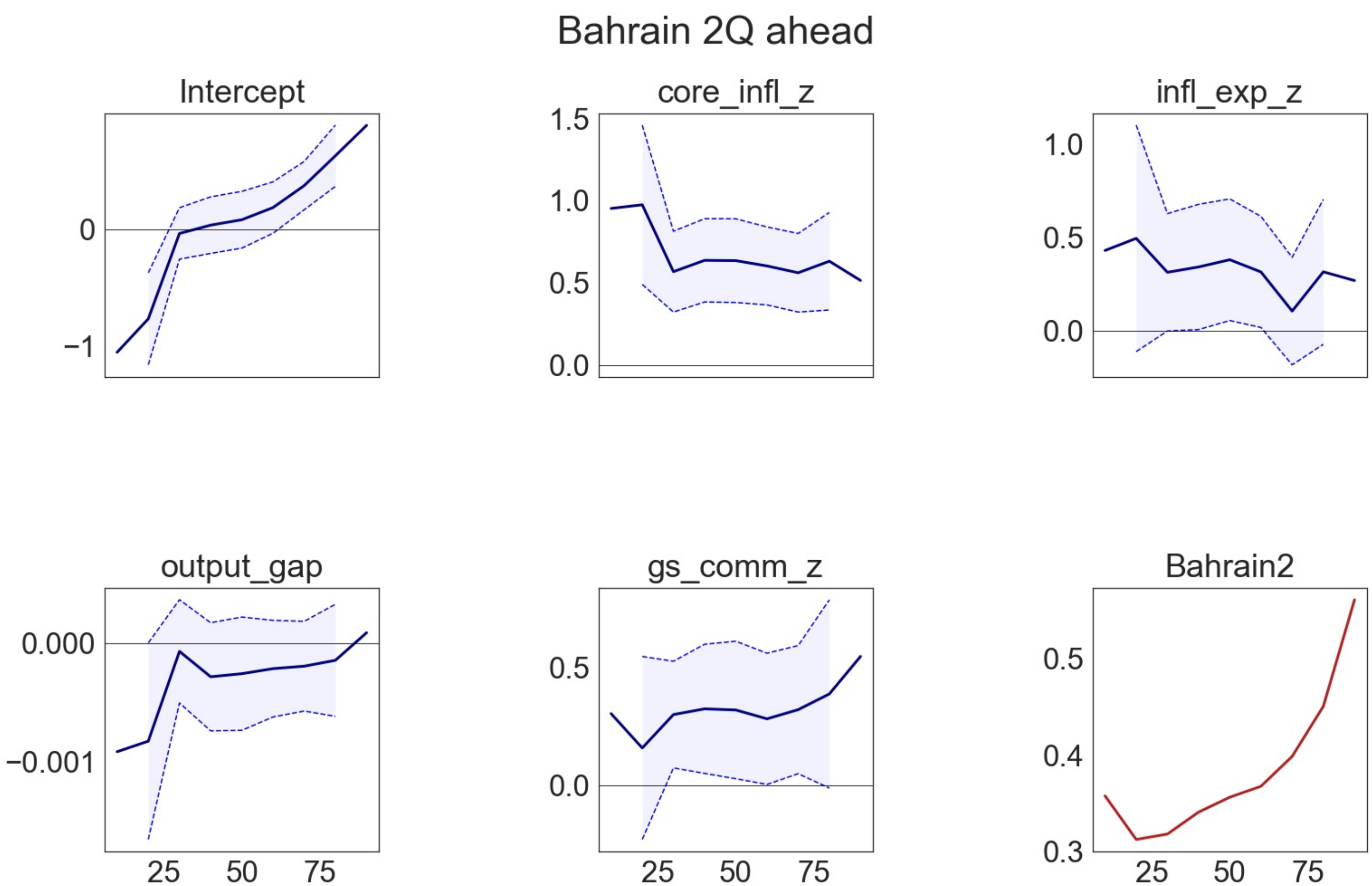
	Algeria	Armenia	Bahrain	Egypt	Iran	Jordan	Kazakhstan	Lebanon	Morocco	Oman	Pakistan	Tunisia	UAE
Core Inflation	-0.0922579	-0.0994558	0.4845504***	0.4195608***	-0.009004	-0.4040957**	0.1745353	-0.3891954	-0.2948147*	0.9016229***	-0.0346878	0.4983559***	-0.4592576*
	0.26	0.42	0.01	0.02	0.96	0.08	0.35	0.35	0.13	0	0.85	0	0.2
Inflation Expectations	-0.3246123***	-0.0935936	0.3322314***	0.1202242	0.9124813***	0.3558176***	0.4445018***	-0.0972418	-0.0539157	-0.5619749***	0.0601302	0.1316716	0.3272545*
	0	0.86	0.05	0.28	0	0	0	0.48	0.73	0.01	0.57	0.69	0.19
Output Gap	0.0002228	-0.0050338***	-0.0019300***	-0.0086566**	-0.0180458***		0.0025377	0.0004665	-0.0025730***	-0.0000332*		-0.0005709*	-0.000542
	0.49	0	0.01	0.07	0		0.26	0.74	0.03	0.14		0.15	0.46
Exchange Rate	1.0049073***	0.3271818	0	0.2727087***	-0.3041564	0.1328773***	-0.4653001***		-0.3184770**		0.3877597***	0.2252192***	
	0	0.28	.	0.01	0.24	0.03	0.02		0.07		0	0.02	
Commodities	0.5154859**	0.6636534***	0.8250012***	-0.2015048*	1.3518269***	0.1827964	-0.6409641***	-0.0881649	-0.1353215	0.0037902	0.6388697***	0.5100771***	1.5477106*
	0.06	0.01	0	0.15	0	0.35	0	0.65	0.46	0.96	0.01	0	0.13
Industrial Production - Jordan						0.0000024***							
						0							
Industrial Production - Pakistan											-0.0006357		
											0.36		
Constant	0.0375197	0.050977	0.0444004	-0.2470369**	0.1369073	-0.1026065	-0.1208117*	-0.3227842*	-0.0339935	0.3056562**	0.1038705	0.2268401	0.6642141
	0.8	0.88	0.76	0.06	0.42	0.51	0.14	0.15	0.8	0.06	0.52	0.32	0.34
No. of Obs.	39	40	39	48	35	56	68	31	44	57	46	40	30
R-Squared	0.70	0.26	0.40	0.35	0.77	0.17	0.33	0.03	0.30	0.60	0.32	0.53	0.16
BIC	88.93	112.58	105.66	141.66	71.35	175.05	189.97	88.18	134.34	129.93	138.12	95.28	108.40

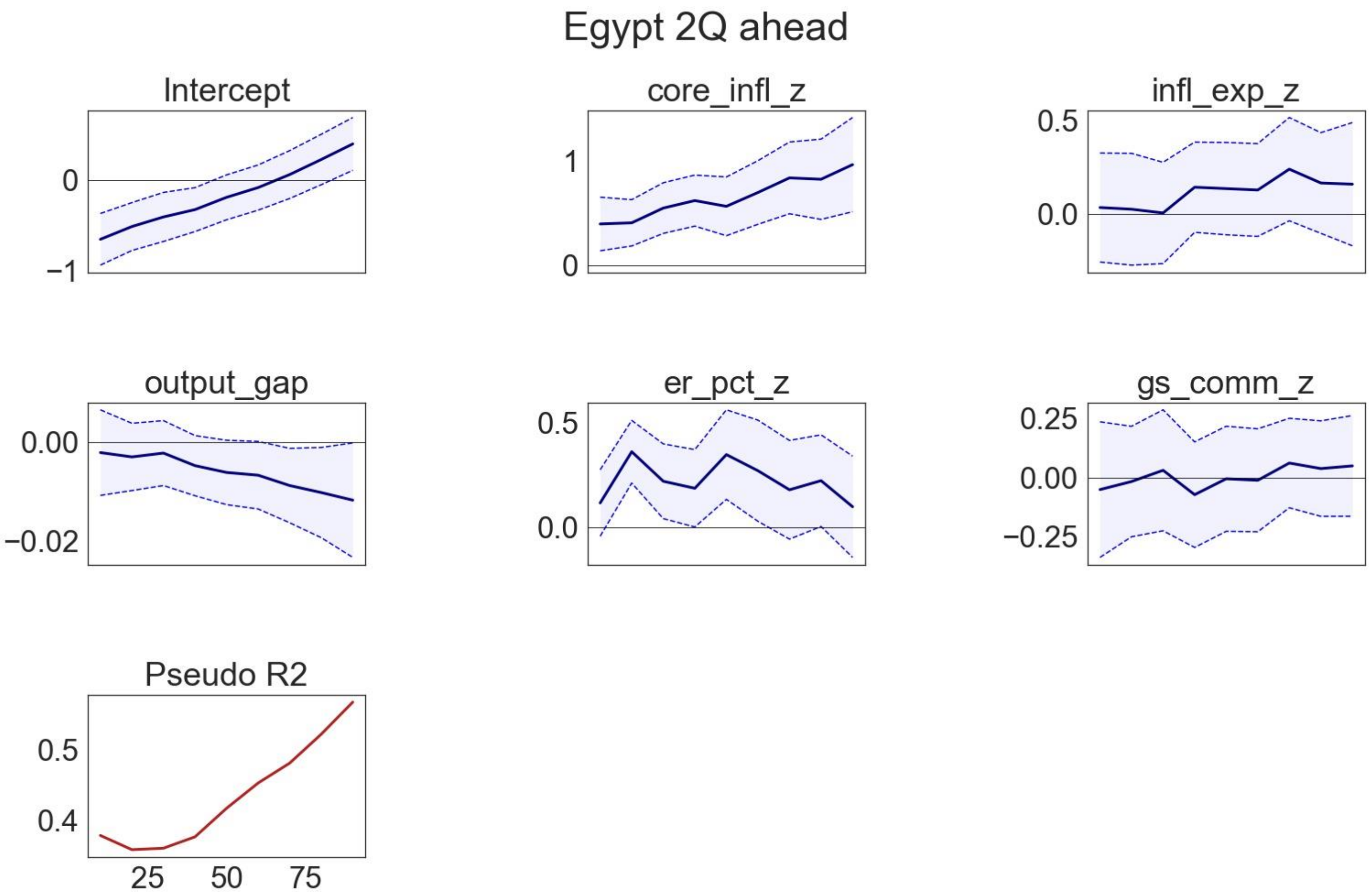
* p<0.2 ** p<0.1 *** p<0.05. HAC Standard Errors used.

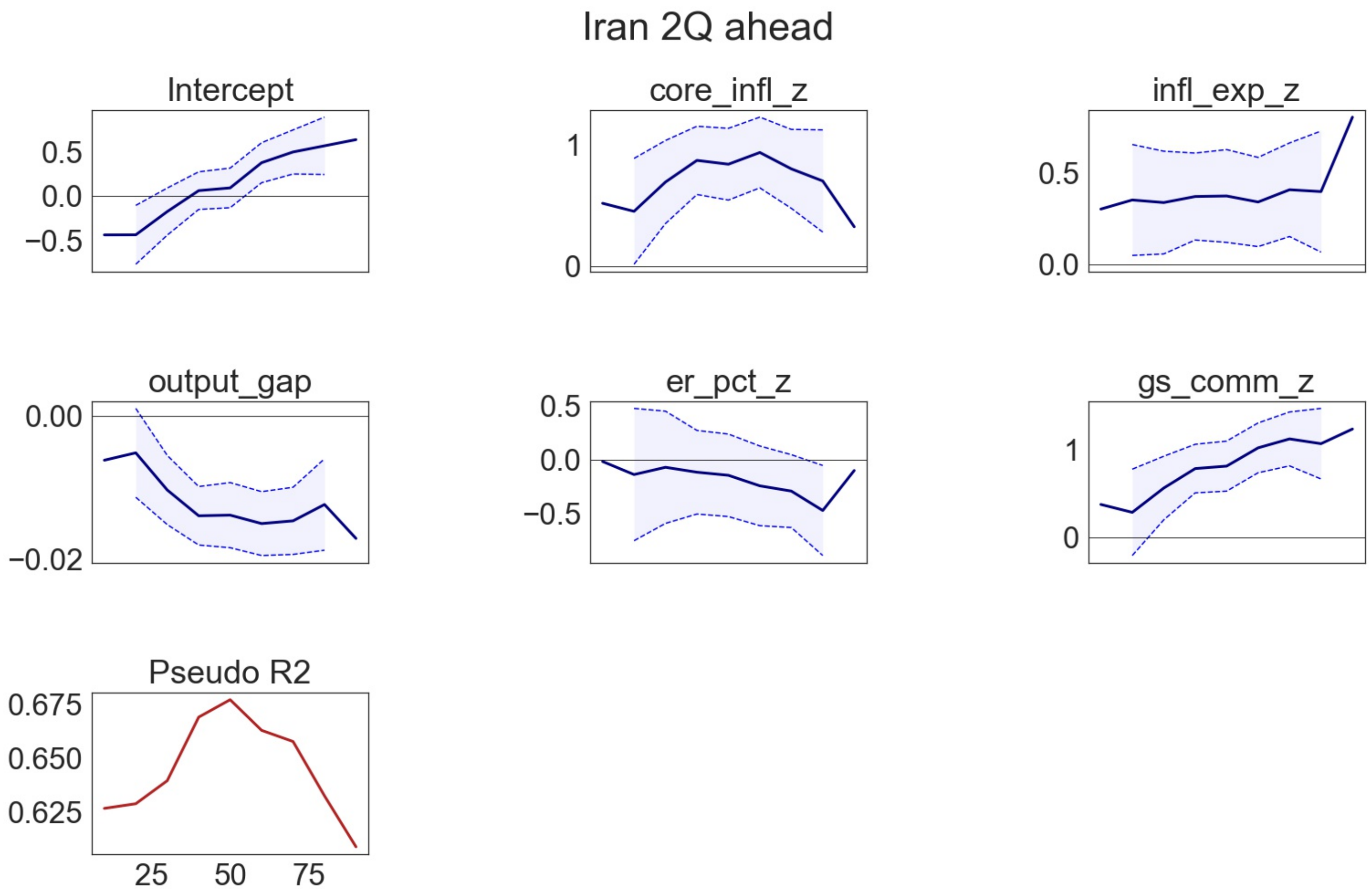
Appendix III. Quantile Regressions for Two-Quarter-Ahead Core Inflation By Country

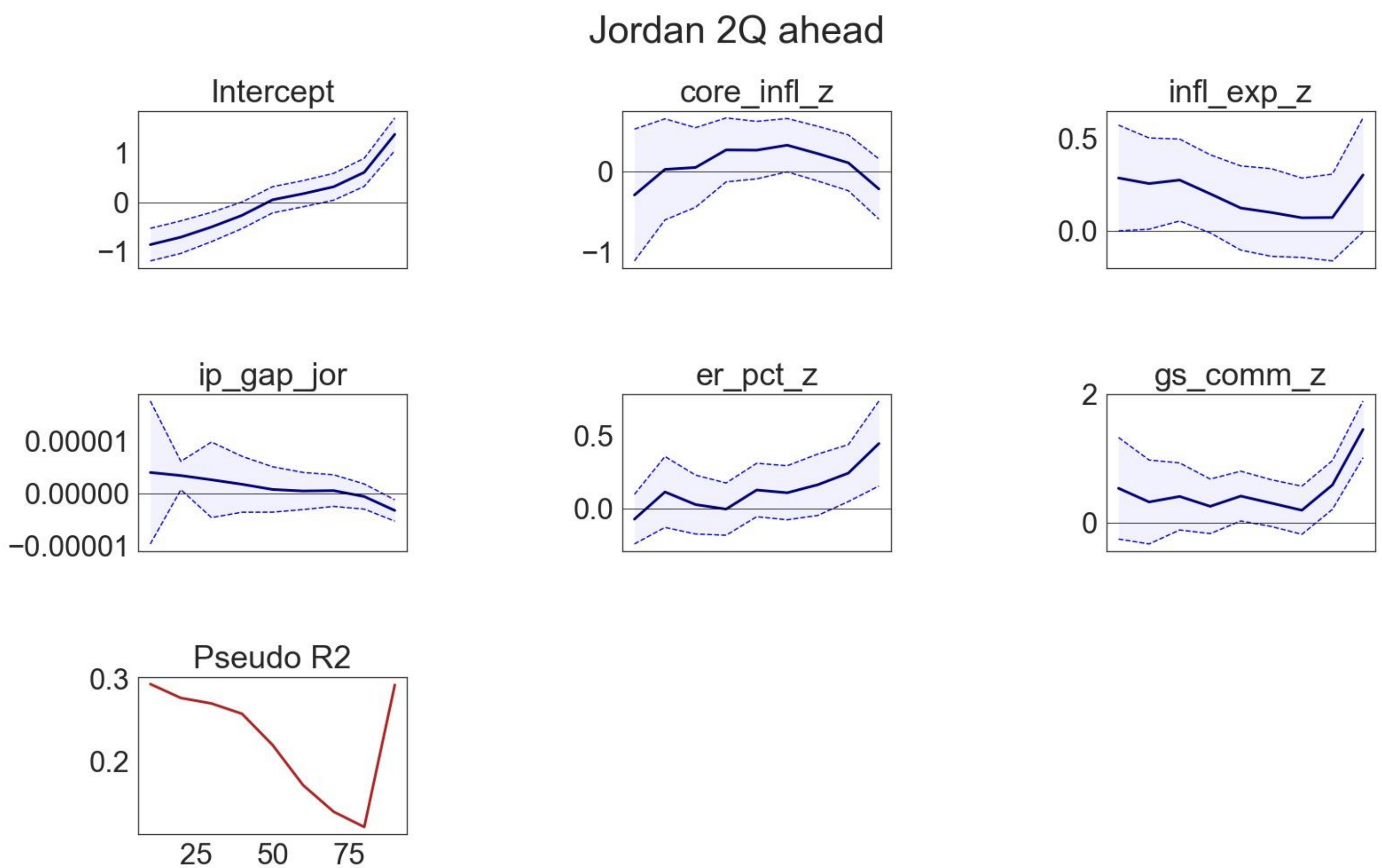


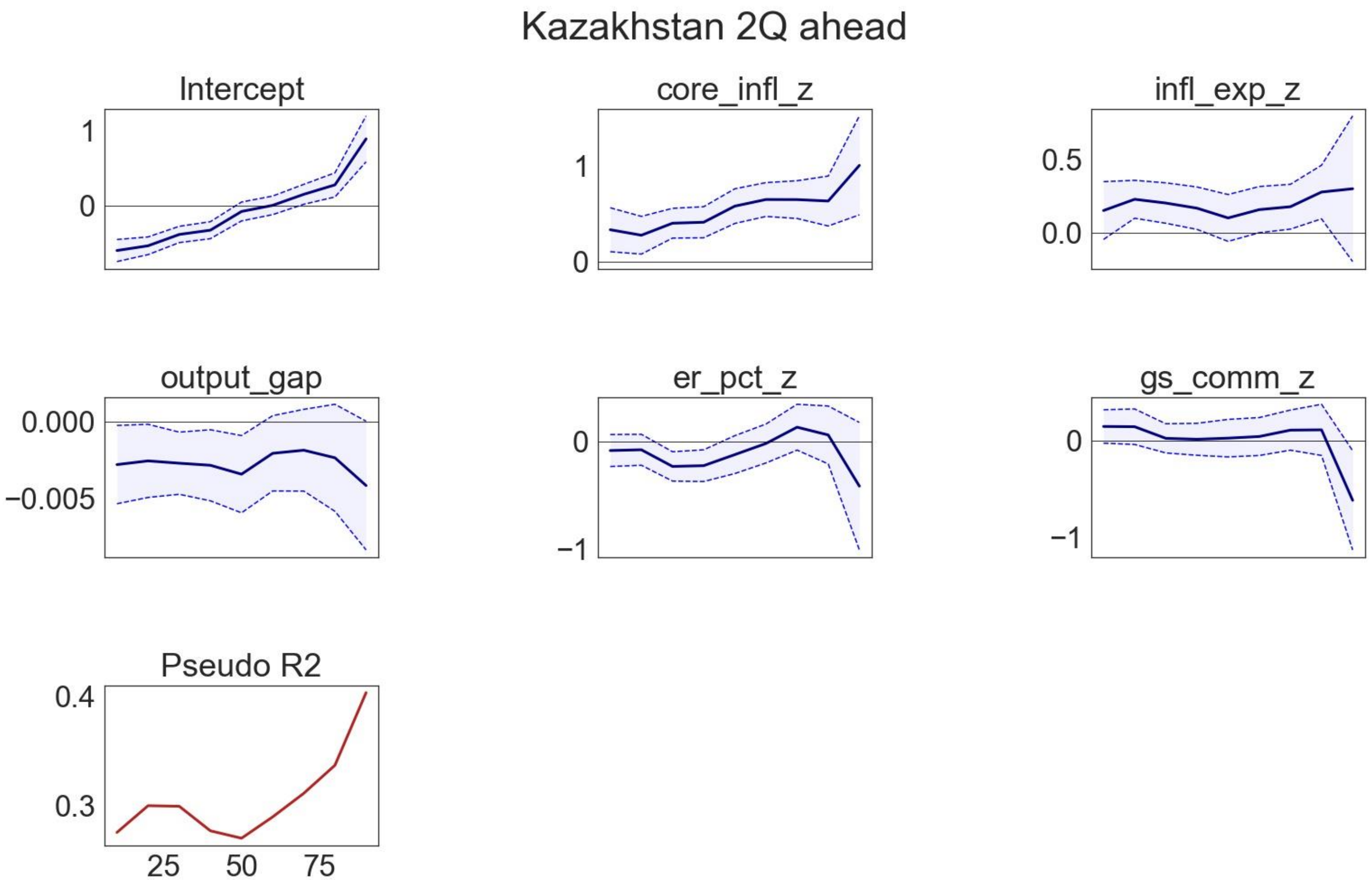

Armenia 2Q ahead
Intercept
1
0
−1
core_infl_z
0.5
0.0
infl_exp_z
0.0
−2.5
output_gap
0.000
−0.005
er_pct_z
1
0
gs_comm_z
1
0
Pseudo R2
0.4
0.3
25
50
75

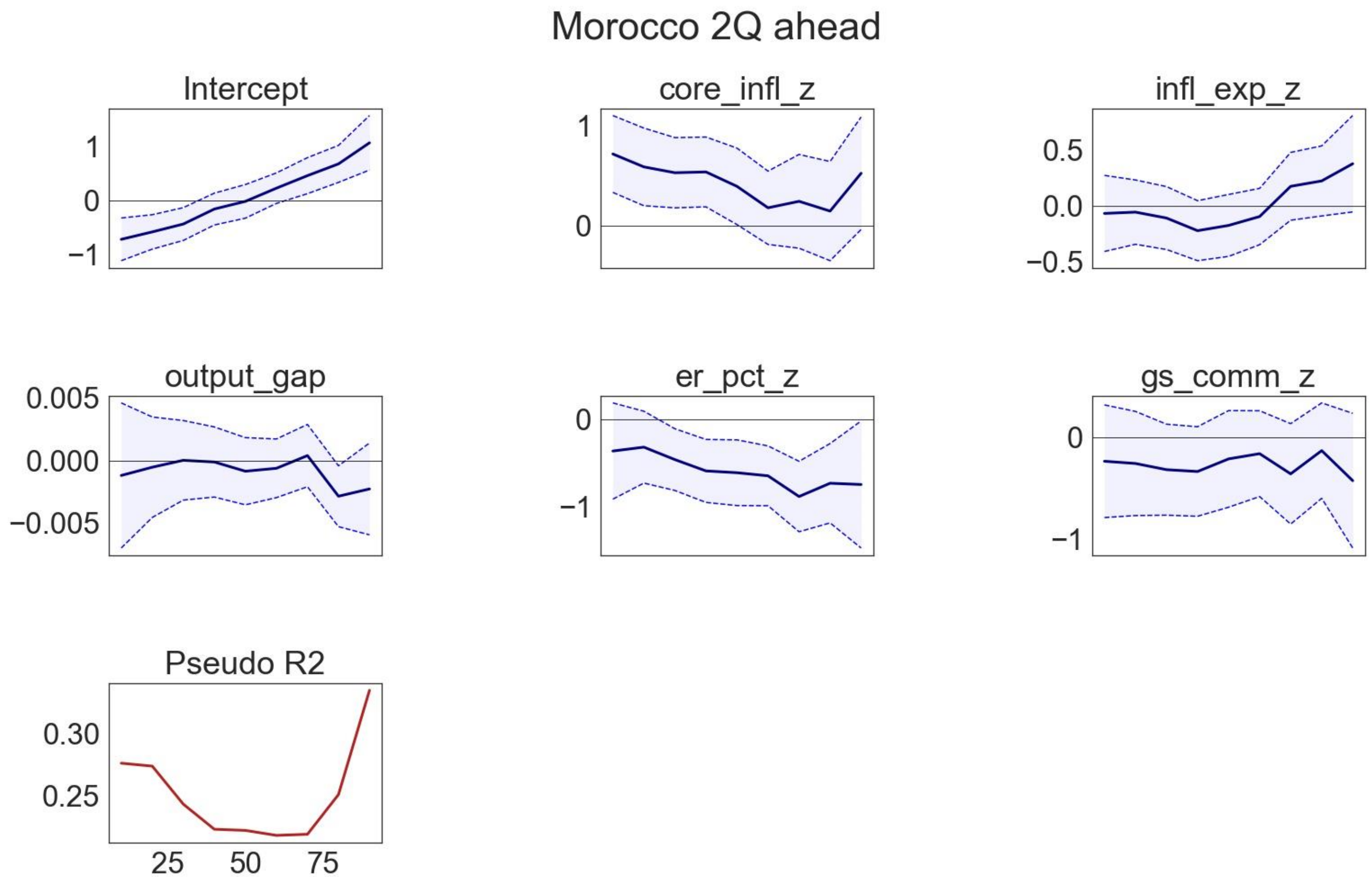

Bahrain 2Q ahead
Intercept
0
−1
core_infl_z
1.5
1.0
0.5
0.0
infl_exp_z
1.0
0.5
0.0
output_gap
0.000
−0.001
25 50 75
gs_comm_z
0.5
0.0
25 50 75
Bahrain2
0.5
0.4
0.3
25 50 75

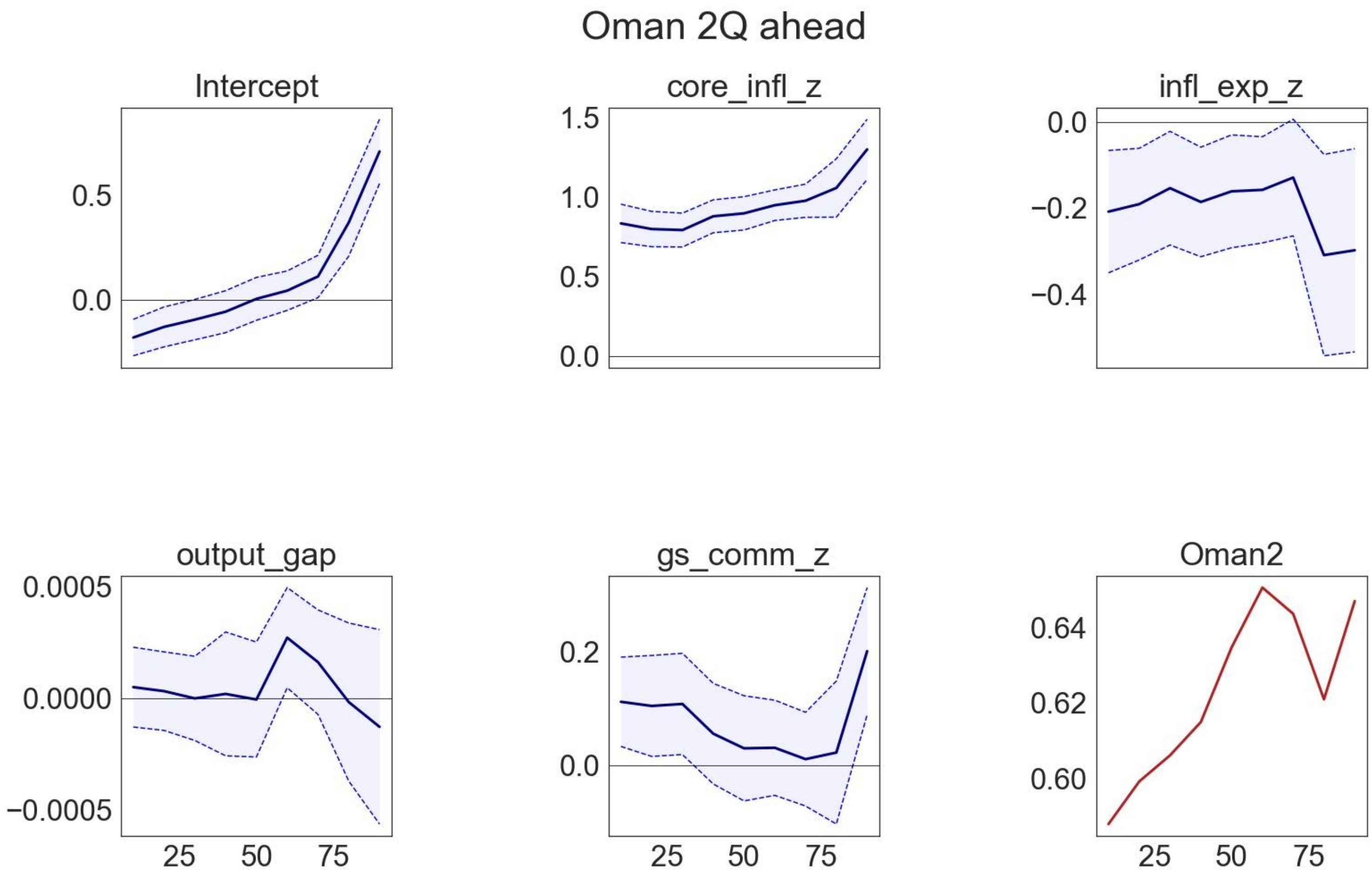

Egypt 2Q ahead
Intercept
0
−1
core_infl_z
1
0
infl_exp_z
0.5
0.0
output_gap
0.00
−0.02
er_pct_z
0.5
0.0
gs_comm_z
0.25
0.00
−0.25
Pseudo R2
0.5
0.4
25
50
75

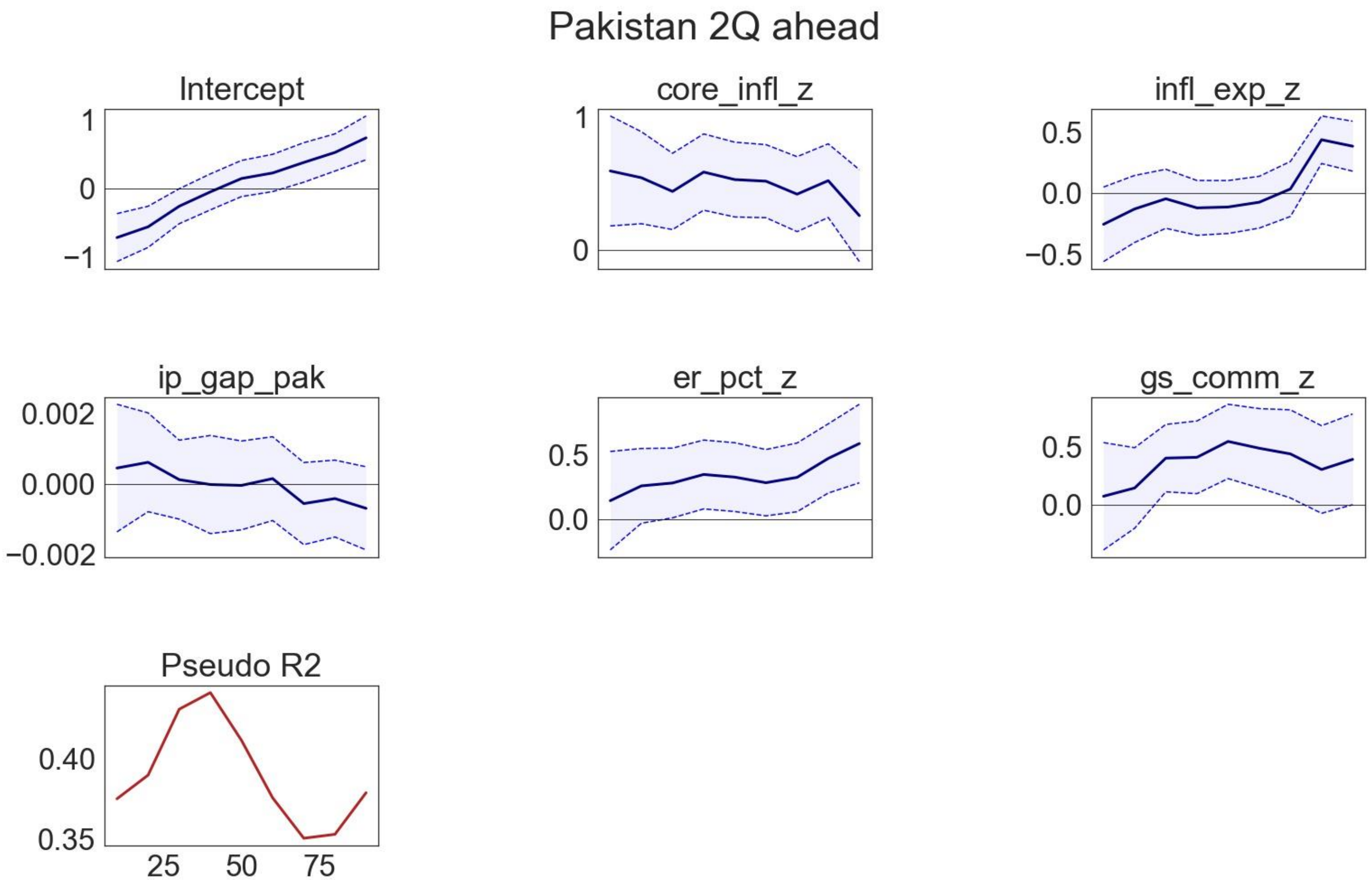

Iran 2Q ahead
Intercept
0.5
0.0
−0.5
core_infl_z
1
0
infl_exp_z
0.5
0.0
output_gap
0.00
−0.02
er_pct_z
0.5
0.0
−0.5
gs_comm_z
1
0
Pseudo R2
0.675
0.650
0.625
25
50
75

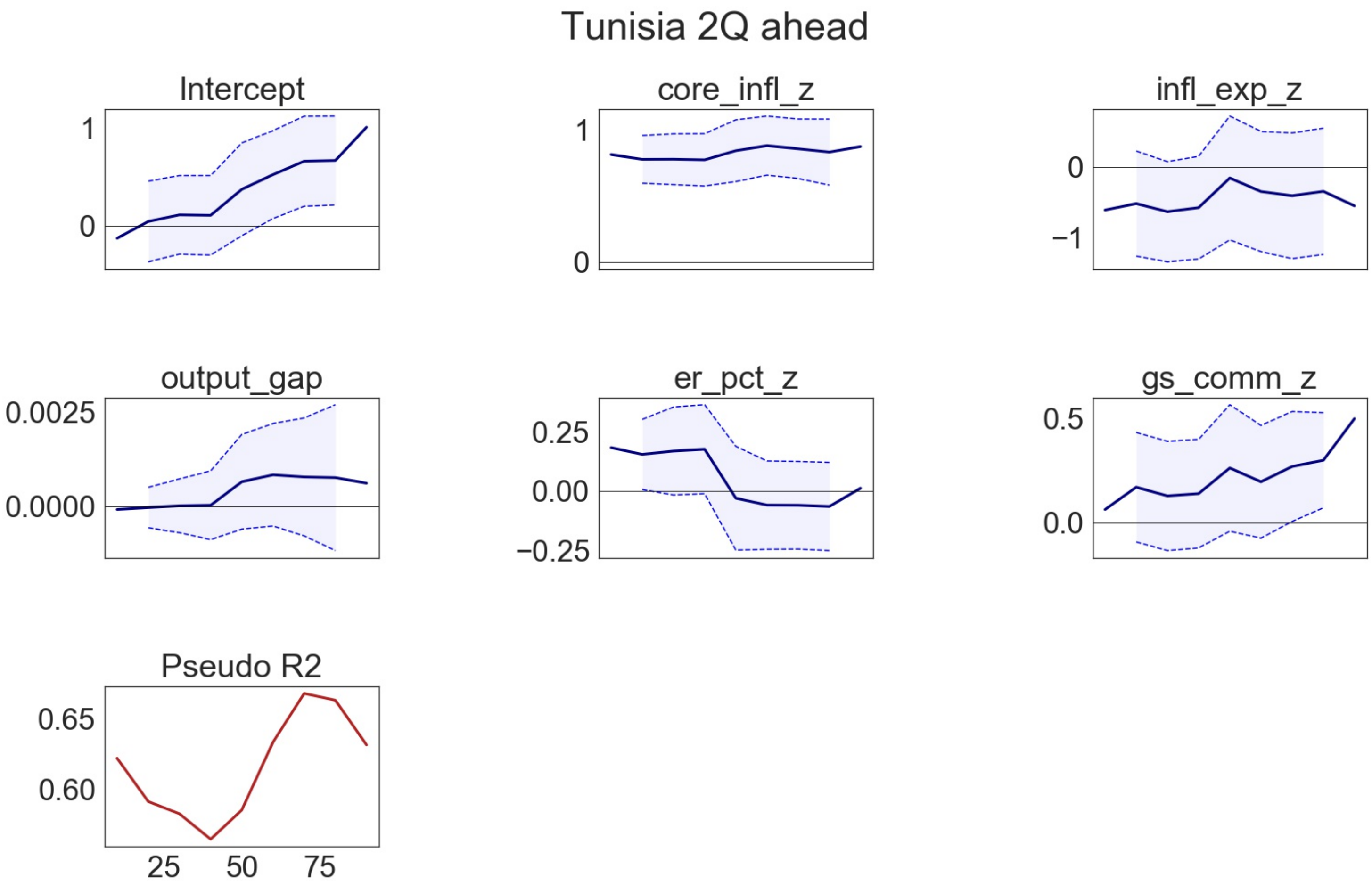

Jordan 2Q ahead
Intercept
1
0
−1
core_infl_z
0
−1
infl_exp_z
0.5
0.0
ip_gap_jor
0.00001
0.00000
−0.00001
er_pct_z
0.5
0.0
gs_comm_z
2
0
Pseudo R2
0.3
0.2
25
50
75

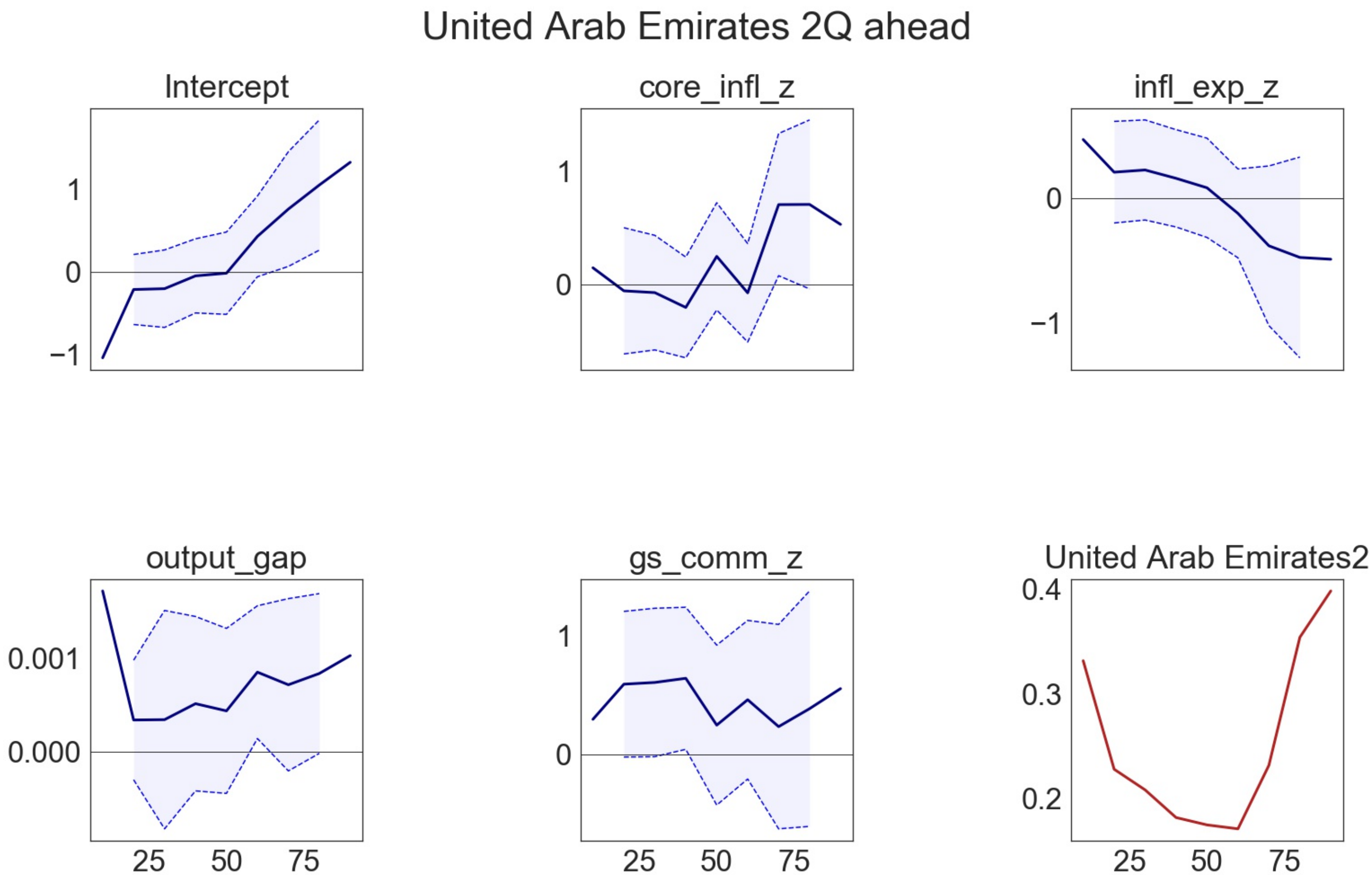

Kazakhstan 2Q ahead
Intercept
core_infl_z
infl_exp_z
output_gap
er_pct_z
gs_comm_z
Pseudo R2
1
0
1
0
0.5
0.0
0.000
−0.005
0
−1
0
−1
0.4
0.3
25
50
75


Morocco 2Q ahead
Intercept
1
0
−1
core_infl_z
1
0
infl_exp_z
0.5
0.0
−0.5
output_gap
0.005
0.000
−0.005
er_pct_z
0
−1
gs_comm_z
0
−1
Pseudo R2
0.30
0.25
25
50
75


Oman 2Q ahead
Intercept
core_infl_z
infl_exp_z
output_gap
gs_comm_z
Oman2
0.5
0.0
1.5
1.0
0.5
0.0
0.0
−0.2
−0.4
0.0005
0.0000
−0.0005
0.2
0.0
0.64
0.62
0.60
25
50
75


Pakistan 2Q ahead
Intercept
core_infl_z
infl_exp_z
ip_gap_pak
er_pct_z
gs_comm_z
Pseudo R2
1
0
−1
0.5
0.0
−0.5
0.002
0.000
−0.002
0.40
0.35
25
50
75


Tunisia 2Q ahead
Intercept
core_infl_z
infl_exp_z
output_gap
er_pct_z
gs_comm_z
Pseudo R2
1
0
1
0
0
−1
0.0025
0.0000
0.25
0.00
−0.25
0.5
0.0
0.65
0.60
25
50
75


United Arab Emirates 2Q ahead
Intercept
core_infl_z
infl_exp_z
output_gap
gs_comm_z
United Arab Emirates2
1
0
−1
0.001
0.000
0.4
0.3
0.2
25
50
75

Appendix IV. Four-Quarter-Ahead Core Inflation - Quantile Coefficients by Regressor[9]

Current Core Inflation

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	-0.489	-0.003	-0.025	-0.071	-0.021	-0.112	-0.127	-0.066	-0.062
Armenia	-0.222	-0.063	-0.035	-0.111	-0.110	-0.069	-0.080	-0.056	-0.199
Bahrain	0.547	0.748	0.650	0.513	0.295	0.331	0.248	0.307	0.462
Egypt	0.335	0.321	0.275	0.212	0.158	0.136	0.287	0.411	0.701
Iran	0.323	0.225	0.220	0.191	0.172	-0.056	-0.054	0.033	-0.543
Jordan	-0.737	-0.225	-0.166	-0.273	-0.204	-0.238	-0.265	-0.268	-0.068
Kazakhstan	0.162	0.334	0.318	0.259	0.259	0.400	0.305	0.470	0.597
Morocco	-0.316	-0.498	-0.382	-0.177	-0.246	-0.288	-0.251	-0.136	-0.431
Oman	0.773	0.730	0.718	0.701	0.744	0.750	0.740	1.043	1.176
Pakistan	0.065	0.002	-0.230	-0.115	-0.266	-0.250	-0.122	-0.096	0.000
Tunisia	0.663	0.453	0.458	0.642	0.655	0.637	0.689	0.746	1.146
United Arab Emirates	-0.402	-0.418	-0.451	-0.536	-0.591	-0.544	-0.419	-1.199	-1.246
Country Average	*0.059*	*0.134*	*0.112*	*0.103*	*0.070*	*0.058*	*0.079*	*0.099*	*0.128*

Less Inflationary *More Inflationary*

Inflation Expectations

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	-0.088	-0.144	-0.173	-0.297	-0.354	-0.377	-0.418	-0.428	-0.331
Armenia	0.189	0.1645	0.1407	0.3314	0.338	0.6418	0.8737	0.9863	-0.355
Bahrain	0.2418	0.1941	0.2838	0.2711	0.2049	0.466	0.4443	0.4008	0.3025
Egypt	0.1329	0.0678	0.2007	0.3342	0.1808	0.1821	0.1356	-0.109	-0.239
Iran	0.4558	0.4926	0.607	0.7903	0.7499	0.9749	0.9435	1.0935	1.2026
Jordan	0.4293	0.4537	0.4781	0.4242	0.223	0.1446	0.1414	0.0738	0.2186
Kazakhstan	0.2318	0.2115	0.204	0.2863	0.2612	0.2802	0.3522	0.4591	0.5731
Morocco	-0.426	-0.477	-0.287	-0.043	-0.116	0.0055	-0.051	0.1261	0.2693
Oman	-0.314	-0.284	-0.295	-0.245	-0.148	-0.174	-0.203	-0.815	-1.123
Pakistan	-0.149	0.0857	0.149	0.1074	0.0004	0.153	0.1298	0.0862	0.3698
Tunisia	-0.599	-0.108	-1.137	-1.172	-0.646	-0.729	-0.769	-0.696	-0.923
United Arab Emirates	0.0047	0.0748	0.1604	0.158	0.0933	-0.136	-0.277	-0.519	-0.625
Country Average	*0.009*	*0.061*	*0.028*	*0.079*	*0.066*	*0.119*	*0.108*	*0.055*	*-0.055*

[9] *For a given variable, the heat maps below show the coefficients for each country at different quantiles. Except for the output gap, the variables are all standardized; this means the coefficient equals the size of the standard deviation movement in 2Q-ahead core inflation associated with a one standard deviation movement in the variable shown.*

Output Gap

	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001
Armenia	0.002	0.000	-0.002	-0.001	-0.002	-0.004	-0.003	-0.005	-0.007
Bahrain	-0.002	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	-0.001
Egypt	-0.002	-0.003	-0.005	-0.005	-0.003	-0.004	-0.005	-0.010	-0.014
Iran	-0.009	-0.009	-0.013	-0.018	-0.018	-0.020	-0.020	-0.024	-0.015
Jordan 1/	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kazakhstan	0.001	0.000	0.000	-0.001	-0.001	-0.001	0.001	0.004	-0.003
Morocco	-0.004	-0.003	-0.002	-0.002	-0.001	-0.003	-0.004	-0.003	-0.002
Oman	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
Pakistan 1/	0.001	0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.001	-0.001
Tunisia	-0.002	0.002	0.004	0.000	-0.001	0.000	-0.002	-0.004	-0.011
United Arab Emirates	-0.005	-0.005	-0.004	-0.004	-0.005	-0.006	-0.006	-0.008	-0.009
Country Aveage	*-0.002*	*-0.001*	*-0.002*	*-0.003*	*-0.003*	*-0.003*	*-0.003*	*-0.004*	*-0.005*

1/ Industrial production used instead of GDP

Exchange Rate[1/]

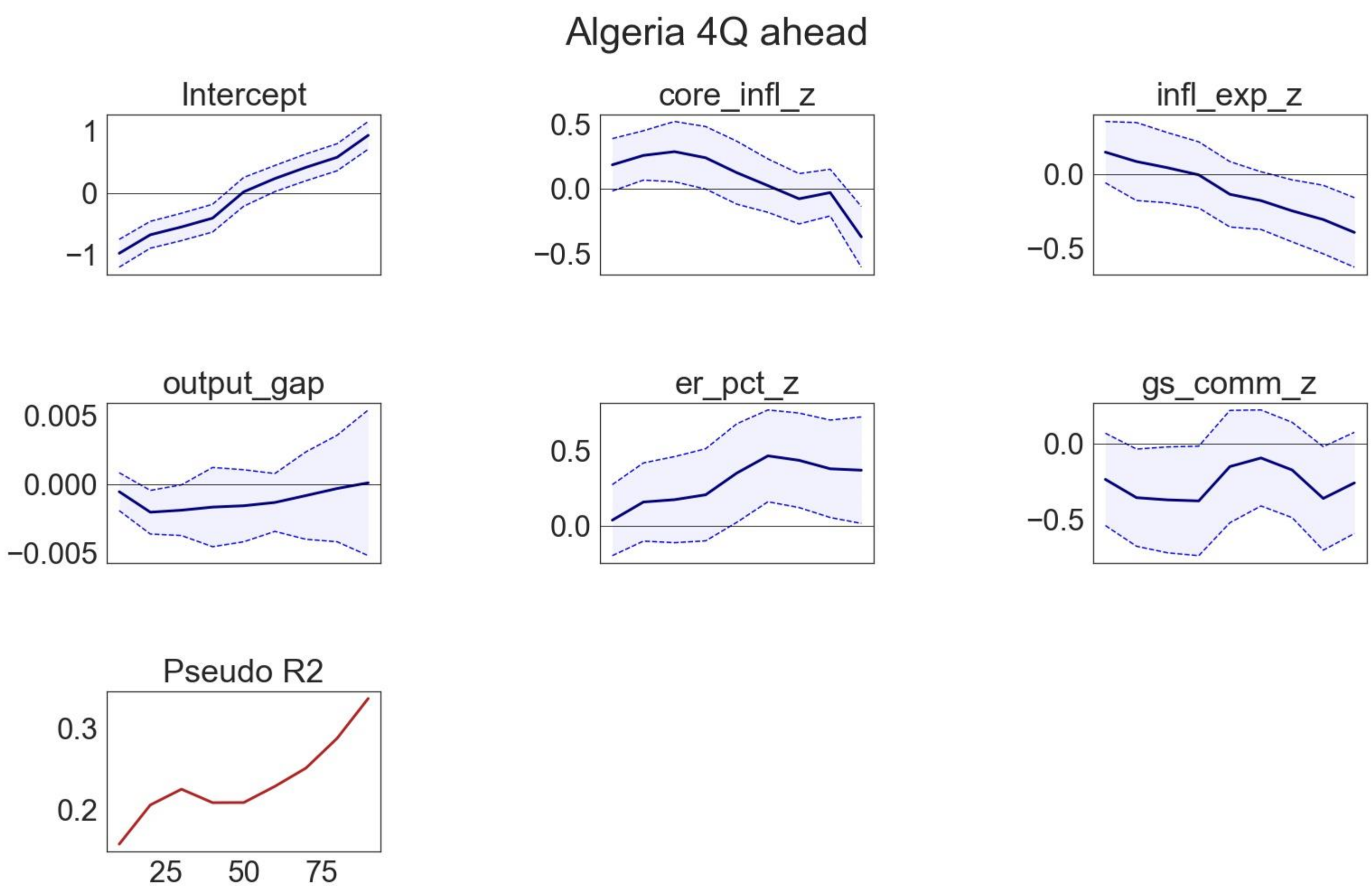
	Quantiles								
	10	20	30	40	50	60	70	80	90
Algeria	1.0153	0.7835	0.7651	0.8355	0.7238	0.8726	0.9156	0.9504	1.1547
Armenia	-0.095	-0.112	0.0068	-0.093	-0.046	-0.002	0.0099	0.6134	0.7314
Egypt	0.1619	0.1921	0.3198	0.3315	0.3205	0.3458	0.2516	0.1463	-0.061
Iran	-0.144	-0.285	-0.243	-0.397	-0.238	-0.327	-0.349	0.245	-0.063
Jordan	0.1687	0.2958	0.2867	0.2473	0.1537	0.1058	0.0877	0.0362	0.0578
Kazakhstan	-0.377	-0.372	-0.351	-0.347	-0.355	-0.505	-0.508	-0.696	-0.245
Morocco	-0.383	-0.244	-0.163	-0.339	-0.429	-0.405	-0.38	-0.359	-0.41
Pakistan	0.3021	0.3324	0.3783	0.3875	0.5933	0.5741	0.4397	0.3563	0.2732
Tunisia	0.2135	0.129	0.2839	0.1587	0.2327	0.2444	0.2225	0.158	-0.013
Country Aveage	*0.096*	*0.080*	*0.143*	*0.087*	*0.106*	*0.100*	*0.077*	*0.161*	*0.158*

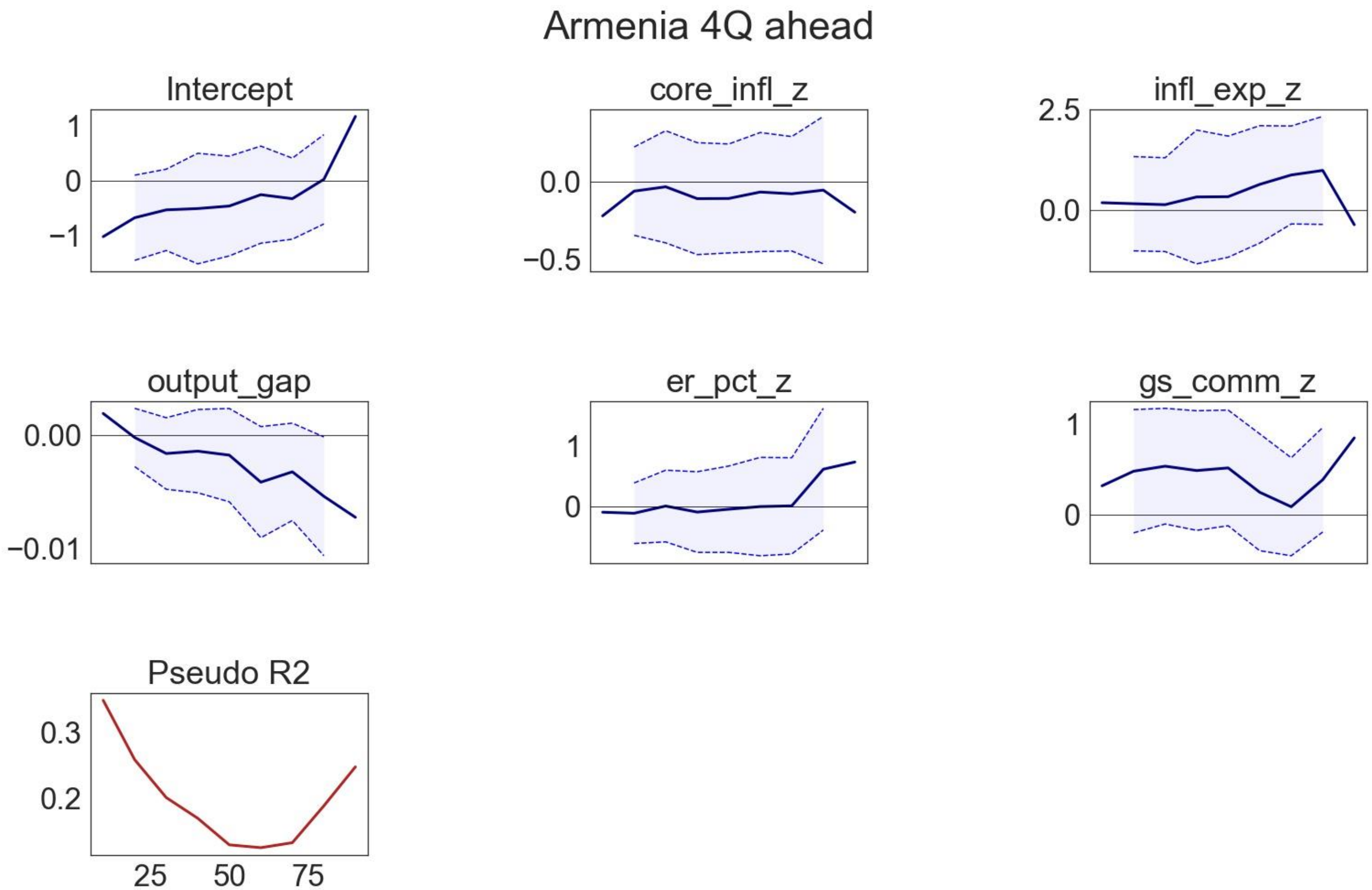
1/ Increase in the exchange rate translates to a depreciation. Bahrain, Oman, and the United Arab Emirates are excluded because they have fixed exchange rates.

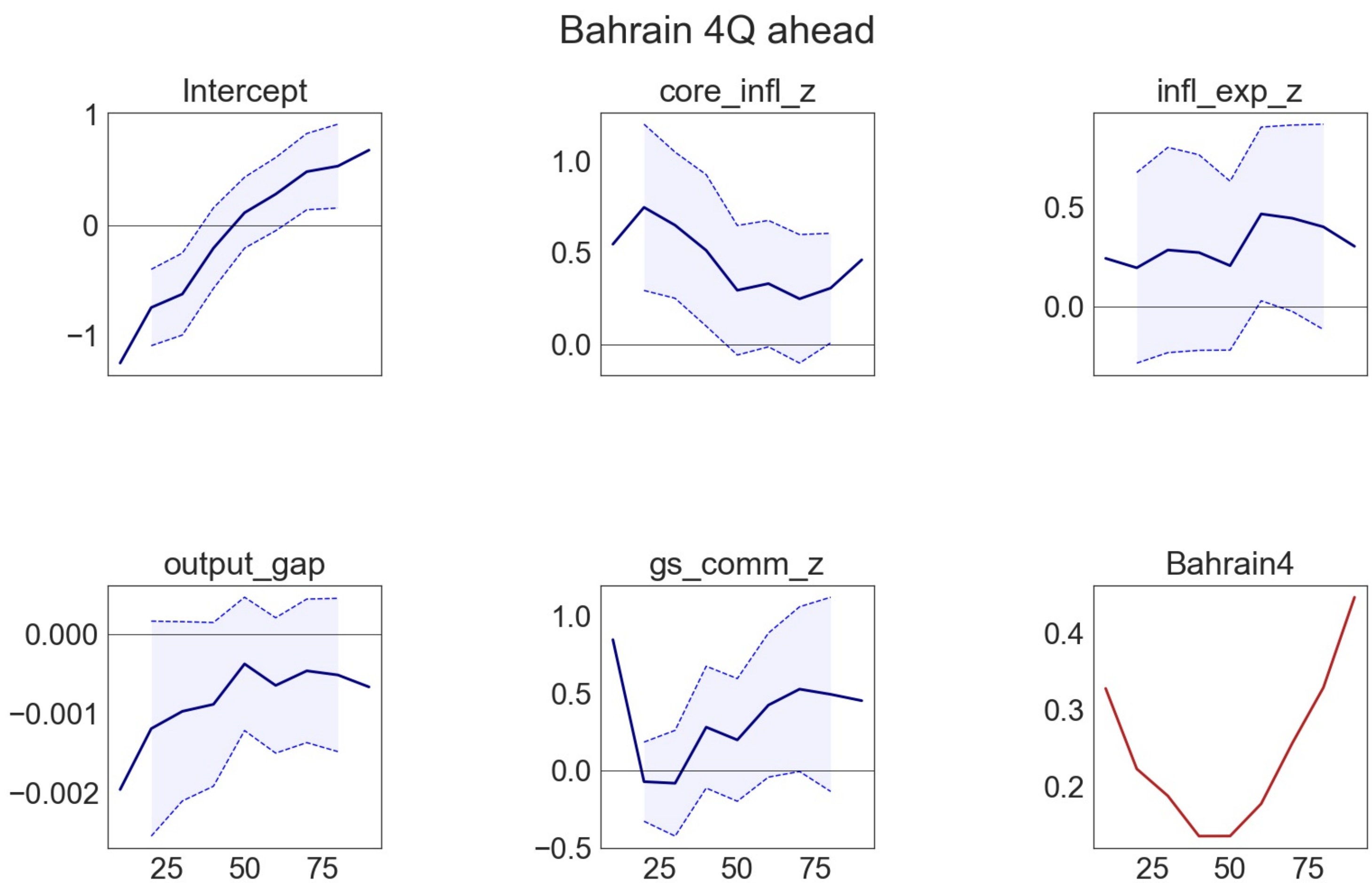
Commodity Prices

	Quantiles								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
Algeria	-0.181	-0.146	-0.137	0.2679	0.1537	0.0832	0.3242	0.4384	0.7827
Armenia	0.3215	0.4825	0.538	0.4899	0.519	0.2505	0.0906	0.3886	0.8501
Bahrain	0.8499	-0.072	-0.082	0.2821	0.1992	0.4252	0.5287	0.495	0.4538
Egypt	-0.008	-0.097	-0.079	-0.128	-0.316	-0.34	-0.429	-0.732	-1.072
Iran	0.6468	0.7827	0.949	1.267	1.4096	1.5157	1.568	1.7077	1.3118
Jordan	0.5735	-0.051	-0.063	0.0617	0.2534	0.1151	0.1362	0.0675	-0.117
Kazakhstan	-0.424	-0.276	-0.27	-0.164	-0.197	-0.263	-0.311	-0.844	-1.133
Morocco	0.3676	0.5029	0.2339	-0.231	-0.226	-0.18	-0.171	-0.217	-0.076
Oman	0.0028	0.0042	0.0031	-0.002	-0.016	-0.001	0.01	0.0444	0.2145
Pakistan	0.0448	0.338	0.6515	0.6858	0.848	0.8628	0.9237	0.9586	1.0057
Tunisia	0.1706	0.3883	0.2429	0.1739	0.2732	0.2656	0.4064	0.5673	1.0972
United Arab Emirates	0.4994	0.5564	0.7622	0.8543	0.7465	0.8742	0.9639	1.4406	1.3237
Country Average	*0.239*	*0.201*	*0.229*	*0.296*	*0.304*	*0.301*	*0.337*	*0.360*	*0.387*

Appendix V. Quantile Regressions For Four-Quarter-Ahead Core Inflation By Country




Armenia 4Q ahead
Intercept
1
0
−1
core_infl_z
0.0
−0.5
infl_exp_z
2.5
0.0
output_gap
0.00
−0.01
er_pct_z
1
0
gs_comm_z
1
0
Pseudo R2
0.3
0.2
25
50
75


Bahrain 4Q ahead
Intercept
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0
−1
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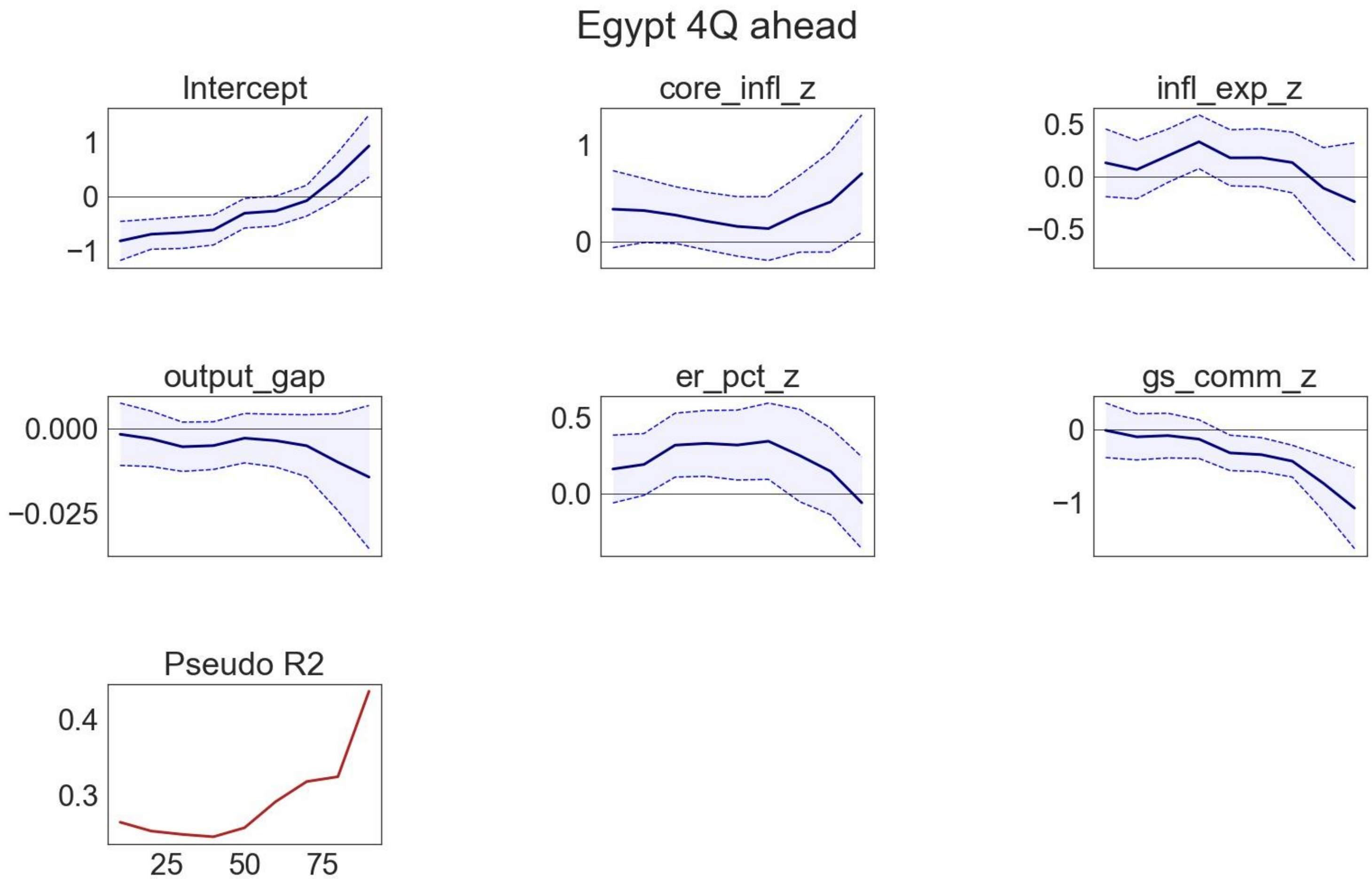
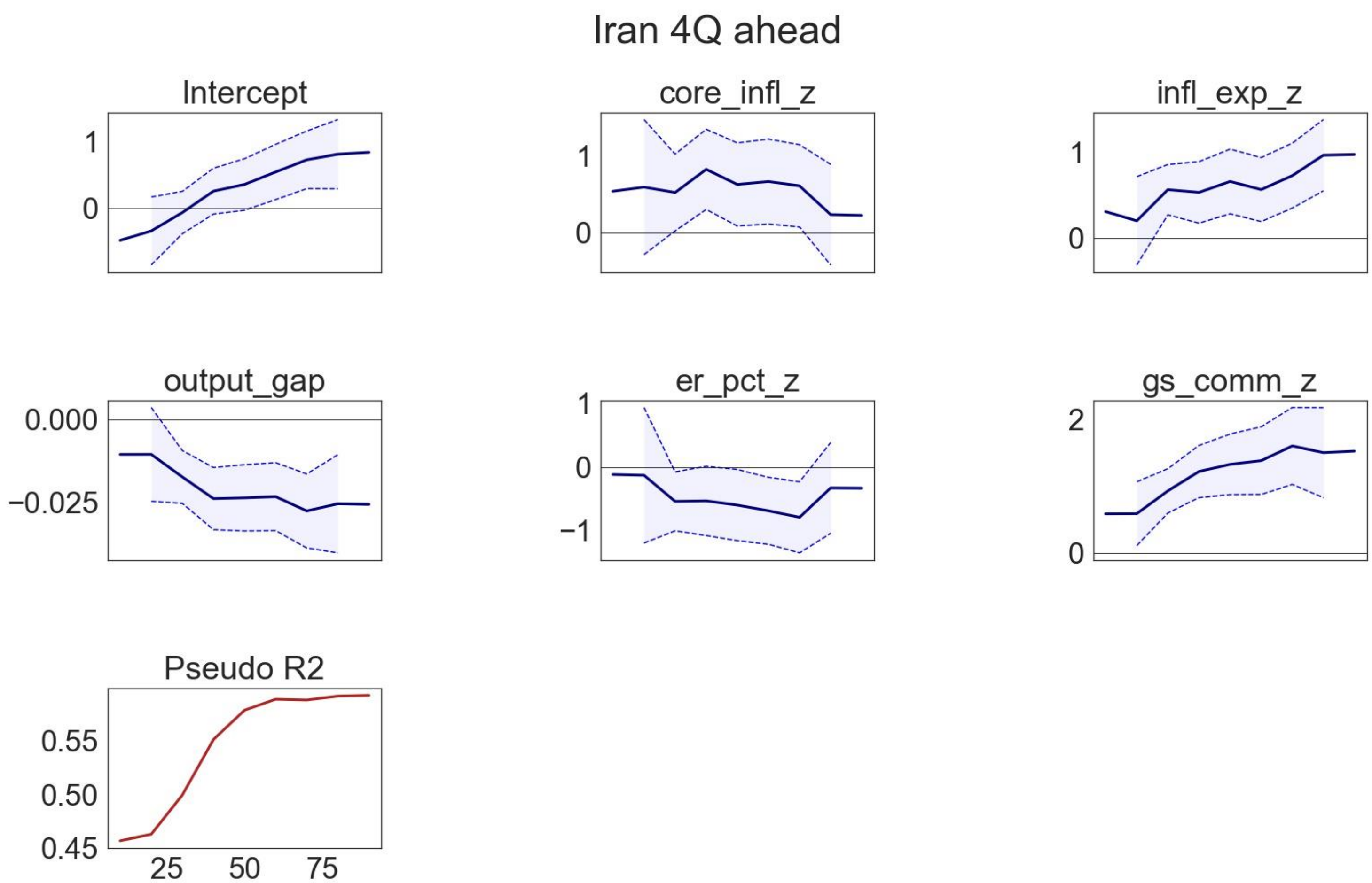
0.5
0.0
infl_exp_z
0.5
0.0
output_gap
0.000
−0.001
−0.002
25 50 75
gs_comm_z
1.0
0.5
0.0
−0.5
25 50 75
Bahrain4
0.4
0.3
0.2
25 50 75


Egypt 4Q ahead
Intercept
1
0
−1
core_infl_z
1
0
infl_exp_z
0.5
0.0
−0.5
output_gap
0.000
−0.025
er_pct_z
0.5
0.0
gs_comm_z
0
−1
Pseudo R2
0.4
0.3
25
50
75


Iran 4Q ahead
Intercept
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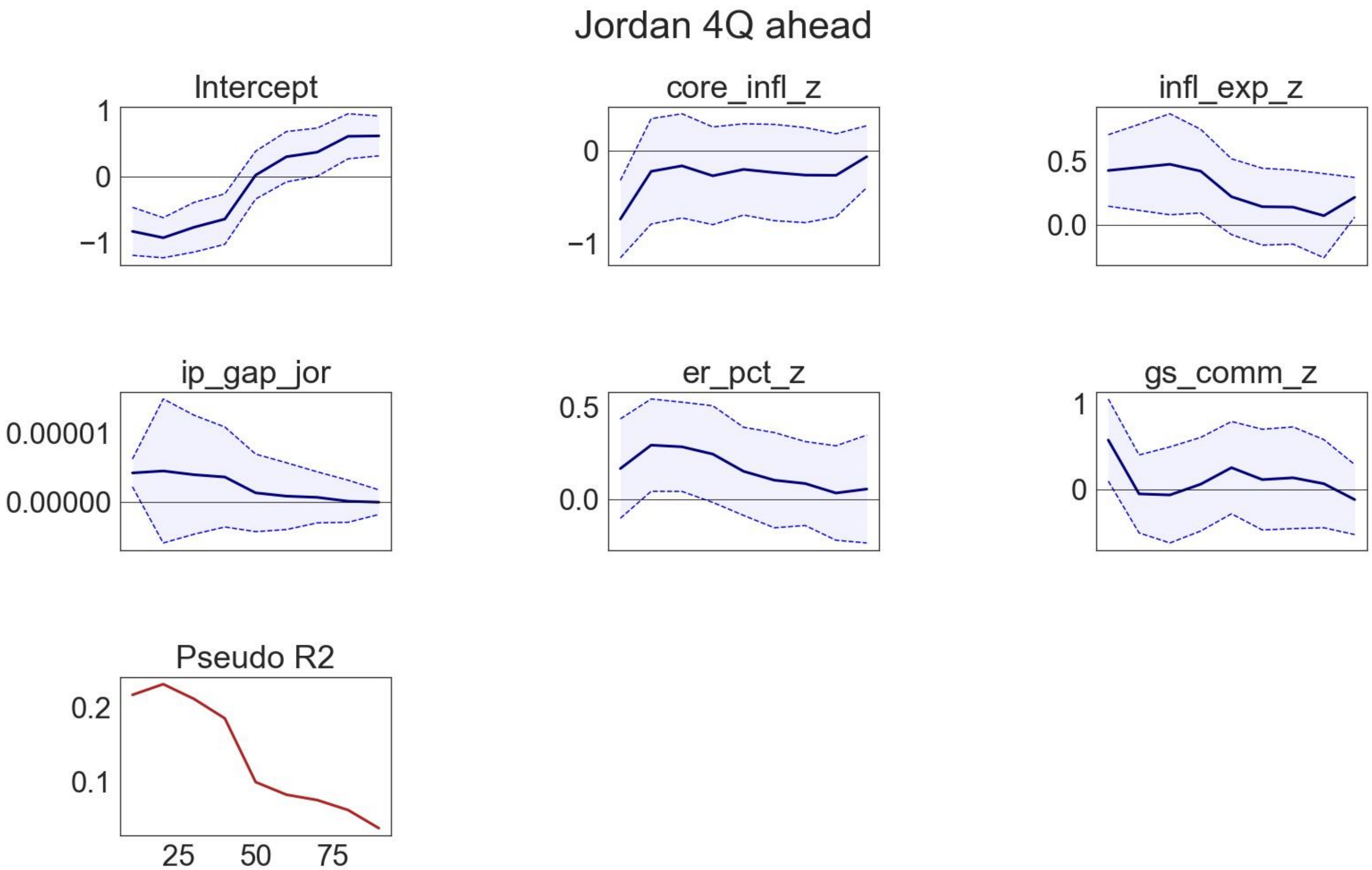
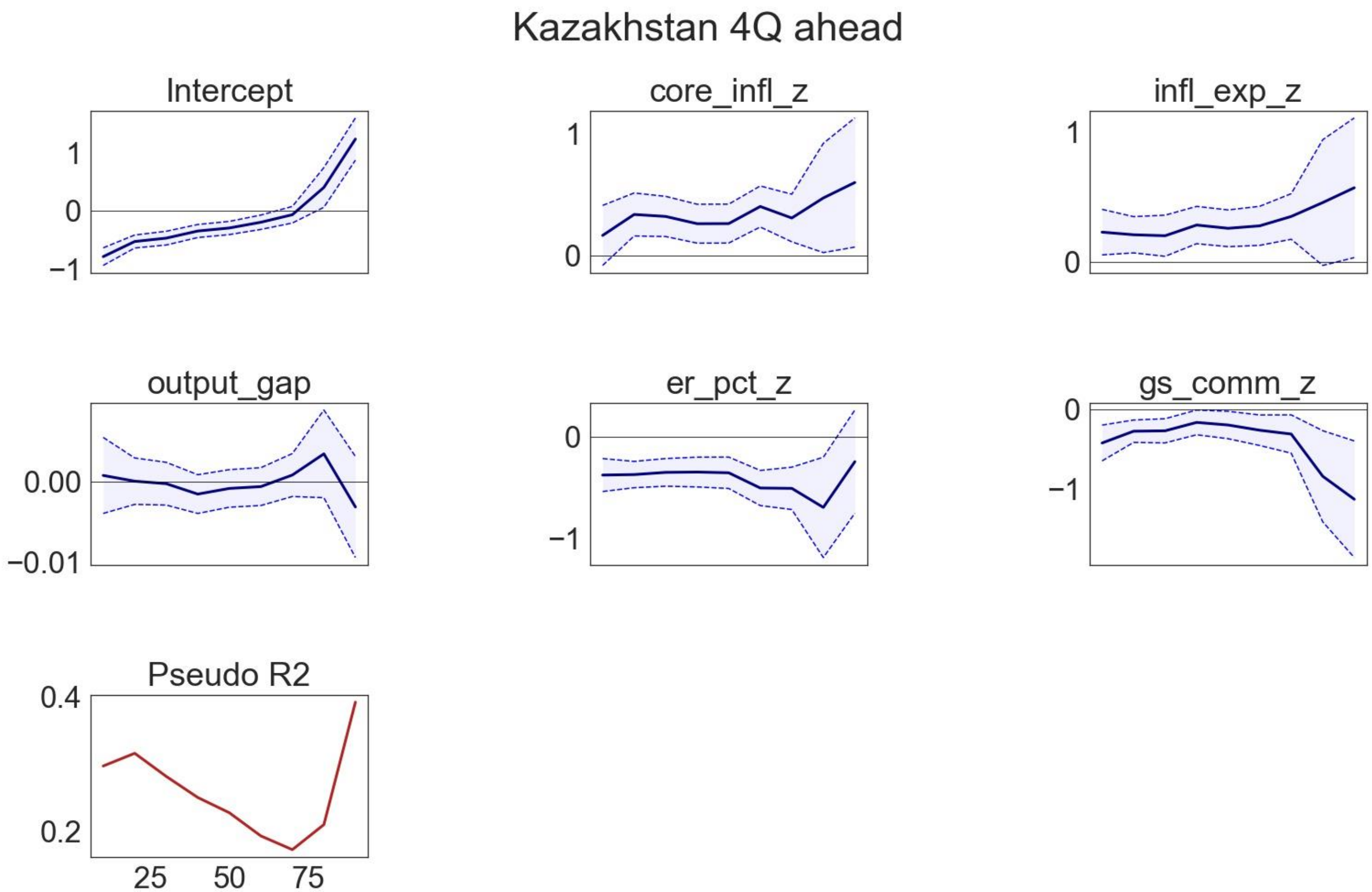
core_infl_z
1
0
infl_exp_z
1
0
output_gap
0.000
−0.025
er_pct_z
1
0
−1
gs_comm_z
2
0
Pseudo R2
0.55
0.50
0.45
25
50
75


Jordan 4Q ahead
Intercept
1
0
−1
core_infl_z
0
−1
infl_exp_z
0.5
0.0
ip_gap_jor
0.00001
0.00000
er_pct_z
0.5
0.0
gs_comm_z
1
0
Pseudo R2
0.2
0.1
25
50
75


Kazakhstan 4Q ahead
Intercept
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−1
core_infl_z
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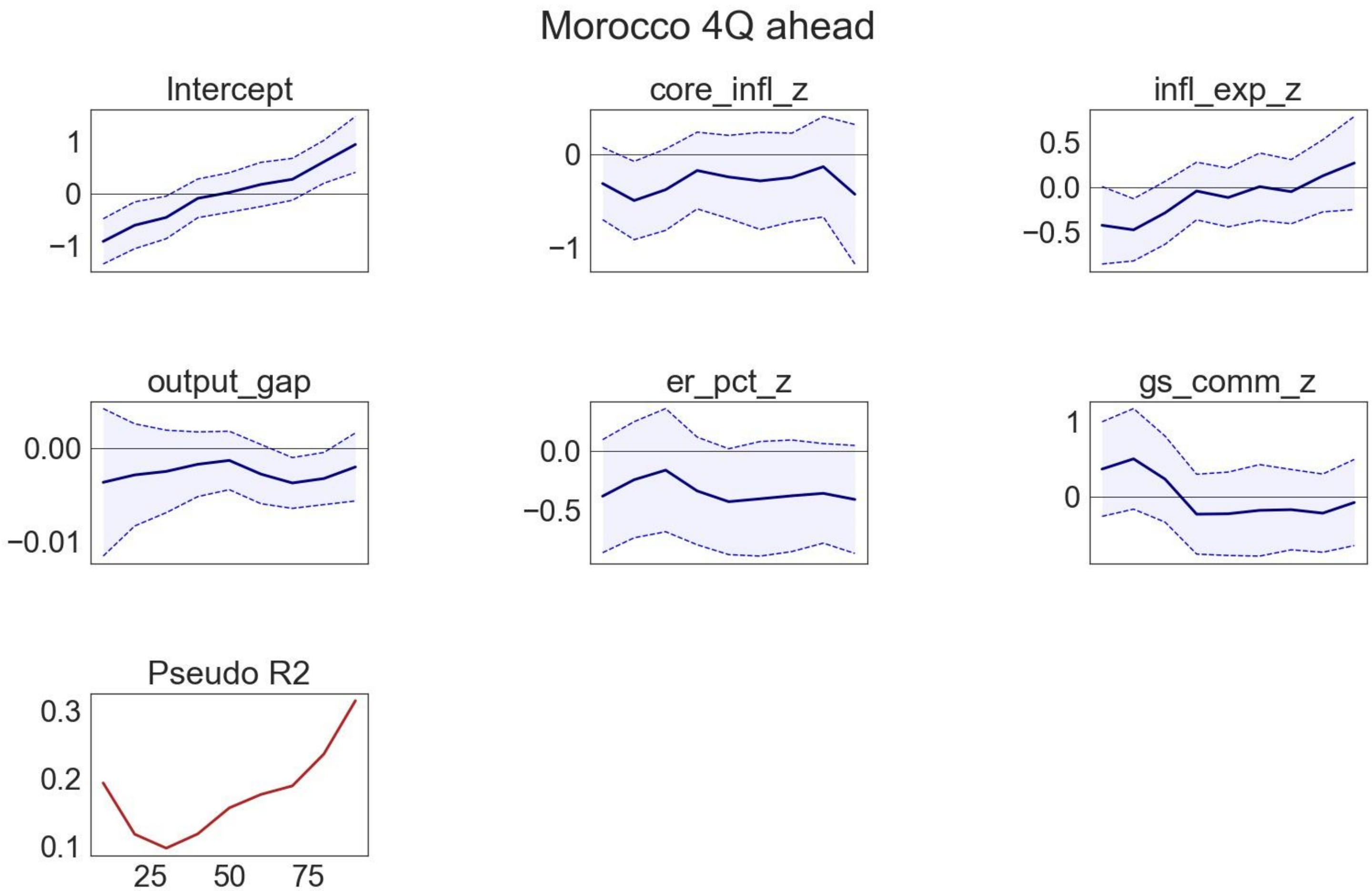
0
infl_exp_z
1
0
output_gap
0.00
−0.01
er_pct_z
0
−1
gs_comm_z
0
−1
Pseudo R2
0.4
0.2
25
50
75


Morocco 4Q ahead
Intercept
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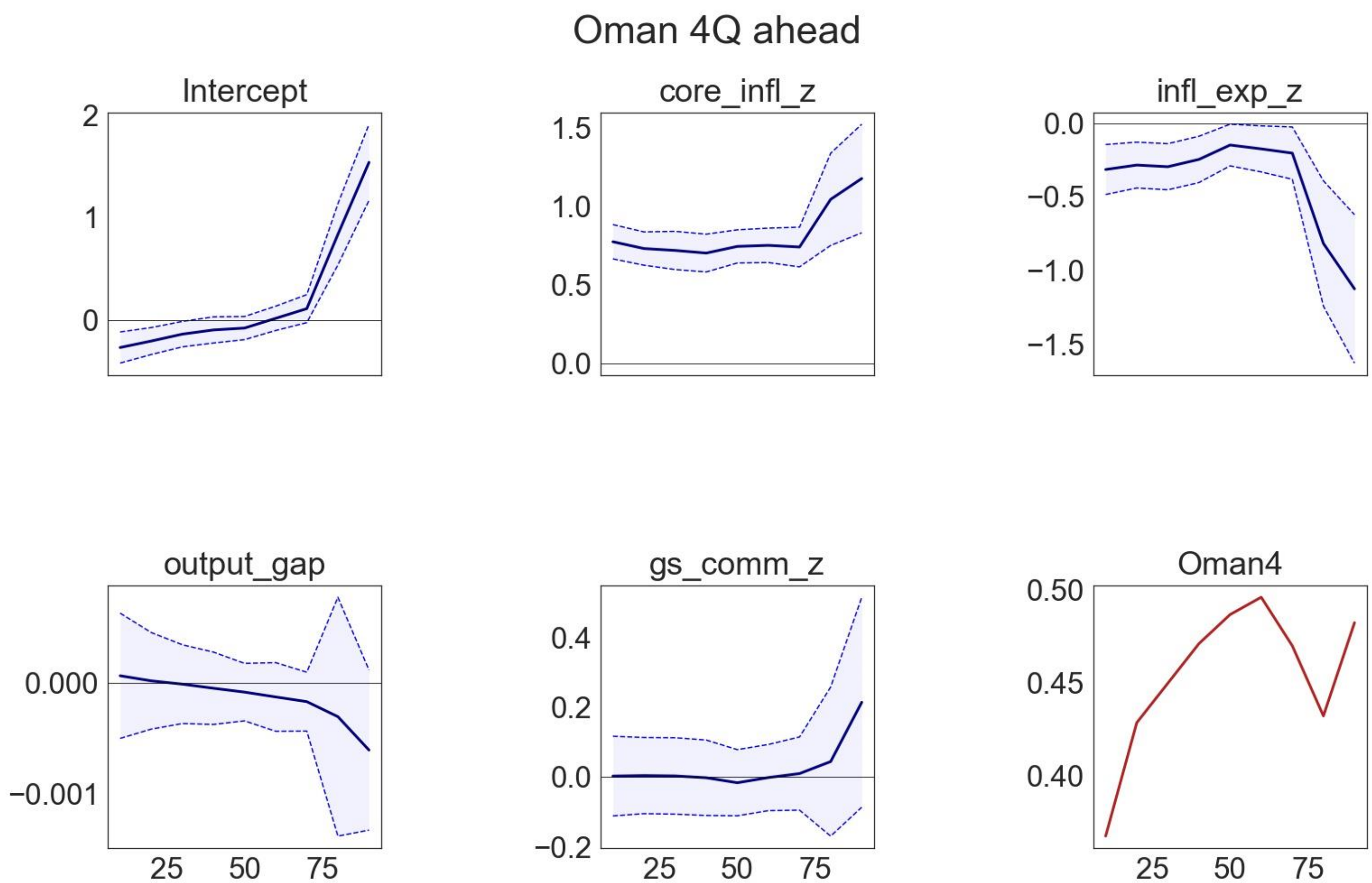
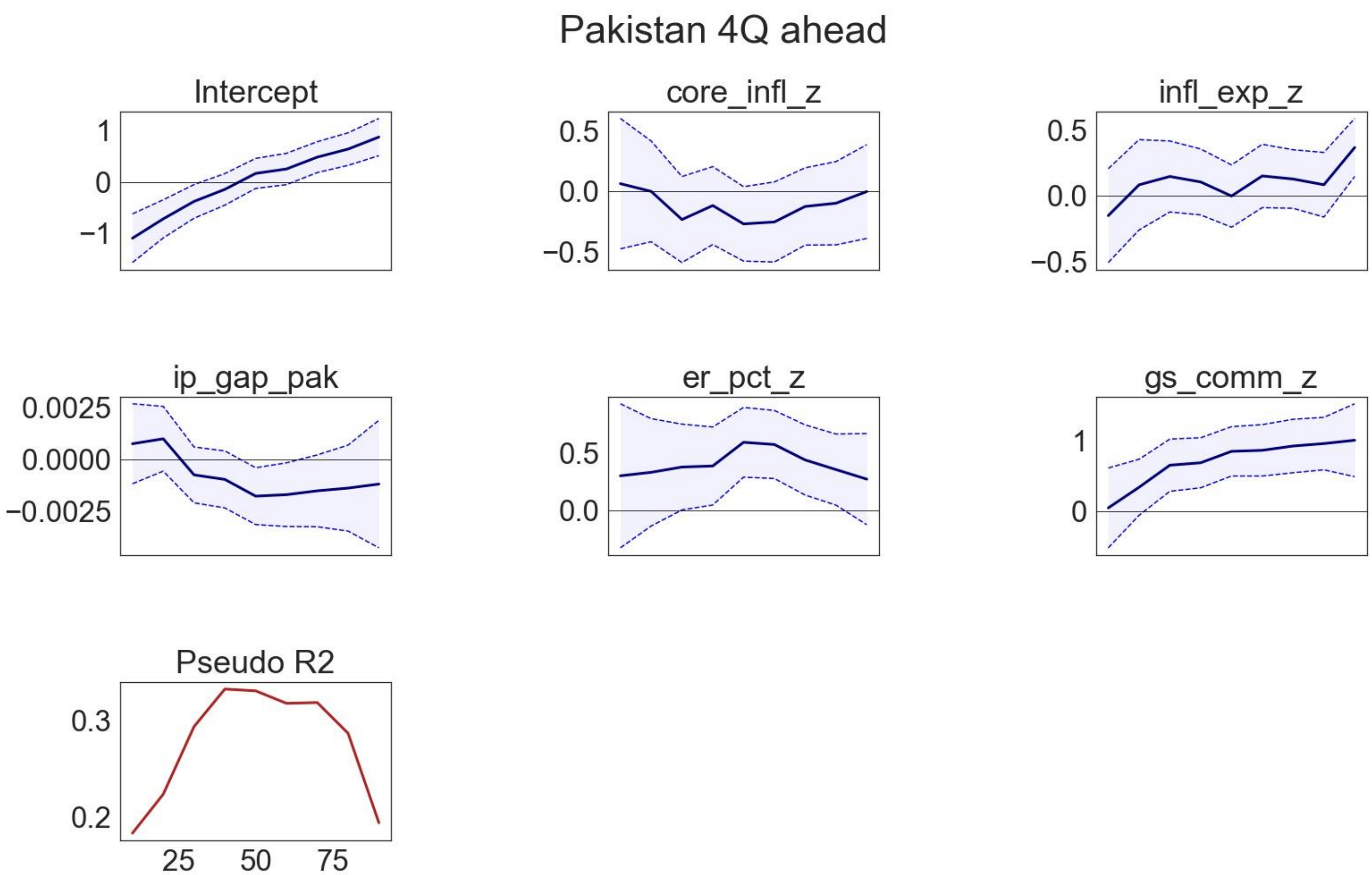
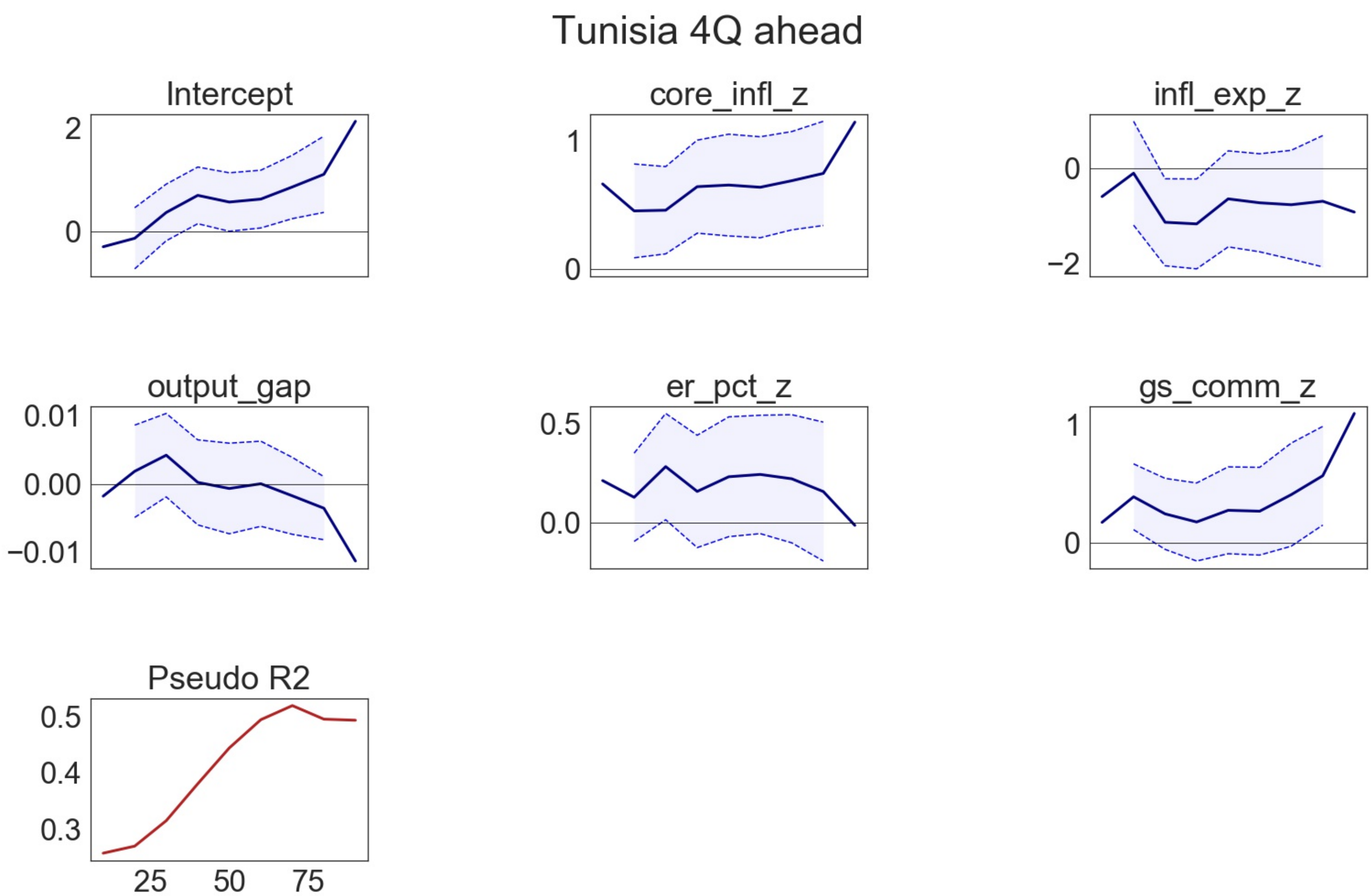
0
−1
core_infl_z
0
−1
infl_exp_z
0.5
0.0
−0.5
output_gap
0.00
−0.01
er_pct_z
0.0
−0.5
gs_comm_z
1
0
Pseudo R2
0.3
0.2
0.1
25
50
75


Oman 4Q ahead
Intercept
core_infl_z
infl_exp_z
output_gap
gs_comm_z
Oman4
2
1
0
1.5
1.0
0.5
0.0
0.0
−0.5
−1.0
−1.5
0.000
−0.001
0.4
0.2
0.0
−0.2
0.50
0.45
0.40
25
50
75


Pakistan 4Q ahead
Intercept
1
0
−1
core_infl_z
0.5
0.0
−0.5
infl_exp_z
0.5
0.0
−0.5
ip_gap_pak
0.0025
0.0000
−0.0025
er_pct_z
0.5
0.0
gs_comm_z
1
0
Pseudo R2
0.3
0.2
25
50
75


Tunisia 4Q ahead
Intercept
2
0
core_infl_z
1
0
infl_exp_z
0
−2
output_gap
0.01
0.00
−0.01
er_pct_z
0.5
0.0
gs_comm_z
1
0
Pseudo R2
0.5
0.4
0.3
25
50
75

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PUBLICATIONS

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