Aston Business School
Birmingham

Vertical and Horizontal Integration Economies in English and Welsh WoCs and WaSCs and the Potential Implications for Introducing Competition

David Saal, Pablo Arocena, Alex Maziotis, and Thomas Triebs
Aston Centre for Critical Infrastructure and Services
and
Universidad Publica de Navarra, Spain

Aston Business School
Birmingham

Outline of the Presentation

- Paper 1: Previous Literature on Vertical and Horizontal Integration Economies in the Water and Sewerage Industry
- Paper 2: WOC Study Estimating the Cost Implications of Integration Economies and Unbundling Water Activities.
- Implications for Vertical Unbundling on Efficient Upstream Pricing and Consideration of the Scope for Marginal Efficient Entry
- Consider Relationship to Ofwat's Recent Hypothetical Market Structure Proposals to Facilitate Today's Discussion

- Paper 3: WaSC WoC study Estimating the Cost Implications of Integration Economies Within and Between Water and Sewerage Activities.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Scale and Integration Economies in the Water Industry: a Survey of the Literature in the Light of Reform Proposals

forthcoming February 2011

David Saal, Pablo Arocena, Alexandros Maziotis, and Thomas Triebs

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

Current Accounting Separation Structure (Ofwat, 2009)

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Integration Economies for Water Only Companies

Water Activities	Water Production			Water Delivery
Ofwat Accounting Separation[1]	Water Resources	Raw Water Distribution	Water Treatment	Treated Water Distribution
Variable Cost Models				
Garcia et al (2007) (US)[2]				
Stone & Webster Consultants (2004) (UK)				
Martins et al (2008) (Portugal)[3]				
Garcia & Thomas (2001) (France)[3]				
Total Cost Models				
Stone & Webster Consultants (2004) (UK)				
Urakami (2007) (Japan)				
Urakami & Tanaka (2009) (Japan)				
US[4]				
Torres & Morrison Paul (2006)				
Hayes (1987)				
Kim & Clark (1988)				
Kim (1995)				

Coding: Integration Economies

Notes

[1]Separate blocks define individual outputs

[1]Ofwat's retail activity is excluded because none of the studies separates this activity

[2]As water prices increase economics of scope between water production and distribution increase

[3]Includes water losses as output. Economies of scope between water distribution and water losses was found

[4]US studies do not distinguish between production and delivery but between customer categories

Aston Business School
Birmingham

Conclusions on Water Only Integration Economies

- Considerable international evidence that there are economies of vertical integration between water production and water distribution activities.
- Economies of vertical integration may be partially related to balancing the cost trade off between water losses and water treatment to thereby satisfy water demand in a least cost manner.
- UK: Integration economies between water delivered (production) and water connected properties (distribution)
- US: Integration economies between volumes of water delivered to households and non-households.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Previous Evidence on Vertical Integration Economies with both Water and Sewerage Activities

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Integration Economies for Water and Sewerage Companies

Water & Sewerage Activities	Water Production			Water Delivery	Waste-water Collection	Waste-water Production		
Ofwat Accounting Separation[1]	Water Resources	Raw Water Distribution	Water Treatment	Treated Water Distribution	Sewage Collection	Sewage Treatment	Sludge Treatment	Sludge Disposal
Variable Cost Models								
Stone & Webster Consultants (2004) (UK)								
Nauges & Van den Berg (2007) (Brazil, Romania, Moldova)								
Martins et al (2006) (Portugal)								
Mamsten & Lekkas (Sweden)								
Total Cost Models								
Stone & Webster Consultants (2004) (UK)								
Saal & Parker (2000) (UK)[2]								
Lynk (1993) (UK)[3]								
Hunt & Lynk (1995) (UK)[3]								
De Witte & Marques (2008) (Portugal)								

Coding: Integration Economies; Disntegration Economies; Inconclusive

Notes:

[1]Separate blocks define individual outputs

[1]Ofwat's retail activity is excluded because none of the studies separates this activity

[2]Statistically insignificant disintegration economies without any adjustments for quality. Statistically significant integration economies were found after adjustments for quality

[3]Includes environmental services as output

Conclusions: Models Assessing Integration Economies with Both Water and Sewerage Activities

Within Water Activities –

Stone and Webster (2004) confirms the conclusions of the Water only models that integration economies between water production and distribution activities are likely to exist, particularly in the total cost specification

Integration Economies for Water and Sewerage Companies

Water & Sewerage Activities	Water Production			Water Delivery	Waste-water Collection	Waste-water Production		
Ofwat Accounting Separation[1]	Water Resources	Raw Water Distribution	Water Treatment	Treated Water Distribution	Sewage Collection	Sewage Treatment	Sludge Treatment	Sludge Disposal
Variable Cost Models								
Stone & Webster Consultants (2004) (UK)								
Nauges & Van den Berg (2007) (Brazil, Romania, Moldova)								
Martins et al (2006) (Portugal)								
Mamsten & Lekkas (Sweden)								
Total Cost Models								
Stone & Webster Consultants (2004) (UK)								
Saal & Parker (2000) (UK)[2]								
Lynk (1993) (UK)[3]								
Hunt & Lynk (1995) (UK)[3]								
De Witte & Marques (2008) (Portugal)								

Coding: Integration Economies; Disntegration Economies; Inconclusive

Notes:

[1]Separate blocks define individual outputs

[1]Ofwat's retail activity is excluded because none of the studies separates this activity

[2]Statistically insignificant disintegration economies without any adjustments for quality. Statistically significant integration economies were found after adjustments for quality

[3]Includes environmental services as output

Conclusions: Models Assessing Integration Economies with Both Water and Sewerage Activities

Within Sewerage Activities –

Limited evidence based on S&W 2004 suggests cost discomplementarities.

This result is not supported by forthcoming work on the Portuguese Sewerage sector where evidence of integration economies is found for sewerage companies that are not vertically integrated with water.

Integration Economies for Water and Sewerage Companies

Water & Sewerage Activities	Water Production			Water Delivery	Waste-water Collection	Waste-water Production		
Ofwat Accounting Separation[1]	Water Resources	Raw Water Distribution	Water Treatment	Treated Water Distribution	Sewage Collection	Sewage Treatment	Sludge Treatment	Sludge Disposal
Variable Cost Models								
Stone & Webster Consultants (2004) (UK)								
Nauges & Van den Berg (2007) (Brazil, Romania, Moldova)								
Martins et al (2006) (Portugal)								
Mamsten & Lekkas (Sweden)								
Total Cost Models								
Stone & Webster Consultants (2004) (UK)								
Saal & Parker (2000) (UK)[2]								
Lynk (1993) (UK)[3]								
Hunt & Lynk (1995) (UK)[3]								
De Witte & Marques (2008) (Portugal)								

Coding: Integration Economies; Disntegration Economies; Inconclusive

Notes:

[1]Separate blocks define individual outputs

[1]Ofwat's retail activity is excluded because none of the studies separates this activity

[2]Statistically insignificant disintegration economies without any adjustments for quality. Statistically significant integration economies were found after adjustments for quality

[3]Includes environmental services as output

Conclusions: Models Assessing Integration Economies with Both Water and Sewerage Activities

Between Water and Sewerage Activities:

The evidence is mixed and depends on activities considered.

Results are sensitive to cost specification (VC or TC model),

output (volumes or **connected properties**),

operating characteristics (quality).

Aston Business School
Birmingham

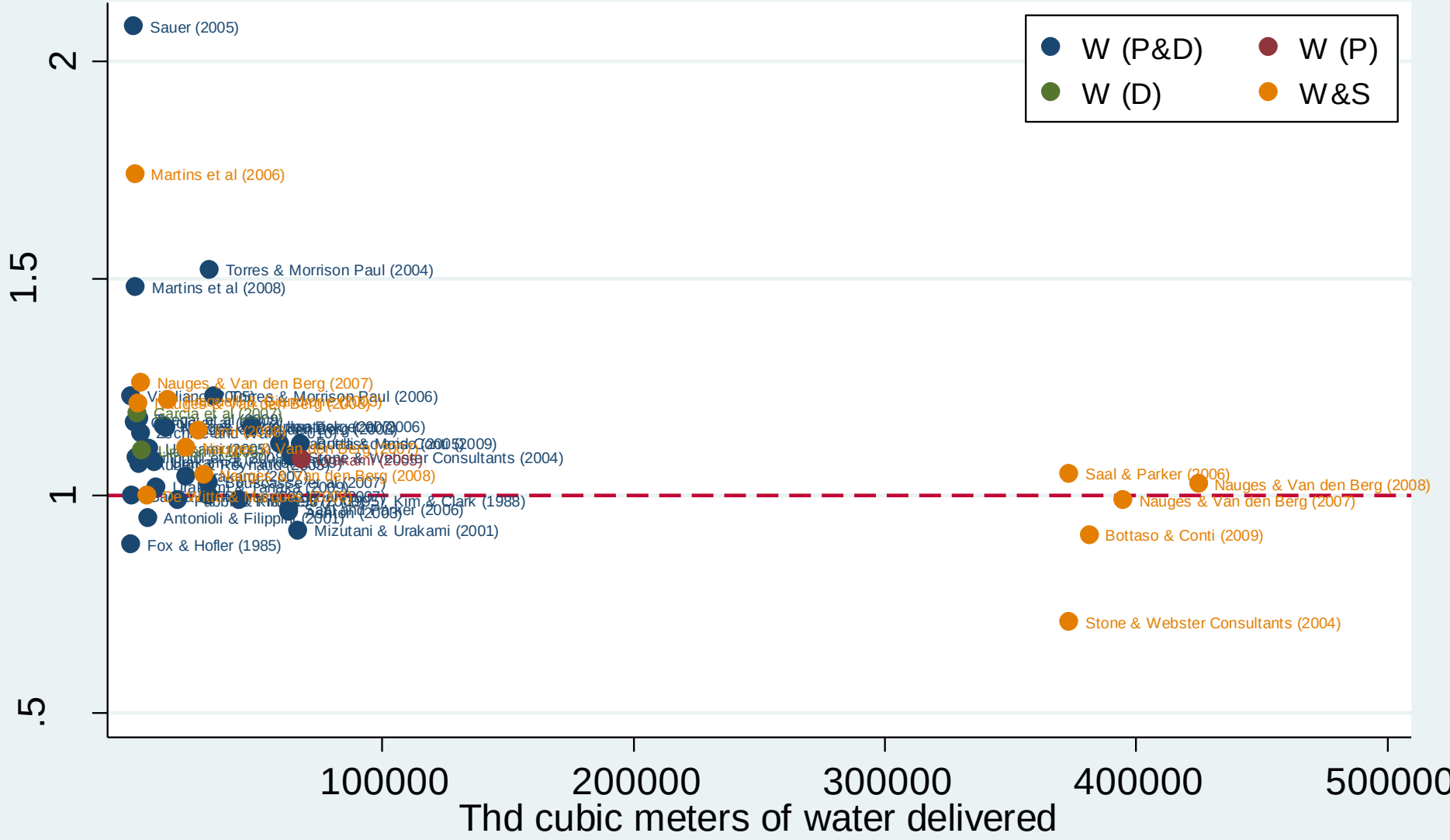
Previous Evidence on Economies of Scale in the Water and Sewerage Industry

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Literature Meta-Analysis

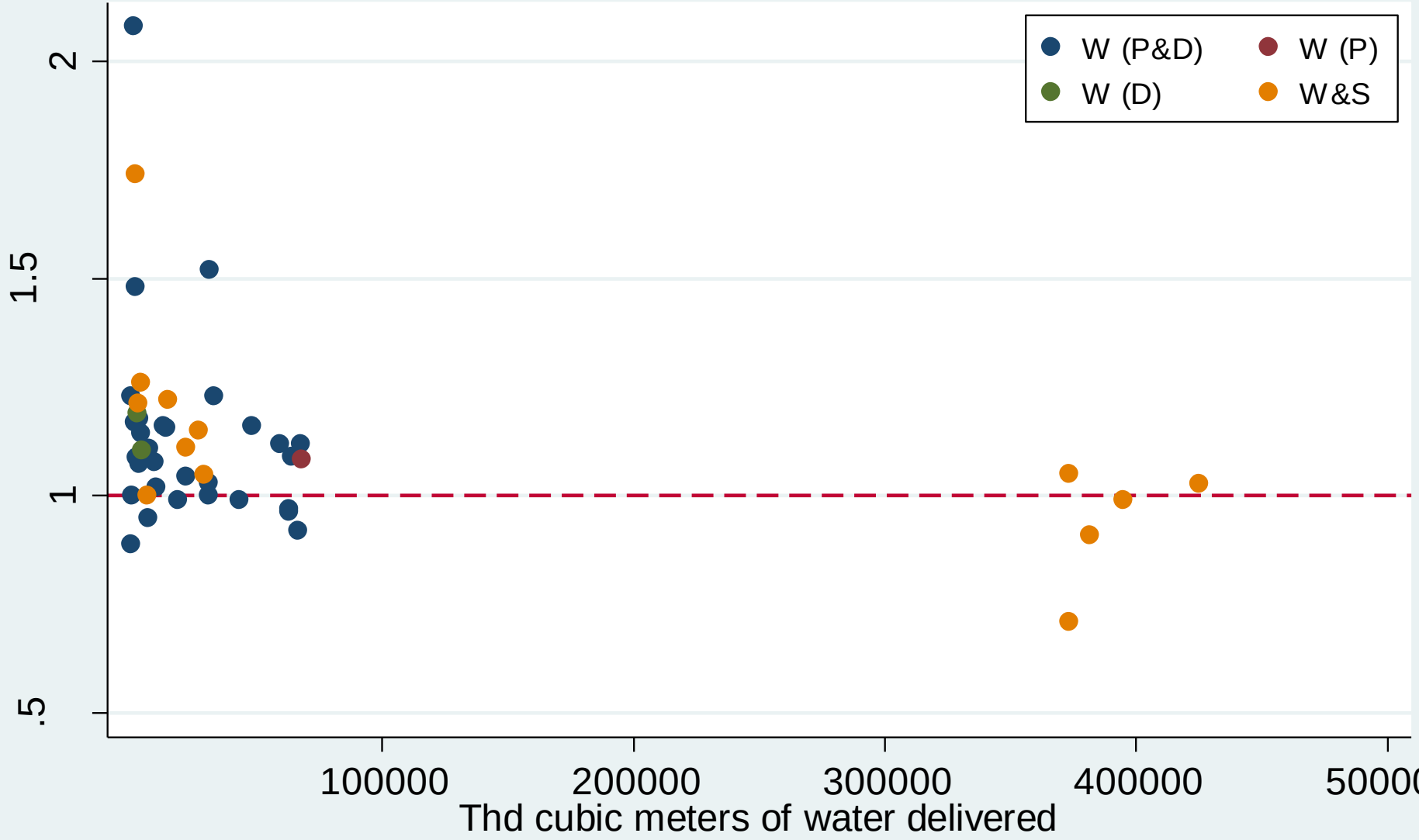
Evidence for Economies of Scale



Observations are for average long-run economies of scale

Literature Meta-Analysis

Evidence for Economies of Scale



Observations are for average long-run economies of scale

Aston Business School
Birmingham

Conclusions: Economies of Scale

- Average UK WaSC is extremely large by international standards.
- UK " sample average firm" is operating at constant returns to scale or with diseconomies of scale.
- LARGER FIRMS DEFINETELY OPERATING WITH DISECONOMIES OF SCALE
- Very Small WoCs likely to operate with economies of scale, but candidate mergers are now likely to be only with economies beyond efficient scale size.
- **INTERNATIONAL AND DOMESTIC EVIDENCE SUGGESTS MANY UK UTILITIES ARE BEYOND OPTIMAL SCALE**

- **Please remember these estimates are for the average firm in each sample and larger (smaller) firms should have lower (higher) estimated scale economies**

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Economies of Integration in the English and Welsh Water Only Companies and the Assessment of Alternative Unbundling Policies

December 2010

David Saal, Pablo Arocena
and Alexandros Maziotis

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

Conceptual Model - WoC Only Model 1993-2009

Vertical, Horizontal and Global Integration Economies

Scale Economies

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

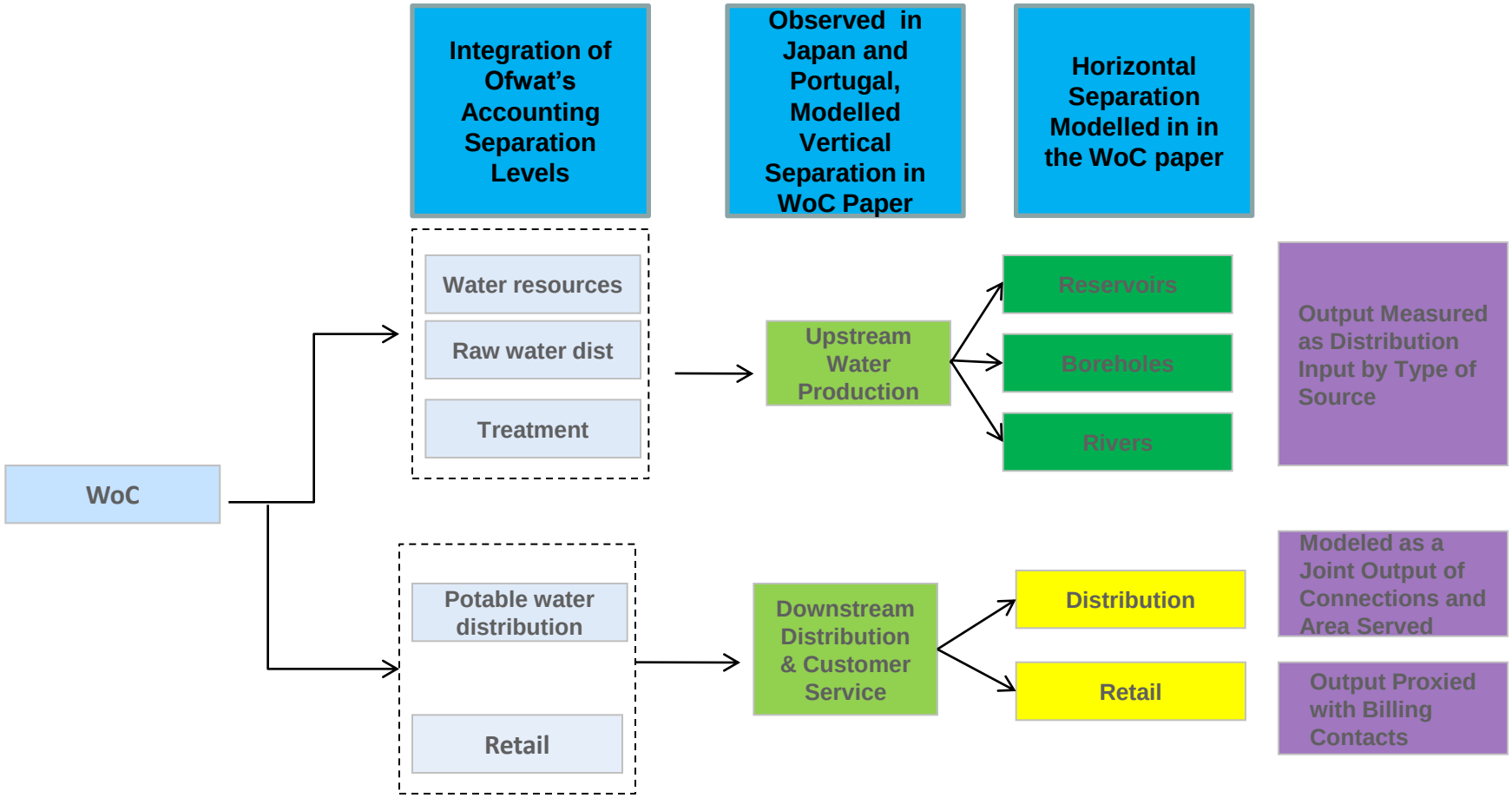
Aston Business School
Birmingham

Current Accounting Separation Structure (Ofwat, 2009)

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Relationship between Accounting Separation, Observed Separation in Japan and Portugal and the WoC Model's Assumed Separation



Aston Business School
Birmingham

Integration Economies

- Integration economies are said to exist if it is more efficient to produce several different products within a single firm than splitting up the production of each product, or subset of products, between separate specialized firms. The degree of integration economies at *y,* of any potential partition of the *N* outputs into separate firms producing U (e.g. Upstream) and D=N-U (Downstream) outputs can therefore be defined as

$$VIE_{U,D}(y) = \frac{C(y_U) + C(y_D) - C(y_N)}{C(y_N)}$$

If $VIE_{U,D}(y)>0$, then there are economies of integration. It is more efficient to produce U (Upstream) and D (Downstream) within a single firm than splitting up the production of each product between separate specialized firms.
If $VIE_{U,D}(y)<0$, then there are economies of disintegration.
If $VIE_{U,D}(y)=0$, then there are no economies of integration.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Global (Overall) Integration Economies

$$GIC_N(y) = \frac{\left[\sum_{n=1}^{u} C(y_n) - C(y_U)\right] + \left[\sum_{n=u+1}^{N} C(y_n) - C(y_D)\right] + \left[C(y_U) + C(y_D) - C(y_N)\right]}{C(y_N)} =$$

$$= \frac{HIE_U + HIE_D + VIE}{C(y_N)}$$

where HIE_U measures the cost savings derived from the horizontal integration between upstream products, HIE_D represents the cost savings from horizontal integration downstream, and *VIE* is the cost savings from vertical integration between both stages.

If $GIC_N(y) > 0$ this indicates that the costs of producing all products jointly in a single company is strictly lower than producing the same levels of products in separated specialized units.

$GIC_N(y)$: compares the costs of full integration with those of full specialization, and thereby indicating the degree of aggregate or overall integration economies as the proportion of such cost savings on the total integrated costs.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Global Economies of Scale

- The degree of scale economies defined over the entire product set *N*, at *y*, is given by

$$S_N(y) = \frac{C(y)}{y \cdot \nabla C(y)} = \frac{C(y)}{\sum_{n=1}^{N} y_n C_n(y)}$$

where $y = (y_1, y_2, \ldots, y_n)'$ is a $N \times 1$ vector of products, $C(y)$ is the cost function and $C_n(y)$ is the marginal cost of product *n.*

If $S_N(y) > 1$, then there are increasing returns to scale
If $S_N(y) < 1$, then there decreasing returns to scale
If $S_N(y) = 1$, then there are constant returns to scale

Output specification should ideally control for the volumetric, transport, and connections aspects of providing water services to be a complete measure of scale economies

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Product Specific Economies of Scale

The magnitude of a firm's operations may change is through variation in the output of one product, holding the quantities of other products constant.

$$S_n(y) = \frac{IC_n}{y_n C_n} = \frac{C(y) - C(y_{N-n})}{y_n C_n} = \frac{AIC_n}{C_n}$$

where IC_n is the incremental cost of producing output n, $C(y_{N-n})$ is the total cost of jointly producing all the outputs except output n, AIC_n is the average incremental cost of producing output n and C_n is the marginal cost of product n.

If $S_n(y)>1$, then there are increasing returns to scale with respect to output n
If $S_n(y)<1$, then there are decreasing returns to scale with respect to output n
If $S_n(y)=1$, then there are constant returns to scale with respect to output n

This is not a scale economy for unbundled production but measures the elasticity of incremental costs with respect to an increase in a single output, while holding other outputs constant

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Quadratic Cost Function Methodology

$$C_{i,t} = \alpha + \sum_{n}^{N} \beta_n y_{n,i,t} + \sum_{g=1}^{G} \delta_g w_{g,i,t} + \frac{1}{2}\sum_{m=1}^{N}\sum_{n=1}^{N} \beta_{mn} y_{m,i,t} y_{n,i,t} + \frac{1}{2}\sum_{h=1}^{G}\sum_{g=1}^{G} \gamma_{hg} w_{h,i,t} w_{g,i,t}$$

$$+ \sum_{n=1}^{N}\sum_{g=1}^{G} \theta_{ng} y_{n,i,t} w_{g,i,t} + \psi t + \frac{1}{2}\upsilon t^2 + \sum_{n}^{N} \zeta_n y_{n,i,t} t + \sum_{g=1}^{G} \lambda_g w_{g,i,t} t$$

where C_{it} = total costs of the *i*-th firm at time t, y_{nit} = quantity of output *n*, w_{git} = price of input *g*, *N* = total number of outputs, *G* = total number of inputs, t=time period and the Greek characters represent unknown parameters to be estimated.

Application of Shephard's Lemma (Diewert,1974), and given the assumption of symmetry for the β and γ parameters, we obtain the *m* factor demand equations as:

$$x_{g,i,t} = \delta_g + \sum_{h=1}^{G} \gamma_{h,g} w_{h,i,t} + \sum_{n=1}^{N} \theta_{ng} y_{n,i,t} + \lambda_g t$$

x_{gi} = the quantity of input *g* at time t

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

Model Specification and Data Description

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Table 3 - Sample Descriptive Statistics

Variable	Mean	Std.Dev.	Min	Max
Outputs				
U- Total Water Input to Distribution System (Ml)	78,122.5	72,502.5	10,216.3	328,252.0
U1- Water Input From Reservoirs (Ml)	5,953.8	13,970.2	-	71,971.1
U2- Water Input From Boreholes (Ml)	40,991.9	45,953.5	-	209,263.0
U3- Water Input From Rivers (Ml)	31,176.4	37,697.5	-	160,388.0
D1 - Quality Adjusted Water Connected Properties (000s)	280.0	264.7	15.9	1,201.3
D2- Water Service Area (km squared)	1,483.0	1,137.3	100.0	5,657.0
D3- Total billing contacts	203,415	205,342	8,322	1,135,400
Total Economic Cost Estimates				
C1 - With Ofwat Capital Price Assumptions with Gilt Risk Free Rate (per £)	54.856	50.027	9.222	237.357
C2 - With Ofwat Capital Price Assumptions & Ex Ante Risk Free Rate (per £)	56.069	51.656	9.046	249.747
C3 - With S& W(2004) Capital Price Assumptions & 3% Risk Premium (per £)	55.849	50.426	9.508	230.817
Input Prices				
K1- Capital Price -Ofwat PR. Assumptions with Gilt Risk Free Rate (per £)	0.0297	0.0068	0.0177	0.0503
K2 - Capital Price -Ofwat Periodic Review Ex Ante Assumptions (per £)	0.0307	0.0073	0.0171	0.0522
K3 - Capital Price -S& W Assumptions with 3% Risk Premium (per £)	0.0308	0.0071	0.0193	0.0523
L - Labour Price (per FTE, £ millions)	0.0333	0.0066	0.0197	0.0783
E- Energy Prices (per Gwh, £ millions)	0.049	0.011	0.031	0.082
O - Other Costs Price Deflator	0.787	0.094	0.686	1.000
Input Quantities				
XK - MEA Capital Stock (£) (millions)	1036.6	936.2	132.9	3872.9
XL - FTE Employment	318.9	247.0	63.0	1083.0
XE - Energy Usage (Gwh)	62.707	60.592	4.364	295.797
XO- Deflated Other Expenditure (£ millions)	13.898	13.633	1.620	62.137

Note: 243 Observations. Total Costs and Input prices are expressed in real terms by dividing them with the RPI index (2009=1)

Table 1 – Characteristics of Water Abstraction Sources

Variable	Mean	Std.Dev.	Min.	25th Perc	Median	75th Perc	Max.
Percentage of Water Input Sourced from Reservoirs	6.50	12.73	0.0	0.0	0.0	6.4	54.0
Percentage of Water Input Sourced from Boreholes	56.00	35.83	0.0	15.8	68.6	87.0	100.0
Percentage of Water Input Sourced from Rivers	37.50	32.02	0.0	11.0	30.0	63.0	100.0

Note: 243 Observations

Table 2 – Water Abstraction Sources by Firm Type

Panel A. Average Distribution Input (Ml) by Firm Type and Water Source

Firm Categories	Obs	Distribution Input	Reservoir Abstraction	Borehole Abstraction	River Abstraction
Reservoir, River, Borehole	89	93,119.5	16,255.9	37,027.0	39,835.7
Borehole, River	111	88,135.8	-	53,050.7	35,085.3
Borehole	35	22,200.1	-	22,200.1	-
River	8	17,003.1	-	-	17,003.1
All Observations	**243**	**78,122.5**	**5,953.8**	**40,991.9**	**31,176.4**

Panel B. Average Share of Distribution Input from Various Sources by Firm Type

Firm Categories	Obs	Distribution Input	Reservoir Abstraction	Borehole Abstraction	River Abstraction
Reservoir, River, Borehole	89	93,119.5	0.177	0.391	0.431
Borehole, River	111	88,135.8	-	0.597	0.403
Borehole	35	22,200.1	-	1.000	-
River	8	17,003.1	-	-	1.000
All Observations	**243**	**78,122.5**	**0.065**	**0.560**	**0.375**

Aston Business School
Birmingham

Global, Vertical, and Horizontal Integration Results

Table 5 -Estimated Integration Economy Estimates for the Sample Average Firm With Alternative Capital Cost Assumptions

	K1 Ofwat Assumptions Except for Gilt Risk Free Rate	K2 Ofwat Assumptions and ex ante Risk Free Rate	Stone and Webster Assumptions with 3% Risk Premium
Cost Estimates (£ millions)			
Fully Integrated Costs - C(U1,U2,U3,D1,D2,D3)	***55.943***	***56.855***	***57.197***
Upstream Only Costs - C(U1,U2,U3,0,0,0)	***37.290***	***32.772***	***38.237***
U1 only costs - C(U1,0,0,0,0,0)	***2.837***	***2.351***	***2.845***
U2 only costs - C(0,U2,0,0,0,0)	***17.392***	***15.572***	***17.647***
U3 only costs - C(0,0,U3,0,0,0)	***8.576***	***7.700***	***8.769***
Downstream Only Costs - C(0,0,0,D1,D2,D3)	***51.342***	***49.159***	***53.094***
Distribution Only Costs - C(0,0,0,D1,D2,0)	***36.983***	***37.436***	***37.337***
Retail Only Costs - C(0,0,0,0,0,D3)	***7.677***	***8.108***	***7.480***
Vertical Integration Savings between Upstream and Downstream C(U1,U2,U3,0,0,0)+C(0,0,0,D1,D2,D3)- C(U1,U2,U3,D1,D2,D3)	***32.690***	***25.075***	***34.134***
Upstream Integration Savings C(U1,0,0,0,0,0)+C(0,U2,0,0,0,0)+C(0,0,U3,0,0,0)-C(U1,U2,U3,0,0,0)	**-8.485**	-7.148	**-8.976**
Downstream Integration Savings C(0,0,0,D1,D2,0)+C(0,0,0,0,0,D3)- C(0,0,0,D1,D2,D3)	-6.682	-3.615	-8.277
Global Integration Savings C(U1,0,0,0,0,0)+C(0,U2,0,0,0,0)+C(0,0,U3,0,0,0)+C(0,0,0,D1,D2,0) +C(0,0,0,0,0,D3) -C(U1,U2,U3,D1,D2,D3)	17.523	14.312	16.880
Integration Economies			
Vertical Integration Economies - between upstream and distribution	***0.584***	**0.441**	***0.597***
Horizontal Integration Economies - in upstream	**-0.152**	-0.126	**-0.157**
Horizontal Integration Economies - in downstream	-0.119	-0.064	-0.145
Global Integration Economies	0.313	0.252	0.295

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (0.05) level, except for economies of scale estimates which are statistically different from 1 at these levels

- Global Integration Economies Amount to 25.2-31.3 percent
- Vertical Integration Economy are 44,1-58.4 percent
- Horizontal Economies Between Upstream and Between Downstream Activities are Negative and Statistically significant for Upstream
- We are somewhat cautious on the interpretation of the downstream integration results, as we do not think our retail output proxy fully separates retail from network customer service activities
- **The results suggest integration economies largely accrue from integration of upstream and downstream activities.**

Aston Business School
Birmingham

Cost Implications of Alternative Potential Unbundling Options

- Estimates Derived for GIE, VIE, and HIE are based on assumptions of full global, vertical, and/or horizontal separation
- However, many other potential separations are feasible.
- We therefore explored the estimated cost implications for 19 alternative configurations of the sample average firm's output to better understand the cost implications of unbundling.

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

The First 5 Partitions Support the GIE,VIE, and HIE Estimates

Table 6 Estimated costs of the average firm's output in alternative Partitions – Assuming the Preferred Capital Cost Assumptions (millions of £)

Partition No	Structural Configuration	Estimated Cost	Excess Relative to Fully Integrated Costs	Excess Cost/Fully Integrated Costs
	Fully Integrated			
1	C(U1,U2,U3,D1,D2,D3)	**55.943**	**-**	-
	Vertical Separation With Full Integration of Upstream and Downstream Activities			
2	C(0,0,0,D1,D2,D3)+C(U1,U2,U3,0,0,0)	**88.633**	***32.690***	***0.584***
	Fully Disintegrated			
3	C(0,0,0,D1,D2,0)+C(0,0,0,0,0,D3)+ C(U1,0,0,0,0,0) + C(0,U2,0,0,0,0) + C(0,0,U3,0,0,0)	**73.465**	17.523	0.313
	Vertical Separation, Downstream Disintegration, and Full Upstream Integration			
4	C(0,0,0,D1,D2,0)+C(0,0,0,0,0,D3)+C(U1,U2,U3,0,0,0)	**81.950**	26.008	0.465
	Vertical Separation, Downstream Integration, and Full Upstream Disintegration			
5	C(0,0,0,D1,D2,D3)+ C(U1,0,0,0,0,0) + C(0,U2,0,0,0,0) + C(0,0,U3,0,0,0)	**80.148**	***24.205***	***0.433***

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level.

Note the pattern that separation of retail from other downstream activities results in large standard errors - **e.g. may relate to this being a relatively poor proxy for retail activities given its relationship to network related customer service activities**.

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

The Next 3 Partitions Further Support the Presence of Statistically Significant Vertical Integration Economies

Table 6 Estimated costs of the average firm's output in alternative Partitions – Assuming the Preferred Capital Cost Assumptions (millions of £)

Partition No	Structural Configuration	Estimated Cost	Excess Relative to Fully Integrated Costs	Excess Cost/Fully Integrated Costs
	Vertical Separation, Downstream Integration, and Partial Upstream Disintegration			
6	C(0,0,0,D1,D2,D3)+C(U1,0,0,0,0,0)+C(0,U2,U3,0,0,0)	**84.966**	***29.023***	***0.519***
7	C(0,0,0,D1,D2,D3)+C(0,U2,0,0,0,0)+C(U1,0,U3,0,0,0)	**81.683**	***25.741***	***0.460***
8	C(0,0,0,D1,D2,D3)+C(0,0,U3,0,0,0)+C(U1,U2,0,0,0,0)	**81.905**	***25.962***	***0.464***

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level.

E.g. estimates suggest that as long as full vertical separation is implemented, even with the benefits of partial horizontal separation, statistically significant vertical integration economies are present.

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

9-17 Explore Retention of Partial Unbundling to Explore the Source of VI Economies

Table 6 Estimated costs of the average firm's output in alternative Partitions – Assuming the Preferred Capital Cost Assumptions (millions of £)

Partition No	Structural Configuration	Estimated Cost	Excess Relative to Fully Integrated Costs	Excess Cost/Fully Integrated Costs
	Partial Vertical Integration with Two Upstream Technologies and Downstream Integration			
9	C(U1,U2,0,D1,D2,D3)+ C(0,0,U3,0,0,0)	**59.688**	3.746	0.067
10	C(U1,0,U3, D1,D2,D3)+ C(0,U2,0,0,0,0)	**66.827**	***10.885***	***0.195***
11	C(0,U2,U3,D1,D2,D3)+ C(U1,0,0,0,0,0)	**56.284**	0.341	0.006
	Partial Vertical Integration with One Upstream Technologies and Downstream Integration			
12	C(U1,0,0,D1,D2,D3)+ C(0,U2,U3, 0,0,0)	**80.583**	***24.641***	***0.440***
13	C(0,U2,0,D1,D2,D3)+ C(U1,0,U3,0,0,0)	**63.475**	***7.532***	***0.135***
14	C(0,0,U3,D1,D2,D3)+C(U1,U2,0,0,0,0)	**71.058**	***15.115***	***0.270***
15	C(U1,0,0,D1,D2,D3)+ C(0,U2,0, 0,0,0)+C(0,0,U3,0,0,0)	**75.765**	***19.823***	***0.354***
16	C(0,U2,0,D1,D2,D3)+ C(U1,0,0,0,0,0)+C(0,0,U3,0,0,0)	**61.939**	5.997	0.107
17	C(0,0,U3,D1,D2,D3)+C(U1,0,0,0,0,0)+C(0,U2,0,0,0,0)	**69.300**	***13.358***	***0.239***

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level.

- Note that in most cases retention of vertical integration between downstream activities and some upstream activities still results in statistically significant excess costs relative to the fully integrated structure .
- Partitions 9-11, demonstrate that the retention of VI for boreholes is particularly critical.
- But 13 and 16 demonstrate that keeping borehole VI only results in a minimum excess cost of 10.7 percent

9 and 10 are therefore the best candidates for retaining VI benefits, but allowing for some separated upstream production

Table 6 Estimated costs of the average firm's output in alternative Partitions – Assuming the Preferred Capital Cost Assumptions (millions of £)

Partition No	Structural Configuration	Estimated Cost	Excess Relative to Fully Integrated Costs	Excess Cost/Fully Integrated Costs
	Partial Vertical Integration with Two Upstream Technologies and Downstream Integration			
9	C(U1,U2,0,D1,D2,D3)+ C(0,0,U3,0,0,0)	**59.688**	3.746	0.067
10	C(U1,0,U3, D1,D2,D3)+ C(0,U2,0,0,0,0)	**66.827**	***10.885***	***0.195***
11	C(0,U2,U3,D1,D2,D3)+ C(U1,0,0,0,0,0)	**56.284**	0.341	0.006

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level.

e.g. results suggest that we could vertically separate either of these two types of water production to generate contestability while still retaining the benefits of competition.

While 6.7% is a substantial increase in costs, policy makers **might** conclude that this would be a cost worth paying to have the 37.5 percent of WOC water abstraction that is sourced from rivers outside the vertically integrated firm , especially if reliable estimates suggested that the potential dynamic benefits of introducing competition exceeded this estimated cost.

But our estimates suggest that to make the unbundled firm economically sustainable, this would require inefficient pricing above the marginal cost of vertically integrated production!

	U1- Water Input From Reservoirs	U2- Water Input From Boreholes	U3- Water Input From Rivers
Sample Average Distribution Input (Ml) (from Table 3)	5,953.8	40,991.9	31,176.4
Stand alone Firm Producing the Average Water Input (£ millions) (from Table 5)	2.837	17.392	8.576
Unit Cost of Water Input After Full Separation (£ per cubic meter)	0.477	0.424	0.275
Estimated Marginal Cost with Full Integration (£ per cubic meter) (From Table 4)	0.430	0.264	0.225
Markup Above Vertically Integrated MC needed to Sustain Separated Production	1.107	1.607	1.223

The "Low Cost" Upstream Unbundling Options are Economically Inefficient as they require economically sustainable standalone prices in excess of the vertically integrated marginal cost of production.

Reservoir separation results in only a 0.6 percent excess costs relative to fully integrated costs, but requires a markup of 10.7 percent over vertically integrated marginal costs to make such production economically sustainable

River Separation result in only a 6.7 percent excess cost but requires a 22.3 percent markup over efficient marginal costs!

Two Final Alternative Configurations:
18 - Scottish Retail Separation
19 - Integrated Upstream Production and Retail

Table 6 Estimated costs of the average firm's output in alternative Partitions – Assuming the Preferred Capital Cost Assumptions (millions of £)

Partition No	Structural Configuration	Estimated Cost	Excess Relative to Fully Integrated Costs	Excess Cost/Fully Integrated Costs
	Partial Vertical Integration with Full Upstream Integration and Downstream Disintegration			
18	C(U1,U2,U3, D1,D2,0)+C(0,0,0,0,0,D3)	**55.607**	-0.335	-0.006
19	C(U1,U2,U3, 0,0,D3)+ C(0,0,0,D1,D2,0)	**75.229**	19.287	0.345

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level.

Retail Separation is Found to Effectively be a Costless Unbundling Option.

However, the underlying estimates suggest this results from the almost perfect balancing of increased costs associated with vertically separating “retail activities” from upstream activities, and a decrease in cost associated with the horizontal separation of “retail activities” from distribution network activities

In contrast, an energy like integration of water production and retail activities results in excess costs of 34.5 percent due to lost integration economies between network activities and upstream activities

Estimated Global and Product Specific Scale Economies

The Average WoC is estimated to have Slight Diseconomies of Scale Except for Retail!

Table 7 Estimated Cost Elasticity and Economies of Scale for the Sample Average Firm With Alternative Capital Cost Assumptions

	K1 Ofwat Assumptions Except for Gilt Risk Free Rate	K2 Ofwat Assumptions and ex ante Risk Free Rate	K3 Stone and Webster Assumptions with 3% Risk Premium
Global Economies of Scale	***0.964***	***0.959***	***0.965***
Product Specific Economies of Scale			
U1- Water Input From Reservoirs (Ml)	***0.974***	***0.990***	***0.980***
U2- Water Input From Boreholes (Ml)	***0.602***	***0.698***	***0.594***
U3- Water Input From Rivers (Ml)	***0.687***	***0.724***	***0.660***
D1 and D2- Distribution Network Activities	***0.560***	***0.626***	***0.587***
D3- Retailing	***1.331***	***1.251***	***1.353***

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (*0.05*) level, except for economies of scale estimates which are statistically different from 1 at these levels

- If volumetric, connections, and transportation related outputs are properly controlled for, most WoCs are operating beyond their optimal scale.

- This is very consistent with international evidence on scale economies and relative size of water utilities.

- It is also consistent with the previous English and Welsh evidence, if one reads the previous literature.

- Given this literature it is difficult to understand the proposed changes to the water merger regime

Possible Implications of the Upstream Product Specific Scale Economy Results

- **Marginal Cost Pricing of Upstream Outputs Produced in the VI Firm is Potentially Feasible and Economically Sustainable**
  - We interpret these results as suggesting that, while the presence of strong vertical integration economies favours the retention of vertical integration, **there are in principle no barriers to employing marginal cost pricing to improve the efficient allocation of water resources in the English and Welsh water industry.**
  - Stated differently, marginal cost pricing of upstream outputs could be self funding, unlike the situation that would occur in a textbook natural monopoly where average costs always exceed marginal costs.
  - This has the further implication of suggesting that the current regulatory pricing system, which effectively uses average cost pricing, itself contributes significantly to the inefficient use of water resources in England and Wales, as consumer prices cannot and do not reflect the increasing marginal cost of water abstraction and treatment associated with increased water consumption, even on metered tariffs.
  - But would economic rents result, and how would we allocate them?

Possible Implications of the Upstream Product Specific Scale Economy Results

- **Efficient Marginal Entry to the Upstream Firm is Feasible if the Entrant's MC<Vertically Integrated MC**
  - Such efficient marginal entry could occur if firms were willing to inject treated water into a vertically integrated firm's distribution network at a price less than or equal to the incumbent's marginal cost of water production.
  - Given our finding of decreasing product specific economies of scale in upstream activities for the average WoC, it is entirely plausible that some small marginal entrants might be able to produce treated water at a cost lower than that of the incumbent firm.
  - **The implementation of such an approach would require not only further research to better understand the conditions required for efficient marginal entry, but also development of an appropriate access pricing system properly accounting for local variability in the marginal costs of water production and transportation costs.**
  - Stated differently, while the devil is in the details, maintaining the WoCs' existing structure and allowing marginal upstream entry could be a potential policy option that would allow efficient entry in upstream water activities without imposing costly vertical separation policies.

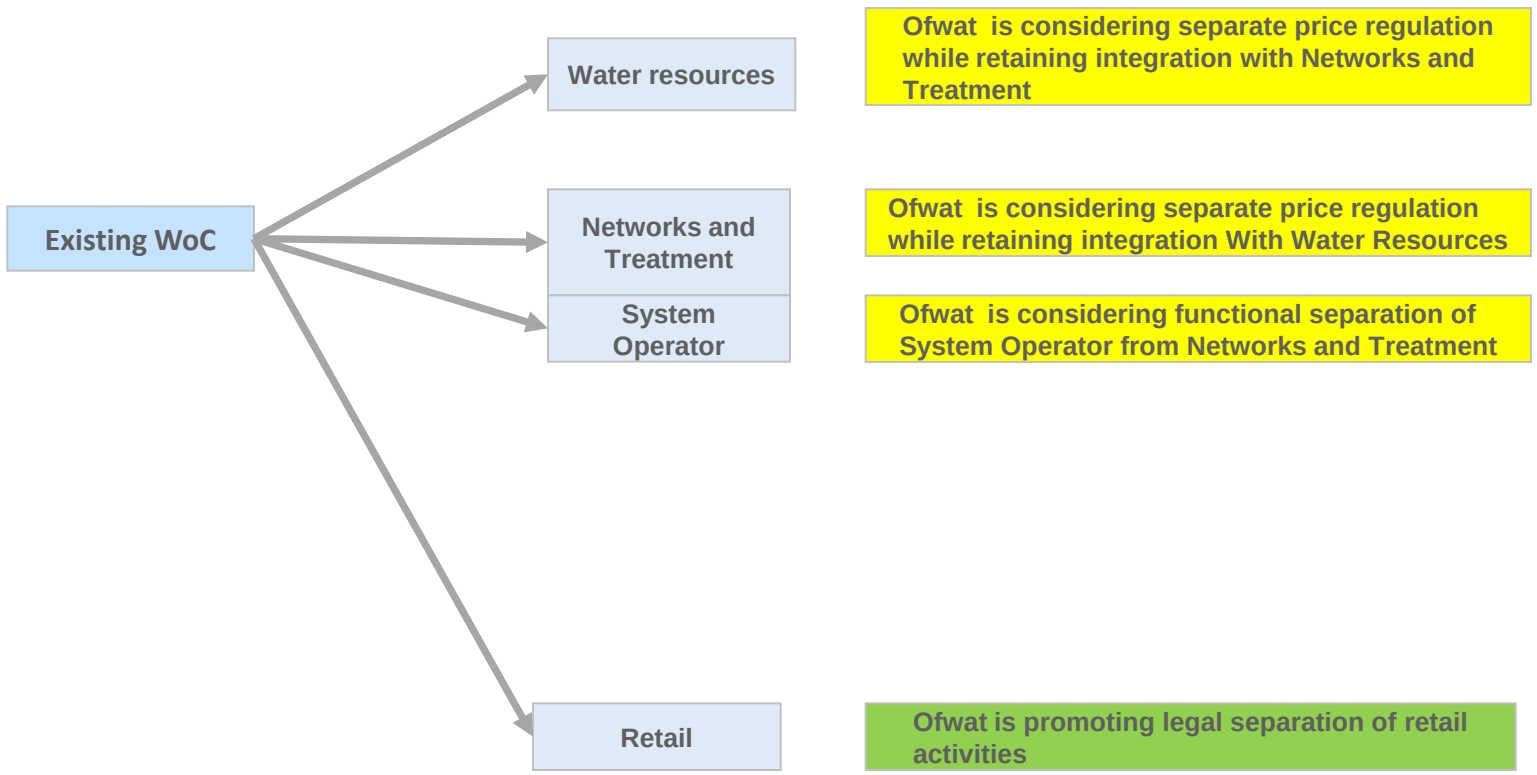
Summary and Policy Implications

Summary and Policy Implications

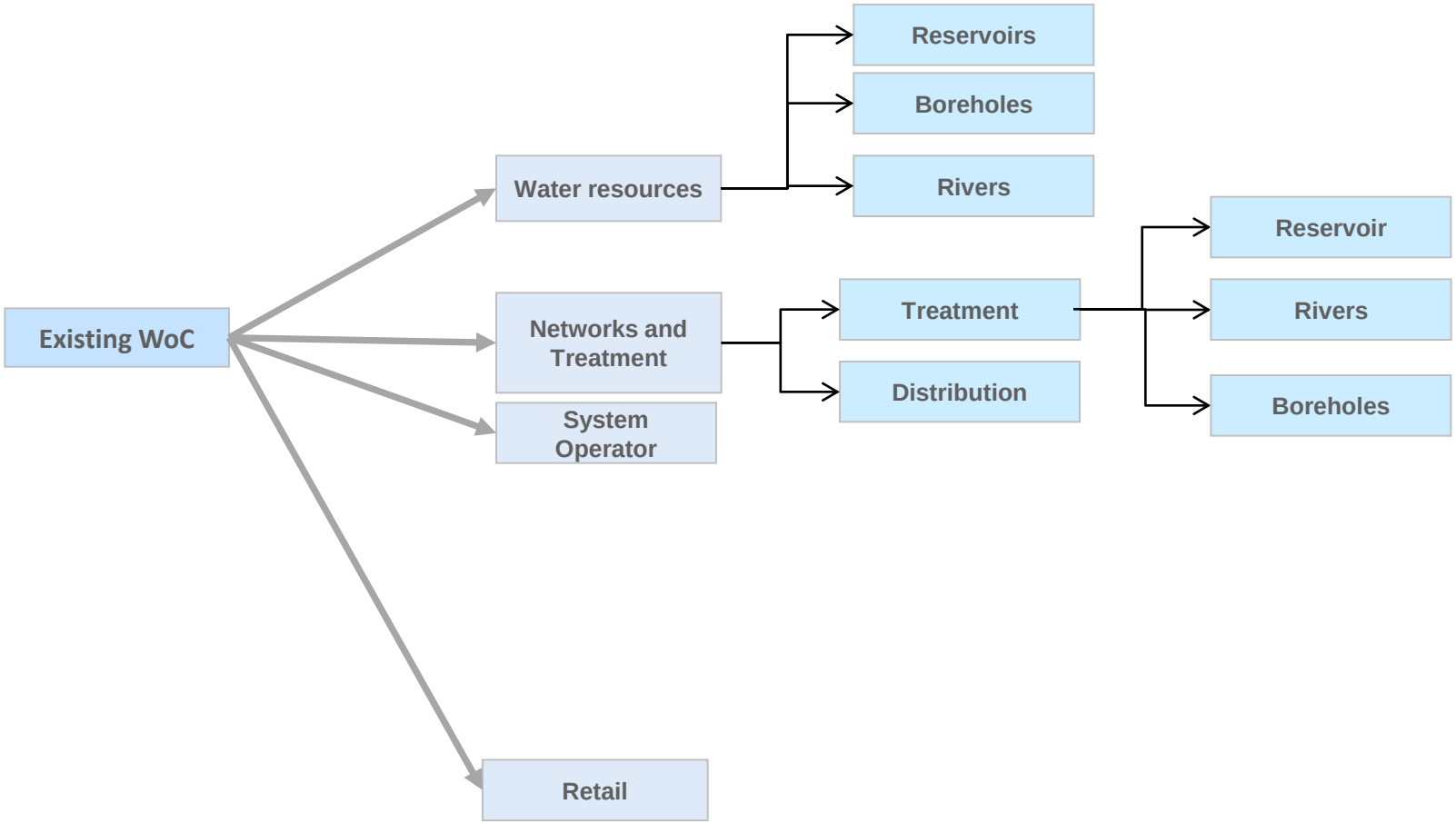
- Vertical separation of upstream water production activities and downstream distribution network activities is likely to impose considerable cost increases and should therefore be avoided
- The separation of borehole abstraction from downstream distribution activities would be particularly expensive relative to fully integrated costs
- While the impact of separating reservoir and river abstraction would be more modest. However, these relatively “costless” unbundling options would only be financially sustainable if policy makers were willing to accept economically inefficient pricing.
- The separation of retailing from a fully integrated upstream and downstream distribution network operation may be a relatively costless policy option.
- The significant degree of diseconomies of scale prevailing for the average firm suggest that further mergers between WoCs should not be promoted.
- Maintaining the WoCs’ existing structure and allowing marginal upstream entry could be a potential policy option that would allow efficient entry in upstream water activities without imposing costly vertical separation policies.
- This last option would require the development of locally appropriate access pricing to facilitate efficient marginal entry, or there is strong potential for inefficient entry

Comparison to Ofwat's Evolving Thinking to Aid Today's Discussion

Ofwat's Hypothetical Model for upstream water markets: January 2011: "The Current State of Evolving Thinking"



The boundaries in the estimated WoC model clearly differ, but it is unclear whether this structure would fully ameliorate the potential impact of lost vertical integration economies



Aston Business School
Birmingham

The Cost Implications of Alternative Vertical Configurations of the English and Welsh Water and Sewerage Industry

January 2011

David Saal, Pablo Arocena
and Alexandros Maziotis

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

Conceptual Model and Results- WaSCs and WoCs Model 1993-2009 Employing Quadratic Cost Function to Estimate Vertical and Global Integration Economies

EFMD EQUIS ACCREDITED

Accredited by Association of MBAs

Aston Business School
Birmingham

Global (Overall) Integration Economies

$$GIC_N(y) = \frac{GIE_N}{C(y_N)} = \frac{IES_W}{C(y_N)} + \frac{IES_S}{C(y_N)} + \frac{IES_{W,S}}{C(y_N)} = VIE_W + VIE_S + VIE_{W,S}$$

If $VIE_{W,S}$ >0, then the costs of producing water and sewerage products jointly in a single firm is strictly lower than producing the same levels of products in separated specialized firms.
If VIE_S>0, then the costs of producing all sewerage products (upstream and downstream) jointly in a single firm is strictly lower than producing the same levels of products in separated specialized firms.
If VIE_W>0, then the costs of producing all water products (upstream and downstream) jointly in a single firm is strictly lower than producing the same levels of products in separated specialized firms.

If $GIC_N(y)$ >0 this indicates that the costs of producing all products jointly in a single company is strictly lower than producing the same levels of products in separated specialized units.

$GIC_N(y)$: compares the costs of full integration with those of full specialization, and thereby indicating the degree of aggregate or overall integration economies as the proportion of such cost savings on the total integrated costs.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Table 1 Sample Descriptive Statistics

Variable	Average WoC	Average WaSC	Sample Average	Std. Dev.	Min	Max
Outputs						
Y1- Total Distribution Input (Ml)	78,123	456,070	233,694	260,328	10,216	1,049,120
Y2- Equivalent Population Served (000s)	-	6,153	2,533	3,888	-	14,325
Y3- Water Connected Properties (000s)	325.0	1,874	963	1,042	43	3,736
Y4- Sewerage Connected Properties (000s)	-	2,244	924	1,410	-	5,737
Total Economic Costs						
TC - (£ millions)	54.856	734.080	334.439	407.020	9.222	1604.990
Input Prices						
K - Capital Price (per £)	0.030	0.023	0.027	0.007	0.012	0.050
L - Labour Price (per FTE, £ millions)	0.033	0.035	0.034	0.006	0.020	0.078
E- Energy Price Deflator (per Gwh, £ millions)	0.048	0.045	0.047	0.010	0.031	0.073
O - Other Costs Price Deflator	0.787	0.799	0.792	0.096	0.686	1.000
Input Quantities						
XK - Capital Stock (£) (millions)	1,036.6	22,222.4	9,757.2	13,346.8	132.9	48,632.9
XL - Employees	318.9	3,092.1	1,460.4	1,714.0	63.0	7,445.0
XE - Energy Usage (Gwh)	64.4	639.1	300.9	356.5	4.2	1,670.3
XO- Deflated Other Expenditure (£ millions)	13.9	140.3	65.9	81.1	1.6	341.3
Operating Characteristics						
Z1 - Water Density (Population/Area Served)	540.1	361.4	466.5	309.1	135.2	2800.0
Z2 - Sewerage Density (Population/km main)	-	169.28	69.68	84.16	-	224.66
Z3 - % distribution input from boreholes	0.560	0.306	0.455	0.343	-	1.000
Z4 - per capita water consumption (l/d)	157.7	157.4	157.6	26.0	124.6	317.8
Z5 - Distribution Losses/Dinput	0.134	0.185	0.155	0.048	0.088	0.319
Z6 - Drinking Water Quality (% zonal compliance)	0.849	0.805	0.831	0.146	0.200	1.000
Z7 - Sewage Treatment Quality (% of population receiving secondary treatment or higher)	-	0.852	0.351	0.437	-	1.000

Note: 413 Observations. Total Costs and Input prices are expressed in real terms using the RPI index (2009=1).

Table 3 Integration economy and scale economy estimates for the sample average firm

Cost Savings From Integration	
$IES_{W,S}$ - Integration of Water (Y1,Y3) and Sewage (Y2,Y4)	***-51.5***
IES_W - Integration of Water (Y1 and Y3)	***78.4***
IES_S - Integration of Sewage (Y2 and Y4)	***73.9***
$GIES_N$ -Global Integration Economy Savings	**100.8**
Integration Economies (as a share of a fully integrated costs)	
$VIE_{W,S}$ - Integration of Water (Y1,Y3) and Sewage (Y2,Y4)	***-0.133***
VIE_W - Integration of Water (Y1 and Y3)	***0.202***
VIE_S - Integration of Sewage (Y2 and Y4)	***0.191***
GIE_N - Global Integration Economies	**0.260**
Cost Elasticities	
Y1- Total Distribution Input (Ml)	***0.247***
Y2- Equivalent Population Served (000s)	***0.318***
Y3- Water Connected Properties (000s)	***0.168***
Y4- Sewerage Connected Properties (000s)	***0.230***
Scale Economies $S_N(y)$	***1.038***

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (0.05) level except for scale economies which are significantly different from one

Table 4 Alternative Decomposition of Global Integration Economies by Network and Volumetric Production Activities

Cost Savings From Integration (£ millions)		
$IES_{V,D}$	- Integration of Volumes (Y1,Y2) and Networks (Y3,Y4)	***99.88***
IES_V	- Integration of Volumes (Y1 and Y2)	12.56
IES_D	- Integration of Networks (Y3 and Y4)	-11.65
$GIES_N$	- Global Integration Economy Savings	**100.80**
Integration Economies (as a share of a fully integrated costs)		
$VIE_{V,D}$	- Integration of Volumes (Y1,Y2) and Networks (Y3,Y4)	***0.257***
VIE_V	- Integration of Volumetric Production (Y1 and Y2)	0.032
VIE_D	- Integration of Networks (Y3 and Y4)	-0.030
GIE_N	- Global Integration Economies	**0.260**

Estimates in **bold** (***bold italic***) are significantly different from zero at 0.10 (0.05) level

Aston Business School
Birmingham

Conclusions

- Our research tested the presence of vertical integration economies in the English and Welsh water and sewerage industry.
- A four output quadratic total cost function model was specified, which controls for water and sewage network activities as well as abstraction and treatment activities, and a number of relevant firm operational characteristics.
- There are statistically significant cost savings associated with the full integration of all network, abstraction and treatment activities, amounting to 26 percent of fully integrated costs.
- Global vertical integration estimates are fully attributable to vertical integration economies within the water and sewage systems that respectively amount to 19.1 and 20.2 percent of fully integrated costs.
- In contrast, we find significant diseconomies of vertical integration between water and sewage activities amounting to 13.3 percent of fully integrated costs.
- An alternative vertical industry configuration based on the separation of network from volumetric based activities would also significantly raise costs by 25.7 percent.
- Scale economies are present but tiny, which when taken together with the inverse relationship between firm size and density, and our estimates of the cost increasing effect derived from decreasing density, indicate that augmenting firms' scale of operations beyond the sample mean would not lead to long run average cost reductions.

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs

Aston Business School
Birmingham

Policy Implications

- **The vertical separation of water and sewerage operations may have the potential to create substantial cost savings.**

- **However, a policy of vertical separation of upstream and downstream water operations, as well as upstream and downstream sewage operations is likely to be prohibitively expensive.**

- **Policy makers must carefully consider the integration economy relationships between all stages of the supply chain, if they wish to properly consider the implications of either unbundling reforms or of further mergers between existing firms in the water and sewerage industry.**

EFMD EQUIS ACCREDITED
Accredited by Association of MBAs