Technological Change and Learning Curves In the Context of the TranSust.Scan Network

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Motivation (I)

- Workpackage 2, Task 2:

  Learning curves have been suggested as meaningful presentations of technological change in economy-environment models, and their strengths and weaknesses in the context of a sustainability perspective are to be investigated

⇨ **literature review on learning curves and technological change**

Motivation (II)

Paper addresses theory of technological change in a broader context

- Learning Curve Concept
- Endogenous Growth Theory
- Innovation Theory
- Theory of Technology Diffusion

A special focus remains on learning curves:

- due to description in Workpackage 2, Task 2 and
- the prevalence of the concept in empirical modeling

Focus: Learning Curves (I)

Learning curves capture various learning effects besides learning by doing :

- Learning by using
- Learning by interacting
- Learning from inter-industry spill-overs
- Learning by researching
- Learning by exploring

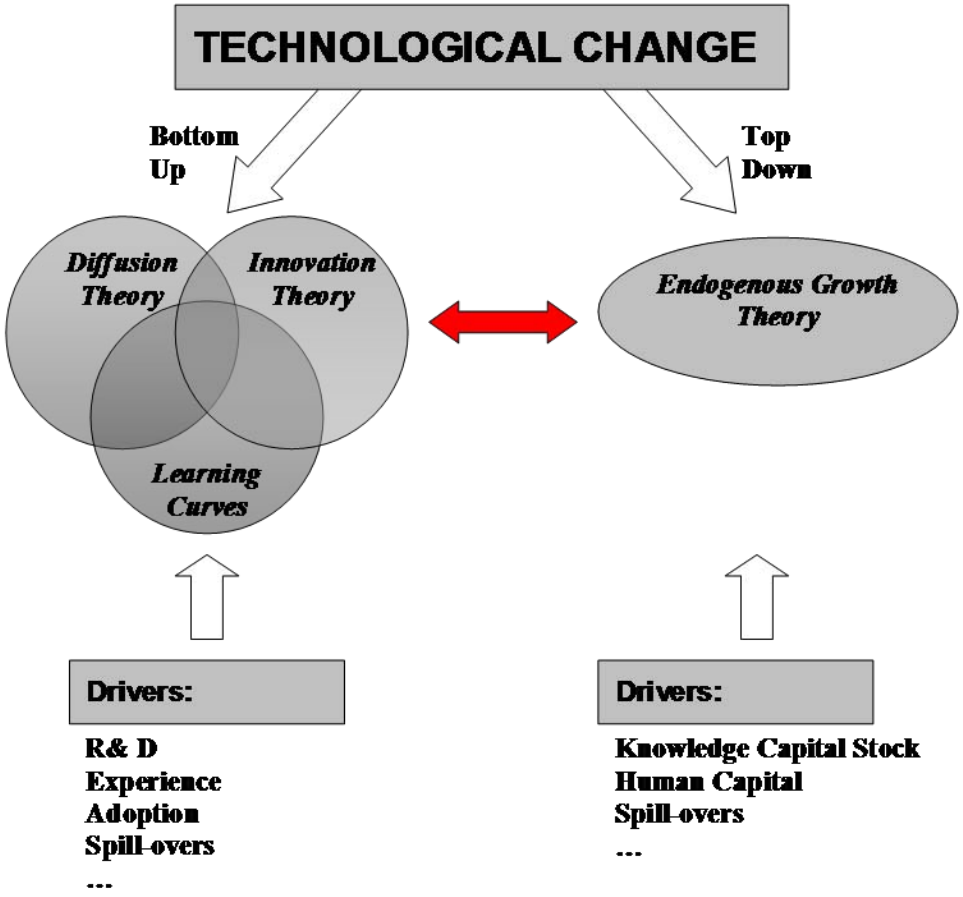
Extension of the concept of learning curves:

The recently developed two-factor learning curves that can capture two types of learning at the same time (mostly learning by doing and learning by researching)

Linking the theoretical approaches

- Bottom up concepts show a pronounced overlapping with respect to the drivers of technological change
  - Focus on particular drivers mainly determines the specific categorisation:
    - Learning curves primarily address experience
    - Innovation theory mainly addresses R&D
    - Diffusion theory primarily addresses adoption of technologies
- The drivers of technological change also establish a link to endogenous growth theory (top down perspective).
  - Spill-overs are a main driver of technological change
  - R&D is considered as contributing to the accumulation of the knowledge capital stock and to economic growth

Links between the theoretical approaches



Review of empirical modeling of ETC

- Review of empirical modelling of ETC
  - Literature survey on learning curves and energy technologies
  - Review of the TranSust.Scan models that explicitly tackle endogenous technological change

- Basis of TranSust.Scan review
  - Questionnaires on technological change
  - Model description provided

Characterisation of TranSust.Scan models (I)

- 6 out of the 12 models are explicitly dealing with endogenous technological change

Model	Institution	ETC	No ETC	Description
DART	IfW	x		Global multi-regional, multi-sectoral recursive dynamic model
DEMETER	IVM-VU	x		Long-term integrated assessment model
GAIN	WIFO	x		Extended energy model
IMACLIM-S	SMASH-CIRED		x	Multisectoral macroeconomic general equilibrium framework
IMACLIM-R	SMASH-CIRED		x	Energy systems model
IMPEC	LIFEA		x	Multisectoral macro model
KLUM	University of Hamburg		x	Global agricultural land allocation model
MARKAL	ECN	x		Bottom-up energy system optimisation model
PACE	ZEW		x	Comparative-static multi-region, multisectoral CGE model
POLES	SMASH-CIRED			
WITCH	FEEM	x		Regional integrated assessment hard-link hybrid model
W8D	LIFEA	x		Macroeconomic model of the Polish economy

Characterisation of TranSust.Scan models (II)

- learning curves are the prevailing concept in empirical modelling in TranSust.Scan models
  - 4 models use learning curves
  - GAIN and WITCH use a hybrid modelling approach

    GAIN: learning curves and innovation theory

    WITCH: learning curves and endogenous growth theory

Model[2]	LC[1]	EGT[2]	IT/DT[3]	Model Description
DART			x	top-down model
DEMETER	x			top-down model that is calibrated to fit bottom-up descriptions of certain energy technologies
GAIN	x		x	bottom-up
MARKAL	x			bottom-up
WITCH	x	x		top-down structure with a detailed description of the energy sector.

1 Learning Curves

2 Endogenous Growth Theory

3 Innovation / Diffusion Theory

Summary

- Review of theoretical and empirical modelling of ETC
  - Focus on the links between various theoretical approaches
  - Application in TranSust.Scan models

- LC predominant concept in empirical modelling
  - Rather straight forward empirical implementation
  - Evidence on ex post observations and ex ante estimation match considerably well