Resource Economics
Lecture 4

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Short run mechanisms and empirical tests

Overview

- The previous lectures have been analyzing some models and mechanisms that affect extraction and prices of exhaustible resources in the long run.
- This lecture is about
  - A rough overview of how the main (long run) models can be tested.
  - Mechanisms affecting (mainly oil) prices in the short run.

Testing the basic Hotelling result

$$\frac{p_{t+1}}{p_t} = r_{t+1} + \varepsilon_t$$

A problem with this test is that while p_t is decided today it is the expectations of p_{t+1} and r_{t+1} that matter.

$$\frac{E(p_{t+1})}{p_t} = E(r_{t+1}) + \varepsilon_t$$

But how can we measure them?

Adaptive expectations

- Heal & Barrow 1980.
- Use forward prices (the price payed today for buying a commodity in the future)
- Assume that the expected interest is what we observed in the previous periods.

$$E(r_{t+1}) = r_t + r_{t-1} + r_{t-2} + r_{t-3}$$

Adaptive expectations

$$\frac{p_{t+1}}{p_t} = ar_t + br_{t-1} + cr_{t-2} + dr_{t-3} + growthcontrols + \varepsilon_t$$

- Model predicts a+b+c+d>0

TABLE I

Copper forward

Variable	A	URTF	RTF
$r_c(-1)$	0·436*	0·519*	0·503*
$r_c(-2)$	−0·176*	−0·328*	0·066
g	−0·020	−0·024	0·021
r	0·018	0·016	0·015
$r(-1)$	−0·018	−0·015	−0·013
$r(-2)$	−0·002	−0·004	−0·009
$r(-3)$	0·018	0·017	0·017
$r(-4)$	−0·013	0·012	−0·001
$r(-5)$	−0·003	−0·008	−0·009
$r_c(-3)$		0·301*	
$r_c(-4)$		−0·124	
$g(-2)$		0·089	
$r(-6)$		0·017	
$r(-7)$		−0·013	
R^2	0·212	0·294	
S	0·067	0·065	0·066
$\sum r$	0·00040	0·00013	0·00009
F		2·89*	
α		−0·42	−0·38*
χ^2			7·17

Results

- No support of the theory. Many other similar tests reject Hotelling's predictions as well.

But…

- Hotelling's model provides prediction on profits, not prices.

Modifying the prediction

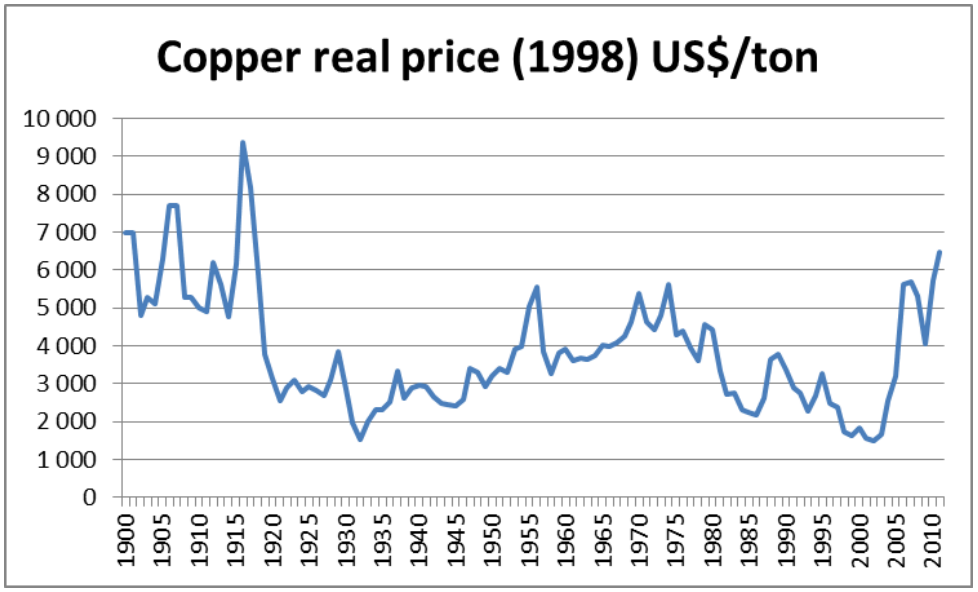
- Recall the Hotelling model with mining costs.

$$\frac{E(p_{t+1} - M'_{t+1})}{p_t - M'_t} = E(r_{t+1})$$

- If mining costs are falling due to technology or if we discover cheaper deposits the price may initially fall.
- But as costs go to zero and discoveries ‘’must’’ eventually run out the prices should eventually increase.
- A U-shaped price path.

Results

- Some empirical studies suggest a U-shaped price path (see Slade & Thile, 2009).
- But this can be resolved by ocular inspection and is then dependent on time period used...



- ...and holding other things equal a higher interest should lower the price less or increase it more.
- But it may be drowned by all the noise.
- Other studies (Lin & Wagener, 2007) suggest that costs have not fallen. Thus we should not expect the falling initial part of the U-shape.

Structural tests

- Build a model (e.g. Hotelling with extraction costs), use explicit functional forms and derive some results and test them specifically.

$$\frac{E(p_{t+1} - M'_{t+1})}{p_t - M'_t} = E(r_{t+1}) + \varepsilon_t$$

- We want to measure the scarcity rent = p – M’

Structural models

$$\frac{E(p_{t+1} - M'_{t+1})}{p_t - M'_t} = E(r_{t+1}) + \varepsilon_t$$

- We want to measure the scarcity rent = p – M’
- p can be measured
- but costs are heterogenous so one has to do a firm specific test. I.e. use a functional form for M which specifies what determines it. Calibrate it and then you get M’ which can be used to back out p –M’.
- Downside is that your assumptions on M have to be correct.
- Since M is heterogenous need to use firm specific data of costs and extraction.
- ...but this makes external validity limited.

Results

- Very few find support of the Hotelling model.
- One paper (Stollery, 1983) finds support with a 15% discount rate.
  - The size of the scarcity rent is then around 6% of the price, i.e. not an important factor.
  - Standard in macro is 1-7% discount.
  - Higher is possible if resource price has positive correlation with ”stock market”. In finance this is called a positive beta. No support for this.
  - But... oil companies often say they use 20%+ return on investment (and require break-even in 20 yrs).
  - But But ... maybe oil companies not relevant in determining scarcity, more likely governments should care.

Directly measuring scarcity

- The scarcity rent represents the value of the resource under ground.
- Can use prices of mines when they are sold.
- Problem: selling whole mines happens very rarely.

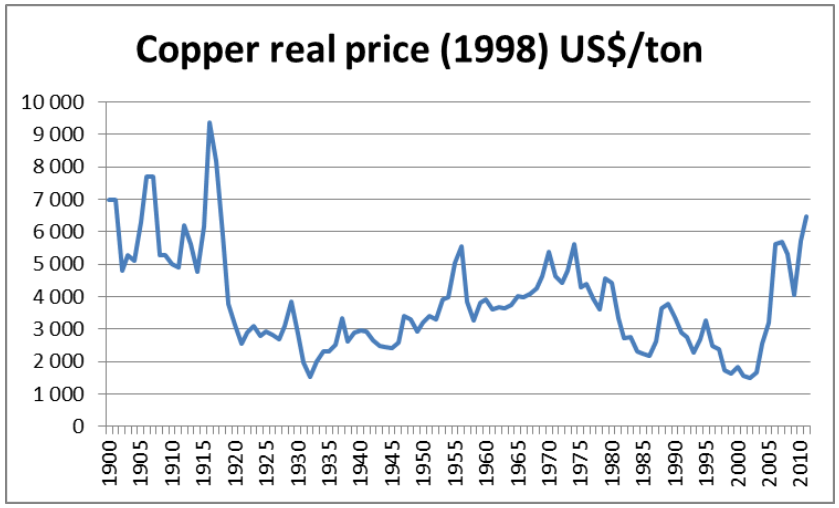
Other issues

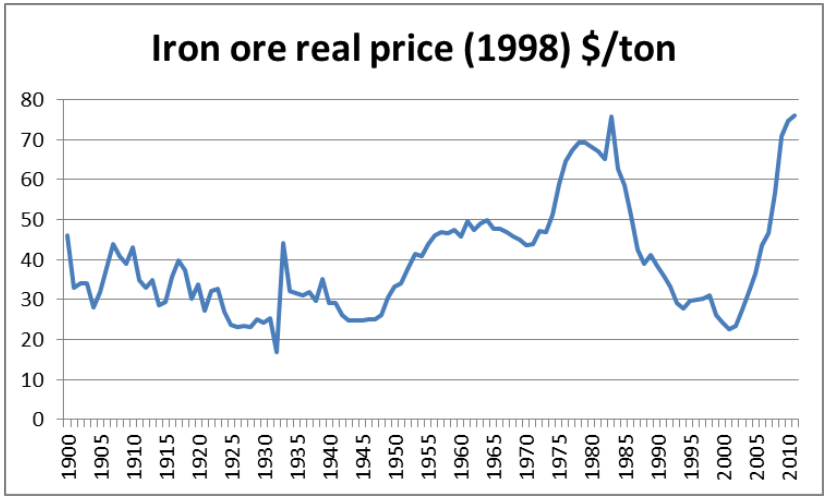
- What is monopoly profits and what are scarcity rents? One study (Ellis & Halvorsen, 2002) suggests the latter to be more important in oil.
- Many studies find cartelization to be important in oil.
- The general picture is that some (few) studies support the Hotelling result. But if enough studies are done one is bound to find something (spurious) eventually.
- But are we measuring the right thing?
- Most models presented this far are about the very long run. In resource markets scaling production up or down quickly is not possible. Hence short run interest rates may not be a relevant measure. Need to use expected interest on, e.g., stocks for the next decades. But that is hard to measure.

Short run mechanisms

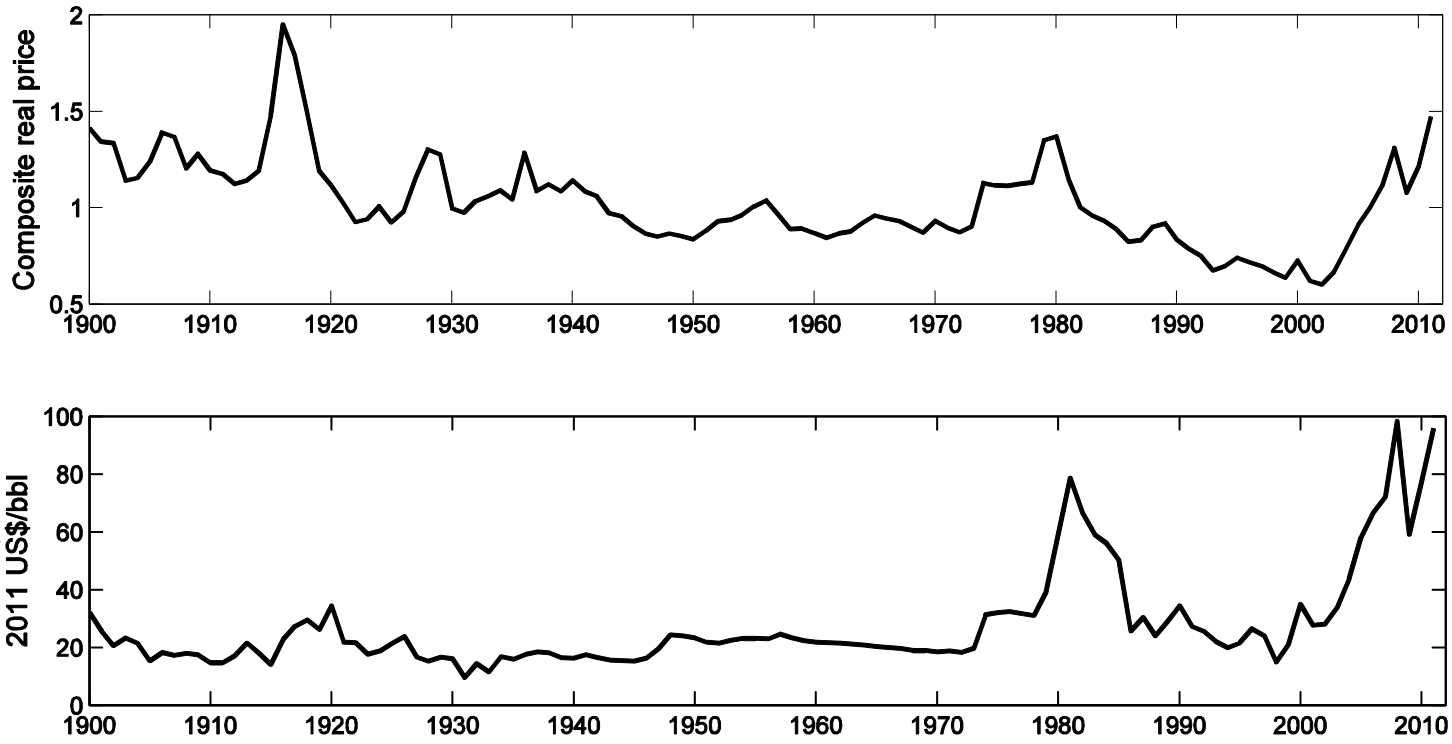
- Why are resource prices so volatile?
- What explains some specific historical events?

Volatility


Copper real price (1998) US$/ton
10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


Iron ore real price (1998) $/ton
80
70
60
50
40
30
20
10
0
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Volatility


Composite real price
2
1.5
1
0.5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Real oil price
2011 US$/bbl
100
80
60
40
20
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Volatility - Scalability

- Most models presented this far are about the very long run. In resource markets scaling production up or down quickly is not possible.
- Opening of new mines typically has a lead time of 5+ years.
- Getting a green light may take decades.
- Shutting down a mine temporarily is very costly.
- Hence, if demand increases or decreases suddenly then we may get under- or over-supply.
- With low substitutability (lecture 2) this can create very large price fluctuations.
- Example: Leontieff production function.

Volatility - scalability

- If scalability is a problem then short run interest rates (like in Heal & Barrow's study) may not be a relevant measure. Need to use expected interest on, e.g., stocks for the next decades.
- But that is hard to measure.
- Pointless to measure scarcity rents on firm level.

Volatility – biased forecasts

- Building a mine necessitates a forecast of supply and demand for the next years.
- What if we make the wrong forecast for a few years?
- Kilian & Hicks (2009) look at actual market forecasts in the period 2003-2008.
- They show that the market expected lower growth in China than was realized.
- This would explain the increasing oil price in 2003-2008 – there was not enough investment to meet this demand in the short run.
- What does that say about the future?
- Are expectations rational?

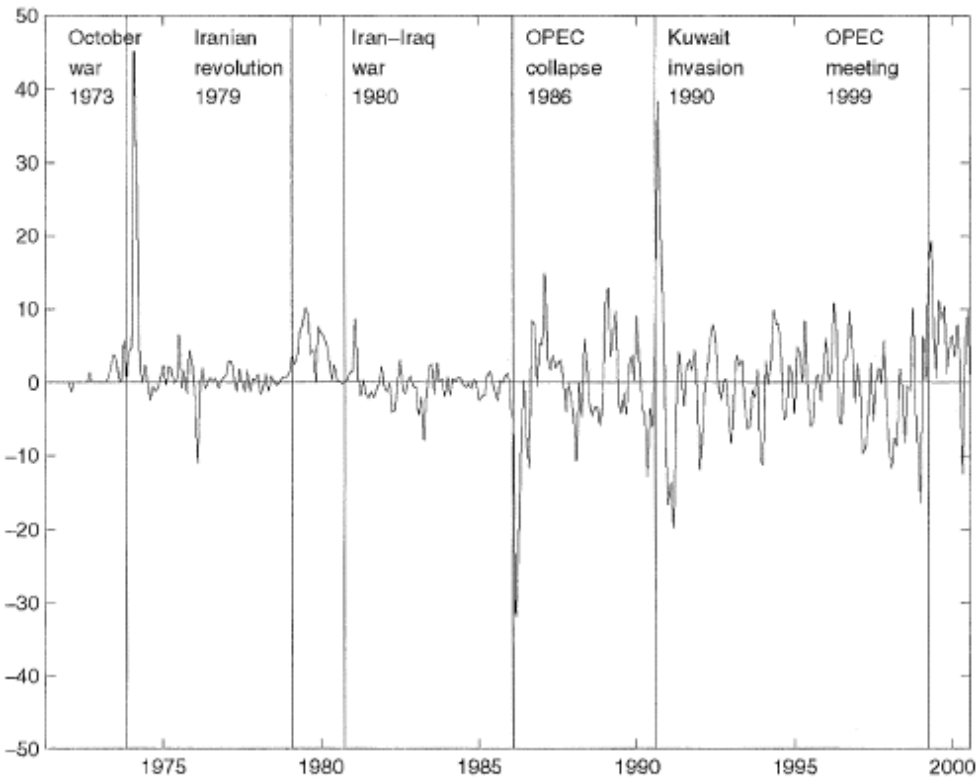
Speculation

- Did speculation on the oil market cause the price to surge in 2003-2008?
- See: The Role of Speculation in Oil Markets: What Have We Learned So Far?, Fattouh et al (2012)
- Speculation, defined as those trading in oil not for own consumption.
- Hypothesis:
  - 2003 there was an influx of investors from outside the oil industry.
  - These investors stored oil awaiting future prices, which led to higher prices already at that point in time.
- But speculation indeces (extent of speculation) are not correlated with prices.
- Oil futures are bad predicters of later observed prices. Guessing that the price next year will be the same as this year is on average more accurate.
- The claim is that high ”futures prices” caused inventories to increase thus to undersupply today and a higher price. But oil futures not correlated with inventories.

Wars

- Large body of research shows prices of commodities may cause wars.
- But do wars affect commodity prices?

Figure 1 PERCENTAGE CHANGE IN NOMINAL PRICE OF OIL



Source: The underlying oil price series is refiner's acquisition cost of imported crude oil (DRI code: EEPRPI) for January 1974 to July 2000. We use the U.S. producer price index for oil (DRI code: PW561) and the composite index for refiner's acquisition cost of imported and domestic crude oil (DRI code: EEPRPC) to extend the data back to March 1971.

Source: Barsky & Kilian 2002

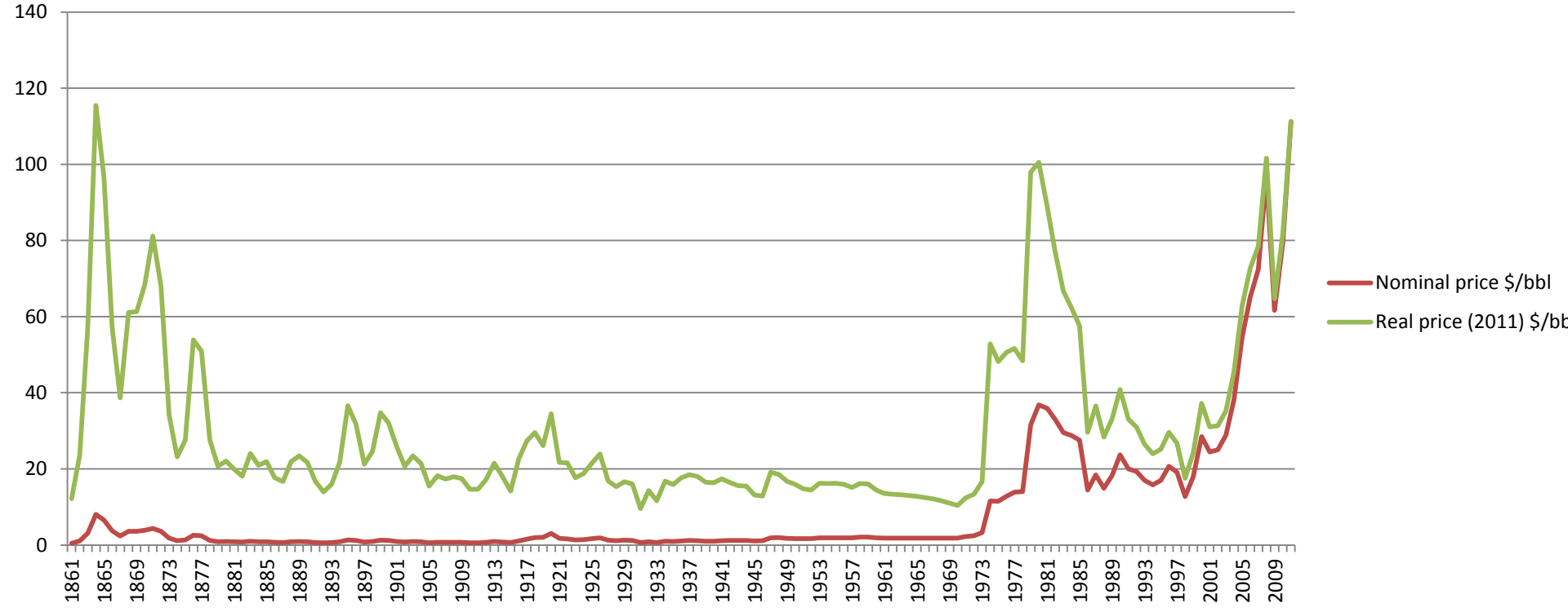
Wars

- Decreasing supply in producing countries→increasing price.
- Stocking up on inventories outside of producing countries→increasing price.
- Pessimism about the future economy, lower demand→decreasing price.
- I.e. mechanisms go in different directions.
- Empirically:
  - Yes: Wars increase price of oil (other commodities unknown)
  - But mainly through stocking up of oil in inventories (see Barsky & Kilian, 2002). I.e. long run supply interuptions are less important.
- Expected wars and unexpected wars will have effects with very different timing.

Price regulation

- Prior to 1973, nominal oil price is regulated by Texas Railroad Commission (dating back to Texas oil boom of 1920s).
- The government forecasts oil consumption and then sets production targets and pins the oil price accordingly.
- Oil price shocks during 1948-1972 were associated with
  - exogenous oil supply disruptions in Middle East that were
  - unforeseen by government and required ex-post adjustments of the regulated price of oil.
- I.e. inability to properly foresee supply.

Price regulation



- An illustration (Hamilton, 2003): After WWII the nominal price is fixed (by US gvmnt) and hence real price falls at exactly speed of inflation.
- OPEC is formed 1960, wants to increase price, but cannot (due to price regulation).
- In early 70:s, the US lets go of price peg and price increases all at once.

Price regulation and monopolies

- The previous story suggests that the formation of a monopoly whose power is delayed caused the price to rise by 125% which caused the oil crisis.
- But, for instance, the price of other commodities rose by nearly as much (e.g. 92% for iron ore).
- This price rise cannot be explained solely by extraction costs increasing for metals when oil price is high.
- This suggests that demand may have had something to do with it.
- More specifically, research (=Kilian and co-authors) shows that expansionary monetary policy played an important role.