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Some Economics of Seasonal Gas Storage

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ROADMAP

- The problem: how important seasonality is? Some data on the US Gas Industry
- Our view: ingredients for the analysis
 - competitive storage
 - limit cycles
 - exhaustible supply
- Estimation of the model
 - The problem: policy instruments for countries that depend on foreign import to exert monopsony power
 - Evaluation of the impact on storage, prices and welfare of price cap, tariffs, cross subsidies
- Open questions



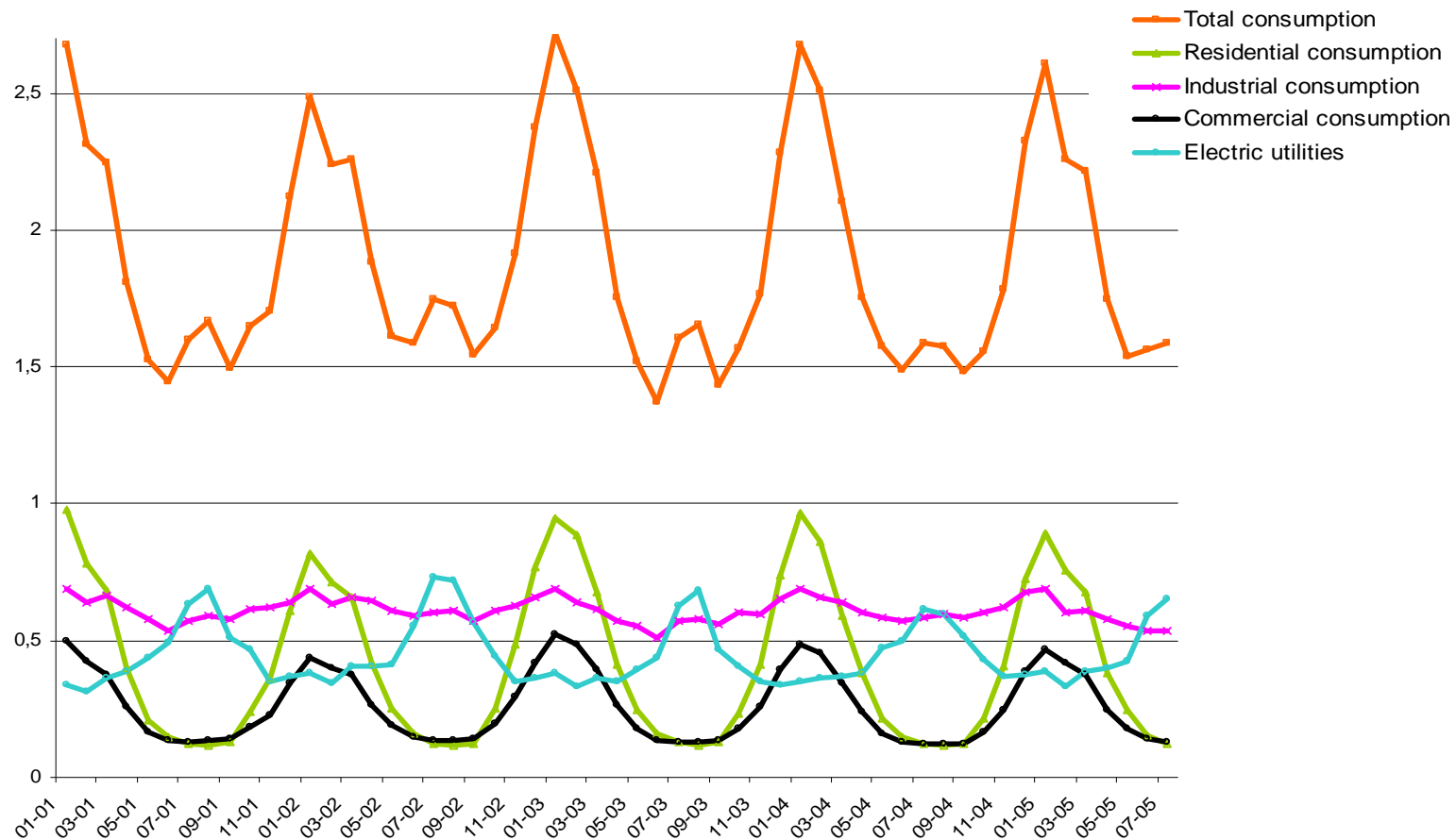
The US Gas Industry

- US: major player in the gas industry at the world level
 - Second producer, first importer
- Production sector: rather competitive
 - There are about 8,000 gas producers, ranging from small operations to major international oil companies
 - The five largest producers account for around 25% of total US output.
- The natural gas market exists
- Data reliable and publicly available (main source: EIA)

...a rather different picture if compared to EU!

Consumption

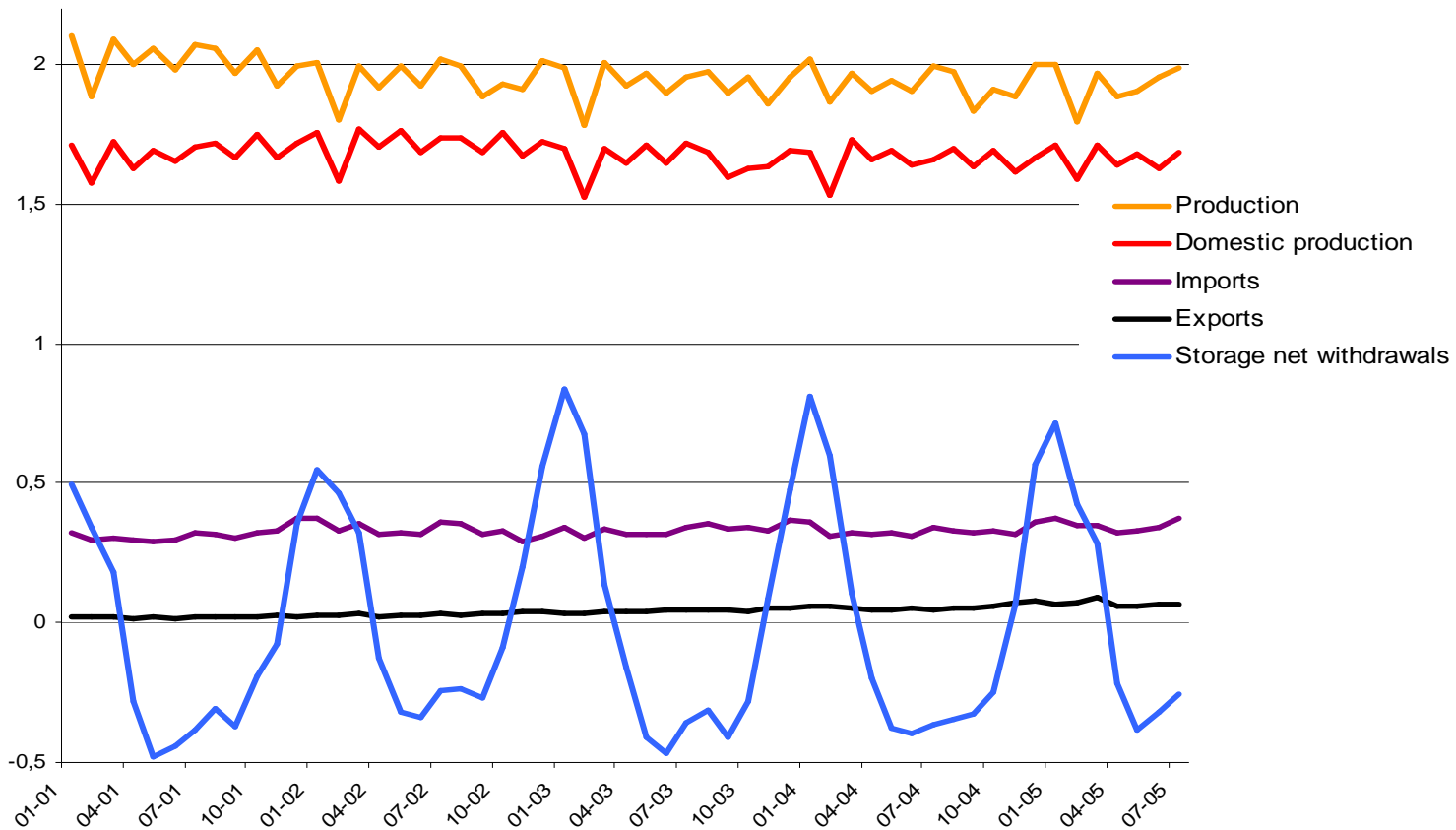
- Weather is the primary driver of gas consumption.
- Electric utilities' consumption is counter-cyclical, but overall the yearly cycle alternates between winter peaks and summer troughs





Production

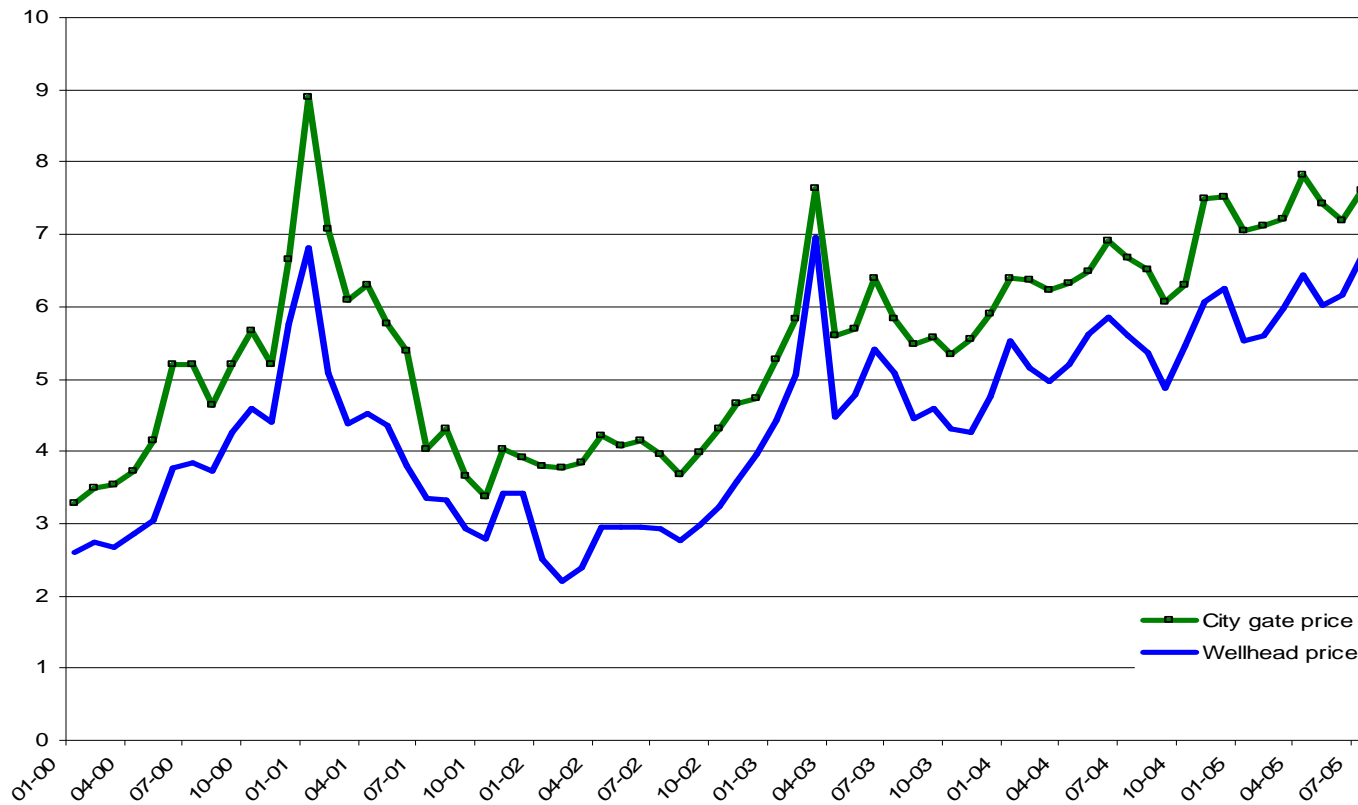
- Extraction from gas wells as well as imports are flat
- storage plays a key role in balancing seasonal and short-term loads





Prices

- Seasonality of the price is hardly visible
 - Over the last twenty years, the average price over the winter is significantly higher than the average price during the previous summer.





Sketch of the model

- Time is discrete and infinite; a year is composed of two six-month periods; it starts with summer and ends with winter.
- To focus on stock variation (more easily observable), we model excess supply function in summer and in winter
- Storage is assumed to be a competitive activity with constant returns to scale up to the maximum capacity
- With positive storage, there are 2 fundamental equations:
 1. the *no-arbitrage condition*
 2. *conservation of matter*
- Price-taking behavior of the agents, strictly increasing excess supply functions, linearity of the storage technology: the competitive equilibrium maximizes total surplus



Three key results

1. Restricting the rate at which supply and demand change over time, we prove the **convergence to seasonal pattern in finite time**
2. Robustness to random shocks: if the shocks are limited (support is bounded), then there is **no possible state of the economy in which speculators store at the end of the winter for the coming summer**
3. Cycles and trends: the equilibrium is never stationary and **the economy crosses three significantly different phases:**
 - **the beginning** (low prices): the economy follows a trend at the wellhead, but is cyclical at the consumption place; the pipeline is congested; positive storage
 - **the transition** (intermediate prices): as in the previous case, but with the pipeline congested in winter only
 - **the end** (high prices): no storage - only imports



European countries: first or second phase?



Estimation of the model

- Based on the stochastic version of the model
- The observed variables per season (summer or winter) are:

Δ = variation of the stock

p = average price

Y = GDP

T = average temperature

where season average temperature and GDP are exogenous controls



- The equilibrium involves, for each year, four equations (linear specification, 3SLS):
 - excess supply in summer
 - excess supply in winter
 - price arbitrage
 - annual balance.

- The dataset covers April 1986 (year in which deregulation started) to March 2005

- **Results:** overall, **the theory we exposed is not contradicted by the data**
 - Annual cycles, no catch-up effects, significant impact of temperature and GDP, estimated interest rate at 10%; no significant impact of storage unit cost



Welfare effects of price policies

- Estimation of domestic production and net imports
 - Sample: from 1993 to 2005
- Three scenarios:
 1. *Pure competition.*
 2. The *optimal price cap* for residents (consumers and domestic producers) with winter efficient rationing
 3. The residents' optimum: *optimal tariffs*, associated equilibrium prices and quantities (no rationing)



Three key results

1. The optimal price cap is less distortionary than optimal tariffs
 - these latter are nevertheless, by definition, more attractive for the residents.
2. The optimal tariffs are very large (about \$7 per MMcf) and do more than halve the import price.
 - This effect is due to the relative inflexibility of imports.
3. The price cap discourages storage, as predicted, and more than tariffs, whose effect is ambiguous in our theoretical model.




« *Realism* » of the suggested policy analysis for the US market

- As from 1978, in the US, progressive market liberalization

- Energy Policy Act of 2005
 - moderating the recurrence and severity of "boom and bust" cycles while meeting increasing demand at reasonable prices
 - proposals to ensure adequate domestic energy supply and infrastructure.

- Public interventions
 - Gas price cap (temporary or emergency measure)
 - Excise tax

Lessons for European countries?



Scenario	Perfect comp.	Opt. price cap	Opt. tariffs
Total surp./year	0	-1.06	-1.84
Dom. surp./year	-12.7	-11.5	-10.4
Stocks (10^6)	1.65	1.47	1.60
Summer			
Import price	2.49	1.29	1.23
Domestic price	2.49	1.29	7.51
Tariff	0	0	6.28
Winter			
Import price	2.56	1.6	0.91
Domestic price	2.56	1.6	8.08
Tariff	0	0	7.16

Table 2. Comparison of three price policies.

Quantities in MMcf, prices in \$/MMcf, surpluses in M\$.

The total maximum surplus is set by convention to 0, other surplus are given as differences with the maximum.



Open questions

- How do seasonality match security of supply?
 - Storage management rules
 - Other instruments for (demand) flexibility
- Storage capacity
 - Acces to storage conditional on capacity saturation
 - Investment

Descriptive Statistics

Variable	Unit	Mean	Std. Dev.	Min.	Max.
GDP_S	B\$	8313	1439	6262	10846
GDP_W	B\$	8317	1436	6265	10838
Wells	#	307129.7	49949.19	241527	401480
T_S	°F	62.77842	.6637795	61.57	63.88
T_W	°F	44.41	.145406	41.97	46.71
Δ_S	MMcf	1638388	325292.7	1160000	2262996
Δ_W	MMcf	-1649048	294352.6	-2323528	-1163000
Dom. prod. S	MMcf	9331938	621662	7970839	1.01×10^7
Dom. prod. W	MMcf	9600006	303795	8898230	1.01×10^7
Net imp. S	MMcf	1282275	453669	469932	1930174
Net imp. W	MMcf	1164139	505577	261408	1819766
p_S	\$/Mcf	2.46	1.13	1.46	5.42
p_W	\$/Mcf	2.53	1.22	1.56	5.57

Table 3. Descriptive statistics.

Note: MMcf = one million cubic feet, Mcf = one thousand cubic feet. GDP in annual value.

Core equations of the model

Equation	Coeff.	St. Err.	z	$P > z $
$\Delta_{yS} = \dots$				
Constant	1.57×10^7	6.82×10^6	2.30	.022
p_{yS}	2.50×10^5	1.46×10^5	1.72	.086
Y_{yS}	-35.4	93.2	-0.38	.705
T_{yS}	-2.29×10^5	1.05×10^5	-2.18	.029
$\Delta_{yW} = \dots$				
Constant	-5.51×10^6	1.78×10^6	-3.08	.002
p_{yW}	2.58×10^5	1.10×10^5	2.33	.020
Y_{yW}	-336	91.6	-3.66	.000
T_{yW}	1.35×10^5	4.76×10^4	2.84	.005
$p_{yW} = \dots$				
Constant	-.168	.181	-0.93	.351
p_{yS}	1.10	.068	1.47*	.144*

*Tested against 1.

Table 1. Core equations of the seasonal storage model.

Domestic Production

A.5 Production and imports

Equation	Coeff.	St. Err.	z	$P > z $
Summer dom. prod.				
Constant	8.60×10^6	9.18×10^5	9.37	.000
p_{yS}	-1.40×10^5	1.27×10^5	-1.10	.280
Wells	4.59	3.66	1.25	.217
Summer net imp.				
Constant	1.05×10^6	1.44×10^5	7.29	.000
p_{yS}	2.08×10^5	4.66×10^4	4.46	.000
Winter dom. prod.				
Constant	1.08×10^7	6.47×10^5	16.71	.000
p_{yW}	9070	8.47×10^4	0.11	.915
Wells	-3.18	2.58	-1.23	.226
Winter net imp.				
Constant	1.19×10^6	1.31×10^5	9.09	.000
p_{yW}	1.92×10^5	4.03×10^4	4.78	.000

Table 4. Domestic production and imports.