Oil Prices, Inflation Expectations and Monetary Policy

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The sharp declines in oil prices starting in late 2014 sparked a debate about their effect on inflation and the world economy (e.g. GEP January 2015). The decline in oil prices lowered inflation in the short run and in some cases pushed some economies that already experience very low inflation into deflation. More surprisingly, data from the US, Euro area, UK and Israel shows that oil prices have a strong correlation with inflation expectations for the medium term, as measured by five-year breakeven inflation rates.[3] Before the global financial crisis this correlation was weaker and expectations were firmly anchored at the 2% level. However, from the onset of the global crisis, the correlation is quite high (Table 1 and Figure 1).

In this note we decompose the change in oil prices to global demand and supply shocks. Using this decomposition we show that following the onset of the crisis inflation expectations reacted quite strongly to global demand conditions and oil supply shocks. These findings suggest that the public's belief in the ability of monetary authorities to stabilize inflation at the medium term horizon has deteriorated. This could be due to A. greater emphasis put by monetary authorities on stabilizing economic activity as opposed to stabilizing inflation. B. Asymmetric behavior of central banks with respect to negative deviations from the inflation target. C. The public's perception about the effectiveness of monetary policy around the zero lower bound.

Table 1: Correlation between Five-Year Breakeven Inflation Rates and Annual Rates of Change in USD Oil Prices

(Monthly, 2004M1-2015M6)

	2004M1-2008M8	2008M9-2015M6
USA	0.19	0.54
Euro area	0.55	0.59
Israel	0.49	0.61
UK	0.22	0.47

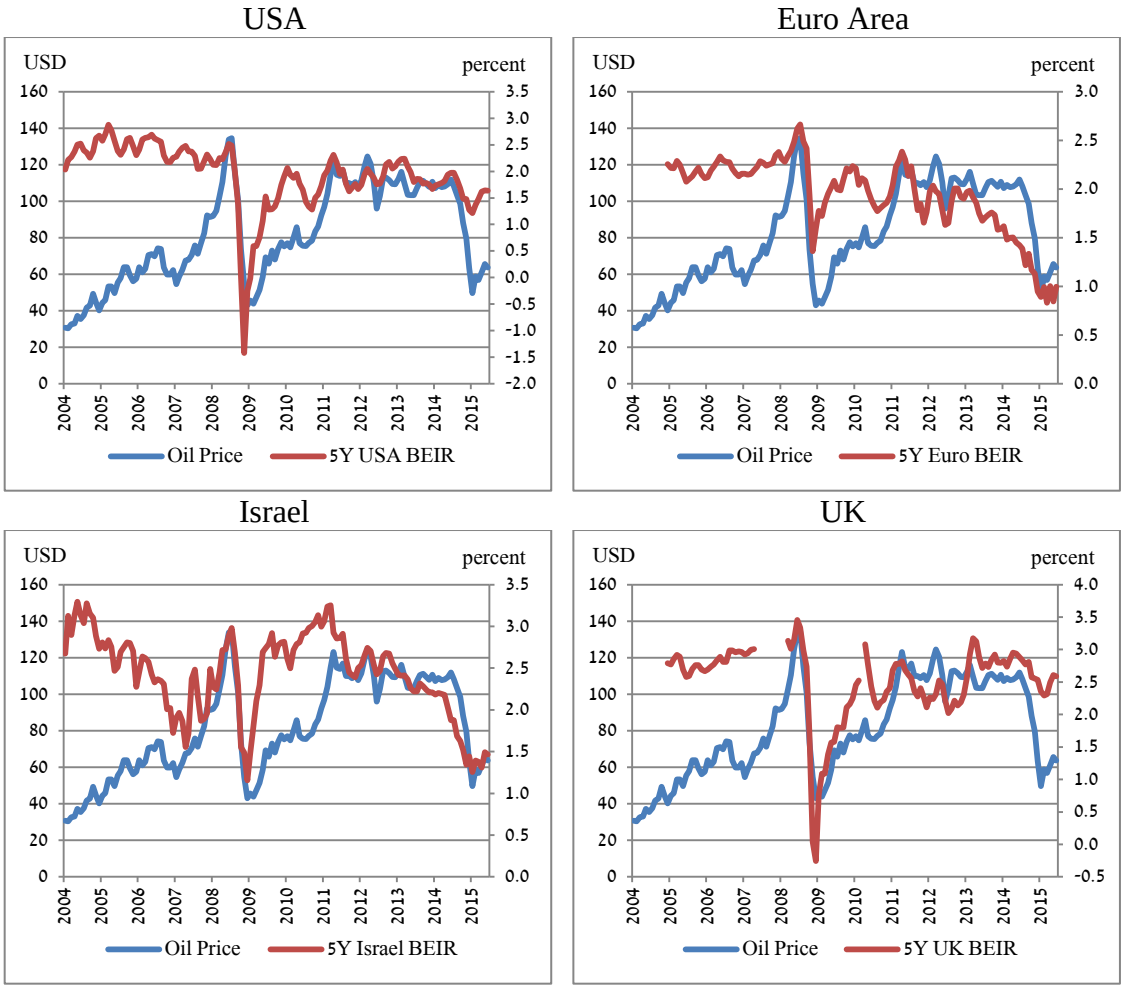
[1] Hebrew University, Bank of Israel research dept. and CEPR
[2] Bank of Israel research dept.
The views expressed in this note do not reflect the views of the Bank of Israel or its Monetary Policy Committee.
[3] For the Euro area we used a GDP-weighted average of separately estimated breakeven rates for France and Germany. In many economies the market for indexed bonds is too thin.

Decomposing oil prices changes

The effect of oil prices on five-year breakeven inflation expectations is surprising since oil related products are a small fraction of the CPI. One possibility is that oil prices affect production costs of many goods and therefore there is a strong and relatively quick pass-through from oil prices to the general price level. Another possibility is that global aggregate demand affects both the prices of oil and prices of other goods such that we observe a 'spuriously' high correlation between oil prices and inflation expectations. Any combination of these explanations is also possible.

Figure 1: Five-Year Breakeven Inflation Rates and Oil Prices

(Monthly, 2004M1-2015M6)

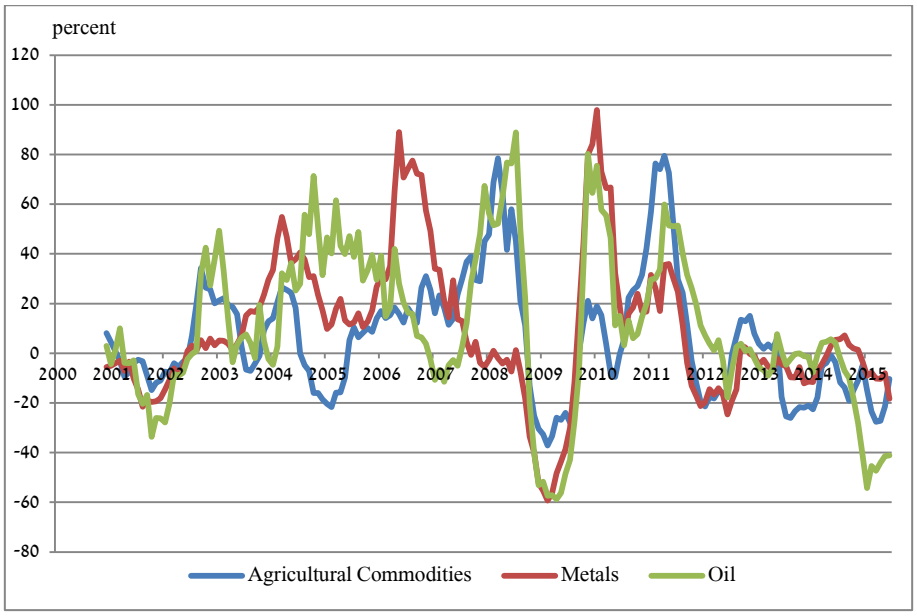


For the Euro area we used a GDP-weighted average of separately estimated breakeven rates for France and Germany.

Source: Bloomberg and the Bank of Israel.

We exploit the fact that a large number of commodities' contracts are traded in financial markets. While each commodity is affected by idiosyncratic supply and demand shocks, they are also affected by common 'global demand' shocks. In fact, in the period we examine – 2000 to 2015 - the correlation between the main commodity indices, oil, metals and agricultural goods, is above 40%[4] (Figure 2 and Table 2).

Figure 2: Annual Rates of Change of Major Commodity Indices
(Monthly, 2000M1-2015M6)



Source: Bloomberg and authors' calculations.

Table 2: Correlations of Annual Rates of Change of Major Commodity Indices
(Monthly, 2000M1-2015M6)

	Agriculture	Metals	Oil
Agriculture	1	0.43	0.60
Metals	0.43	1	0.57
Oil	0.60	0.57	1

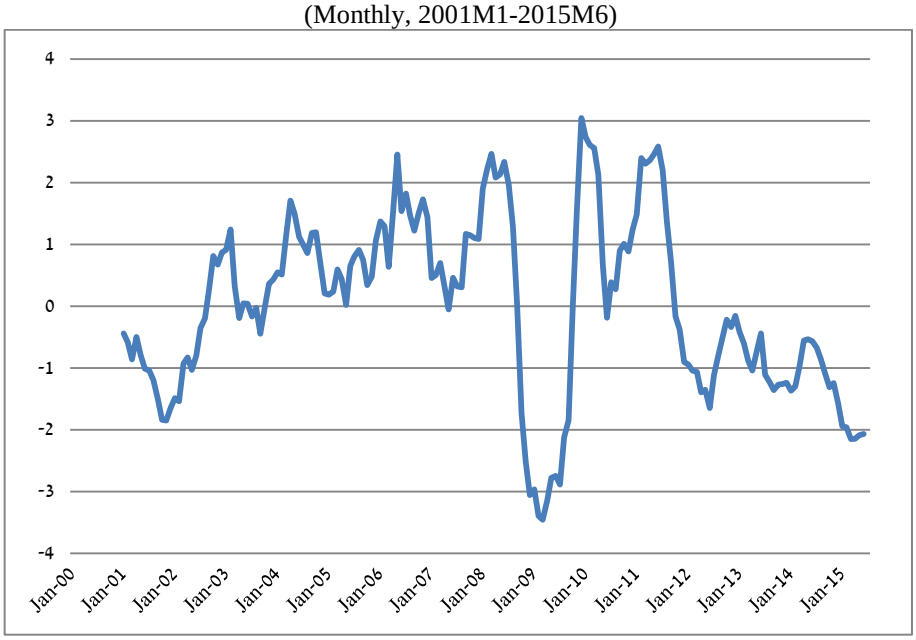
Source: Bloomberg and authors' calculations.

We extract the first principal component of the three indices - a factor that accounts for 70% of their common variation. We plot the first principal component and find

[4] The correlation in levels is above 80%. However since we are ultimately interested in the effect on inflation we report the annual rate of change.

that it tracks very well global economic activity (Figure 3).[5,6] Focusing on the latest data points we learn that global demand is decelerating, therefore, part of the decline in oil prices reflects a slowing down of the world economy.

Figure 3: Co-movement of Major Commodity Indices
First Principal Component of Annual Rates of Change in Prices of Oil, Metals and Agricultural Commodities
(Monthly, 2001M1-2015M6)



Source: Bloomberg and authors' calculations.

The economic press, however, focused on dramatic developments on the supply side of oil production, namely, increased competition from alternative energy sources. We use the commodity indices data to test this hypothesis. We regress oil prices on the indices of metals and agricultural commodities, controlling for weather conditions in the U.S. and major agricultural producing countries in Latin America (Figure 4). The residuals from the equation capture the idiosyncratic shocks to oil prices. [7,8] We find that the residual is stationary, indicating that it does in fact likely capture supply

[5] The loadings on the first principal component are 0.61, 0.55 and 0.57 for oil, metals and agricultural commodities respectively. It is therefore clear that the principal component captures a common factor of these commodities and is not dominated by oil price changes. Furthermore, the principal component is highly correlated with IMF's estimates of global GDP and trade volume (correlations above 0.8).

[6] A similar approach was taken in Byrne et al. (2013). They constructed a common factor of asset prices based on low-frequency data and examined variables that affect co-movements in asset prices. We construct a high-frequency common factor of prices and use it as an explanatory variable for oil prices and inflation expectations.

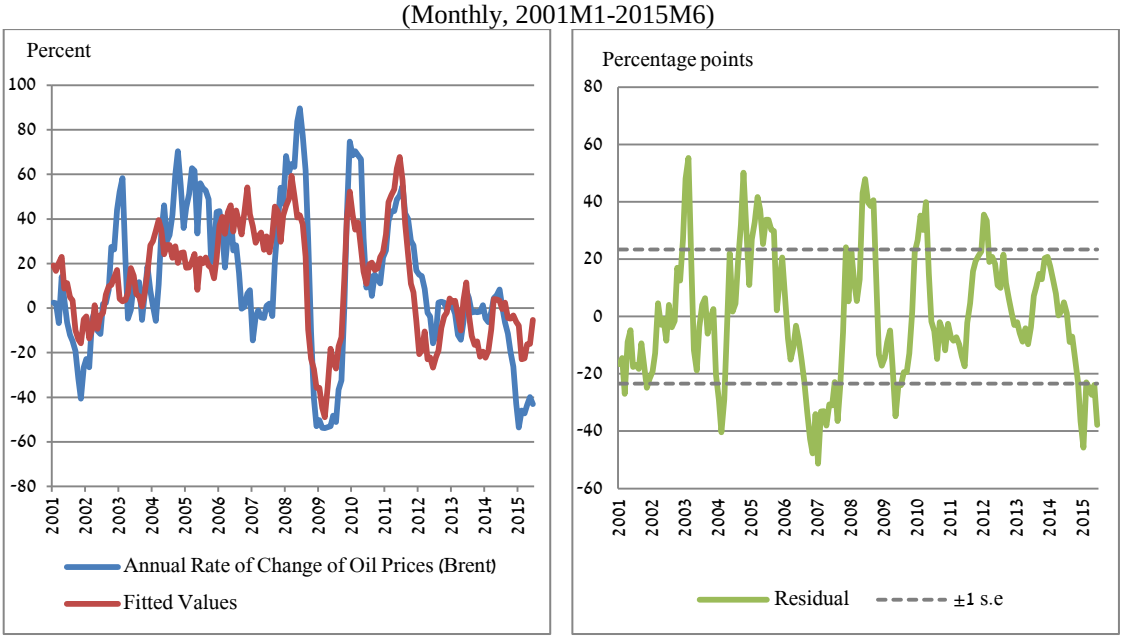
[7] We controlled for shocks to oil demand by including weather conditions in the U.S.

[8] Interestingly, we find that after controlling for weather conditions, the elasticity of oil prices with respect to other commodity prices is about 0.5. This implies that the oil cartel smooths oil prices relative to the behavior of other commodities.

shocks. Second, we see highly negative residuals between November 2014 and June 2015 when oil prices fell significantly more than other commodities. This suggests that the world economy faced a significant positive supply shock (in addition to the common negative demand shock).

Figure 4: Oil Prices Diverged from Other Commodities in Late 2014

Regression of Oil Prices on the Prices of Metals and Agricultural Commodities
(Monthly, 2001M1-2015M6)



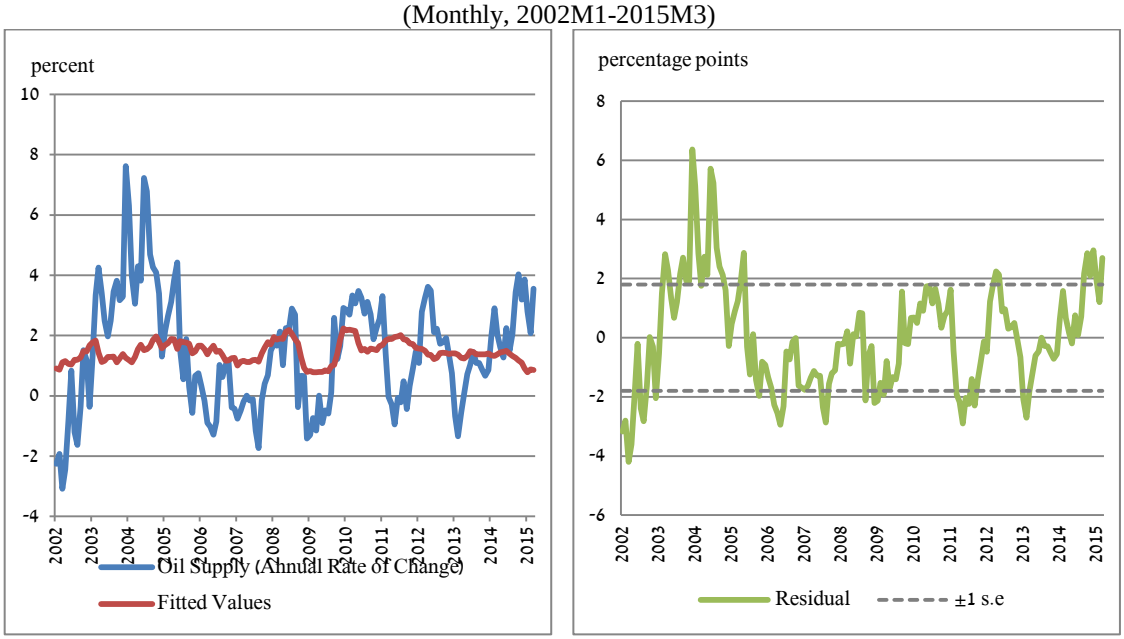
The regression estimated: ***oil = 28.94+0.31*metal + 0.52*agr +14.77*dprecrisis -1.46*d0 -0.43*d1+ 0.43*d2–2.18*d3+1.34*d4+0.08*tem_arg+0.28*tem_brz+0.06*tem_ec+ 0.17*tem_mw - 0.55*tem_wc***
Where *dprecrisis* is a dummy for the period 2001M01-2008M08 and *d0-d4*, *tem_arg*, *tem_brz*, *tem_ec*, *tem_mw*, *tem_wc* are variables controlling for weather in the USA, Argentina and Brazil. All commodities are stated in annual rates of change.
Source: Bloomberg, USA National Drought Mitigation Center and authors' calculations.

We arrive at the same conclusion by studying the relationship between oil supply (quantities) and prices. Positive correlation between quantities and prices is suggestive of demand shocks and a negative one is suggestive of supply shocks. More formally, we regress a simple supply equation of the quantities of oil supplied on oil prices controlling (two stage estimation) for demand by using the first principle component we derived above. This allows us to identify supply shocks[9]. Taking the results with appropriate caution (Figure 5) we note that recently oil production has increased by 3% beyond what demand would have warranted for.[10]

To conclude, our results indicate that the decline in oil prices reflects both a decline in global demand for goods and a large positive supply shock in the oil industry.

[9] We controlled for idiosyncratic demand shocks to oil using weather conditions in the U.S.
[10] Similar conclusions are derived in GEP, January 2015.

Figure 5: Oil Supply Shock in Late 2014
Regression of Oil Supply on Oil Prices
(Monthly, 2002M1-2015M3)



We estimated a 2SLS regression: ***oil_supply = 1.39 + 0.01*oil_price- 0.22*dprecrisis***, with instrument variables pc1 (the first principal component of commodities depicted in Figure 3) and *d0-d4, tem_arg, tem_brz, tem_ec, tem_mw, tem_wc* (as specified in the note of Figure 4).

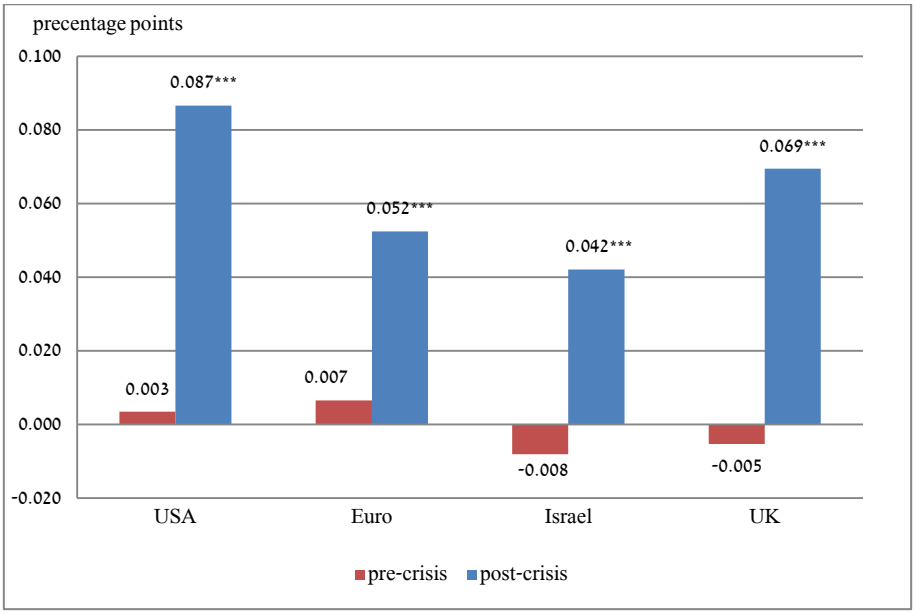
Oil prices and five-year expected inflation

We now proceed to test for the relationship between oil prices and expected inflation. We estimated a regression of five-year breakeven inflation rates on oil prices, allowing for a different effect before and after the global crisis.[11] Similarly to the correlations reported in Table 1, the regression results (Figure 6) show a strengthening of the relationship between oil prices and medium-term inflation expectations after the onset of the global crisis. In fact, in all four cases we cannot reject the hypothesis that prior to the global crisis, oil prices and breakeven rates were uncorrelated.

[11] Detailed specifications of these regressions are given in Appendix A.1.

Figure 6: The Effect of Oil Price Changes on Inflation Expectations

Percentage Point Change in Five-Year Breakeven Inflation Rates Caused by a 10% increase in Oil Prices
(Monthly, 2004M1-2015M6)



Notes:

1. For the Euro area we used a GDP-weighted average of separately estimated breakeven rates for France and Germany.
2. Asterisks represent significance levels (* 10% significance level, ** 5% significance level, *** 1% significance level, no asterisks – effect is not significant).

Source: Bloomberg, Bank of Israel and authors' calculations.

In order to capture the forces that drive global inflation expectations and examine the effects of oil prices on these forces, we extracted the first principal component of five-year breakeven inflation rates from the USA, Euro area, Israel and the UK. As is apparent in Figure 7, this factor is highly correlated with the first principal component of commodity indices, suggesting a high correlation between expected inflation and global demand.

In order to estimate the extent to which the global demand embedded in oil prices effects expected inflation, we decomposed oil prices to two elements: one capturing global demand effects and the other capturing idiosyncratic supply effects.[12] A regression of the first principal component of inflation expectations on decomposed oil price changes reveals a similar picture to the one portrayed in Figure 6. While prior to the global crisis, neither type of change in oil prices was significantly

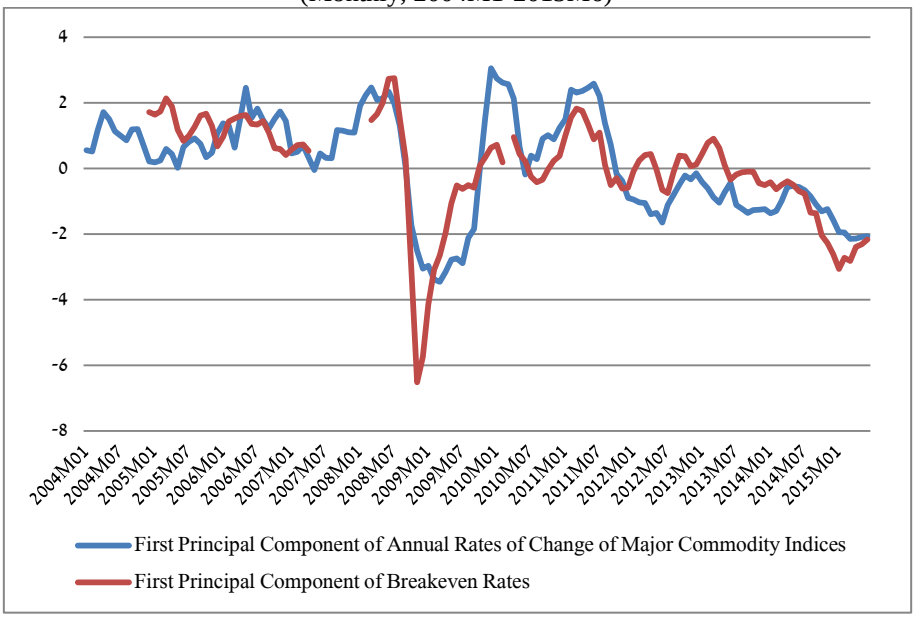
[12] The decomposition was conducted with a regression of oil prices on the first principal component of commodity indices. The fitted value from this regression represents the part of oil price affected by global demand, while the residual represents the part affected by supply. (To be more precise, the residual represents supply effects on oil prices as well as idiosyncratic demand effects. We controlled for the latter using weather conditions in the U.S.)

correlated with inflation expectations, from the onset of the crisis, both types of changes are significantly correlated. In Table 3 we derive the country-specific elasticities of oil supply changes on inflation expectations.[13]

We conclude that the tightening relationship between oil prices and inflation expectations reflects a tightening relationship between global demand and medium term inflation expectations, as well as an increased effect of idiosyncratic supply shocks to oil on inflation expectations.

Figure 7: Global Demand and Global Expected inflation

First Principal Component of Major Commodity Indices and of Global Breakeven Inflation Rates
(Monthly, 2004M1-2015M6)



Source: Bloomberg, Bank of Israel and authors' calculations.

Table 3: Effects of Global Demand Shocks and Oil Supply Shocks on Inflation Expectations

Percentage Point Change in Five-Year Breakeven Rates
(Monthly, 2004M1-2015M6)

	Effect of a 10% Annual Increase in Oil Prices Caused by a *Global Demand Shock*		Effect of a 10% Annual Increase in Oil Prices Caused by a *Supply Shock*	
	Pre-crisis	**Post-Crisis**	**Pre-crisis**	**Post-Crisis**
USA	0.008	0.084	-0.013	0.066
Euro	0.004	0.044	-0.007	0.035
Israel	0.005	0.051	-0.008	0.040
UK	0.006	0.063	-0.010	0.049

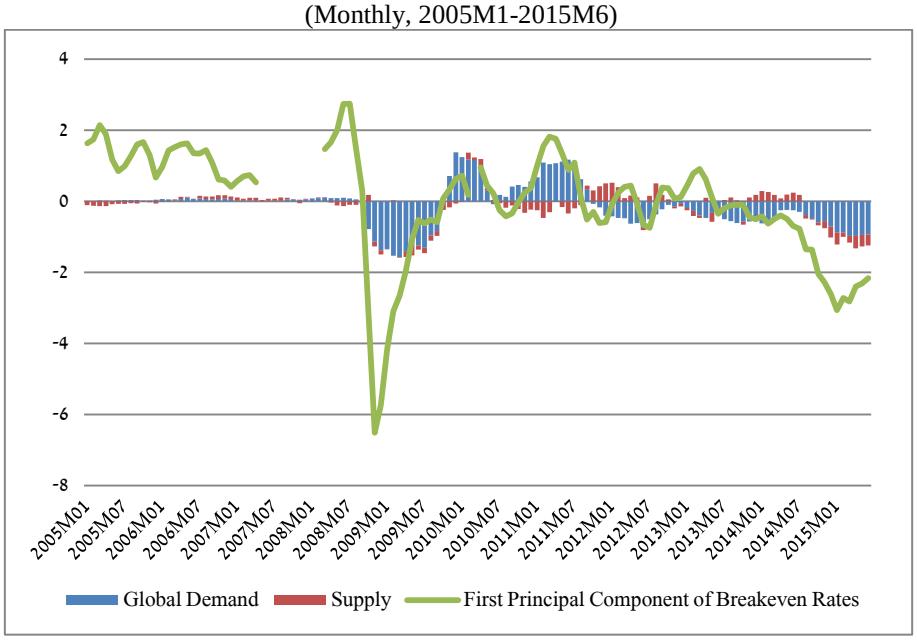
[13] Details regarding the estimation procedure and outputs are given in Appendix A.2.

Monetary policy implications

Before the global financial crisis oil prices were not correlated with five-year expected inflation. During the crisis, we saw that global demand and supply conditions reflected in oil prices became strongly correlated with inflation expectations. Examining the contribution of these factors (Figure 8) reveals that while both factors contribute more to the developments in inflation expectations since the onset of the crisis, global demand has a more dominant effect.[14] In fact, it seems that in the post-crisis period global demand explains a substantial part of the development in global expected inflation.

Figure 8: The Contribution of Global Demand Shocks to Expected Inflation is Much Higher than that of Oil Supply Shocks

(Monthly, 2005M1-2015M6)



What can explain this change? We offer two possible, mutually non- exclusive, explanations: The first is a change in monetary policy. Before the global financial crises monetary authorities followed, or were expected to follow, a Taylor rule that puts a large weight on meeting the inflation target and little weight on stabilizing output. Afterwards, monetary authorities were more concerned with stabilizing the output (or employment) gap. It could be that the public interpreted this as a decline in the commitment to uphold the inflation target in the medium term. A variant of this

[14] The contributions were calculated as the size of each shock multiplied by the estimated marginal effect of that shock on the principal component of breakeven rates. See Appendix A.2 for more details.

explanation is that when inflation deviates below the target, the public believes that monetary authorities will be less aggressive in attempting to move it back into the target zone. The second explanation is that because interest rates have reached the zero lower bound, the public doubts the ability of monetary authorities to meet the inflation target.[15]

Some questions remain. Did inflation targeting become unanchored in the medium term? If this is the case, has future stabilization of inflation become more costly (until the public learns that weight has shifted again to inflation)? Has the credibility of the monetary regime declined?

References

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[15] Recent recipes provided by Kimball (2015) and Rogoff (2014).

Appendix – Estimations of Oil Prices Effects on Breakeven Inflation Rates

A.1 A Reduced Form Analysis

The effects of oil prices on inflation expectations as reported in Figure 6 were estimated in four country-specific regressions of the form:

$$(1)\ \boldsymbol{BEIR_i = \beta_1 + \beta_2 oil + \beta_3 oil * dprecrisis + \beta_4 x_i + \beta_5 x_i * dprecrisis + \beta_6 dprecrisis + \beta_7 dlehman_i + \eta_i}$$

Where $BEIR_i$ is the five-year breakeven inflation rate in country i, oil is the annual rate of change in the USD price of an oil barrel, $dprecrisis$ is a dummy variable that equals one in the period 2004M01-2008M09 and zero otherwise, x_i is the three-months lagged annual depreciation of country i's local currency versus the USD (omitted in the U.S. regression) and $dlehman_i$ is a dummy variable that equals one circa September 2008 (indicating known liquidity problems in country *i*'s government bonds market). The regressions also contained controls for autoregressive errors. Results are reported in Table A.1.

Table A.1: Regressions of Five-Year Breakeven Inflation Rates on Oil Prices (Equation (1))

	const.	oil	$oil * dprecrisis$	x_i	$x_i * dprecrisis$	$dprecrisis$	R^2
USA	1.5907	0.0086	-0.0083	-	-	0.9063	0.92
	(0.539)	(0.0019)	(0.0028)			(0.1655)	
Euro	1.5547	0.0052	-0.0046	0.0072	-0.0014	0.3185	0.94
	(0.5391)	(0.0010)	(0.0016)	(0.0029)	(0.0064)	(0.1477)	
Israel	2.2396	0.0041	-0.0052	0.0147	-0.0185	0.1905	0.88
	(0.2121)	(0.0020)	(0.0029)	(0.0065)	(0.0122)	(0.3102)	
UK	2.3735	0.0069	-0.0075	0.0032	-0.0146	0.3828	0.88
	(0.1527)	(0.0026)	(0.0039)	(0.0080)	(0.0170)	(0.2386)	

Note: In parenthesis are the standard errors.

A.2 Decomposition to Supply and Global Demand Effects

Decomposing the effect of oil prices on inflation expectation to supply and demand effects was conducted in three stages as follows. First, we extracted the first principal component of annual rates of change of major commodity indices and the first principal component of breakeven inflation rates (see Figure 7). Second, we regressed oil prices on the first principal component of the major commodity indices, controlling for weather conditions in the U.S. and major agricultural producing countries in Latin America:

$$(2)\quad \boldsymbol{oil = \delta_1 + \delta_2\, pc1\_cmdty + \alpha * w + \epsilon}$$

Where w is a vector of variables controlling for weather in the USA, Argentina and Brazil. In the third stage we regressed the first principal component of breakeven inflation rates on the fitted value and residual in (2) (controlling for autocorrelation):

$$(3)\quad \boldsymbol{pc1\_beir = \gamma_1 + \gamma_2\delta_2 pc1\_cmdty + \gamma_3 dprecrisis * \delta_2 pc1\_cmdty + \gamma_4\epsilon + \gamma_5 dprecrisis * \epsilon + \gamma_8 dprecrisis + \gamma_9 dlehman_i + \mu}$$

The output of regressions (2) and (3) are given in Tables A.2 and A.3, respectively. Note that prior to the global crisis, neither type of shock to oil prices had a significant effect on the global factor of inflation expectations ($\gamma_2 + \gamma_3$and $\gamma_4 + \gamma_5$ are insignificant), yet post-crisis effects of both shocks (γ_2 and γ_4) are significant. Figure 8 in the main body of the note illustrates the contributions of both shocks to $pc1\_beir$, i.e., it depicts the series $(\gamma_2 + \gamma_3 dprecrisis) * \delta_2 pc1\_cmdty$ and $(\gamma_4 + \gamma_5 dprecrisis) * \epsilon$.

Table A.2: Regression of Oil Prices on Principal Component of Commodities (Equation (2))

	const.	$\boldsymbol{pc1\_cmdty}$	$\boldsymbol{R^2}$
$\boldsymbol{oil}$	24.26	18.60	0.90
	(31.54)	(0.69)	

Note: In parenthesis are the standard errors.

Table A.3: Regression of Principal Component of Breakeven Inflation Rates on Principal Component of Commodities and the Residual of Equation (2) (Equation (3))

	$\boldsymbol{\delta_2 pc1\_cmdty}$	$\boldsymbol{dprecrisis * \delta_2 pc1\_cmdty}$	$\boldsymbol{\epsilon}$	$\boldsymbol{dprecrisis * \epsilon}$	$\boldsymbol{R^2}$
$\boldsymbol{pc1\_beir}$	0.023	-0.021	0.018	-0.022	0.93
	(0.006)	(0.009)	(0.006)	(0.010)	

Note: In parenthesis are the standard errors.

To obtain the country-specific elasticities, we regressed each county's breakeven inflation rates on $pc1\_beir$**:**

$$(4)\quad \boldsymbol{BEIR_i = \alpha_i * pc1\_beir + \xi_i}$$

Table A.4 reports the results of these regressions. Table 3 in the main body of the note reports $\alpha_i\gamma_2, \alpha_i(\gamma_2 + \gamma_3), \alpha_i\gamma_4$ and $\alpha_i(\gamma_4 + \gamma_5)$ which represent percentage point changes in breakeven rates caused by a one percent increase in oil prices driven by supply or global demand, before and after the global crisis.

Table A.4: Regression of Breakeven rates on Principal Component (Equation (4))

	$pc1\_beir$
USA	0.36
	(0.11)
Euro	0.19
	(0.11)
Israel	0.22
	(0.14)
UK	0.27
	(0.15)

Note: In parenthesis are the standard errors.