Future Nuclear construction costs: what does the past tell us?

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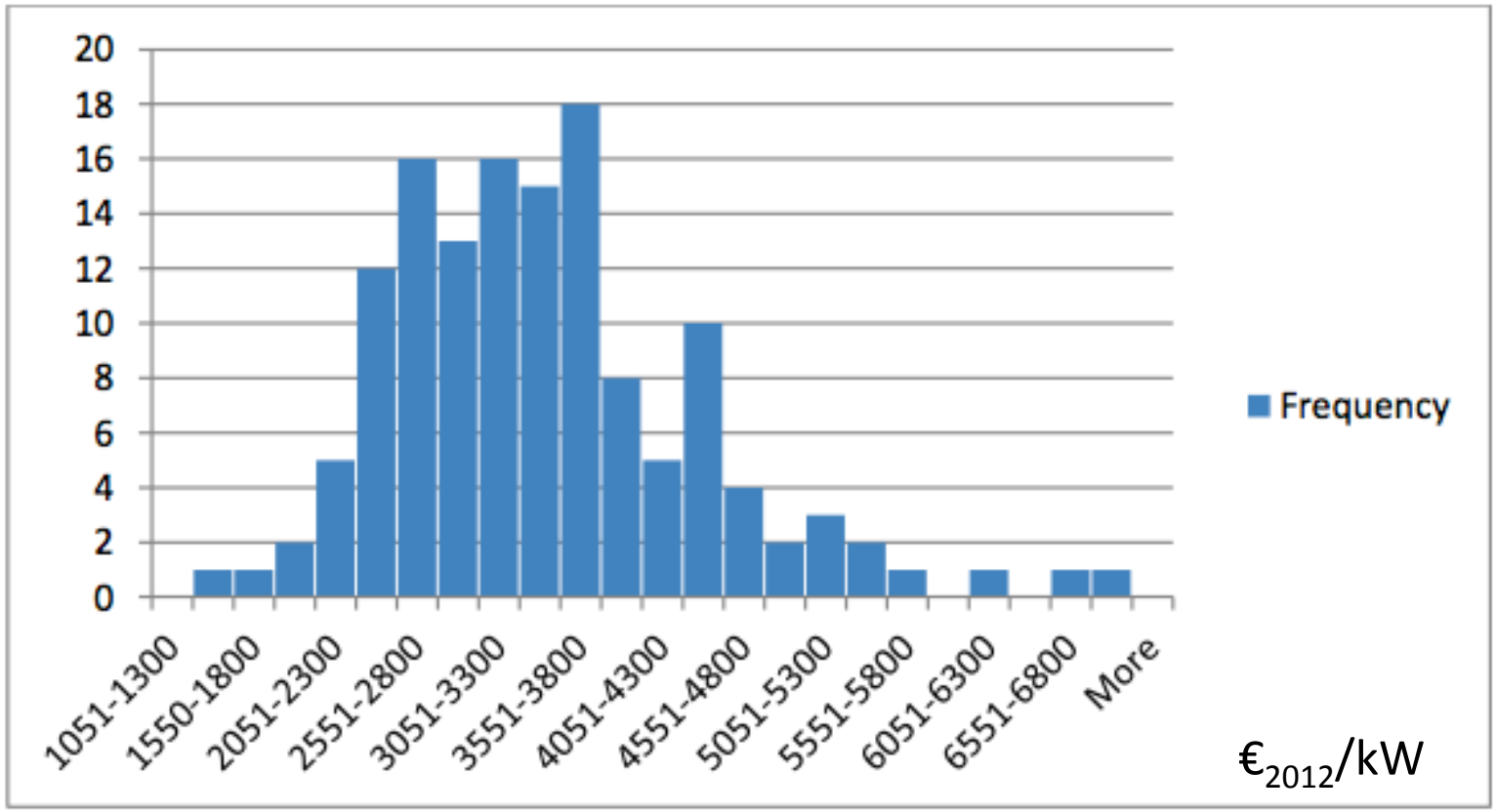
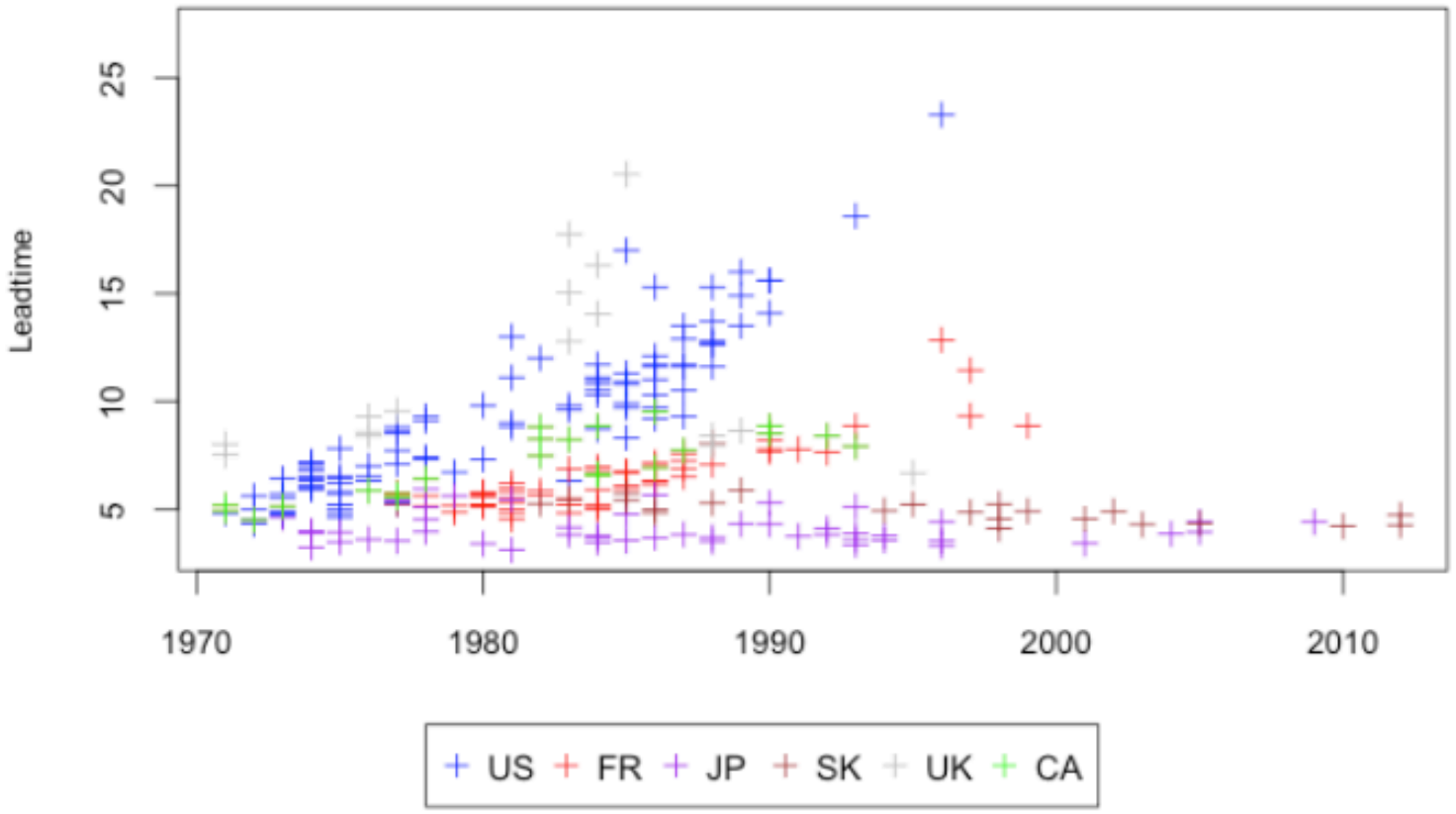
Overnight construction costs (W. D'haeseleere, 2013)



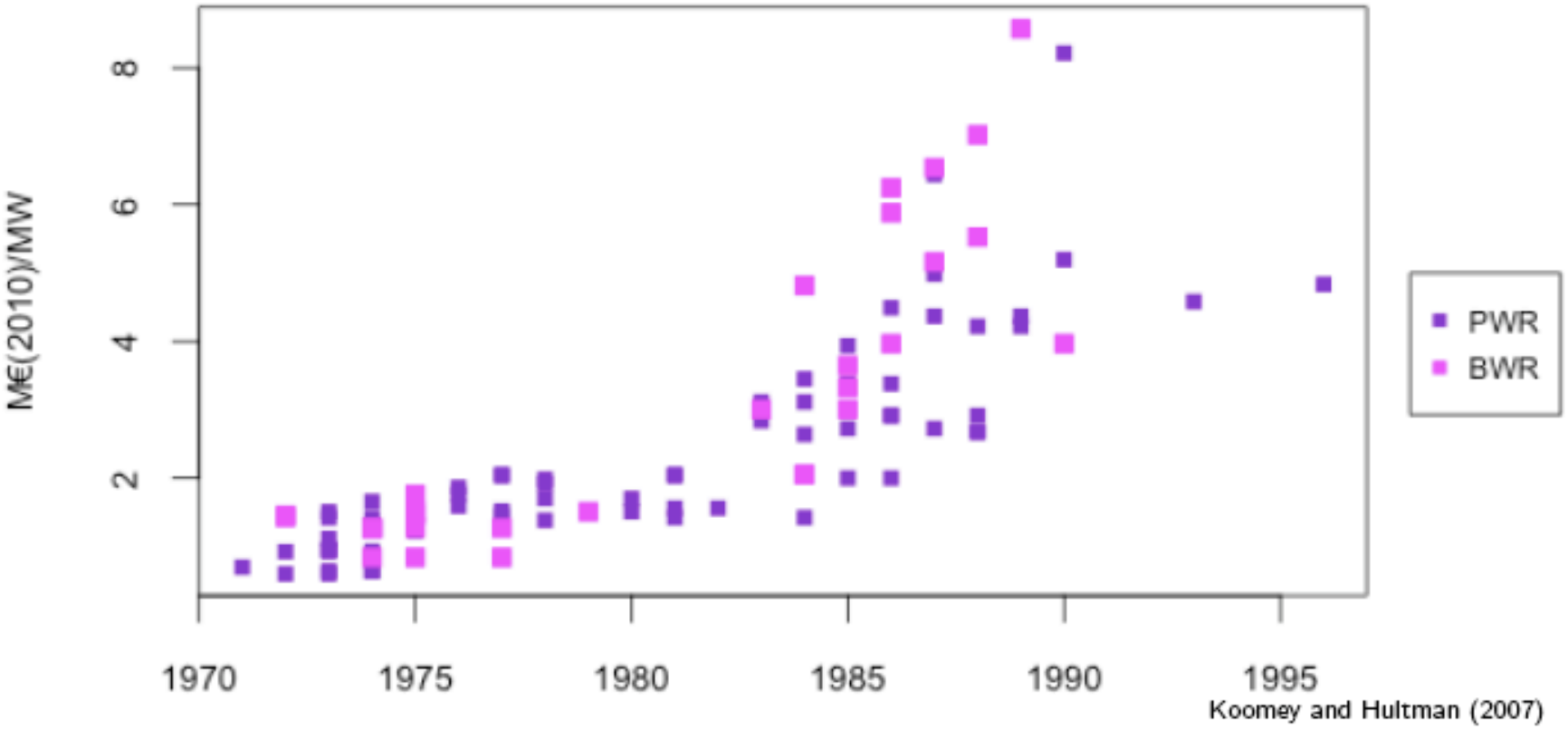
Histogram for the 137 data points for the overnight construction cost (OCC) from a disparate set of references (mostly PWRs, but also a few BWRs, and so-called "generic" plants). The intervals of the bins are 250 EUR_{2012} wide.

Construction lead-times in OECD countries (Berthélemy and Escobar, 2013)



Past evolution of the U.S nuclear construction costs

In the US, the overnight cost in USD2010/MW of the first reactor was almost 7 times less than the cost of the last one



Cost drivers for the U.S nuclear fleet

Effect	Komanoff (1981)	Zimmerman (1982)	Cantor &Hewlett (1988)	McCabe (1996)	Cooper(2010)
Scale	-0.2%	+0.17%	+0.13% offsetting by leadtime effect	-0.22% but no significant	+0.94%offsetting by leadtime effect
Learning	-7.0% by doubing the experience	-11.8% first unit -4% second unit	-42% first unit -18% second unit Only for utilities	-9% by 1 unit of builders experience added	0.9% by 1% increase in builders experience
Regulatory	+15.4% +24%	+14% time trend	+10%time trend	Not included	+0.179% NCR Rules +0.096% ΔNCR Rules

1. The scale effects that were found in some papers were rejected in recent papers, when the effect on the lead-time was taken into account in the cost equation
2. The estimates of learning effects differ substantially across the papers. In the latest ones they were found significant only when the projects were managed by the utilities. There is no evidence to support learning effects at the industry level
3. All the literature have found that the regulatory requirements are one of the main drivers of the cost escalation, even before the Three Mile Island accident

What can we learn from the experience of the two largest fleets in the world?

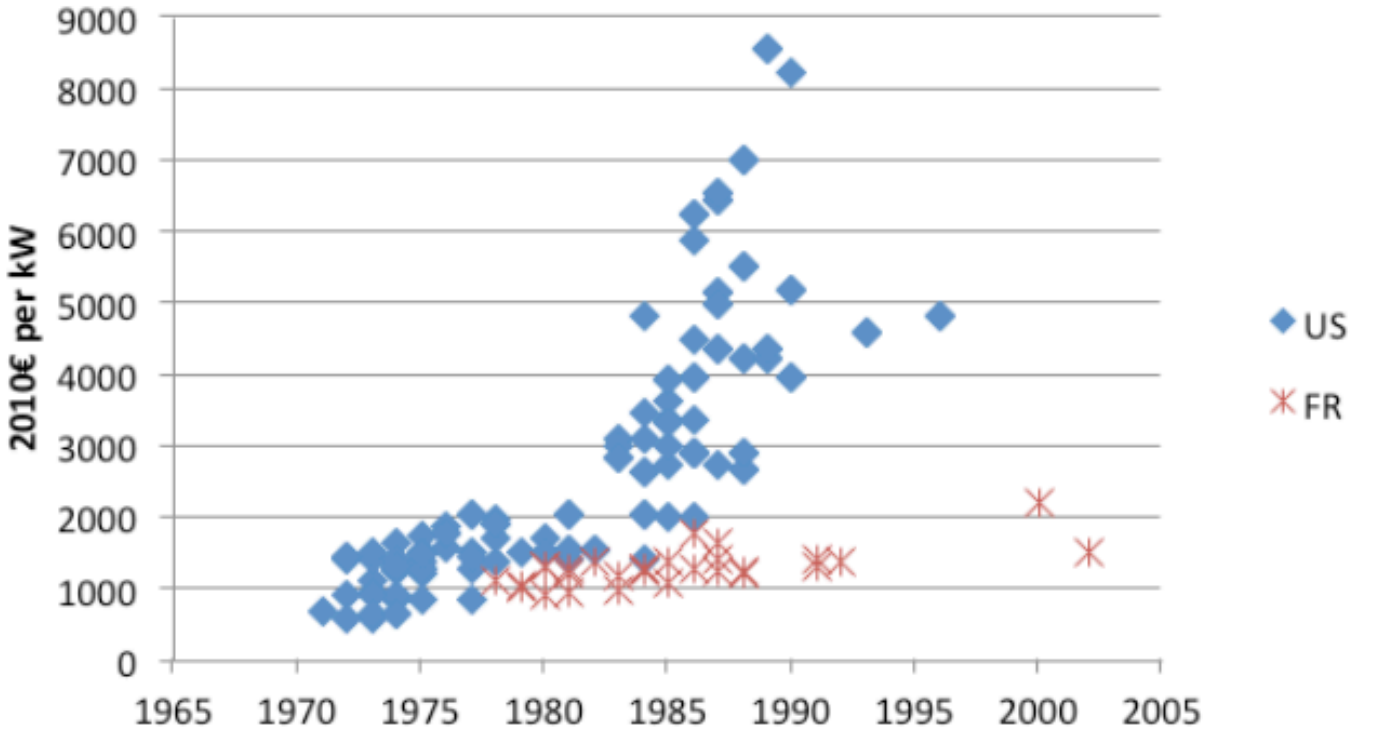


Figure : Overnight construction costs for the French and U.S nuclear fleet

Disentangling construction cost and lead-time

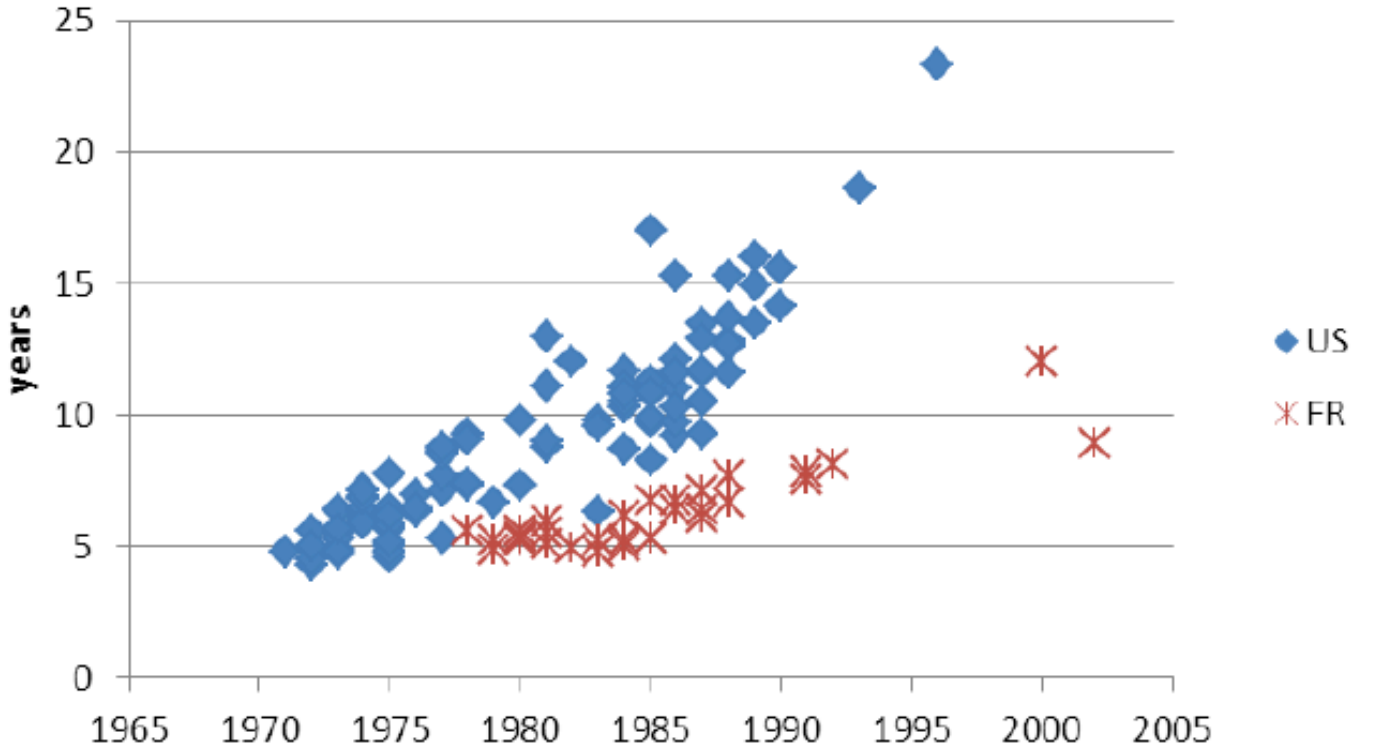


Figure : Construction lead-times for the French and U.S nuclear fleet

What does econometrics tell us?

	Model 1				Model 2			
Variable	Cost		Leadtime		Cost		Leadtime	
ln .*Leadtime*	1.933	***			1.064	*		
	(0.580)				(0.622)			
ln .*ExpArqMo*	-0.142	***	0.009		-0.149	***	0.009	
	(0.038)		(0.011)		(0.034)		(0.011)	
ln .*ExpArqNoMo*	0.025		0.026	***	0.029		0.026	***
	(0.034)		(0.009)		(0.031)		(0.009)	
ln .*ExpNoArqMo*	0.046		0.010		0.038		0.010	
	(0.039)		(0.012)		(0.035)		(0.012)	
ln .*ExpNoArqNoMo*	-0.068		0.141	***	-0.039		0.141	***
	(0.096)		(0.017)		(0.087)		(0.017)	
HHI_mo	0.454		-0.566	***	0.374		-0.566	***
	(0.537)		(0.160)		(0.485)		(0.160)	
ln .*Know*					1.416	***		
					(0.522)			
ln *Cap*	-0.769	***	0.125	**	-0.624	***	0.125	**
	(0.192)		(0.053)		(0.182)		(0.053)	
Arq. Utility	-0.256	***	0.009		-0.285	***	0.009	
	(0.093)		(0.028)		(0.085)		(0.028)	
ln .*Demand*			-1.235	***			-1.235	***
			(0.113)				(0.113)	
TMI.US	-0.058		0.272	***	0.115		0.272	***
	(0.184)		(0.0431)		(0.179)		(0.043)	
TMI.FR	-0.015		-0.028		-0.064		-0.028	
	(0.246)		(0.074)		(0.223)		(0.074)	
Cherno	-0.077		0.058	*	-0.030		0.058	*
	(0.123)		(0.031)		(0.113)		(0.031)	
Constant	6.420	**	-2.347	***	-4.182		-2.347	***
	(2.915)		(0.448)		(4.767)		(0.448)	
Country FE	Yes		Yes		Yes		Yes	
Trend + trend^2	Yes		Yes		Yes		Yes	
Obs.	128		128		128		128	
Adj. R^2	0.833		0.955		0.866		0.955	

(Berthélemy and Escobar, 2013)

Scale effect

- Larger reactors are cheaper per MWe
- But larger reactors are longer to be built and lead-time increases cost
- The net effect remains positive: a 10 % increase in capacity reduces the cost by 4.9% (-0,624 + 1,064x0.125)

Variable	Cost		Leadtime	
ln . *Leadtime*	1.064 (0.622)	*		
ln *Cap*	-0.624 (0.182)	***	0.125 (0.053)	**

Learning effect

- Positive learning effects are conditional to the same type of reactor and same constructor (i.e., architect-engineer)
- On average we can expect a 14% reduction in construction costs for the second unit of a reactor type build by the same firm
- The experience gain in other models is not directly transferable to any project

The nuclear fleet variety effect

The construction of an homogeneous fleet reduces leadtime

Variable	Cost		Leadtime	
ln . *Leadtime*	1.064	*		
	(0.622)			
HHI_{mo}	0.374		-0.566	***
	(0.485)		(0.160)	

US AND France data

Variables	(1) (ln *LT*)		(2) (ln *LT*)	
$HHI.Mo_t$	-0.291	**	-0.472	***
	(0.135)		(0.182)	

OECD data

HHI = sum of square market shares of models of reactord under construction in a given country and for given year

Lessons for the future

- The future of nuclear power depends on the ability of vendors and constructors to escape from the cost escalation past trend
  - lower overnight costs and construction time
  - more standardization and learning effects
- Tradeoffs
  - Between standardization and potential gains from adopting technologies with better operating and safety performance
  - Between industry concentration to exploit spillovers and market power