The Significance and Role of Design and Engineering in Developing Country Innovation Systems

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Scope of Comments

1. The D&E component in innovation systems
   - Role in implementing innovation
   - Role in strengthening *emerging* innovation systems
   - Scale of D&E in innovation systems
2. D&E: Significance in the sectoral structure of African economies
   - The sectoral structure of African economic growth
   - D&E role in the sectoral structure and in ***changing*** it
3. D&E: STI indicators and underlying questions

1. D&E in Innovation Systems: what is it?

Design:

- An activity or process that creates the '**specifications**' of products, processes and production systems.
  (not just about the aesthetic form of objects)
- May be 'formal' or 'informal'

Engineering

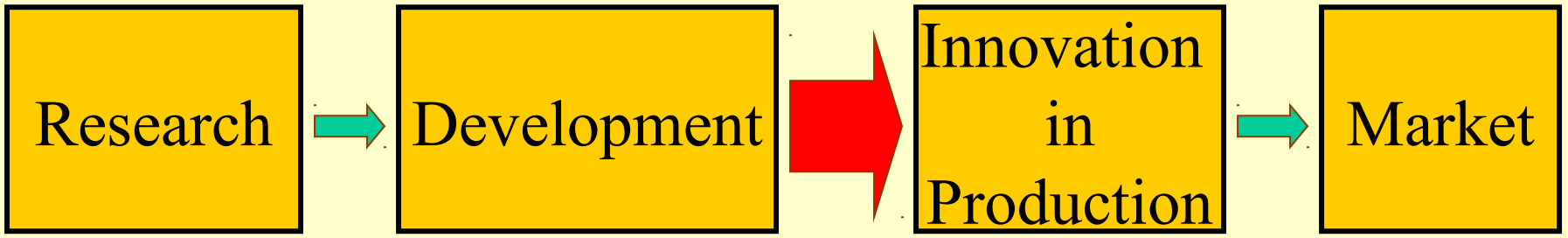
- Overlaps with design
- But extends towards the realisation of specifications in operational forms – includes various kinds of :
  - 'project management' and procurement
  - implementation and 'system integration'
  - testing, initiation and supervision

The role of D&E in implementing innovation

- D&E are key activities that contribute to transforming 'disembodied knowledge' into the concrete realities of implemented technical change
- Some of that is replicative change
- Much of it is incrementally innovative (N-to-F or N-to-M)
- Some is more radically novel (N-to-M or N-to-W)

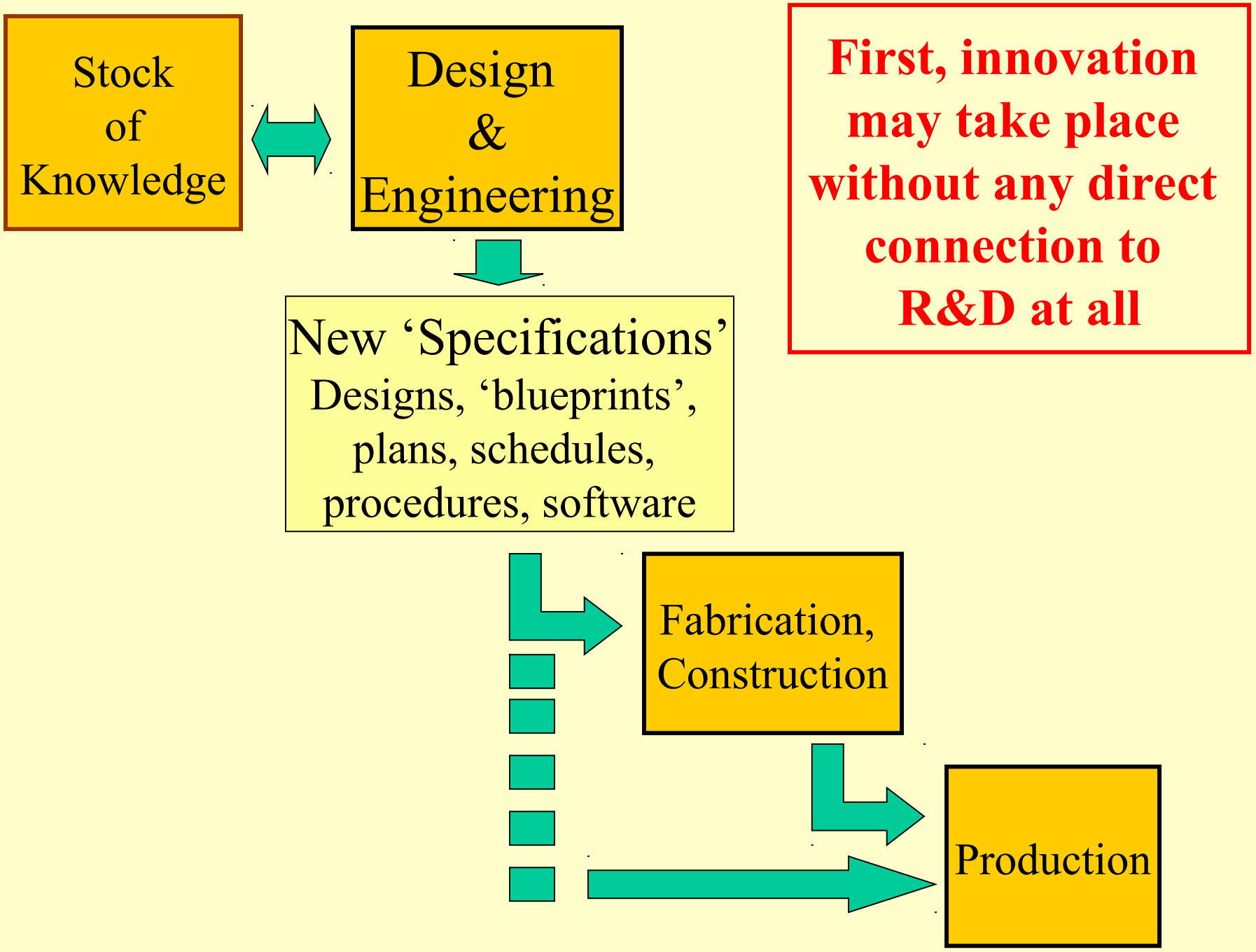
But typically D&E is not even visible in the main ‘maps’ of innovation systems for policy analysis:

e.g. in the conventional ‘linear’ innovation model

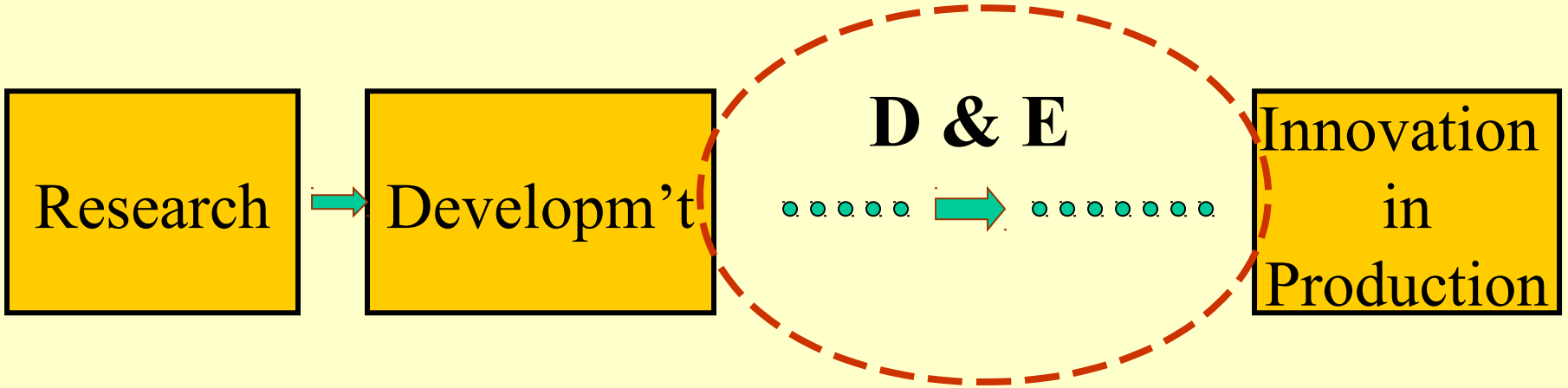


But innovation very rarely involves such a direct link from R&D to innovation

Much more often it depends on two other routes


Stock of Knowledge
Design & Engineering
First, innovation may take place without any direct connection to R&D at all
New 'Specifications'
Designs, 'blueprints', plans, schedules, procedures, software
Fabrication, Construction
Production

Second, when R&D is involved, D&E provides the necessary knowledge-transforming link between R&D and innovation

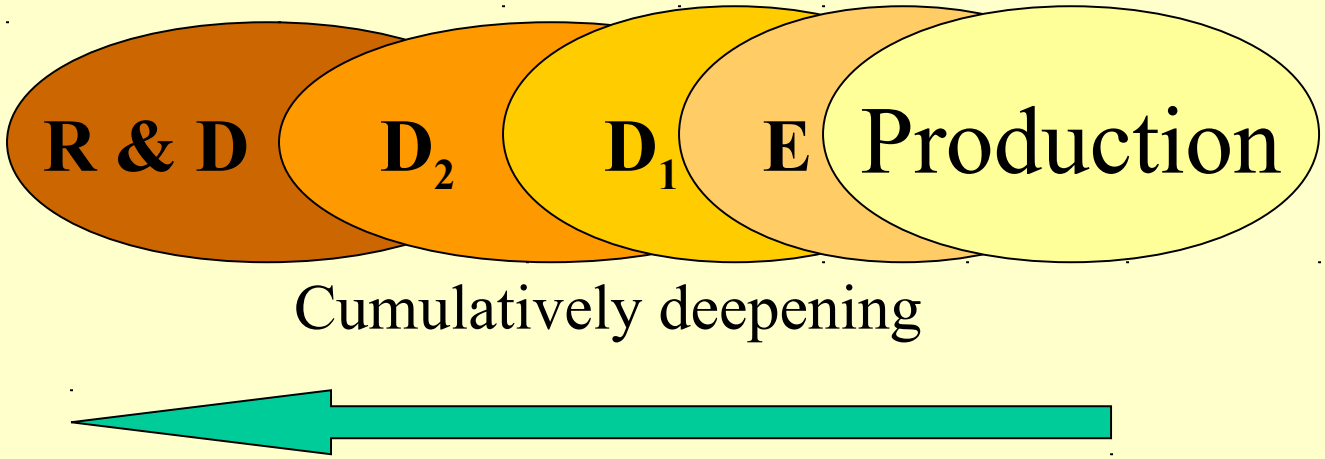


Role in Innovation System Strengthening

(a) Deepening the R&D-intensity of the system:

- D&E capabilities – key steps within cumulative emergence of R&D **in** ***business enterprises***

Firms



(b) Strengthening system ***coherence/integration*** via increasingly well articulated **demands** on R&D in e.g. universities and institutes as well as within firms

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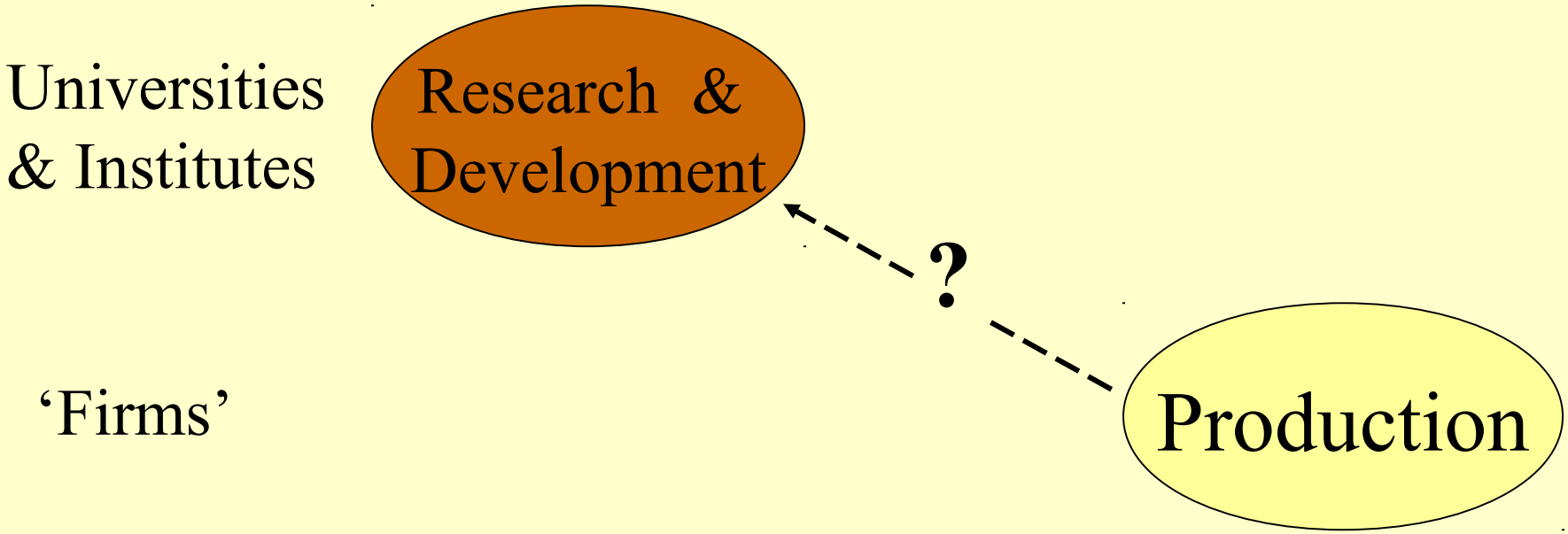

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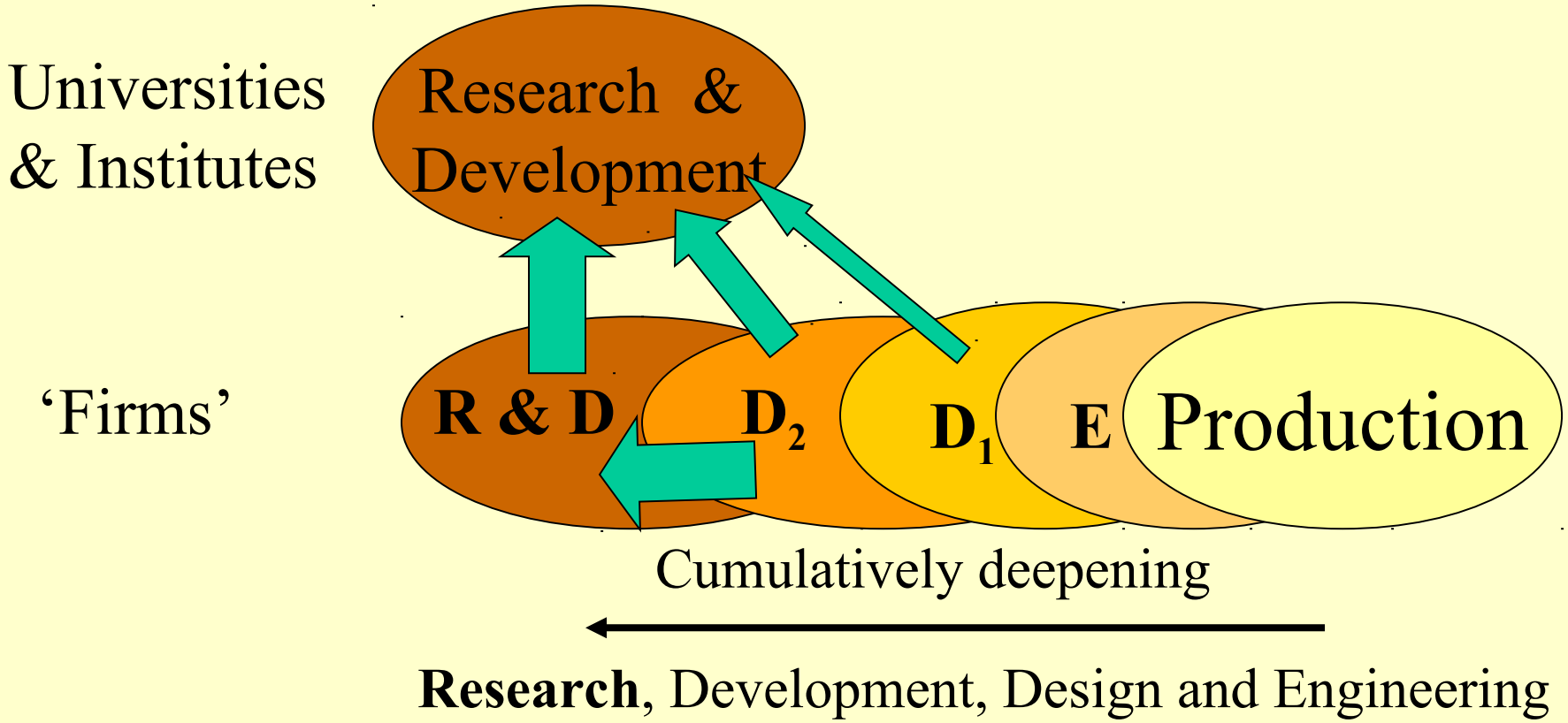
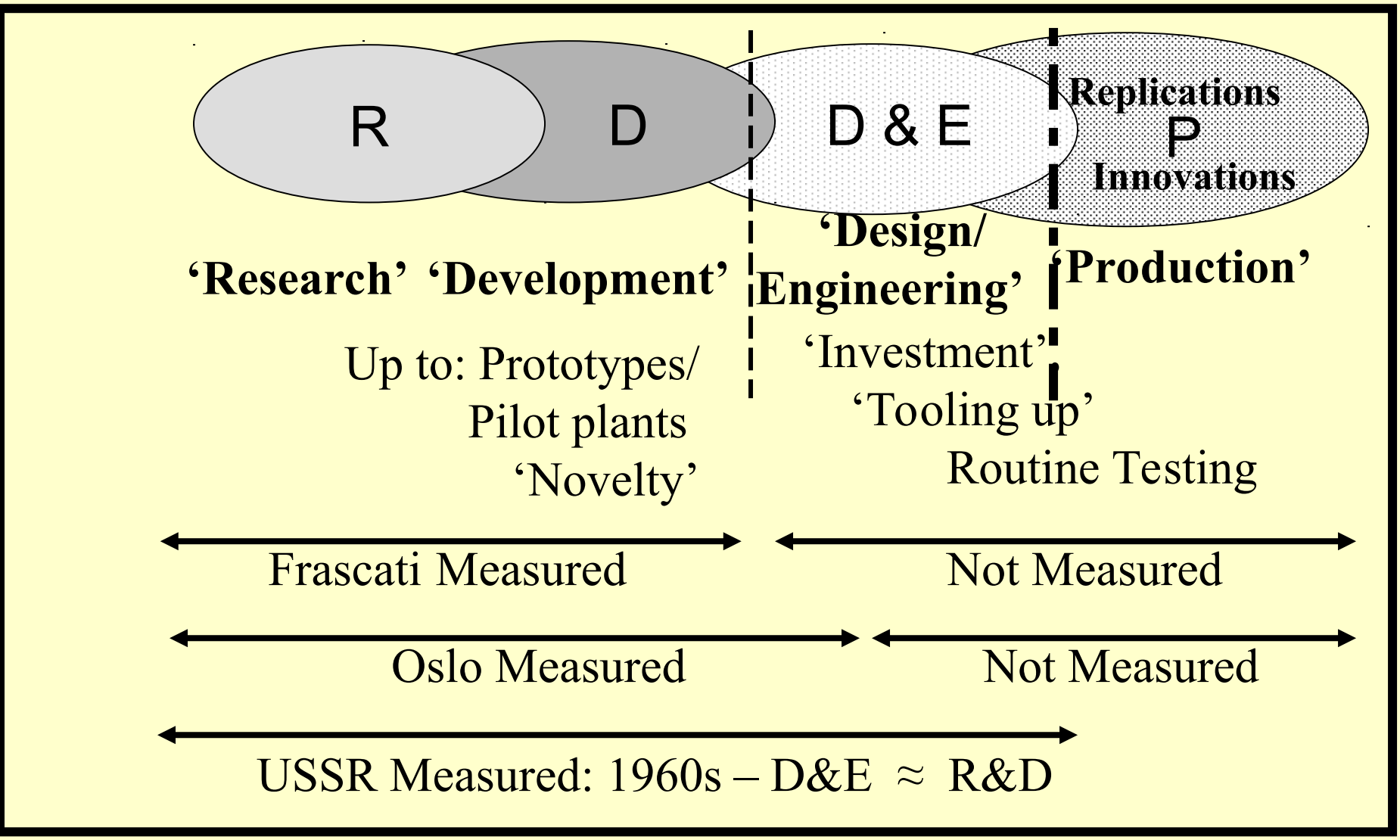


What is the

scale of D & E activities in

the innovation system ?

Measuring and Not Measuring Scientific, Technological and Production Activities



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)

Private sector, UK 2004*

		£ billion	% of GDP
Total	AED	32	2.7
	GERD	20	1.7
	AED/GERD	1.6	

Health warning – there is some degree of overlap between AED and R&D

* Galinda-Rueda et al. (2010)

D&E: Significance in the sectoral structure of African growth

1. Agriculture and fishing — ISIC Divs 01-05
2. Industry — ISIC Divs 10-45
3. Services — ISIC Divs 50-99

2 (a) Industry – Manufacturing — ISIC Divs 15-37

- e.g Food, textiles,paper. Basic metals, Machinery

2 (b) Other Industry

- Mining, oil, gas, quarrying — ISIC Divs. 10-14
- Construction — ISIC Div. 45
- Electricity, gas, water supply — ISIC Divs. 40-41

Particularly important in recent and probably future (East) African growth

(WB – WDI; ISIC Rev 3)

Changing Sectoral Structure
Low and Middle Income Economies

Sector value added as a proportion of GDP

			% Change 1999 - 2009
Middle Income	Agriculture		-23
	Services		5
	Industry		1
	of which:	Manufacturing	-2
		Other Industry	5
Low Income	Agriculture		-28
	Services		13
	Industry		21
	of which:	Manufacturing	12
		Other Industry	**33**

Changing Sectoral Structure: East African Economies

			% Change 1999 - 2009
Kenya	Agriculture		-30
	Services		22
	Industry		- 9
	of which:	Manufacturing	-24
		Other Industry	**23**
Tanzania	Agriculture		-16
	Services		1
	Industry		25
	of which:	Manufacturing	-1
		Other Industry	**50**
Uganda	Agriculture		-36
	Services		18
	Industry		31
	of which:	Manufacturing	-18
		Other Industry	**79**

Two features of these sectors are significant

1. They have particularly ***low R&D-intensity,***
   but with particularly ***high D&E-intensity***,
   and some are ***innovation-intensive*** high-tech.
2. Growth paths dominated by these resource-intensive and capital-intensive sectors **can be** massively 'excluding' in a broad macro sense (e.g. in much of Latin America through most of the 20th century).

But (2) not always so (e.g. the 'Scandinavian model').
Key to the difference appears to be:

- investment in 'knowledge-capital' and 'human capital'

Within that, D&E capabilities seem especially important.

D&E Role: Contributing to structural *change* (transformation) in the economy

D & E as stimulus and initiator of diversification into other new industries: about starting to produce things you haven't produced before

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

[Paul Collier 'Investing in Investing' - *The Plundered Planet*]

With emphasis here on 'upstream' (backward) diversification to new (to economy) input services and goods rather than 'downstream' (beneficiation)

Three routes:

(a) Implicitly – D & E itself as a high value-adding service industry producing and potentially exporting knowledge services

(b) Directly - Via diversification on the basis of D&E capabilities within large/medium firms

(- e.g. 'Project execution' capabilities in Korean firms (Amsden)

(c) Indirectly - Via capability spillovers to new/young firms

D & E Capability Building:
Some key features of the process

- A very large part must be undertaken ***in and by*** 'business enterprises'.
- It involves explicit investment outlays.
- But investment is subject to pervasive 'market failures'.
- And there are also pervasive 'system' (co-ordination) failures

Hence:

Learning and capability building in this area of the innovation system development is a major challenge for ***novel forms of policy***.

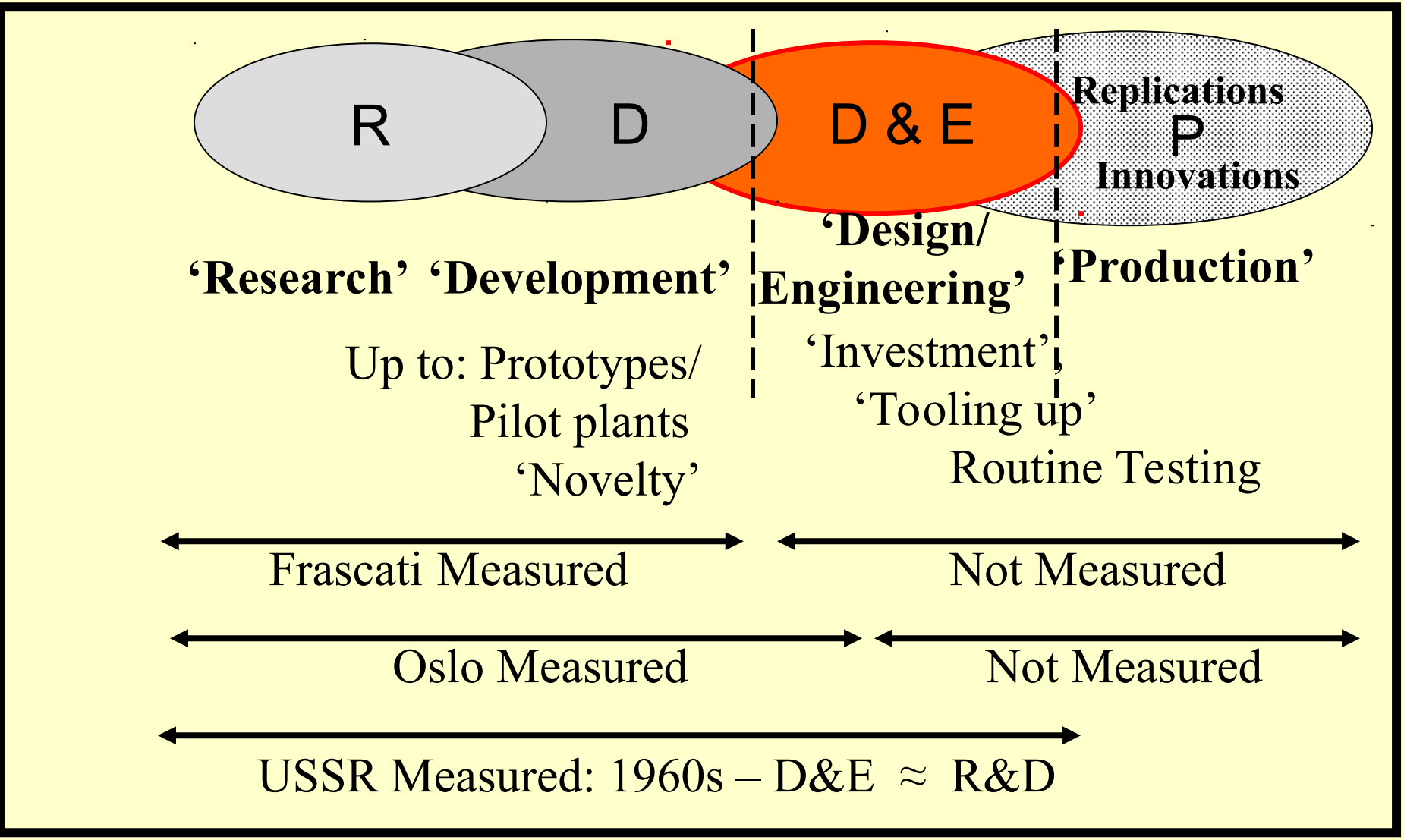
And:

The current decade probably opens up a ***massive opportunity*** for learning and capability development in this area in East Africa.

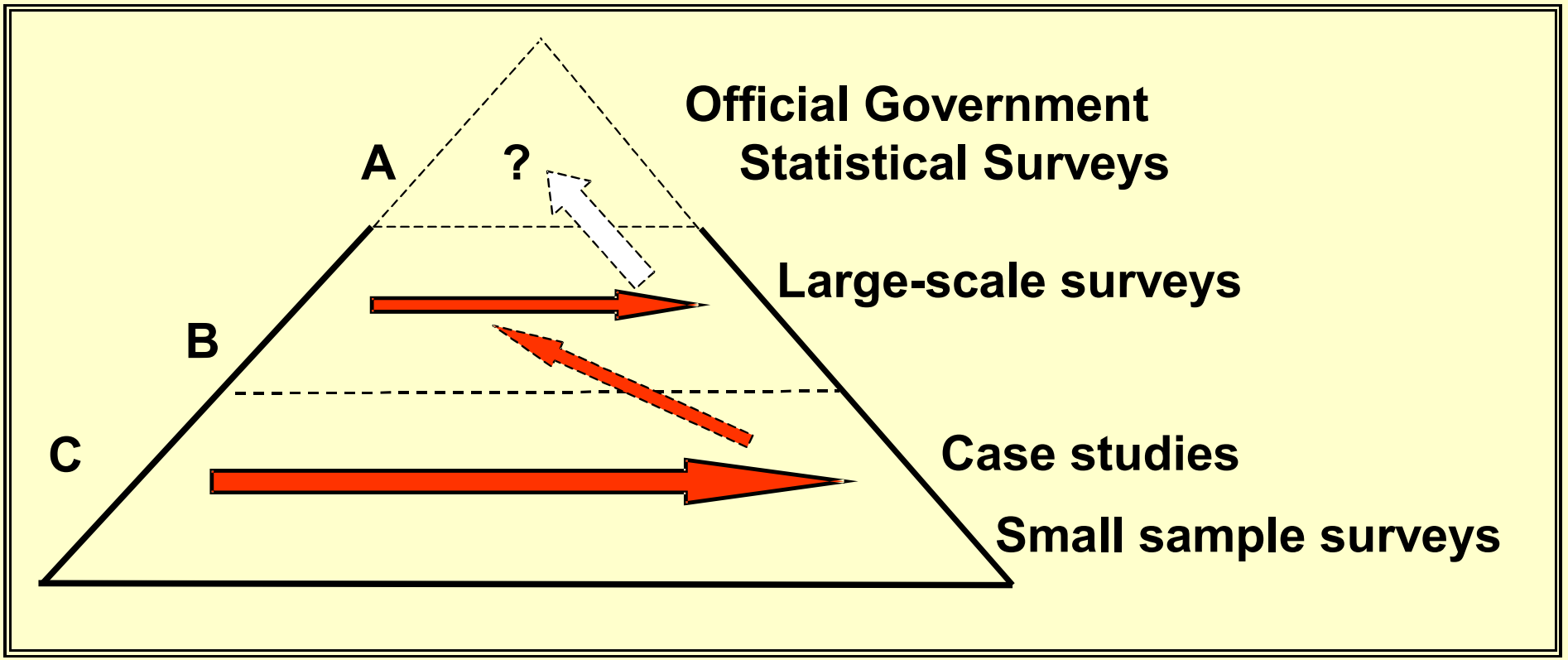
But:

The very limited basis of understanding, data and indicators to support policy is ***a huge constraint*** on grasping that opportunity

Measuring and Not Measuring Scientific, Technological and Production Activities



‘Bottom-up’ and ‘endogenous’ base of
policy-supporting STI indicators in this area



Questions might include – initially basic ‘mapping …

- **Magnitudes:** How much D&E? What Sectors?
- **Actors:** What kinds of organisation? What kinds of people?
- **Roles:** In innovation system? In the structure of the economy?
- **Modes of capability creation/building:**
  Training in universities, etc.? Training and learning In firms?
- **Spillovers:** Of what? To where? 'How much'?
  Via what channels?
- **R&D:** What interface with D&E? Where? For what?
- **Scale:** Of demand and firm? What barriers to entry?
  What roles for cross country collaboration?
- **Policy:** What issues and aims? What obstacles?
  What cross-cutting organisational structure?
  What instruments?

Thank You

Changing Sectoral Structure in Low Income Economies

(Sector Value Added as a Proportion of GDP)

% Change 1999-2009

Middle Income	Agriculture	-23	
	Industry, *of which*:	1	
	Manufacturing		-2
	Other Industry		**5**
	Services	5	
Low Income	Agriculture	-28	
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Capability Developm't

Capability use/applic.

Types of Innovation function

e.g. Ag. R or D or Extension

Types of innovation actor

e.g Central Institutes or fims/farms

Areas/domains of innovation

e.g. Sector (textiles, water services)