Indicators for sustainable energy development: a multivariate cointegration and causality analysis from Tunisian Road Transport Sector

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MOTIVATION

-The consumption of fossil fuels in the transport sector represents the fastest growing source of greenhouse gases. It is a major source leading to global warming.

-In Tunisia, energy consumption of transport activity is still continuous to increase with a share more than 34% of total energy consumption in 2010 (WDI, 2012).

-Transport sector has the second place in terms of energy consumption after industrial sector (35%).

-Petroleum products are the major fuels for transportation in Tunisia (NAEC, 2011)

-In 2010, the road transport has the highest energetic consumption (76%) compared to the others means of transport: it is considered the important source responsible for combustible fossils consumption with 99.4% of petroleum products consumption (WDI, 2012).

MOTIVATION

-Transport energy is a major cause of environmental pollution.
-The CO_2 emissions from road transport have increased from 1.75 million metric tons in 1980 to 4.94 million metric tons in 2010, representing more than 27% of total CO_2 emissions (WDI, 2012).
-Road transportation affects environment by emitting greenhouse gases, and environment also affects road transportation through climate change.

-Transport sector has to meet many challenges. It has to fulfill the challenge of economy, society and environment.

-Action is needed to restrict the use of fossil fuels: Tunisian Government should elaborate a sustainable transport strategy that takes into account the rising of fossil fuels consumption and the negative effects of CO2 emissions at the same time

MEASURES FOR SUSTAINABLE TRANSPORT

- Different measures have been proposed for sustainable transport to copy with climate policy.
- They are classified into two policy measures –renewable energy development (such as bio-fuels) versus reduction of energy consumption
- The restriction of transport related energy consumption can be achieved by using economic instruments such as fuel or carbon taxes.
- However, the strategy of reducing transport energy consumption can have negative effects on economic growth.
- Policy makers should be aware of the nexus between transport energy and economic growth for both energy and environmental policy

OBJECTIVES

- This paper studies causal mechanism between transport value added (PCTVA), road transport energy consumption (PCRTEC) and CO_2 emissions (PCTCO2) from Tunisian transport sector during the period 1980-2010.

-The choice of transport sector is guided by the strong connection between environment and road transportation.

-Recently, interest in the causality question has gained more attention to the concerns about climate change with following proposals to limit CO2 emissions by restricting fossil fuel consumption.

-Since the original works of Kraft and Kraft (1978) and Akarca and Long (1980), the empirical studies on causal relationship between energy consumption and economic growth are on aggregated level.

OBJECTIVES

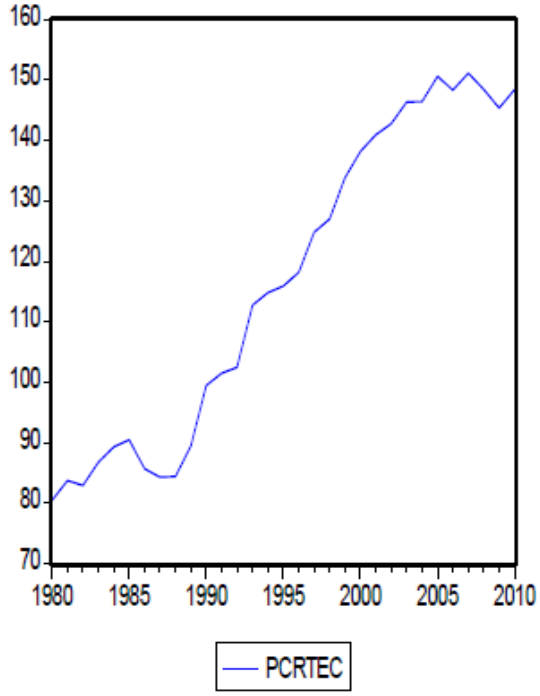
-Our study is one of the few studies which focus on the relationship between energy consumption, GDP and CO2 emissions on disaggregated level.

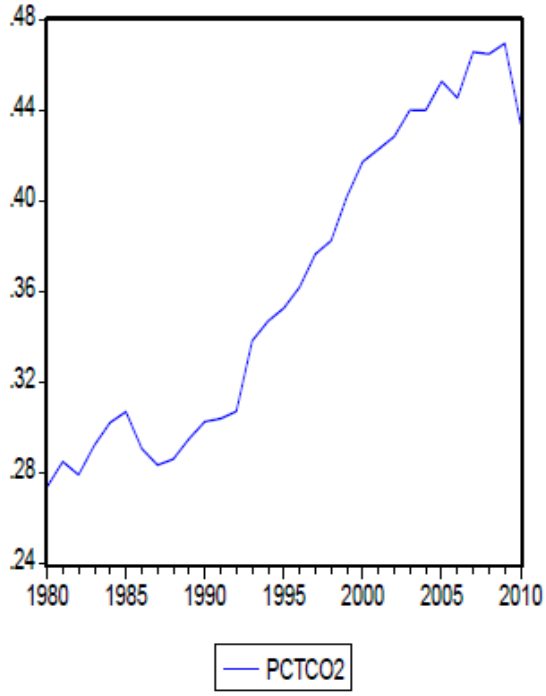
- Its purpose is to provide an insight for policy-makers in the choice and the implementation of adequate strategy reducing road energy consumption:

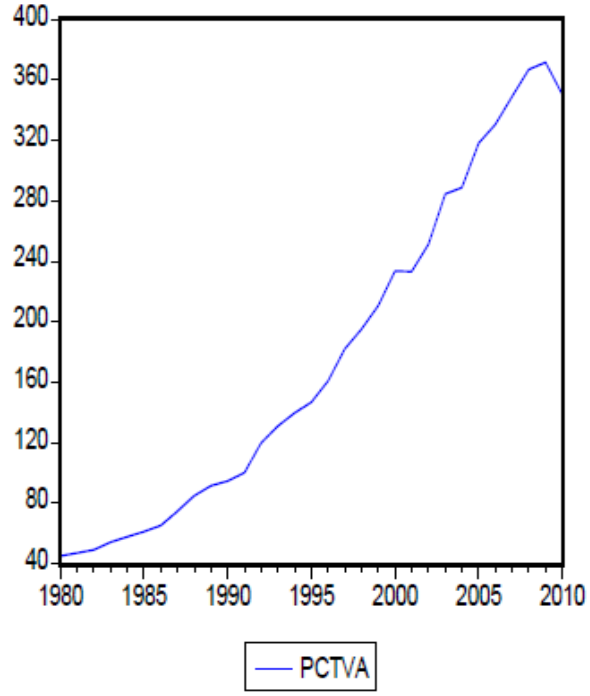
- For example, if causality runs from road transport energy consumption to transport value added, then restricting its use may impede transport GDP.

- However, if such causality direction runs only from transport GDP to road transport energy, then a conservation policy may be desirable.

GRAPHICAL ANALYSIS







We observe that the three variables present similar evolutions of long run and are characterized by a general trend upwards

METHODOLOGY: Multivariate Cointegration and VECM

- We use the Johansen cointegration approach by applying the following steps:

1) Test the variables for stationarity using the ADF and PP tests.
2) Use the AIC and SIC criteria to determine the number of lags used in the cointegration test (order of VAR)
3) Use the trace test to determine the number of cointegrating vectors present.
4) Produce the VECM for all the endogenous variables in the model and use it to carry out Granger causality tests over the short and long run.

RESULTS OF ADF AND PP UNIT ROOT TESTS

Variables	ADF		PP	
	level	First difference	Level	First difference
LNPCRTEC	-0.999	-4.356	-0.999	-4.371
LNPCTVA	-1.496	-4.663	-1.674	-4.614
LNPCTCO2	-0.452	-4.924	-0.465	-4.928
5%	-2.967	-2.967	-2.963	-2.967

All series are not stationary in levels but stationary in first difference. Hence, all variables studied are integrated of order one.

SELECTION OF LAG LENGTH

	VAR(1)	VAR(2)	VAR(3)	VAR(4)
AIC criterion	-12.402	-12.395	-12.360	-12.594*
Schwarz criterion (SC)	-11.826*	-11.387	-10.920	-10.722

The optimal lag lengths in cointegrated VAR models are chosen using the criteria AIC and SC. According to Parsimony low, we retain the lag length p*= 1

JOHANSEN COINTEGRATION TEST RESULTS

Rank test (trace)		
null Hypothesis	Trace statistic	5% Critical value
r= 0	35.335	29.797
r≥ 1	15.077	15.494

The trace test suggests the presence of one cointegrating vector and a long-run equilibrium between the three variables. Hence we estimate a vector error correction model.

MULTIVARIATE COINTEGRATION AND VECM

The methodology used is based on VECM which is specifically adopted to examine the Granger causality between PCTVA, PCTREC and $PCTCO_2$ in Tunisia.

The VECM estimated is written by equations 1, 2 and 3.

$$\Delta Y_t = \beta_{10} + \sum_{1}^{K11} \beta_{11i} \Delta Y_{t-i} + \sum_{1}^{K12} \beta_{12j} \Delta X_{t-j} + \sum_{1}^{K13} \beta_{13r} \Delta Z_{t-r} + \beta_{14} ECT_{t-1} + \mu_{1t} \quad (1)$$

$$\Delta X_t = \beta_{20} + \sum_{1}^{K21} \beta_{21i} \Delta X_{t-i} + \sum_{1}^{K22} \beta_{22j} \Delta Y_{t-j} + \sum_{1}^{K23} \beta_{23r} \Delta Z_{t-r} + \beta_{24} ECT_{t-1} + \mu_{2t} \quad (2)$$

$$\Delta Z_t = \beta_{30} + \sum_{1}^{K31} \beta_{31i} \Delta X_{t-i} + \sum_{1}^{K32} \beta_{32j} \Delta Y_{t-j} + \sum_{1}^{K33} \beta_{33r} \Delta Z_{t-r} + \beta_{34} ECT_{t-1} + \mu_{3t} \quad (3)$$

Y_t, X_t, Z_t, ECT_{t-1} and μ_t denote respectively LNPCTVA, LNPCTREC, $LNPCTCO_2$, error correction term and the error term.

RESULTS OF GRANGER CAUSALITY TESTS

Dependant variable	Source of causation (short-run)			Source of causation (long-run)
	Δy_t	Δx_t	Δz_t	ECT
Δy_t	-	5.218(0.022)	8.670 (0.003)	-0.911
Δx_t	6.013(0.014)	-	6.360 (0.011)	-0.055
Δz_t	0.216(0.641)	6.042 (0.014)	-	-0.460

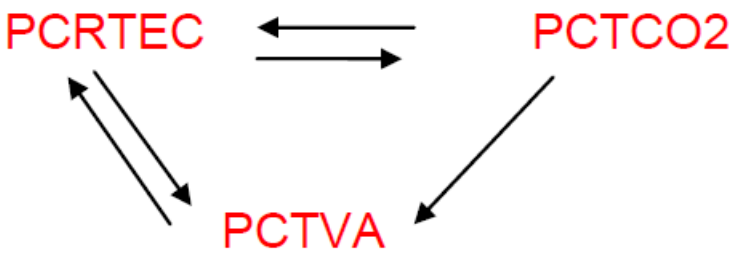
Note: values in parentheses are p-values

-In the short-run, each variable granger cause the other but only transport value added does not granger cause transport CO_2 emissions.

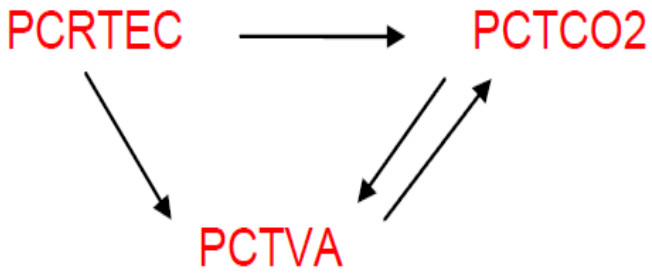
-The ECT coefficients are statistically significant in the first and third equations

RESULTS OF GRANGER CAUSALITY TESTS

SHORT-RUN CAUSALITY



LONG-RUN CAUSALITY



ANALYSIS OF RESULTS

- A unidirectional causality running from road transport-related energy consumption to transport value added : the growth of the Tunisian transport activities depends on energy consumption, but the transport value added does not cause energy use.
- A conservative policy for transport energy would be detrimental to long-run transport GDP.
- Energy and climate policies which are devoted towards a reduction in GHGs should emphasize the use of alternative sources rather than exclusively attempt to reduce overall energy consumption. The development of bio-fuels is, therefore, a promising avenue to ensure an adequate supply of energy to sustain economic performance.

ANALYSIS OF RESULTS

- A unidirectional causality running from road transport energy consumption to transport CO_2 emissions. This result implies that energy consumption affects environment. More attention should be attributed to road transport which causes environmental degradation. It is not possible to meet an increasing energy demand without relying on energy sources that lead to increased CO2.

- There is a bidirectional causality between transport value added and transport CO_2 emissions in the long-run: The Granger causality from CO2 emission to the transport value added can be explained by the fact that an increase in CO2 emission is linked to an increase of input use of fossil fuels in the transport sector. We might expect that increased transport GDP will also increase the demand for energy use and indirectly increase of CO2 emission. Theses results can be confirmed with the EKC model.

POLICY IMPLICATIONS

- The Granger-causality tests conclude that energy and climate policies which are devoted towards a reduction in GHGs should emphasize the use of alternative sources rather than exclusively attempt to reduce energy consumption.
- Policy makers can be trapped in reducing fossil fuels used in the transport sector, through restricting mobility as a climate and energy policy.
- Policymakers should integrate socio-economic and environmental dimensions in their strategy to improve the energy efficiency in transport sector.
- They should encourage infrastructure investments, improve fuel-efficient vehicles and reinforce legislation on controlling emissions in order to copying with policies based on low-carbon development and climate-resilient strategies.

Thank you for your attention