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Plenary Lectures

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Lecture 3

The Commodity Price Super Cycle*

*Background Reading: A. Fernńdez, S. Schmitt-Grohé, and M. Uribe, "Does the Commodity Super Cycle Matter?, manuscript, Columbia University, 2020.

Introduction

• World commodity prices display long cycles known as super cycles.

• Much of the existing literature on commodity price super cycles focuses on documenting their frequency, amplitude, and turning points.

• Less work has been devoted to estimating the importance of commodity price super cycles for economic activity.

• In this lecture, we will identify global disturbances that cause regular cycles and super cycles in world commodity prices and to estimate their contribution to aggregate fluctuations in emerging and developed countries.

Identification of the Commodity Super Cycle

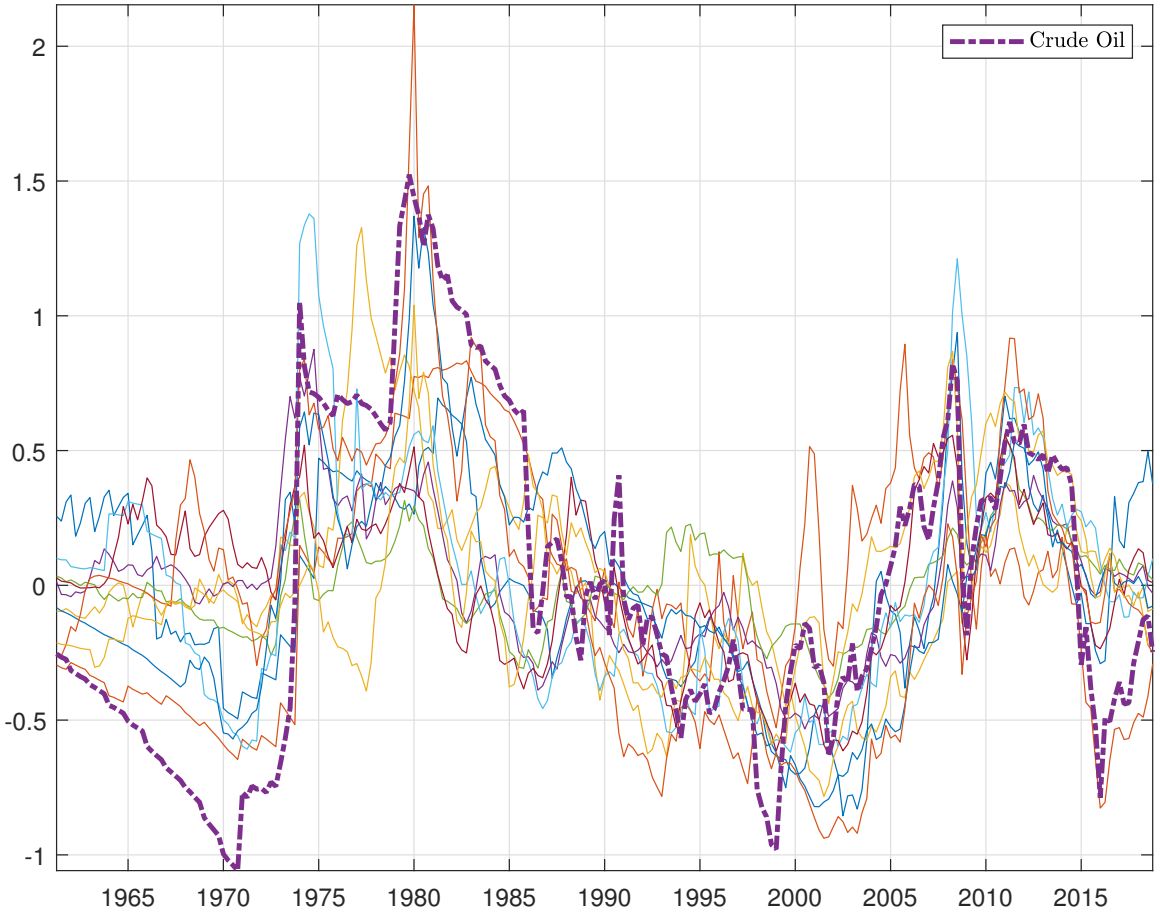
• Much of the existing literature focuses on spectral analysis to identify super cycles in commodity prices (e.g. Cuddington and Jerrett, 2008; Erten and Ocampo, 2013).

• In this lecture, we will identify the commodity super cycle as the common permanent component in all commodity prices.

• This approach produces a commodity super cycle that is in line with the one delivered by the spectral approach (e.g., two peaks post 1960, one around 1980 and one in the early 2010s).

• **Advantages of the Proposed Identification Scheme:**
◇ Delivers one common commodity super cycle, as opposed to one per commodity. This isdesirable, because commodity prices move in tandem over the long run. The common super cycle explains 67-91% of the variance of commodity prices at horizons 5-30 years.
◇ The permanent component approach allows for the simultaneous estimation of permanent/transitory and world/domestic disturbances and their contribution to aggregate activity.

Eleven Commodity Prices



The commodity prices displayed in the figure are beverages, food, agricultural raw materials, fertilizers, metal and minerals, gold, platinum, silver, coal, crude oil, and natural gas.

Related Literature

• Early evidence of comovement in commodity prices: Pindyck and Rotemberg (1990). Spectral analysis: Cuddington and Jerrett (2008) and Erten and Ocampo (2013). Factor models: Alquist et al. (2020). HP-Filtering: Benguria et al. (2018).

• Role of World Prices in VAR models. small contribution of TOT shocks to aggregate activity: Schmitt-Grohé and Uribe (2018). Larger role when expanding the set of world prices: Fernández et al. (2017), Shousha (2016), and Fernández et al. (2015).

• TOT and world-price shocks in SOE models: Mendoza (1995), Kose (2001), Miyamoto and Nguyen (2017), Drechsel and Tenreyro (2018), Schmitt-Grohé and Uribe (2018).

• Transitory versus Permanent shocks as drivers of the business cycle: Aguiar and Gopinath (2007), García-Cicco et al., (2010), Chang and Fernández (2013), Miyamoto and Nguyen (2017).

Elements of the Empirical Model

• Foreign Block: The cyclical components of 11 commodity prices and the world interest rate driven by permanent and transitory world shocks.

• Domestic Block: The cyclical components of output of a set of countries, driven by transitory/permanent domestic/world shocks.

• State-Space Formulation: Shocks and cyclical components are unobserved latent variables.

• **Observables.** Estimation exploits the fact that the model delivers precise predictions for observable variables: the growth rate of 11 commodity prices, the world interest rate, and the growth rate of 24 (quarterly data) or 41 (annual sample) countries.

• Estimation: Bayesian.

• Sample: Quarterly/annual from 1960 to 2018.

The Foreign Block

p_t = vector of 11 real commodity prices and the gross world real interest rate in quarter t (all in logs).

X_t^p = permanent component common to all com. prices.

z_t^p vector of 12 stationary world shocks.

Define the stationary variable

$$\widehat{p}_t = \begin{bmatrix} \widehat{p}_t^1 \\ \vdots \\ \widehat{p}_t^{11} \\ \widehat{r}_t \end{bmatrix} \equiv \begin{bmatrix} p_t^1 - X_t^p \\ \vdots \\ p_t^{11} - X_t^p \\ r_t \end{bmatrix}.$$

The vector $\widehat{p}_t$ is assumed to evolve according to

$$\widehat{p}_t = \sum_{i=1}^{4} B_{pp}^i \, \widehat{p}_{t-i} + C_{pxp} \Delta X_t^p + C_{pzp} z_t^p, \tag{1}$$

Variables $\widehat{p}_t$, ΔX_t^p, and z_t^p are unobservable.

The Domestic Block

$y_t^i =$ log of real output in country i.

$X_t^i =$ domestic permanent component of output in country i.

$z_t^i =$ domestic stationary shock affecting output in country i.

Define the stationary variable

$$\widehat{y}_t = \begin{bmatrix} \widehat{y}_t^1 \\ \vdots \\ \widehat{y}_t^{24} \end{bmatrix} \equiv \begin{bmatrix} y_t^1 - X_t^1 - \alpha^1 X_t^p \\ \vdots \\ y_t^{24} - X_t^{24} - \alpha^{24} X_t^p \end{bmatrix}.$$

Then $\widehat{y}_t$ is assumed to evolve according to

$$\widehat{y}_t = \sum_{i=1}^{4} B_{yp}^i \widehat{p}_{t-i} + \sum_{i=1}^{4} B_{yy}^i \widehat{y}_{t-i} + C_{yxp} \Delta X_t^p + C_{yzp} z_t^p + C_{yx} \Delta X_t + z_t, \quad (2)$$

Variables $\widehat{y}_t$, ΔX_t, and z_t are unobservable.

Recapping

The empirical model is

$$\begin{aligned}\widehat{p}_t &= \sum_{i=1}^{4} B^i_{pp}\widehat{p}_{t-i} + C_{pxp}\Delta X^p_t + C_{pzp}z^p_t \\ \widehat{y}_t &= \sum_{i=1}^{4} B^i_{yp}\widehat{p}_{t-i} + \sum_{i=1}^{4} B^i_{yy}\widehat{y}_{t-i} + C_{yxp}\Delta X^p_t + C_{yzp}z^p_t + C_{yx}\Delta X_t + z_t\end{aligned}$$

The exogenous driving force,

$$u_t \equiv \begin{bmatrix} \Delta X^p_t \\ \Delta X_t \\ z^p_t \\ z_t \end{bmatrix},$$

is assumed to be AR(1)

$$u_t = \rho u_{t-1} + \psi\nu_t,$$

with ρ diagonal and $\nu_t \sim N(\emptyset, I)$.

The model cannot be estimated as is because it is cast in terms of unobservable latent variables.

Observables

$\Delta p_t^i =$ growth rate of commodity price $i = 1, \ldots, 11$.
$\Delta y_t^i =$ growth rate of output in country $i = 1, \ldots, 24$.
$r_t =$ world interest rate.

The observation equations linking unobservable and observable variables are

$$\begin{aligned} \Delta p_t^i &= \widehat{p}_t^i - \widehat{p}_{t-1}^i + \Delta X_t^p; \quad i = 1, \ldots, 11, \\ \Delta y_t^i &= \widehat{y}_t^i - \widehat{y}_{t-1}^i + \Delta X_t^i + \alpha^i \Delta X_t^p; \quad i = 1, \ldots, 24, \end{aligned}$$

These equations make it possible to calculate the likelihood of the data, which can be used to estimate all parameters of the model.
Estimation Approach: Bayesian, with Minnesota-type priors.

Prior Distributions

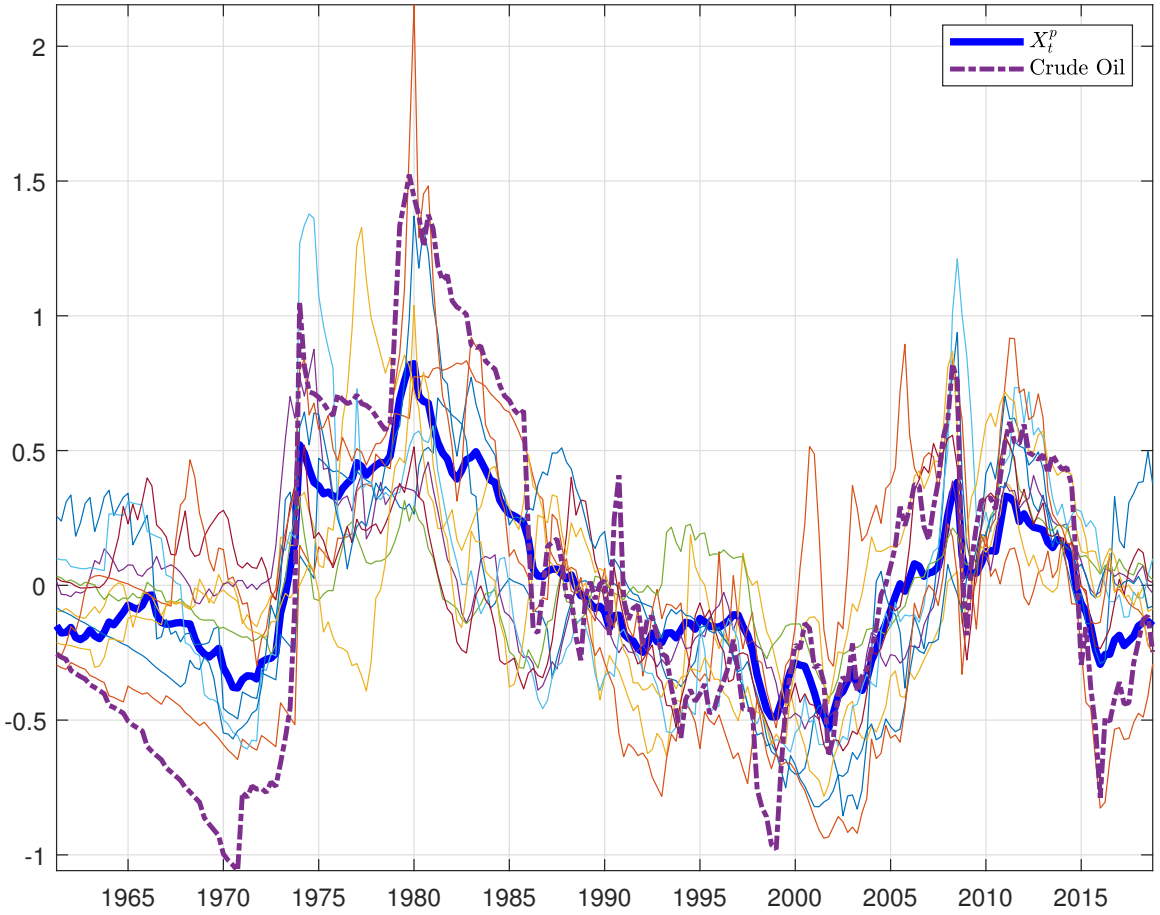
Parameter	Distrib.	Mean	Std Dev
Diag elements of B^1_{pp} and B^1_{yy}	Normal	0.95	0.5
All other elements of B matrices	Normal	0	0.25
Estimated elements of C_{pxp} and C_{pzp}	Normal	0	1
Diagonal of C_{yx}	Normal	-1	1
Elements of C_{yxp} and C_{yzp}	Normal	0	1
Diagonal of ρ(1:25,1:25)	Beta	0.3	0.2
All other estimated elements of ρ	Beta	0.7	0.2
Diagonal of ψ	Gamma	1	1
α_i, $i = 1, \ldots, 24$	Normal	0	1

The Data

- **Frequency:** quarterly.
- **Sample period:** 1960.Q1 to 2018.Q4.

- **World Variables:** the world real interest rate (Treasury Bill rate minus measure of expected inflation) and 11 commodity prices deflated by the US CPI (beverages, food, agricultural raw materials, fertilizers, metal and minerals, gold, platinum, silver, coal, crude oil, and natural gas)
- **Country Variables:** Growth rate of the real, s.a., gross domestic product of 24 small open economies.
- **Countries and Inclusion Criterion:** At least 50 years of quarterly observations of real output, excluding large economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, S. Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
- **Sources:** Commodity prices, World Bank. Output, OECD.

The Commodity Price Super Cycle



Note. The permanent component of the eleven real commodity prices, X_t^p is computed by Kalman smoothing.

Properties of the Estimated Commodity Price Super Cycle

• We interpret the random variable X_t^p as carrying the commodity price super cycle.

• X_t^p is estimated by Kalman smoothing.

• X_t^p appears to capture well the low frequency comovement of the individual commodity prices.

• Over the period 1960 to 2018 commodity prices display two distinct super cycles, one peaking in 1980 and the other in 2008, following the oil price boom of the 1970s and the accession of China to the WTO, respectively.

• The prediction of two commodity super cycles post 1960 is in line with the spectral analysis approach (e.g., Erten and Ocampo, 2013)

Percent of Variance of the Growth Rate of Real Commodity Prices Explained by ΔX_t^p

Price of	Mean	Std. Dev.
Coal	26	3
Crude Oil	60	2
Natural Gas	20	3
Beverages	11	1
Food	21	2
Agr. Raw Materials	20	3
Fertilizers	33	2
Metal and Minerals	30	2
Gold	30	2
Silver	28	2
Platinum	19	1
Mean across prices	27	2
Real Interest Rate	15	8

Note. The reported figures are based on 100,000 draws from the posterior distribution of the variance decomposition.

Observations on the Table

• The permanent component of commodity prices, X_t^p, plays a significant role in explaining movements in world prices.

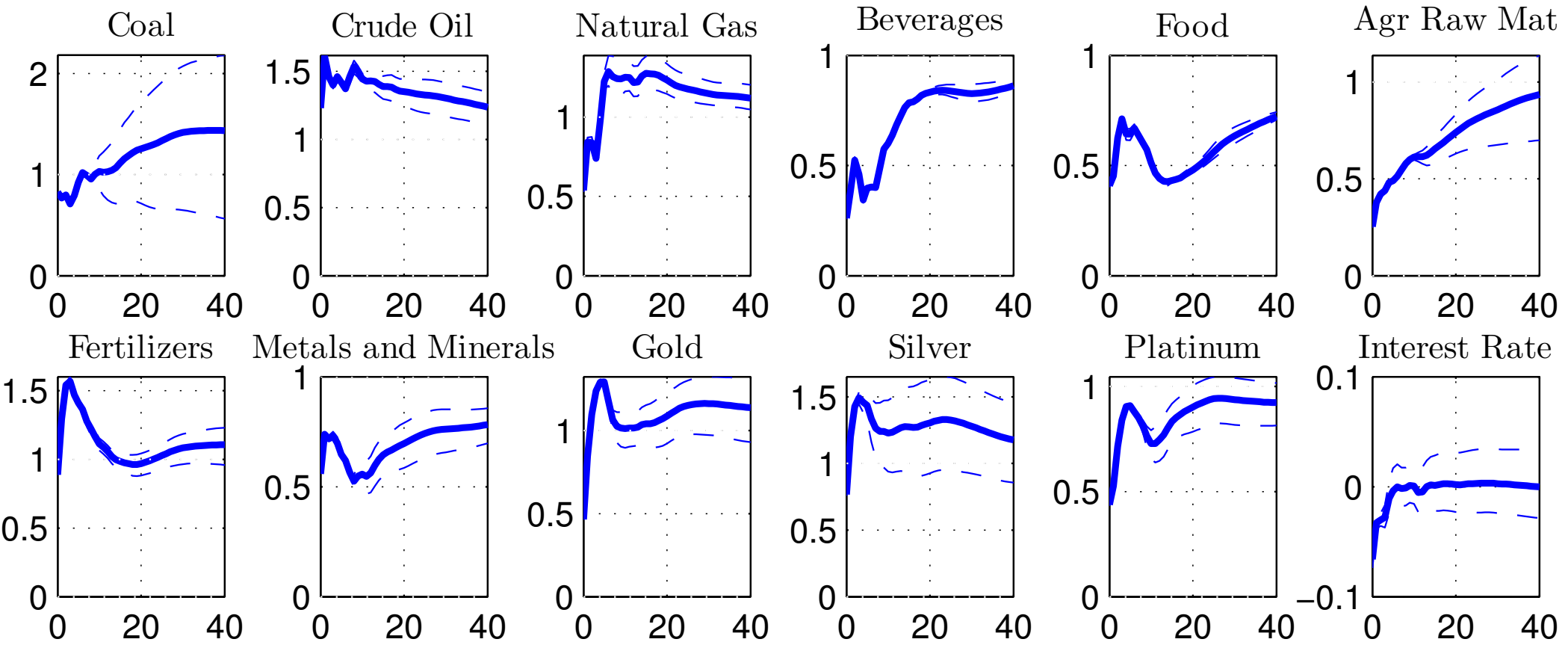
• On average across prices, ΔX_t^p explains more than one fourth of the variance of changes in commodity prices.

• The permanent component plays the largest role in explaining movements in crude oil prices (with a variance share of 60 percent).

• The variance shares are estimated with precision, with standard deviations equal to 2 percentage points on average.

• Estimating the price block of the model separately from the output block (not shown) yields similar results, except for the role of X_t^p in explaining movements in the price of crude oil (60 vs. 35%). Thus, even though the system is recursive, a joint estimation is informative.

Impulse Responses of World Prices to a Unit Long-run Increase in X_t^p



: mean : 95% Sims-Zha asymmetric confidence bands

Observations on the Figure

• For most commodity prices, an increase in X_t^p induces a positive but less than unity impact effect on commodity prices and a slow convergence to the permanently higher level of 1.

• Exceptions are crude oil, which displays overshooting on impact and convergence from above, and natural gas, fertilizers, gold, and silver, which display delayed overshooting.

• An increase in X_t^p has a negative effect on the world interest rate.

Variance Decomposition of Output Growth

		Shock		
Country	ΔX_t^p	z_t^p	ΔX_t^i	z_t^i
Australia	7	61	1	32
Belgium	8	84	7	1
Canada	10	71	1	19
Denmark	7	65	0	28
France	8	60	1	31
Iceland	5	47	45	2
Italy	10	74	0	17
Luxembourg	10	50	23	18
Netherlands	8	58	33	1
Norway	4	55	19	22
South Africa	9	61	0	29
Sweden	8	54	0	37
Turkey	4	51	0	44
Mean	8	62	12	19

Notes. Averages over 100,000 draws from the posterior distribution of the variance decomposition. To save space, the table shows only every other country (12 out of 24) in the sample from a list sorted alphabetically. See discussion on next slide.

Observations on the Table: How Important is the Commodity Super Cycle for Economic Activity?

• The table on the previous slide shows that on average across countries the permanent component of commodity prices, X_t^p, explains only 8 percent of the overall volatility of output growth.

• By contrast, the transitory components of commodity prices, z_t^p, jointly explain 62 percent of the variance of output growth.

• This result suggests that
(a) World shocks (i.e., X_t^p and z_t^p) are important in explaining output movements in small open economies (70%).
(b) However, the vast majority of the observed movements stem from stationary world disturbances (z_t^p), not from permanent disturbances causing the commodity price super cycle (X_t^p).

• The table also speaks to the literature on the role of permanent shocks (X_t^p and X_t^i) versus transitory shocks (z_t^p and z_t^i) in driving business cycles. Transitory shocks are estimated to play a larger role than permanent shocks.

Forecast Error Variance Decomposition of the Level of Output

Shock	X_t^p				z_t^p				X_t^i				z_t			
Horizon	5	10	20	30	5	10	20	30	5	10	20	30	5	10	20	30
Australia	5	2	2	7	82	89	87	80	5	6	8	11	8	3	2	2
Austria	19	27	33	36	74	70	65	63	1	1	1	1	6	2	1	1
Belgium	9	10	13	13	88	87	82	79	3	3	5	8	0	0	0	0
Canada	2	12	33	41	92	85	64	56	3	2	3	3	3	1	0	0
Denmark	6	13	22	24	88	84	76	74	0	0	0	0	6	3	2	2
Finland	5	8	11	10	60	59	50	42	34	32	39	48	1	0	0	0
France	20	27	36	41	70	69	61	56	2	2	2	2	8	2	1	1
Greece	1	2	5	5	95	96	92	91	3	2	2	3	0	0	0	0
Iceland	0	1	1	1	25	22	16	12	65	70	78	84	9	8	5	4
Ireland	4	2	1	2	26	18	11	7	69	79	88	91	1	1	0	0
Italy	12	14	15	14	81	83	83	84	0	0	0	1	7	3	1	1
Korea, Rep.	1	0	1	2	19	11	6	4	80	88	93	94	1	0	0	0
Luxembourg	29	35	36	33	43	36	27	22	25	28	36	44	3	1	1	1
Mexico	1	1	1	3	85	93	94	93	0	0	1	1	13	5	3	3
Netherlands	19	27	30	29	75	67	60	55	4	5	10	16	1	0	0	0
N. Zealand	1	1	3	5	21	18	11	8	74	80	85	86	3	2	1	1
Norway	6	4	5	4	77	77	70	63	14	17	24	32	3	2	1	1
Portugal	24	23	25	25	69	74	74	73	0	0	0	0	7	3	2	1
S. Africa	43	42	38	50	49	55	59	47	1	1	1	1	6	3	1	1
Spain	7	18	30	33	87	80	69	65	0	0	1	1	6	1	1	1
Sweden	8	36	59	67	74	58	38	30	2	2	1	2	16	5	2	1
Switzerland	8	15	29	33	75	75	65	61	1	1	2	3	16	9	4	3
Turkey	1	7	7	9	67	74	77	75	0	0	1	1	31	19	15	15
U.K.	17	28	39	42	77	67	56	52	2	3	4	5	4	2	1	1
Mean	10	15	20	22	67	64	58	54	16	18	20	22	7	3	2	2

Note. Computed at the posterior mean of the estimated parameters and expressed in percentage points.

Observations on the Table
Importance of the Commodity Price Super Cycle for Business Cycles at Different Time Horizons

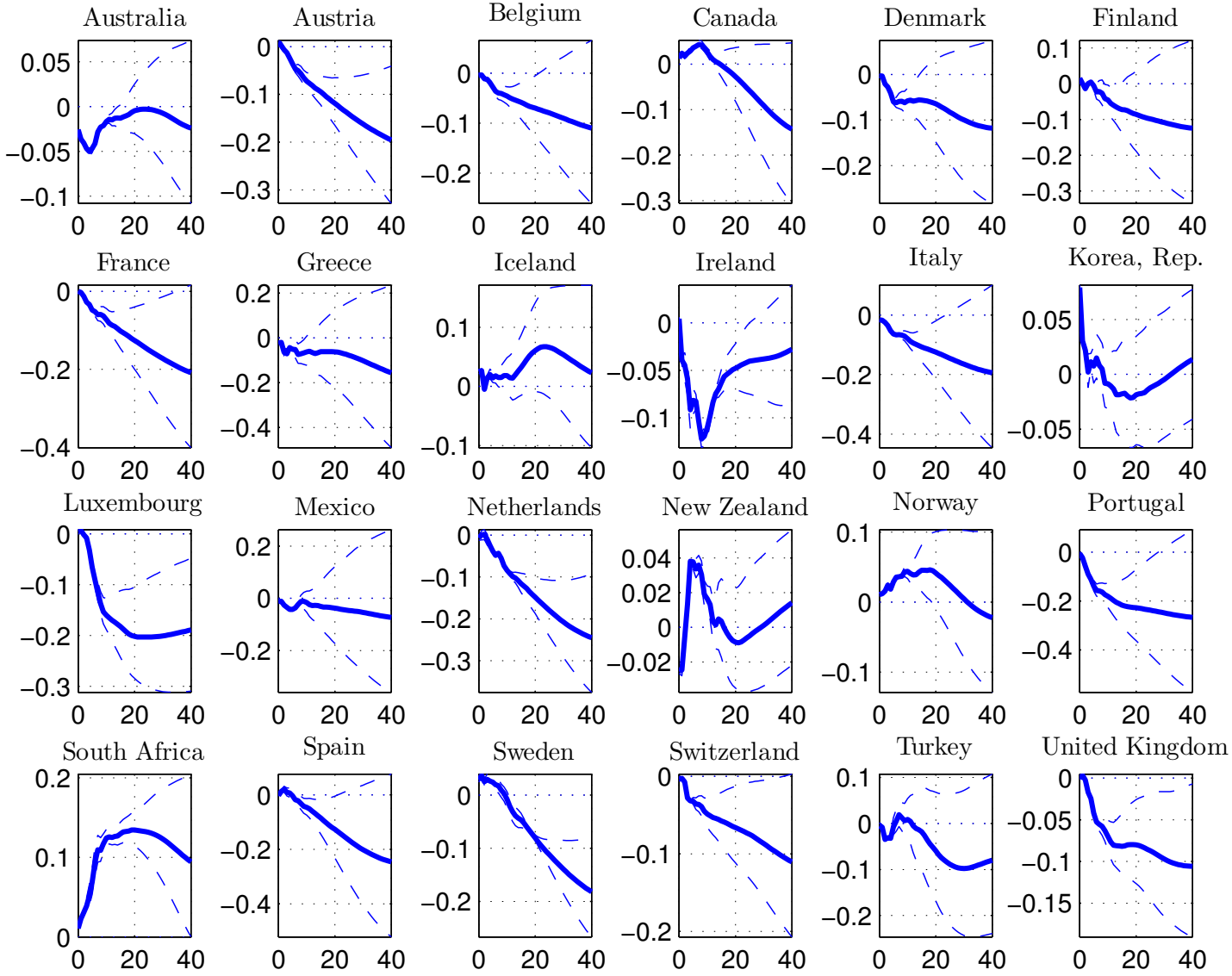
• The contribution of X_t^p to explaining output variations is at most 12% at horizons of 10 years or less (business-cycle frequencies).

• At horizons of 20 and 30 years, the range of frequencies of the commodity super cycle itself, the contribution of X_t^p increases to 19%.

• By contrast, the contribution of stationary world shocks, z_t^p, ranges from 75% at 5 years to 58% at 30 years.

• This result indicates that the economic impact of the commodity super cycle on output relative to that of stationary world shocks is small at business cycle frequencies (10 years or less) and moderate at its own frequency (20 to 30 years).

Response of Output to an Increase in X_t^p



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Observations on the Figure
Output Response to a Permanent Increase in Commodity Prices, X_t^p

• In most countries an increase in the permanent world shock, X_t^p, is contractionary.

• One possible explanation is that the sample includes mostly developed open economies that are not primary commodity producers.

• But even for primary commodity producers the output effect of an increase in X_t^p could be ambiguous:
(a) If some commodities are imported and used as intermediate inputs in domestic production.
(b) If the increase in the price of the exported commodity generates a large enough wealth effect that contracts labor supply.

Emerging Countries

Annual Data

• Long quarterly time series for output are available mostly for developed countries. To increase the participation of emerging countries, the present analysis is based on annual data.

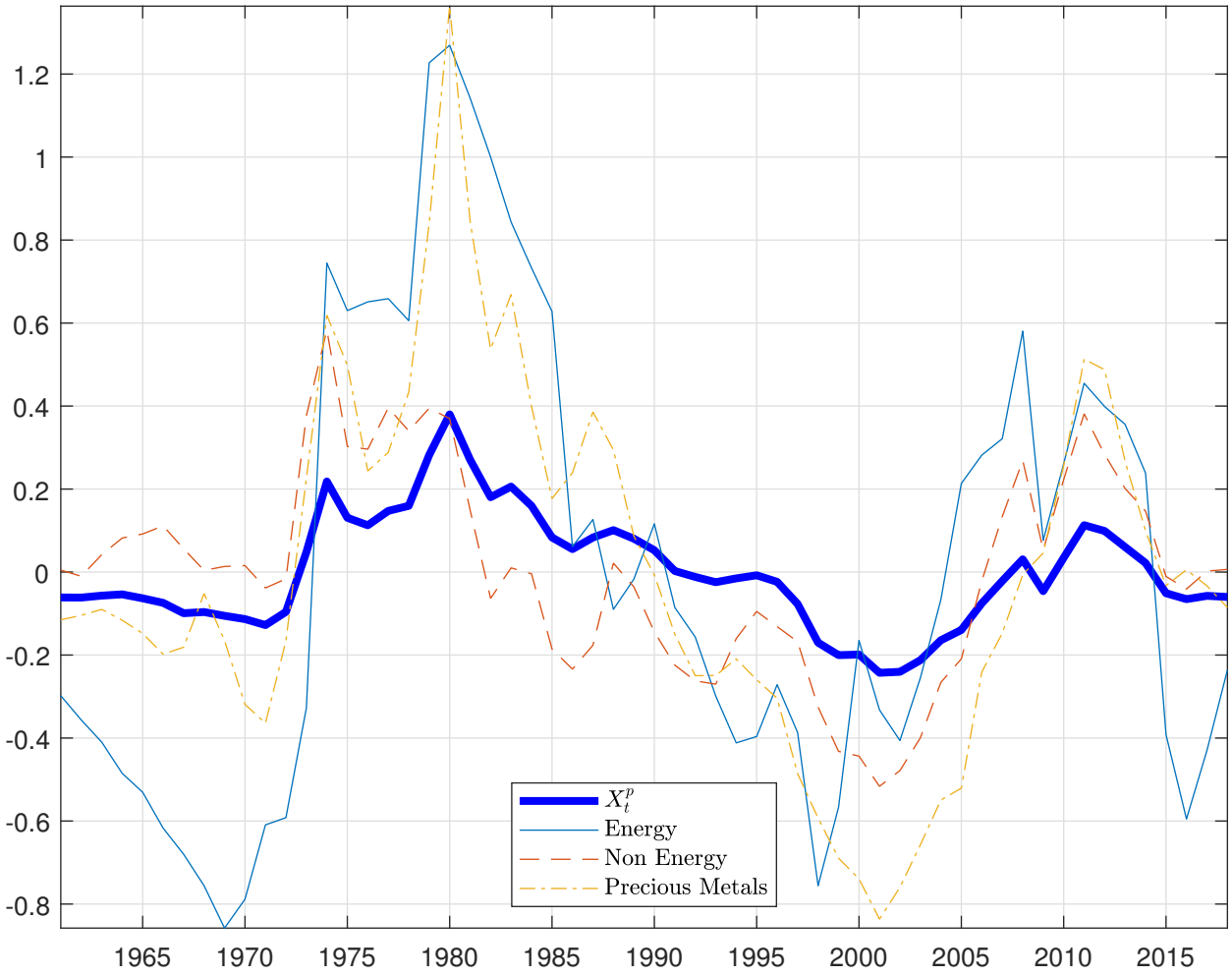
• Sample: 1960 to 2018, 24 emerging countries, 17 developed countries.

• Same empirical model.

• 1 time lag.

• Three commodity-price indices: energy, non energy, and precious metals, following the World Bank's Pink Sheet aggregation scheme.

The Commodity Price Super Cycle in Annual Data



Observation: Annual super cycle similar to its quarterly counterpart: A smooth stochastic trend of the underlying prices with peaks in 1980 and 2012.

Percent of Variance of the Growth Rate of Annual World Prices Explained by ΔX_t^p

Price of	Mean	Std. Dev.
Energy Commodities	98	1
Non Energy Commodities	94	2
Precious Metals	94	1
Mean	95	1
Interest Rate	25	18

Note. Based on 100,000 draws from the posterior distribution of the variance decomposition.

Observations on the Table

• As in the quarterly estimation, the commodity super cycle is an important driver of commodity prices.

• A difference is that now shares are higher. The permanent component, X_t^p, explains more than 90 percent of the variation in the growth rate of the three commodity prices .

• This is to some extent expected because of the aggregation across time (yr. vs. qrt.)and commodities (3 vs. 11).

• The commodity super cycle explains 25 percent of movements in the world interest rate (vs. 15 percent with quarterly data mostly from developed countries.).

Variance Decomposition of Annual Output Growth

	Shock			
Country	ΔX_t^p	z_t^p	ΔX_t^i	z_t^i
Mean	18	39	19	23
Mean Emerging	18	32	24	25
Mean Developed	19	48	13	20
Argentina	16	8	74	1
Bolivia	26	55	0	19
Chile	10	18	0	71
Costa Rica	25	42	28	4
Ecuador	34	32	33	1
India	10	24	63	2
Korea, Rep.	19	55	26	1
Mexico	12	40	47	1
Panama	14	16	0	70
Peru	18	19	0	63
South Africa	35	27	1	36
Australia	6	27	64	4
Belgium	21	64	1	13
Canada	16	43	1	40
France	18	77	2	4
Iceland	8	17	0	75
Luxembourg	28	22	50	1
Norway	10	39	3	49
Spain	23	53	0	24

Observations on the Table

• As under quarterly data of mostly developed economies, world shocks (X_t^p and z_t^p) play a major role in explaining the variance of output growth.

• Also, of the contribution of world shocks to output fluctuations the majority is stationary shocks, z_t^p.

• This pattern applies when one limits attention to emerging countries: world shocks explain more than fifty percent of the variance of output, and of this almost two thirds is stationary world shocks.

• The fact that stationary world shocks, z_t^p, explain a much larger share of the variance of output growth than of the variance of the growth rate of prices, indicates that world shocks may be only partially mediated through commodity prices.

• The table also speaks to the stationary vs. permanent shock literature: The majority of fluctuations in aggregate activity in the emerging countries considered stems from stationary domestic and world disturbances.

Forecast Error Variance Decomposition of the Level of Output: Annual Data

Shock	X_t^p				z_t^p				X_t^i				z_t			
Horizon	5	10	20	30	5	10	20	30	5	10	20	30	5	10	20	30
Mean	15	19	23	27	52	52	49	46	11	13	16	18	22	16	11	9
Mean Emerging	19	24	30	34	40	38	34	31	15	17	20	21	26	21	16	13
Mean Developed	9	12	14	17	69	72	70	66	5	7	11	13	17	9	5	4
Argentina	45	33	20	14	10	6	4	3	45	61	76	83	1	0	0	0
Bolivia	1	6	48	65	63	69	41	30	0	1	1	1	36	25	10	5
Chile	5	5	11	20	15	16	15	14	0	1	3	4	80	78	71	63
Costa Rica	11	10	38	60	68	61	35	18	17	26	26	21	3	2	1	0
Ecuador	59	67	66	63	34	26	23	21	7	7	11	16	1	1	0	0
India	9	10	16	17	54	64	64	61	32	24	20	21	5	2	1	1
Korea, Rep.	9	7	5	9	77	54	49	45	12	38	45	46	3	1	0	0
Mexico	19	22	24	24	70	64	57	53	10	14	19	23	1	0	0	0
Panama	13	26	36	36	14	14	13	14	0	1	1	2	73	59	50	47
Peru	24	38	38	35	13	12	20	27	0	0	1	1	63	50	42	37
South Africa	45	54	59	60	20	18	17	16	1	1	2	4	35	27	22	20
Turkey	4	3	4	6	35	22	12	8	61	75	84	86	1	0	0	0
Australia	0	0	0	0	69	62	46	36	24	34	52	62	7	4	2	1
Belgium	9	7	9	13	86	90	88	83	1	1	2	3	4	2	1	1
Canada	15	15	15	14	50	59	64	65	1	1	2	3	35	25	19	17
France	2	1	5	13	94	96	92	84	1	2	2	2	3	2	1	1
Iceland	8	14	26	35	27	41	46	43	0	0	1	1	65	44	28	21
Luxembourg	28	37	33	27	47	32	22	18	23	31	45	55	1	1	0	0
Norway	1	6	17	24	48	66	69	65	3	4	4	4	48	23	10	7
Spain	6	15	21	22	69	72	72	72	0	0	1	1	25	12	7	6
United Kingdom	29	36	37	35	52	39	31	26	17	24	32	39	2	1	0	0

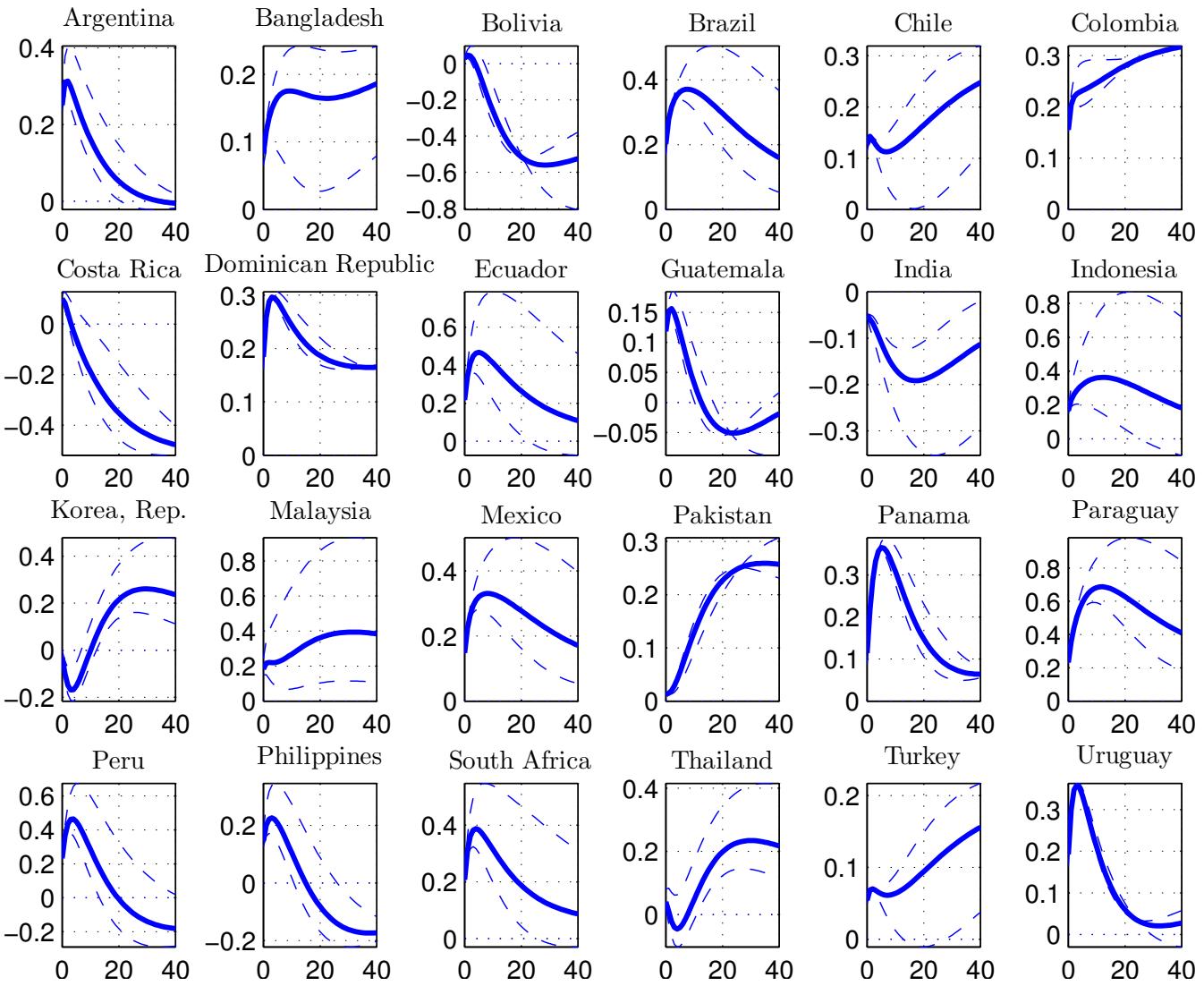
Observations on the Table

• The importance of stationary world shocks in accounting for movements in output continues to obtain at different horizons in the enlarged dataset

• This pattern is stronger in developed countries.

• The permanent world shock, X_t^p, is a significant driver of aggregate fluctuations in emerging economies, but not the dominant one:
◇ At forecasting horizons of 5 and 10 years, the mean share of variance explained by z_t^p is 40 and 38%, respectively, compared to 19 and 24% explained by X_t^p.
◇ At horizons of 20 and 30 years, the role of nonstationary world shocks increases,but does not dominate that of stationary world shocks. X_t^p explains 30 and 34% of the FEV of output growth compared to 34 and 31% explained by z_t^p.

IRF of Output to an Increase in X_t^p: Emerging Economies



: mean : 95% Sims-Zha asymmetric confidence bands

Observations on the Figure

• We saw earlier that for developed countries an increase in X_t^p is typically contractionary.

• By contrast, for most emerging countries a permanent increase in commodity prices is expansionary.

• A possible explanation for this difference could be that in emerging countries the production of primary commodities represents a larger share of total output than it does in developed countries.

Conclusions from Lecture 3

• This lecture investigates empirically the importance of the shock responsible for the commodity price super cycle as a driver of aggregate activity in emerging and developed economies.

• The shock driving the commodity price super cycle is defined as a common permanent component in real commodity prices.

• Estimates indicate that permanent and stationary world shocks explain more than half of the variance of output growth on average across countries.

• However more than two thirds of this contribution stems from stationary world shocks.

• This result suggests that world shocks causing low frequency movements in commodity prices play an important but not dominant role in driving fluctuations in aggregate activity.