POLYTRoPOS: POLYvalent model for the evaluation of TRansformative POlicy Scenarios

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POLYTRoPOS

- POLYTRoPOS (POLYvalent model for the ex ante evaluation of TRansformative POlicy Scenarios) is a multi-country, multi-scale, multi-sector computer simulation model designed primarily for the evaluation of system innovation policies.
- Aggregate macroeconomy model implemented in System Dynamics.
- POLYTRoPOS system dynamics model of system innovation approach simultaneously assesses demand-driven transitions and domestic production capability accumulation and diversification.
- In its present form, it consists of a backbone of theory-backed and internally consistent macroeconomic equations, upon which additional meso-economic and political economy detail may be progressively added to improve its policy relevance.

Main characteristics

- Multi-level economy. The model is designed to be flexible enough to be applied to different economies levels without any structural modifications of the equations of the model.
- The model puts special attention to the consideration of innovation processes and technological change. This is done at two steps. First, by modelling several types of technological progress. Second, by considering two types of investment goods and consumption goods sectors.
- The model is designed to be used for policy analysis by changing the prices of the different inputs.
- More detail in public policy can be added at will. By way of illustration, the model incorporates two additional policy instruments: Spending in R&D activities, and public spending in education.

General structure of the economy

- Block 1: Productive sector
- Block 2: Innovation sector
- Block 3: Households
- Block 4: Financial sector
- Block 5: The government
- Block 6: Environment
- Block 7: Rest of the world

General structure

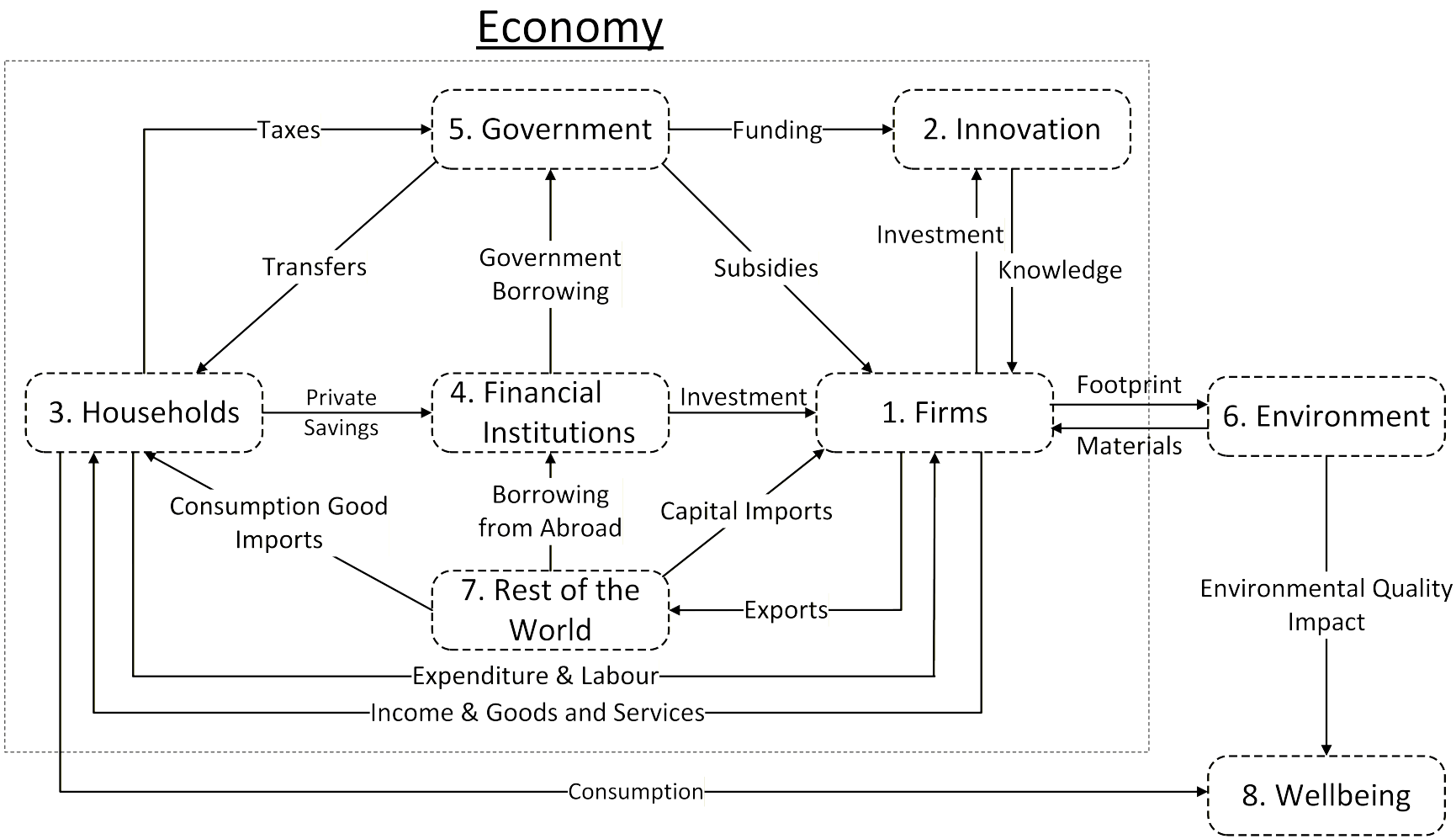

Figure: Scheme of POLYTRoPOS framework

Block 1: The productive sectors

- The production side of the economy is represented by a firms block that consider the following sectors: Energy, raw material, production of investment goods, and production of consumption goods. Energy, raw material and production of investment goods are interpreted as the intermediate production sector, whereas the consumption goods sector is interpreted as the final production sector.
- Two types of energies: electricity and fuels. Both types of energies can be produced using renewable sources or using fossil fuels.
- Physical capital is produced by the accumulation of investment goods, which are produced in the investment goods sector. Two types of investment goods are considered: traditional investment goods and new investment goods.
- For the final production sector (consumption goods), we also distinguish between traditional consumption goods and new consumption goods.

Block 1: Productive sectors

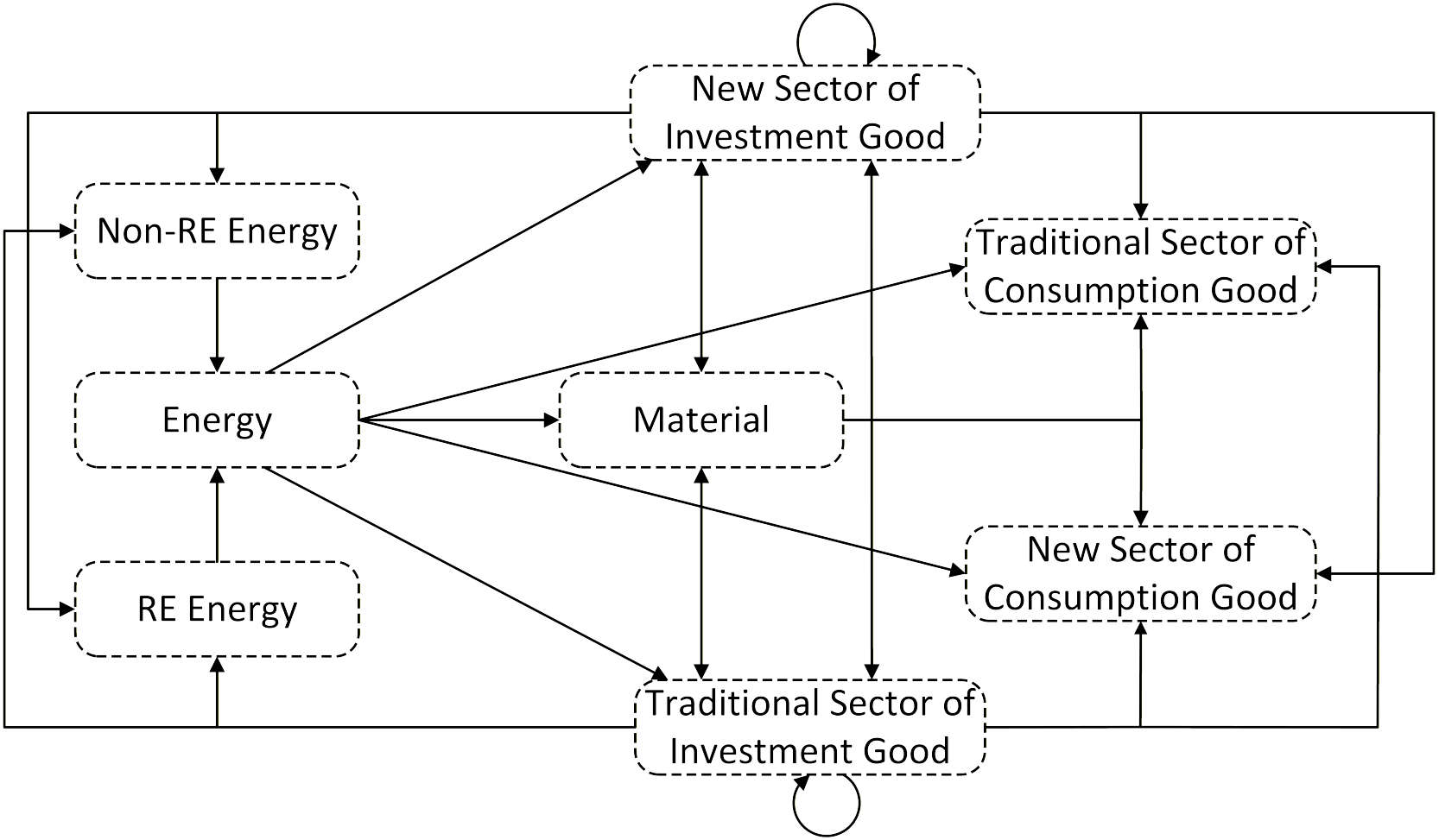

Figure: Productive sectors

Block 1: Productive sectors

- Example of production function (Production of electricity with renewable resources, Cobb-Douglas):

$$E_{N,t} = A_{EN,t} N_{E,t}^{\alpha_{EN}} (Q_{DEN,t} K_{DEN,t})^{\beta_{EN}} (Q_{GEN,t} K_{GEN,t})^{\gamma_{EN}} (H_{EN,t} L_{EN,t})^{1-\alpha_{EN}-\beta_{EN}-\gamma_{EN}}$$

where $A_{EN,t}$ is the aggregate productivity (Hicks-neutral technological progress) representing knowledge, $N_{E,t}$ is the stock of renewable material sources used in the production of electricity, $K_{DEN,t}$ is the new physical capital for production of electricity with renewable sources, $K_{GEN,t}$ is the traditional physical capital for production of electricity using renewable sources, $Q_{DEN,t}$ is the technological change embodied in new capital, $Q_{GEN,t}$ is the technological change embodied in old capital, $L_{EN,t}$ is labor for electricity production from renewable sources, and $H_{EN,t}$ is human capital embodied in labor. Parameters are as follows: α_{EN} is the renewable electricity-renewable energy sources elasticity, β_{EN} is the renewable electricity-new capital elasticity, and γ_{EN} is the renewable electricity-old capital elasticity.

Block 2: The innovation sector

- Innovation is an endogenous process.
- There is an innovation sector which produces three types of technologies: Aggregate productivity (knowledge) for each production sector, human capital, and capital-embodied technology.
- Aggregate productivity or total factor productivity is interpreted as knowledge about how to produce (Know-How), which is specific to each production sector (Hicks, 1932).
- Human capital is interpreted as labor skills embodied in workers (Becker, 1964; Uzawa, 1965).
- Finally, capital-embodied technological progress represents efficiency improvements in capital stock (Johansen, 1959; Hulten, 1992).

Block 3: Households

- The third block represents households. The model defines an utility function (welfare) depending on consumption, leisure, and environmental quality.
- We do not assume any optimization behavior by households, and instead the saving rate can either be fixed exogenously, or can be computed as the fraction of investment goods production.
- Labor supply is exogenously given. This will be relaxed in future versions.

Block 4: Financial institutions

- In this version of the model, the financial sector simply transforms savings into the production of investment goods with no other role in the economy.
- Future versions will develop the financial institutions sector.

Block 5: The government

- We consider an intertemporal budget constraint for the government where public deficit is financed with public bonds.
- Fiscal revenues derives from an income tax, and taxes on productive sectors.
- Government spending takes the form of lump-sum transfers, public investment in R&D activities, public spending in education, and subsidies to productive sectors.

Block 6: The environment

- It is assumed that the production or the use of energy pollutes the environment.
- Fuels produce emissions when they are burn.
- Electricity produce emissions when electricity is produced with fossil fuels.
- Environmental quality deteriorates with emissions.
- Household welfare depends on environmental quality.
- Extension where emissions negatively affect productivity (Nordhaus, 1992).

Block 7: The rest of the world

- Both investment goods and consumption goods are traded with the rest of the world.
- Fossil energy sources and raw material can also be traded with the rest of the world.