ECHAA’s aim is, by means of comprehensive & rigorous analysis, to:

- support & promote evidence-based policy decisions on contribution of built environment to European health sector
- focus on long-term issues of sustainability & appropriateness of estate
- cover service planning, architecture/design, finance, construction & operation of hospitals & other healthcare facilities

Founding Partners:

- DuCHA: within TNO, state Netherlands Organisation for Applied Scientific Research, [www.tno.nl/ducha](http://www.tno.nl/ducha)
- HaCIRIC: collaboration of British universities research centres – Imperial College, Loughborough, Reading & Salford ([www.haciric.org](http://www.haciric.org))
- [Semmelweis University Health Services Management Training Centre]
Scope of my presentation

- Was that an economic crisis?
- What are hospitals anyway?
- Systematisation
- Flow & capacity
The economic crisis – a model

Trade imbalances:
- Resource exporters (OPEC +)
- Mercantilist exporters (CN, J, D)
- Emerging countries’ “insurance”

Thin capital markets in exporters
Inadequate Western savings rates

“Malinvestment” & bubbles, in:
- Western consumer durables, housing
- Real estate
- Exporter excess capital stock
- Inadequate Western industry/infra investment

Capital flows to West:
Finance sector expansion + risk exposure

Bank crisis 9/2008

1990-?

Black swans with long tails...

Lax regulation (US Fed, Basel)

The long-term, balance sheet repair, 2010-???:
- [firms]
- Households
- Finance sector
- Governments

Short-term solutions, 2009:
- Bank rescues
- Automatic stabilisers (2% GDP)
- Discretionary fiscal (tax, spend)
- Monetary (low RoI, QE)

Have long-term imbalances (“vendor finance”) that started all this gone away?
“The Great Recession”; 2009 vs 1929

Source: Eichengreen & O'Rourke March 2010

The recession is mostly over. I think (but “double-dip”, Greece... & remember those global imbalances)
Likely achievement of debt reduction by sector in next 2-3 years

Few governments have even a chance of deleveraging soon – other sectors do it first

Deleveraging channels available eventually for governments:
- Growing out of debt (usually after wars; but can’t depend on net exports in a global crisis!)
- Defaulting (often after currency crisis)
- Inflation
- Belt-tightening (most likely - implies slow growth)
Big government deficits: projections of government ‘Primary Balance’ & ‘Debt’

We need an “exit strategy” for many rich-world governments, to reduce current overspending during the next few years
But high public debt reduces growth: Advanced economies, 1946-2009

The average debt/GDP level will go over 90% this year. As a result, growth in coming years will be slower than normal.
We need significant effort to reduce stock of government debt back to previous levels.

Required average primary balance to stabilize public debt to GDP ratio at 2007 level¹

<table>
<thead>
<tr>
<th>Country</th>
<th>over 5 years</th>
<th>over 10 years</th>
<th>over 20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4.7</td>
<td>2.6</td>
<td>1.6</td>
</tr>
<tr>
<td>France</td>
<td>7.3</td>
<td>4.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Germany</td>
<td>5.5</td>
<td>3.5</td>
<td>2.4</td>
</tr>
<tr>
<td>Greece</td>
<td>5.4</td>
<td>2.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>11.8</td>
<td>5.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Italy</td>
<td>5.1</td>
<td>3.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Japan</td>
<td>10.1</td>
<td>6.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6.7</td>
<td>3.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Portugal</td>
<td>2.2</td>
<td>-0.3</td>
<td>-1.6</td>
</tr>
<tr>
<td>Spain</td>
<td>6.1</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10.6</td>
<td>5.8</td>
<td>3.5</td>
</tr>
<tr>
<td>United States</td>
<td>8.1</td>
<td>4.3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

¹ As a percentage of GDP

Source: Cecchetti BIS Feb 2010 from IMF World Economic Outlook & OECD Economic Outlook

Few countries succeed in running primary balances for long – yet they should be about 5% of GDP for a decade or so.
The economic crisis morphs seamlessly into the ageing bomb...

2010 is about the year when the baby-boomers start to retire, & spending entitlements rise fast (on pensions, but also healthcare)
Scope of my presentation

- Was that an economic crisis?
- What are hospitals anyway?
- Systematisation
- Flow & capacity
How did hospitals change in the last 50-100 years (where did they come from)?

Prior to the late C19, the options for true medical intervention were limited. Preconditions occurred which enabled a *progressively* more activist approach:

- Safe surgery
  - Anaesthesia (Snow & Queen Victoria!)
  - Asepsis (Semmelweis, Lister)...
- Imaging
  - X-rays (Röntgen)...
- Laboratory medicine
  - Biochemistry
  - Haematology
  - Bacteriology (Koch, Pasteur)...
- Pharmaceuticals (antibiotics)...


The hospital today

Hospitals with the characteristics below feel normal, but in fact represent particular healthcare technologies of the last few decades:

- Operating theatres
  - Fast-acting anaesthetics
  - Minimally invasive surgery
  - Reliable prostheses
  - Transplants...
- Radiology departments
  - Imaging – X-Ray, CAT, MRI, PET, ultrasound...
  - Nuclear medicine...
- IT
  - PACS
  - EPR...
- Laboratories
  - Tissue matching
  - Near patient testing...
- Pharmaceuticals...
What we know will change in health(care)

- Continued medical technology growth (diagnostics, surgery, drugs, gene therapy...)
- Demography
  - Ageing populations
  - Co-morbidities
  - Acute diseases becoming chronic, treatable
    - Muscular-skeletal
    - Diabetes
    - Cancers
    - HIV...
- Epidemiology
  - Resurgent diseases (MDR & XDR TB...)
  - New zoonoses
  - Epidemic influenza
  - Nosocomial infections...

Key question: will something called “the hospital” still be the right place to deal with these things (centrifugal vs centripetal forces)?
Economies of scale classically come about because:
- Division of labour
- Initial lump of fixed costs
- Sharing reserves of resources when variable demand
- Pecuniary (quantity) purchasing discounts

But:
- Managerial diseconomies
- Communication difficulties
- Hospitals are very much multi-product facilities
- Case-mix varies, for many reasons

In principle, economies of scale are likely to apply over some size range. But proving this involves sophisticated econometric, production function & mathematical programming techniques
Cost economies of scale

No matter the technique (“flexible” or “ad hoc” econometric, production function, Data Envelope Analysis or “survival” analyses), the conclusion is robust: economies of scale are exhausted in the range 200-400 beds.

There is maybe not an inexorable technical relationship implied here – more a judgement about packages of staff & equipment appropriate to produce the core of complementary services defining a general hospital in our societies.
Output volume & clinical quality

It is common sense (isn’t it?) that clinical outcomes vary positively with volume – a vast literature

But:
- What outcome is being measured (30-day mortality is too crude for many interventions)
- What is “high” volume (differs by specialty)
- Are we measuring hospital or physician volume?
- What is the direction of causality (perhaps hospitals with good outcomes attract patients & better doctors)?
- Case mix... again (very few studies use RCT as distinct from observational: quality differences often disappear)

In conclusion:
- Some weak evidence, in some cases, of volume effects on clinical quality
- But thresholds are often quite low & could have been achieved by within-hospital specialisation
Economies of scope

- Economies of scope are where the cost of a product falls as the output of another increases – because of sharing or joint utilisation of inputs
- They become worth looking at only because the hospital is so definitely a multi-product facility
- Hospital healthcare is relatively more capital-intensive than healthcare in general, & because much of this capital is joint between activities, is likely to generate economies of scope
- The literature tends to show some differences between different categories of hospital (central, district, specialised...)
- But the economies of scope literature is very unsatisfactory, probably because of the complexity of hospitals – most only looks at inpatient, outpatient & A&E
Hospitals last a long time!

Royal London Hospital (since 1757 on the site, this *Front Block* built in 1897; the “Elephant Man”)

Arcospedale di Santa Maria Nuova (founded here 1285, this *Facciata* dates from 1460; Leonardo da Vinci’s dissection slab)

Build, then repent at leisure…
The age of hospitals raises a real strategic question

- Over a fifth of English NHS estate is >60 years old – but still somehow used
- The capital stock concerned must be fully depreciated
- Few other industries have (or want) capital stock this old
- It implies that capital vintages & acceptable capital:labour ratios in hospital healthcare can be dramatically variable (**how can this be so?**)

Good medicine *can* be delivered in ancient monuments. But in what way, & where are the limits?
Scope of my presentation

- Was that an economic crisis?
- What are hospitals anyway?
- Systematisation
- Flow & capacity
Clinical Pathways: the core concept for healthcare systematisation

Integrated disease management/clinical pathways ("whole systems") are:

- Fundamental to clinical & management practice improvement
- Essential input to service delivery (re)design
- Valuable if only as communication & learning mechanism
- Key to effective strategic asset planning
- Immediately applicable within hospitals, but possibly have most impact across settings
- Increasingly applied for large numbers of patients, especially chronic with co-morbidities
Clinical Pathways: penetration

Key: Bottom bar (blue) – actual
Top bar (red) – projected

Caution over reliability of these statistics! No country has reliable records

Source: EuHPN. Survey of Clinical Pathways and Strategic Asset Planning in 17 EU Countries. 2004

A reasonable maximum?

Not there yet, but the direction of travel - & the potential - are clear
Learn from industry (1): two kinds of industrial process

Batch:
- At one time, all “manufactories” like this
- Craft industry still is
- Leads to intermittent flows
- Lots of hospital work is currently like this!

Continuous:
- Edward Deming & Henry Ford assembly lines, & true process industries (minerals, hydrocarbons)
- Systematisation & interchangeability
- 80/20 rules of thumb
- Hospital care to some extent is, & in the future should increasingly, be managed like this
- Extends outside of hospital, before & after patient episode

Lifts versus escalators: flow capacity is more forgiving than batch
Lifts vs escalators: but which is “best”?

1. Passenger presumed willingness to use vertical transport

<table>
<thead>
<tr>
<th>Floors travelled</th>
<th>Division of traffic (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Escalator</td>
<td>Lift</td>
<td>Escalator</td>
<td>Lift</td>
<td>Escalator</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
<td>10</td>
<td>90</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>25</td>
<td>75</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>75</td>
<td>25</td>
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<td>25</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>90</td>
<td>10</td>
<td>90</td>
<td>10</td>
</tr>
</tbody>
</table>

2. Travel times of lifts versus escalators from ground floor, 1 passenger in 2 walking (sec.)

<table>
<thead>
<tr>
<th>Travel to:</th>
<th>1st floor</th>
<th>2nd floor</th>
<th>3rd floor</th>
<th>4th floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment:</td>
<td>L=3</td>
<td>E=1</td>
<td>L=4</td>
<td>E=2</td>
</tr>
<tr>
<td>Average wait time</td>
<td>13</td>
<td>0</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Pass. board time</td>
<td>12</td>
<td>2</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Av. pass. alight time</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Travel time</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Lift delay/walk time</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>22</td>
<td>58</td>
<td>46</td>
</tr>
</tbody>
</table>

Batch can sometimes be better than continuous!
Learn from industry (2): lean production (beyond assembly line)

Production should never be a black box:
1. Every step should add value to the customer (need to define who that is!)
2. Minimise waste (money, materials, mistakes, unplanned readmission, time & inventory); waiting rooms, & wards, are the ultimate inventory (patients’ time has no cost)
3. Aim for “Zero defect” quality
4. Not (necessarily) about adding technology, buildings & labour
5. Align contractual relationships

If you think it’s simple, why is Toyota (still!) by a very long way the most valuable auto company in the world?
Interesting: but how to do it? & where is the connection to the capital stock?
“Queueing theory”, quantifying and managing traffic flow, otherwise known as “Random customer demand meets fixed capacity”. Enjoy:

\[ P = (\Lambda)^n e^{-\Lambda}/n! \]

which is the Poisson distribution of probability of unscheduled patient arrivals in the next interval of time (and there are plenty more equations like that…)

- Before obsessing about applying the maths, firstly manage patient flow problems by attacking predictable peaks & valleys in workload
- What is the critical path capacity constraint? It’s almost never the number of beds (except maybe for rehab). Relieve one constraint, another will pop up (but so what?)
- Service configuration is more important than crude capacity

These methods are widely used in US hospital analyses & management
Scope of my presentation

- Was that an economic crisis?
- What are hospitals anyway?
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“Norm-based” capacity planning, in one country in Western Europe

<table>
<thead>
<tr>
<th>Designation of specialty</th>
<th>Norm (beds/1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical, surgical ICU</td>
<td>2.9</td>
</tr>
<tr>
<td>Elderly</td>
<td>5.0 (pop &gt; 65)</td>
</tr>
<tr>
<td>Rehab, psycho-geriatric</td>
<td>0.52</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>32/000 births</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>37/000 births</td>
</tr>
<tr>
<td>Acute Psychiatry (general hospital)</td>
<td>0.15</td>
</tr>
<tr>
<td>Acute psychiatry (psychiatric hospital)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Add them all up in order to size the hospital

This & other more sophisticated planning both relate to numbers of beds.
The way we were: early US hospital capacity planning...

Hill-Burton specification

...& still are: Hill-Burton fundamentally underlies most hospital capacity planning, centred on bed numbers
Hospital capacity is a mix of buildings, medical & diagnostic equipment, operating theatres, ICUs…

In practice, however, it is almost universal to denominate it in terms of certified or manned beds, forecast using the formula:

\[
\text{Bed numbers} = \text{Population} \times \text{Hospital admissions frequency} \times \text{ALoS} \times \text{Occupancy rate} \times 365
\]

This formula substantially drives the capital planning process for hospitals in most healthcare jurisdictions.

Something similar is used for operating theatre capacity.

But other hospital functions are not integrated.

But the “bed” looked at this way is mostly storage – warehousing patients while the institution works out what to do with them. Hospitals’ function is process more than storage.
A good modern hospital analysis: Pembury NHS Hospital (Kent)

Background:
- 70% of buildings were sub-standard (major backlog maintenance)
- Much of the estate was >50 years, & some >100 years old
- One of main sites is sloping, with difficult patient transfers
- 50% of equipment was obsolete
- Nightingale wards, significant overcrowding of beds & with high occupancy rates
- Working split over 4 geographically separate sites, with patient transfers over 6km

The trust’s analysis:
- Analysis of demand (demographic change, specialty trends, activity targets), & its drivers & offsets
- Full existing site condition survey
- Reviews of whole-system models of care
- Option appraisal on sites (including particularly “do minimum”, “new build”)
- Financial – capital costs including decant, medical & FM operational costs over 30 years, opportunity costs of sites (all these in DCF)
- Non-financial scoring - access, clinical quality, clinical pathway potential, labour retention, future flexibility
- Risk assessment & management, & mitigation plan (much of this for PFI scheme)
Pembury – the decision

- New-build of £590m. Hospital (Option 2), some refurbishment on second site, closure of rest, integration of mental health
- 100% single bed accommodation (unique in UK)
- Service rationalisation across two remaining sites
- Whole-system “graduated care” approach (community care & rehab)
- One-stop assessment, diagnosis & treatment controlled by patient pathways
- Wide-area EPR
- Increasing levels of day-case treatment to within national top 10

A good analysis & a decision for a very modern hospital
The vital demand instrument here is admission frequencies, allowing for “admission avoidance” & diversions to private care:

- Per population cohort
- Epidemiologically-corrected to be speciality-specific (per HRG)

The capacity calculation sums either projections or targets/trends for total bed numbers & operating theatres, based on:

- Average Length of Stay & day-case by specialty (for beds)
- Occupancy rate (for beds & OR)
A better way of looking at “flow”

In the healthcare context, rather than “admissions”, flow:

- Similar patient processes, not similar ailments
- Number of activities undertaken, not number of patients
- Best grouped by complexity, not acuity
- Types of flow – patients, staff & goods – need to be kept separate from each other
- Elective flows also kept separate from emergency ones (which are more predictable, statistically!)

Question 1
How to measure – pathways don’t map to DRGs (which refer to individual admission), nor “Consultants Episode”???
A better way of looking at “capacity”

In the healthcare context, rather than “beds”, capacity:

- Hospitals are immensely complicated processing plants
- Designed in recognition of both continuous & batch processes
- Limited by true network constraints which, like the poor, are always with us - & they’re probably hidden
- Structurally in excess, to cope with inevitably variable flows (seasonal ‘flu…)
- Loose-fit, & as standardised as possible

Question 2
How to measure ability to deliver network processes (it’s not counting singular, simple structures like beds)???
The “Layers” model of capacity

1. Extreme segmented
   - Factory: 9%
   - Hotel: 21%
   - Office: 24%
   - Hot floor: 46%

2. Hybrid model
   - Factory: 13%
   - Hotel: 27%
   - Office: 36%
   - Hot floor: 24%

Netherlands Board for Health Care Institutions, 2007
What we build can vary a lot...

- Hot floor (clinical diagnostic) 30.5%
- Ward (hotel) 32.2%
- Office 23.5%

Building durability, years

Probability of change:
- High
- Low

Capital intensity:
- High
- Low

10 30
A research project on the flow process model for the hospital

Key issue is to combine flow analysis with consideration of the capacity through which that flow passes
My conclusions

- The **economic crisis** is mostly over, but:
  - Imbalances still exist; government debt will rise for years, & must be reduced
  - High public debt will reduce growth (so even harder to pay it down)
  - Repairing the fiscal problem will morph into the ageing entitlements bomb

- The hospital will experience **centrifugal & centripetal forces**:  
  - Technology, demography & epidemiology will often drive care out
  - Little evidence for economies of scale
  - Economies of scope imply that hospitals will remain
  - Hospitals are capital-intensive – some parts very much more than others

- Greater healthcare **systematisation** is inevitable:  
  - Integrated Clinical Care Pathways making inroads for safety & cost reasons
  - Batch vs continuous flows – try (usually) to maximise the latter
  - Operational Research (queueing theory) & “lean” flow ideas have merit but need to be linked to the estate & capital stock

- Conventional hospital analyses are heavily linked to **beds**. But:  
  - The real capacity constraint is in the “signature”, “hot floor” capital stock
  - The way forward is to link flow thinking to a synthesised view of the hospital’s capital stock, in a way which is coherent across healthcare systems

Thank you!  
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