The Application of Econometric Methods in Economic Regulation

Lecture 5: Econometric estimation of cost functions. Application: Rail Competitive Tendering and Water Regulation

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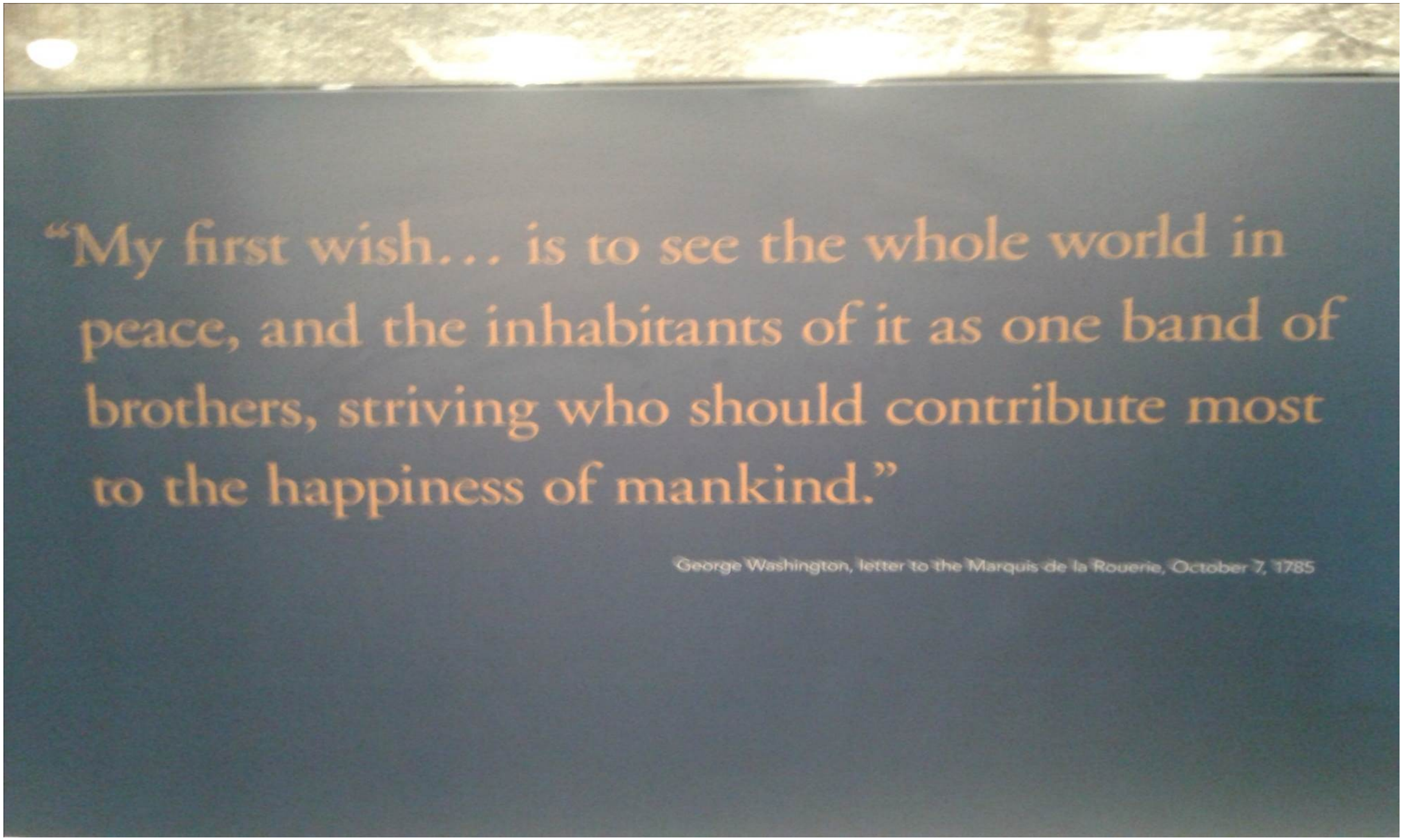
Professor Andrew Smith


"My first wish… is to see the whole world in peace, and the inhabitants of it as one band of brothers, striving who should contribute most to the happiness of mankind."
George Washington, letter to the Marquis de la Rouerie, October 7, 1785

…the invisible hand…

[The rich] consume little more than the poor, and in spite of their natural selfishness and rapacity…they divide with the poor the produce of all their improvements. They are led by an invisible hand to make nearly the same distribution of the necessaries of life, which would have been made, had the earth been divided into equal portions among all its inhabitants, and thus without intending it, without knowing it, advance the interest of the society, and afford means to the multiplication of the species.

The Theory Of Moral Sentiments, Part IV, Chapter I, pp.184-5, para. 10.

Competition for the market: introduction

- Competition in the market not always possible or beneficial:
  - ❑ Natural monopolies in general (destructive competition)
  - ❑ Peculiarities of particular markets (buses: getting a sensible timetable)
- So competition "for the market" i.e. competition to win a monopoly right to supply a particular market
- Government invites bids from competing firms to provide services for a set period of time
- Have our cake and eat it? Keep benefits of single-producer whilst avoiding problems of monopolistic practices
- And no need for regulation….

Some definitions

Private Value Auction

- Each bidder attaches a different value to the good under auction
- Independent private valuations
- E.g. personal tastes differ in valuing "works of art"

Common Value Auction

- The good under auction assumed to have the same value to all bidders
- But there is uncertainty over its value
- Classic example: offshore oil drilling rights

The East Coast Mainline Rail Franchise

- Links London and Edinburgh, with a branch from Doncaster to Leeds

- Right to run services awarded following an auction process

- Does this have the characteristics of a common value or a private value auction?

- Answer: private value component. One group might make more money from it than another (cost efficiency argument or fit with business)

- Also common value component: there is some uncertainty over the value of the franchise (particularly on the revenue side)

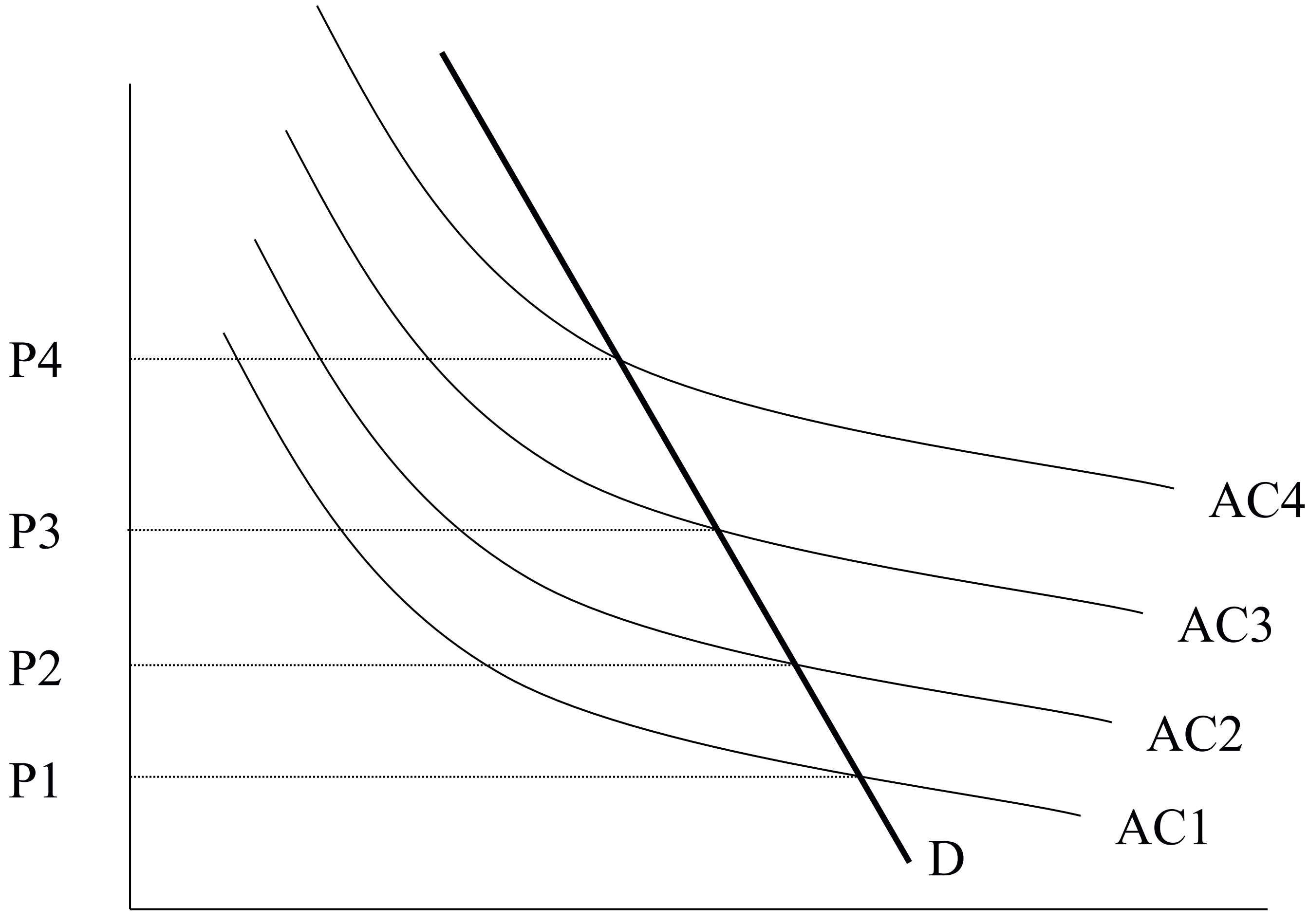
Types of franchising approach

Bidding on…

Price per unit

- Franchise let to bidder offering lowest unit price
- Bidders bid average cost
- Most efficient firm identified

Price bidding franchise



So a rosy picture of franchising

- When competition in the market not possible/desirable…
- Retain scale benefits of single producer in the market..
- But competition for the market leads to P=AC
- And most efficient operator chosen (with incentives to cut costs)
- Without the need for regulation
- However, many complications to this simple story…

Rail franchising in Europe

(Domestic) passenger competition has been the last part of the industry where competition is required by EU legislation

Some countries have pressed ahead in the meantime, most notably Great Britain, Sweden and Germany

The 4th Railway Package will require domestic passenger competition:

- By 2020 for open access (commercial services)
- By 2023 for competitive tendering in respect of public service contracts
- Provisions to restrict competition (protect public finances in respect of open access; and make direct awards for public service contracts, provided there is independent monitoring of this process to ensure it is appropriate).

Franchise size and economies of density (Smith and Wheat, 2012)

	Coeff.	Std.Err.	t-ratio	P-value
Deterministic frontier parameters				
ONE	5.0119	0.1239	40.4575	0.0000
ROUTE	0.6946	0.0359	19.3488	0.0000
TDEN	0.7760	0.0652	11.9061	0.0000
STAT1	0.3207	0.0502	6.3916	0.0000
TIME	-0.0276	0.0177	-1.5588	0.1191
INP	0.3349	0.1005	3.3316	0.0009
TDEN2	0.0382	0.0311	1.2267	0.2200
STAT12	-0.0058	0.0113	-0.5179	0.6046
TIME2	0.0020	0.0012	1.6746	0.0940
TLEN2	0.2980	0.0663	4.4957	0.0000
DENSTAT1	0.0708	0.0501	1.4127	0.1577
TDENLEN	-0.1861	0.0570	-3.2645	0.0011
STAT1LN	0.0385	0.0651	0.5913	0.5543
TLEN	0.4484	0.0811	5.5274	0.0000
LFAC	0.1367	0.0722	1.8933	0.0583

Computation of RTS and RTD

Scale elasticity = 1.0153

RTS = 1 / 1.0153 = 0.9849

Density elasticity = 0.7760

RTD = 1/ 0.7760 = 1.2887

So at the sample mean we have small **scale diseconomies** (but close to constant returns to scale) but **fairly strong economies of density**

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Policy implications

For Britain there are broadly constant returns to scale

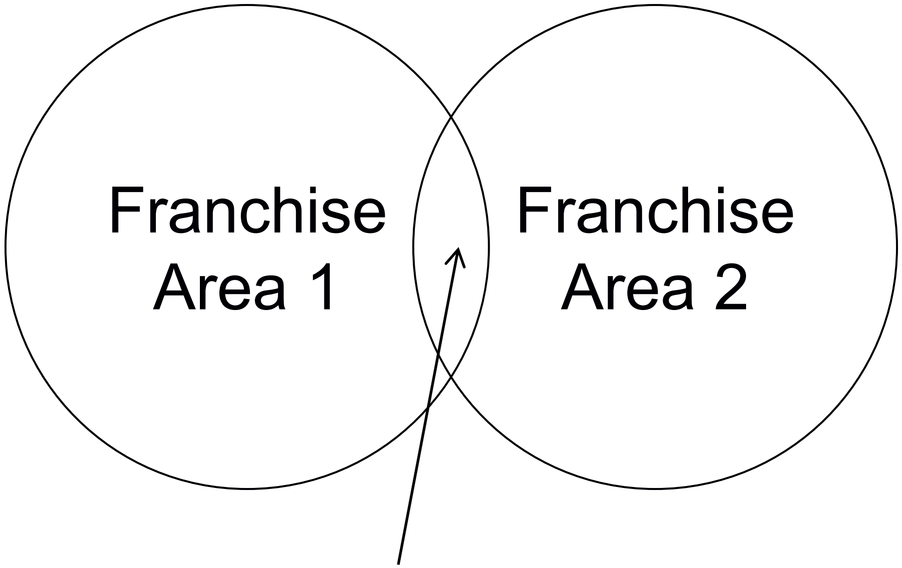
Thus making franchises smaller would not increase costs

However, economies of density mean that it makes sense to have one operator on each route

So if smaller franchises means more **overlapping franchises** (e.g. two operators per route) – it could imply that overall costs go up.

But there may be other benefits of competition on a route

Franchise size and overlaps



So making franchises smaller **could** increase costs

If the two areas were originally one franchise and then split into two there should be no loss of scale economies

But there will now be two operators on the same route on the overlaps – loss of economies of density

Franchise size by country (train-km)

	Mean	Range
Britain	26.5	3.23-44.89
Germany	3.3m	0.1-95m
Sweden	2.6m	0.8-6.3m

Source: Nash et. al., 2013 p. 199

Latest econometric suggests franchises may now be too large (diseconomies of scale). Wheat and Smith (2015)

Linear Homogeneity of degree one in input prices: Cobb-Douglas

This standard property of a cost function means that if all input rises go up by x% costs will also rise x%, other things equal

This can be imposed through parameter restrictions:

E.g. $Ln\ C = b_0 + b_1\ Ln\ Q + b_2\ Ln\ W_1 + b_3\ Ln\ W_2$

We constrain the model such that $b_2 + b_3 = 1$

See spreadsheet

There is another, simpler way of doing this

Linear Homogeneity of degree one in input prices: translog

To see why a simpler method might be useful, consider the following translog function:

$$LnC = b_0 + b_1 LnP + b_2 LnF + b_3 LnW_1 + b_4 LnW_2 + /2b_5 (LnP)^2$$
$$+ /2b_6 (LnF)^2 + /2b_7 (LnW_1)^2 + /2b_8 (LnW_2)^2 + b_9 LnPLnF +$$
$$b_{10} LnPLnW_1 + b_{11} LnPLnW_2 + b_{12} LnFLnW_1 + b_{13} LnFLnW_2$$

Restrictions can be imposed but they are relatively complex

A simpler method

$$LnC = \beta_0 + \beta_1 LnQ + \beta_2 LnW_1 + \beta_3 LnW_2$$

$$LnC - LnW_2 = \beta_0 + \beta_1 LnQ + \beta_2 LnW_1 + (b_3 - 1)LnW_2$$

- Since $b_2+b_3=1$, $(b_3-1)=-b_2$

$$Ln(C/W_2) = \beta_0 + \beta_1 LnQ + \beta_2 LnW_1 - \beta_2 LnW_2$$

$$Ln(C/W_2) = \beta_0 + \beta_1 LnQ + \beta_2 (LnW_1 - LnW_2)$$

$$Ln(C/W_2) = \beta_0 + \beta_1 LnQ + \beta_2 Ln(W_1/W_2)$$

- See spreadsheet

Example from LIMDEP

```
-----------------------------------------------------------------------------
Restricted   least squares regression ............
LHS=LNCOST   Mean                 =        4.88288
             Standard deviation   =         .54507
----------   No. of observations  =            191  DegFreedom   Mean square
Regression   Sum of Squares       =        45.7039           1      45.70390
Residual     Sum of Squares       =        10.7449         189        .05685
Total        Sum of Squares       =        56.4488         190        .29710
----------   Standard error of e  =         .23844  Root MSE              .23718
Fit          R-squared            =         .80965  R-bar squared         .80864
Model test   F[  1,   189]        =      803.91878  Prob F > F*           .00000
Restrictions F[  1,   188]        =        1.31281  Prob F > F*           .25334
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  LNCOST|  Coefficient       Error       t     |t|>T*        Interval
--------+--------------------------------------------------------------------
Constant|    1.81186***      .07070    25.63  .0000     1.67330   1.95042
    LNW1|     .82541***      .02603    31.71  .0000      .77440    .87643
    LNW2|     .17459***      .02603     6.71  .0000      .12357    .22560
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Mar 11, 2019 at 00:36:21 PM
-----------------------------------------------------------------------------
```

How good is the model?

- We have tested or imposed theoretical properties e.g.
- Positive signs on outputs
- Linear homogeneity of degree 1
- But are the results statistically robust?
- Does the model make sense overall?

Statistical significance

- See Econometric models developed by CEPA for Ofwat (PR2014).
- **WM5 model as an example**
- Statistical significance of parameters – are they zero or not – how far are they from one? Intervals
- Are they in line with expectations?
- Fit of the model: R squared and adjusted r squared – not just data mining though

Confidence intervals [1]

- Using simulated example

	Coeff	*s.e.*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.034	0.207	9.845	0.000	1.627	2.442
Ln (Density)	0.758	0.064	11.837	0.000	0.632	0.885
Ln (Length)	0.949	0.045	21.297	0.000	0.861	1.037

- P-value: probability of observing this value (or higher) if the null is true (i.e. if the true value of the parameter is zero)

Confidence intervals [2]

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	t	Sig.	95% Confidence Interval for B Lower Bound	95% Confidence Interval for B Upper Bound
1	(Constant)	7.702	1.490	5.170	.000	4.702	10.703
	TRACK LENGTH	.469	.089	5.255	.000	.289	.648
	TRAIN MILES PER TRACK MILES	.342	.096	3.574	.001	.149	.534
	AVERAGE WEIGHT OF TRAIN	.411	.143	2.882	.006	.124	.699
	PROPORTION OF TRACK MILES WITH AGES GREATER THAN 30 YEARS	-.471	.312	-1.512	.138	-1.099	.157
	PROPORTION OF TRACK LENGTH CWR	.538	.390	1.379	.175	-.248	1.324
	PROPORTION OF TRACK LENGTH WITH MAXIMUM LINESPEED GREATER THAN 100MPH	-.443	.212	-2.091	.042	-.870	-.016
	PROPORTION OF TRACK LENGTH WITH MAXIMUM AXLE LOAD GREATER THAN 25 TONNES	-.448	.202	-2.223	.031	-.855	-.042

a. Dependent Variable: PWAY AND GENERAL EXPENDITURE

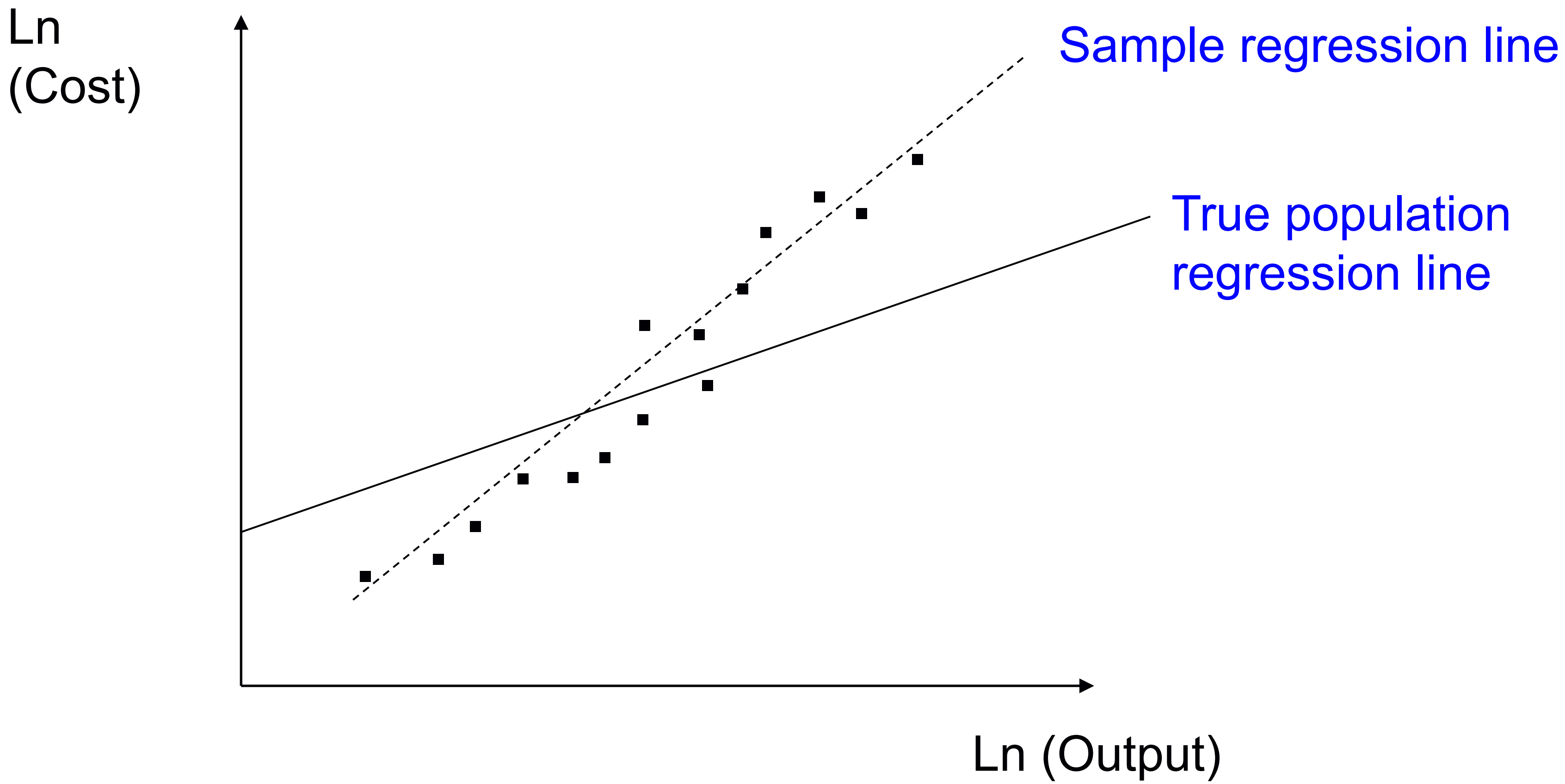
Discussion of multi-collinearity

- Using WM3

Omitted variables

- In general these are a problem because – if they are correlated with the other regressors – they lead to bias in the estimates on the other regressors
- In a regulatory, efficiency context, there is an added problem – omitted variables will end up in the measure of inefficiency (see Lecture 6)
- This leads to a trade-off – desire to include variables if they have an a priori engineering reason for inclusion
- But can create a complex model – where few variables are statistically significant

Where the disturbance is correlated positively with the regressors



Disturbance positively correlated with output – so we get a biased estimate of the relationship between cost and output

Other statistical properties of models

- **Normally distributed error term** – not required for unbiasedness – however required to make statements about statistical significance of the parameter estimates
- **Violation not very serious** – for large samples central limit theorem says that the sampling distribution for the parameter estimates converges to normality
- **Correlation in residuals** – would be expected for panel data – solution – use random effects and / or cluster robust standard errors (though could be some remaining correlation)

RESET test

- Includes powers of fitted costs in the regression model
- $y = ax + \hat{y}2 + \hat{y}3$
- Sometimes (incorrectly) described as a test for omitted variables
- Actually it is a test for non-linearity.
- In the cost modelling literature this test rarely used - the most obvious solution is to try a translog model

Endogeneity

$\text{Ln } Q = \text{Ln } A + a \text{ Ln } K + b \text{ Ln } L + \text{error}$

Error contains inefficiency – likely to be correlation between inefficiency and choice of inputs – creating bias

$\text{Ln } C = b_0 + b_1 \text{ Ln } Q + b_2 \text{ Ln } W_1 + b_3 \text{ Ln } W_2 + \text{error}$

For a cost function, outputs typically exogenously determined – so little issue

But quality may well be a choice variable – could be traded off with cost – creates a bias

Summary

- Competitive tendering a hugely powerful tool for introducing competition for the market where ordinary competition does not make sense
- Econometric models key for establishing the optimal size and structure of franchises in that context
- Cost functions have testable theoretical properties – e.g. linear homogeneity of degree 1
- To be accepted in regulatory / competition policy the model coefficients need to be believable and…
- Ideally statistically significant – and pass other relevant statistical tests
- But model selection is still a challenge…

References / readings

- Smith, A.S.J. and Wheat, P.E. (2012) Evaluating alternative policy responses to franchise failure: evidence from the passenger rail sector in Britain. *Journal of Transport Economics and Policy*, **46** (1), pp25-49.

- Vickers and Yarrow (1988), Privatization: An Economic Analysis, Chapter 3.

- Wheat PE, Smith A. 2015. Do the usual results of railway returns to scale and density hold in the case of heterogeneity in outputs: A hedonic cost function approach.*Journal of Transport Economics and Policy.* **49**(1), pp. 35-47

- CEPA, 'OFWAT COST ASSESSMENT – ADVANCED ECONOMETRIC MODELS' (March 2014)