# Eco-Efficiency and Eco-Productivity change over time in a multisectoral economic system

Topic: Productivity and efficiency analysis 2
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In the literature two approaches of productivity analyses can be found, namely the neoclassical approach and the frontier approach. Neoclassical analysis weights inputs by value shares, a procedure that requires data on factor input shares or prices. This approach imputes productivity growth to factors, but cannot distinguish a movement towards the efficiency frontier and a movement of the latter. In contrast, the frontier approach allows decomposing productivity growth into a movement of the economy towards the frontier and a shift of the latter but cannot impute productivity growth to factors. Ten Raa and Mohnen (2002) were the first who proposed a model to resolve these limitations. They estimated total factor productivity (TFP) growth without recourse to data on factor input prices. In their work they reproduced the neoclassical TFP growth formulas, but in a framework that is Data Envelopment Analysis (DEA) in spirit.

Another contribution to this topic is provided by Luptacik and Böhm (2010). Like ten Raa (1995, 2005) the economy is represented by the Leontief input-output model extended by the constraints for primary factors. Using the multi-objective optimization model the efficiency frontier of the economy is generated. The solutions of the multi-objective optimization problems define efficient virtual decision making units (DMUs). The efficiency of the economy can be obtained as a solution of a DEA model with the virtual DMUs and DMU describing the actual performance of the economy. It can be proved that the solution of the above defined DEA model yields the same efficiency score and the same shadow prices as the models by ten Raa, despite the different variables used in both models. In this way the merits of both approaches can be used.

In this paper the approach by Luptacik and Böhm (2010) is extended in two directions. First, we include anti-pollution activities of the sectors on the input side and the net-generation of pollutants which remain untreated after abatement activity on the output side in the spirit of the well known augmented Leontief model (Leontief, 1970). In that way the eco-efficiency of an economy is analyzed. Second, this extended model is modified to an intertemporal approach in the spirit of the Luenberger productivity indicator in order to investigate the contribution of emissions and abatement activities to efficiency and productivity change over time. This model allows imputing productivity growth to individual factors without losing the possibility to decompose productivity change into efficiency change (catching up) and technology change (frontier shift). For illustration purposes data for USA in observation period 1997 to 2006 are used.