The Role of Design and Engineering in African Innovation Systems-Building

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The Main Steps

1. Clarification of terms
2. The basic argument
3. Design-and-Engineering in innovation systems
4. D & E capabilities in developing countries
5. D & E: a **core** component of innovation systems ?
6. D & E activities widely neglected in policy
7. Building D-&-E Capabilities on Africa

1. Clarification of terms:

‘Design and engineering’ = ?

‘Innovation System’ = ?

‘Innovation system building’ = ?

‘Design and engineering’ = ?

Design – an activity or process:

- not just about creating the aesthetic form of objects
- more comprehensive: creates the full ‘specifications’ of products, processes and production systems.

Engineering

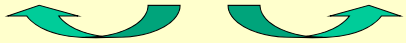
- not a sub-sector of manufacturing production (machinery industry)
- overlaps with design (activity/process of creating specifications’), but extends towards the realisation of those in concrete realities – various kinds of ‘project management’.

‘Innovation System’ = ?

A { Knowledge bases, Activities, Actors/organisations, Interactions/links } Contributing to the creation, diffusion and exploitation of innovations

B { Framework Conditions, ‘Institutional’ contexts } Shaping how ‘A’ emerges, develops and functions

Multi/inter national **National** Sectoral Regional



‘Innovation system building’ = ?

Focus on ‘core’ – i.e. ‘A’ above.

- Not just autonomous emergence/evolution of the structure of knowledge bases, activities, actors and linkages;
- Purposeful and explicit function of public policy
  - more than policy about current expenditure (e.g. what kind of R&D), or capital expenditure (e.g. radio telescopes or molecular biology labs)
  - policy intended explicitly to shift the structure of ‘A’ into particular configurations at particular rates over the longer term.

Shifting the structural configuration of the system 'core':

- The composition of knowledge bases
- The composition of activities carried out
- The composition of actors/organisations
- The properties of inter-actor knowledge links

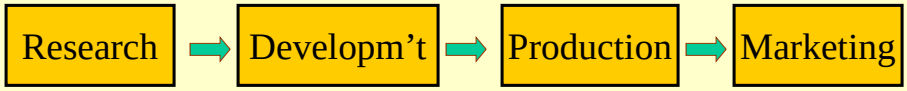
2. The basic argument:

- Design and engineering activities (and hence underlying capabilities) constitute a key 'core' of science, technology and innovation (STI) systems – especially in Africa.
- But those activities and capabilities are woefully neglected in policy analysis and policy practice concerned with building African STI systems.
- Innovation policy in Africa will need to be much more innovative in order to address this 'gap'

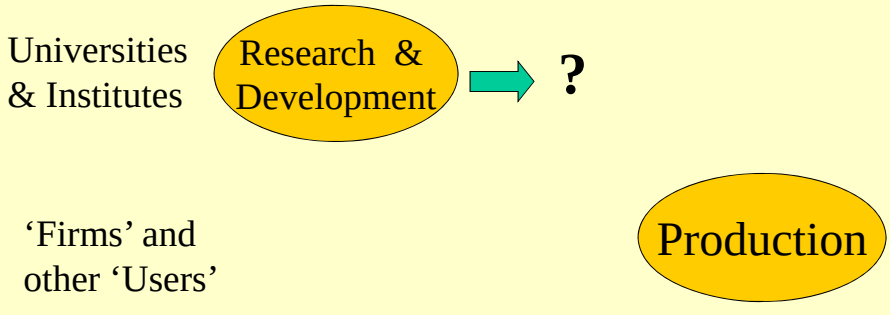
3. ‘Design-and-Engineering’: a Component of Innovation systems?

Not Evidently so in the main ‘maps’ of innovation systems for policy analysis

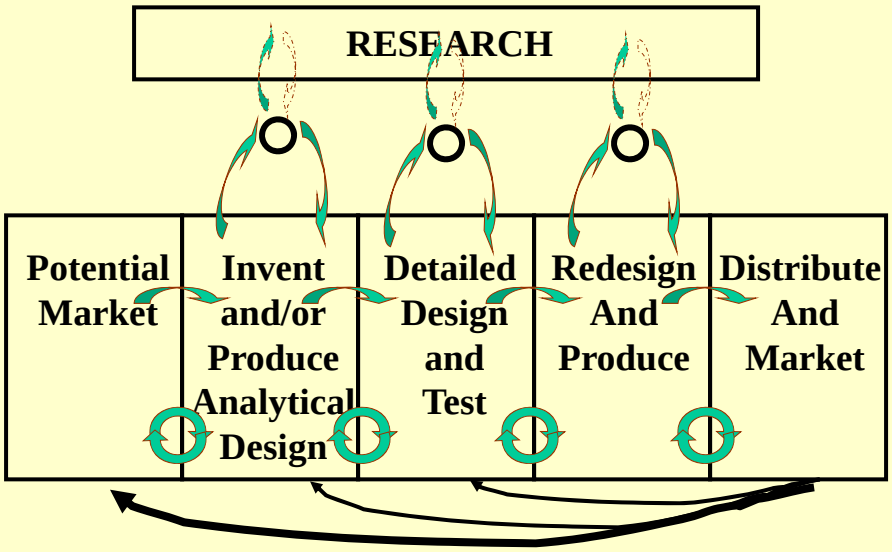
e.g. in the Conventional ‘Linear’ innovation Model



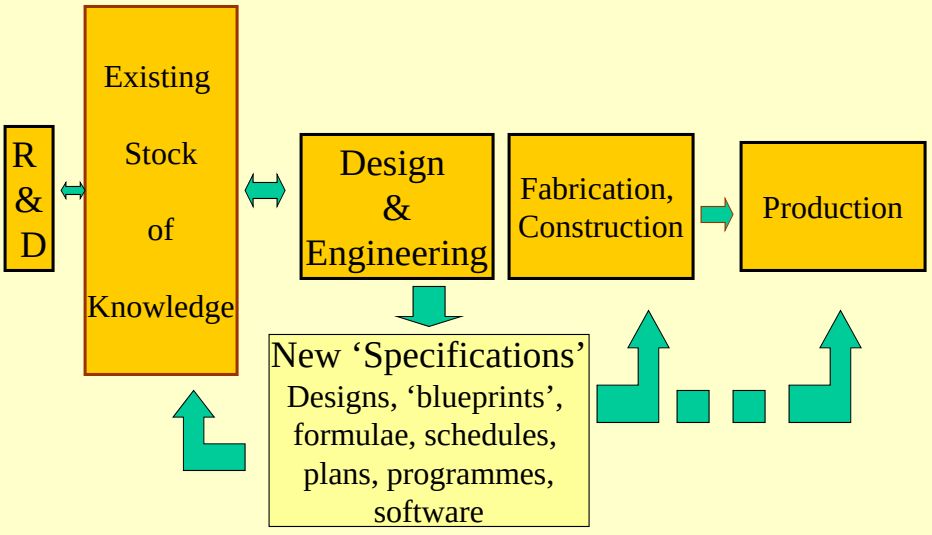
Nor in common types of organisationally structured ‘maps’ of innovation (non-)systems in developing countries – e.g.



Some (neglected) signs: the 'Chain-Linked' Model*

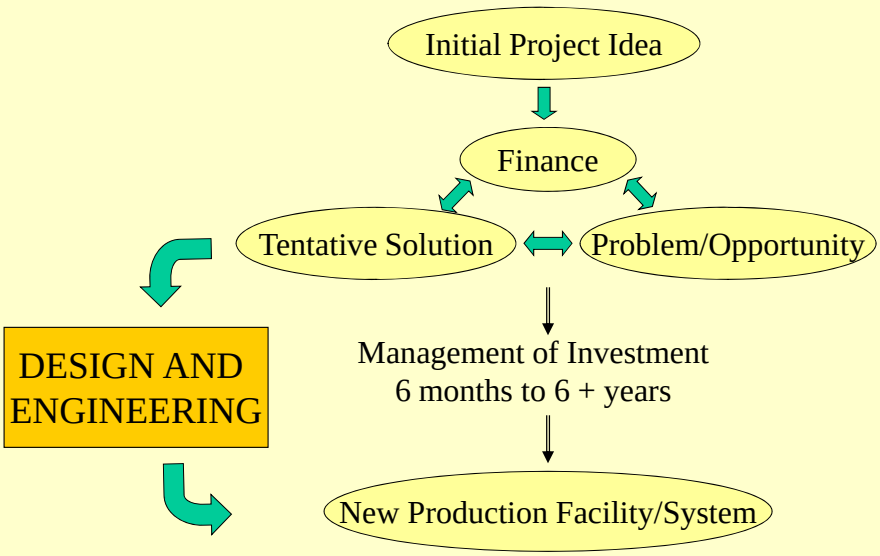


* Kline and Rosenberg (1986)

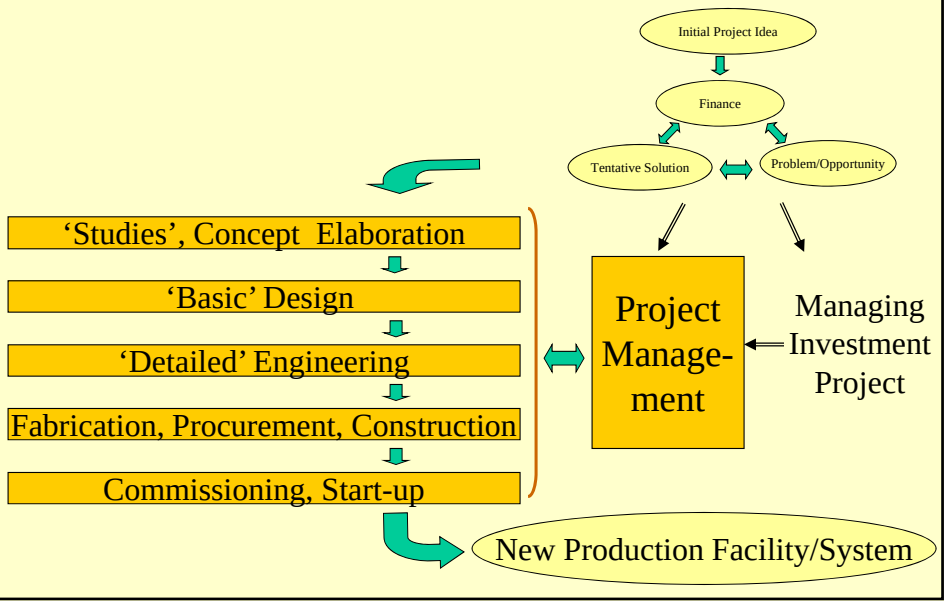


. . . . A process-centred elaboration . . . .

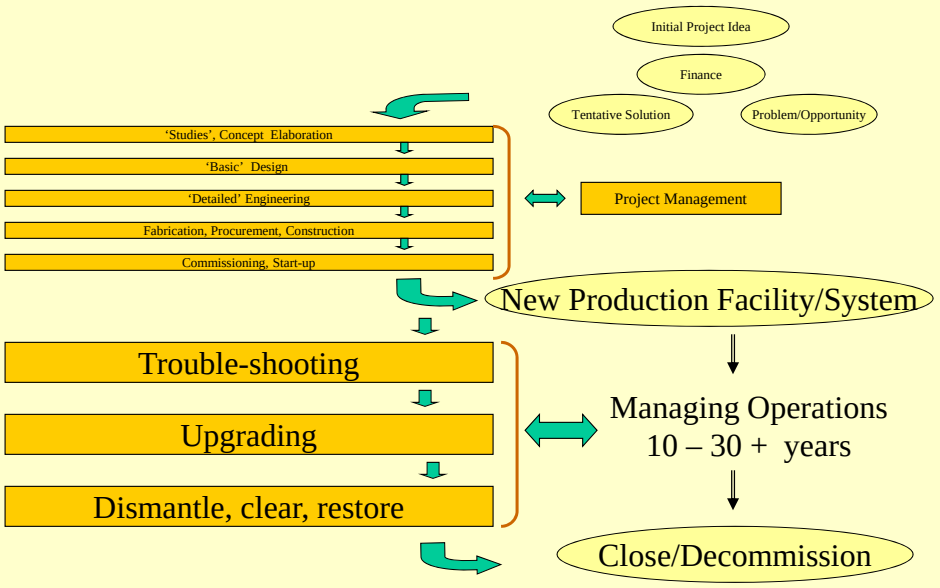
Design and Engineering in the Life of an 'Industrial' Facility I



Design and Engineering in the Life of an 'Industrial' Facility II

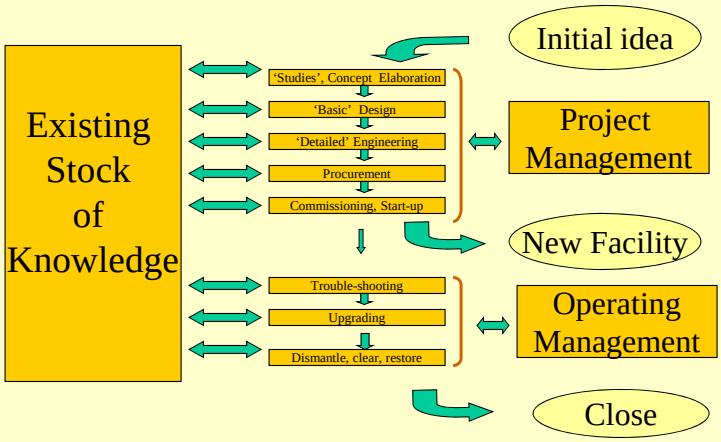


Design and Engineering in the Life of an 'Industrial' Facility III



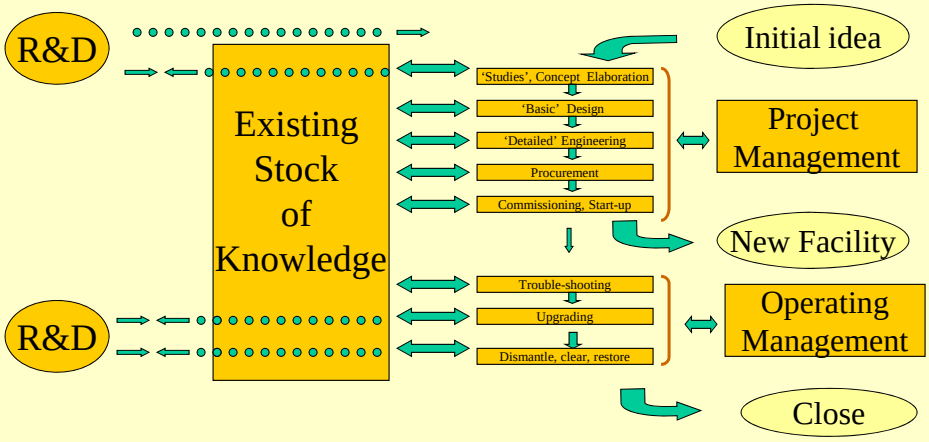
Knowledge inputs to D & E

Draws heavily on various elements in the existing stock



Process-centred D-&-E and R&D

Essentially an intermittent relationship – usually when the stock of knowledge is inadequate for the task facing D&E



4. D & E Capabilities in Latecomer/Developing Countries

Some anecdotes

- Australia - 1950s: The Snowy Mountains Hydro Scheme
- Korea - 1970s and 1980s: Posco and others
- Brazil - late-1970s: Petroquisa and the Copesul project
- South Africa - 1970s and 1980s: the mining industry

Roles of Local D-&-E Capabilities in Developing Countries

(a process/facilities perspective)

1. Incremental D & E based innovation

   (a) shaping key features of new production facilities
   - reducing costs
   - meeting efficiency-raising adaptation needs
   - responding to local sustainability problems and aims

   (b) continuous 'upgrading' of existing facilities

2. Efficiency in managing outsourced D&E in investment/innovation (e.g. Brusoni, 2005)

3. Influence over local sourcing of inputs: for both investment and ongoing current production

4. Role in structural change

(Hausmann and Rodrik (2003): 'Self discovery')

(a) Directly – D & E as production and export of knowledge services

- POSCO: from steel engineering to global software supplier
- SMEC: from local infrastructure engineering to global engineering contractor

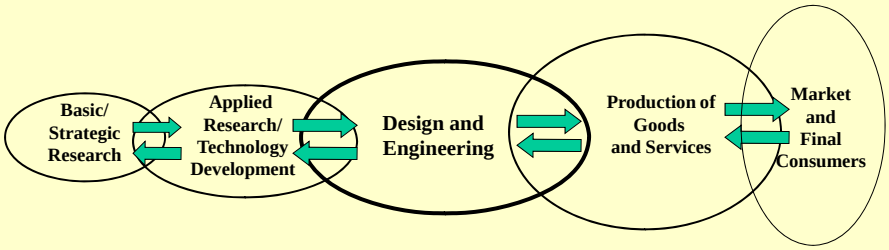
(b) Indirectly – D & E as stimulus and initiator

- e.g. Korean Chaebol and 'Project execution' capabilities (Amsden and Hikino, 1994)

5. 'D & E': A **Core** Component of Innovation systems?

- A key system-linking (integration) role
- Scale: probably much larger than R&D

A key linking role in STI systems

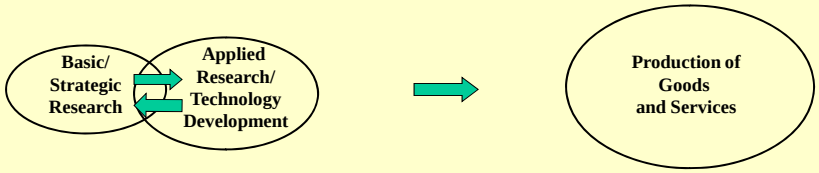


D & E capabilities are a key system component in two ways:

- In linking **existing** R&D and production activities
- In creating **new** R & D-related linkage structures

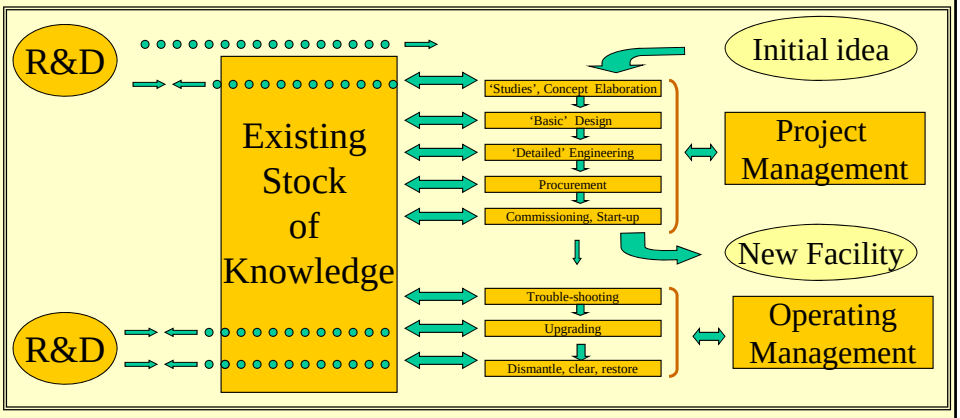
Linking **existing** R&D and production activities

R&D-to-production links very rarely involve:



BUT are .....

..... significantly mediated by D & E activities.



D & E in system development and the emergence of **new** linkage structures

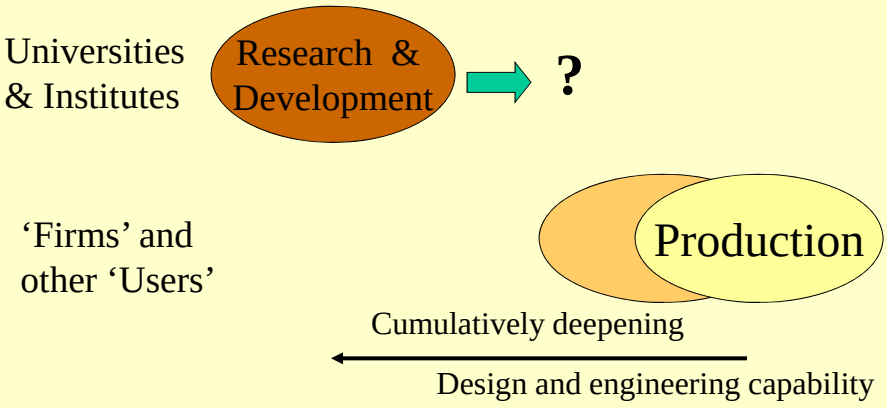
Common disarticulation of developing country systems

Universities & Institutes → Research & Development → **?**

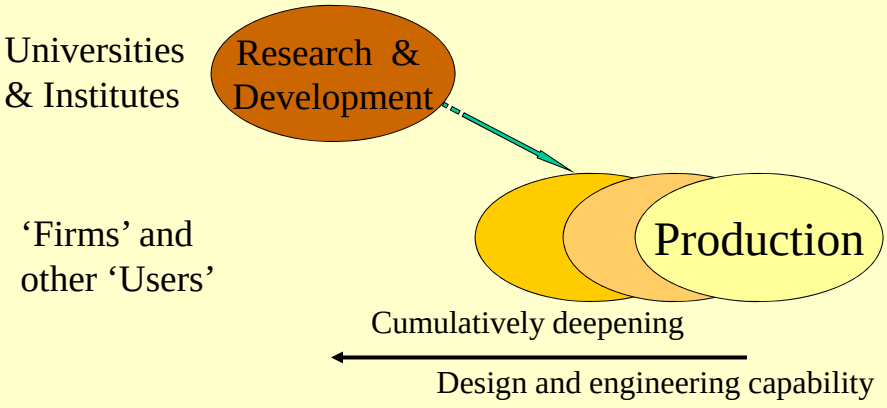
'Firms' and other 'Users' → Production

Frequently seen as problem calling for 'better links'.....

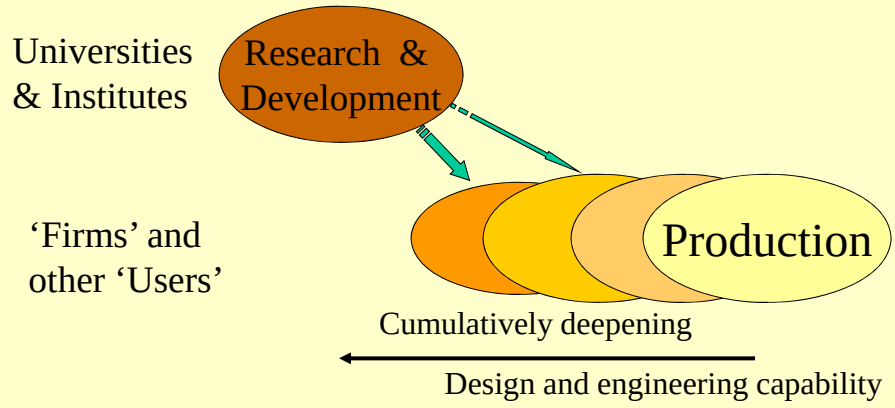
..... But substantial evidence suggests that articulation depends on deepening D & E and Development capabilities in firms and other users .....



..... i.e. on 'better capabilities'

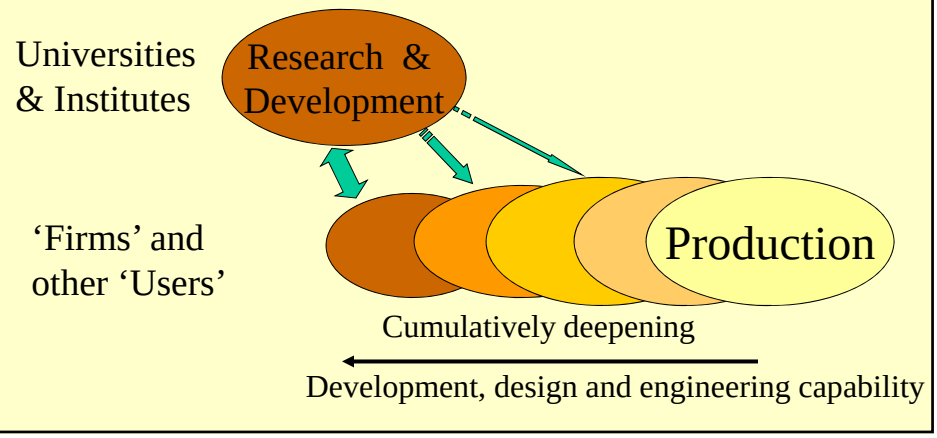


..... involving greater 'absorptive capacity' and .....



..... increasingly well articulated **<u>demands</u>** on R&D

That development sequence is very neatly illustrated by the history of Multotec Process Equipment, Johannesburg. (Roberts, 2005)



The scale of D & E activities
in the innovation system

Greater than R&D ?

The Main Activities of Scientists and Engineers* in the US (2003)

A. Research and Technological Development 10%

B. Design 13%

[Of equipment, processes, structures, models; plus computer programming and systems development)]

C. Management/Supervision 19%

[Of people, projects, quality, productivity, etc.]

D. All Other 58%

[Business, administration, and production (e.g. accounting, sales, maintenance); professional services (e.g. financial, healthcare, legal); teaching; miscellaneous]

- Scientists and engineers: degree qualification in S or E discipline and/or employed in S or E occupation

Source US NSF SESTAT (2003)

"Architectural and engineering design (AED) activities" UK 2004*

Purchased design services	£17 billion
Own account (in-house) design services	£27 billion
Total	£44 billion
GERD – civil and military	£20 billion

Health warning – there is almost certainly some unknown degree of overlap between AED and GERD

* Galinda-Rueda et al. (2008)

6. But D-&-E activities and capabilities are widely neglected in STI policy analysis and policy making

- In OECD economies – e.g. the UK
- In 'Emerging' economies – e.g South Africa
- In Developing economies - Africa

In OECD Economies – e.g. the UK

Growing dissatisfaction with the idea that STI policy (and Management) is little more than R&D policy. In particular

- Design and related creative activities are poorly captured by conventional R&D concepts, categories and data:
  e.g. Salter and Gann, 2003; Dodgson et al., 2005
- Conventional concepts and indicators of innovative activity are especially inadequate in certain kinds of sector: e.g. NESTA, 2006(a); 2006(b)

In South Africa

e.g. the NACI (2006) Background Report for The OECD Country Review of South Africa's National System of innovation

In Africa – e.g.

Africa's Science and Technology Consolidated Plan of Action

2006, New Economic Partnership for Africa's Development, African Ministerial Council on Science and Technology

The CPA ***"articulates Africa's common objective of socio-economic transformation and full integration into the world economy. …[and it] …places emphasis on developing an African system of research and technological innovation…"*** *(p.6)*

The main components of the CPA –

- Centres of Excellence focused on:
- Flagship Research and Development Programmes
- Organised in five main Programme Clusters
  - Biodiversity, Biotechnology and Indigenous knowledge
  - Energy, water and desertification
  - Materials sciences, manufacturing, laser and post-harvest technologies
  - ICTs and space science and technologies
  - Mathematical sciences

In effect, STI policy and system building = R&D policy and system building

"…it is crucial that adequate financial resources are mobilised. AMCOST … may consider … the following interrelated elements;

- ***Substantial increase in national R&D budgets, with each African country taking concrete actions to allocate <u>at least 1% of its GDP to R&D</u> …." (p.69)***

Subsequently in its Cairo Declaration in 2006, AMCOST recommended to the Assembly of Heads of State and Government of the African Union to:

"Promote research and development (R&D) and develop innovation strategies for wealth creation and economic development by allocating at least 1% of Gross Domestic Product (GDP) to R&D by 2010…."

So ?

A view from the UK:

*"Innovation policy needs to be **imaginative** .."*

(NESTA, 2006)

Surely even more so in Africa

- The structure of many economies seems particularly 'D & E – intensive'
- Issues to address enormously different from those currently at the centre of STI policy attaention

7. Building D & E Capabilities in African Innovation Systems: Some key features

- Standard of basic academic training is critical but is only a foundation
- Beyond that, capability development must be undertaken very largely in and by firms – not public institutes
- Involves investment costs: explicit expenditure and management
- Returns to investment subject to risks of non-appropriability (Externalities = social benefit)
- So all the standards problems of 'market failure' arise .

But so also do the problems of system/coordination failure

- D & E learning and capability deepening is largely project-based and cumulative between projects.
- But in many fields only relatively large companies with international activities can provide cumulative continuity
- So, requires an appropriate organisational vehicle that:
  - has incentive to invest in capabilities
  - can accept (even promote) externalities
  - can link capability accumulation through projects
  - can do so on an international basis where needed

Amsden, A. H. and Hikino, T. (1994), Project execution capability, organisational know-how and conglomerate corporate growth in late industrialisation, *Industrial and Corporate Change*, 3 (1), 111-147

Dodgson, M., Gann, D. and Salter, A. (2005), *Think, play,do*, Oxford University Press, Oxford.

Freeman, C and Young, A. (1965), *The Research and Development Effort in Western Europe, North America and the Soviet Union*, OECD, Paris

Galinda-Rueda, F. Haskel, J. and Pesole, A. (2008), How much does the UK employ, spend and invest in design?, Working paper, The Centre for Research into Business Activity, London

Kline, S. and Rosenberg, N. (1986), An overview of innovation, in Landau, R. (Ed), The positive sum strategy: Harnessing technology for economic growth, pp. 275-306.

NESTA (2006), The Innovation Gap: Why policy needs to reflect the reality of innovation in the UK; National Endowment for Science, Technology and the Arts, Research report, October

NESTA (2006), Hidden Innovation: How innovation happens in six 'low innovation' sectors'; National Endowment for Science, Technology and the Arts, Research report, October.

Roberts, S. (2005), Resource-based Technology Innovation in South Africa: Multotec Process Equipment - dense medium cyclone for materials separation, Human Sciences Research Council.

Salter, A. and Gann, D. (2003) Sources of ideas for innovation in engineering design; Research Policy, 32, 1309-

The Place of Work of Specialists and Engineers with Higher education USSR 1960*

	'000s
Scientific and Research Institutions ≈ 'R&D'	272.5
"Project and Design" Organisations ≈ 'D&E'	232.1

(Almost certainly some Frascati-type R&D done in Project and Design organisations)

* Freeman and Young (1965, p.131)