Improving fatalities forecasting in times of recession through the use of panel time series models

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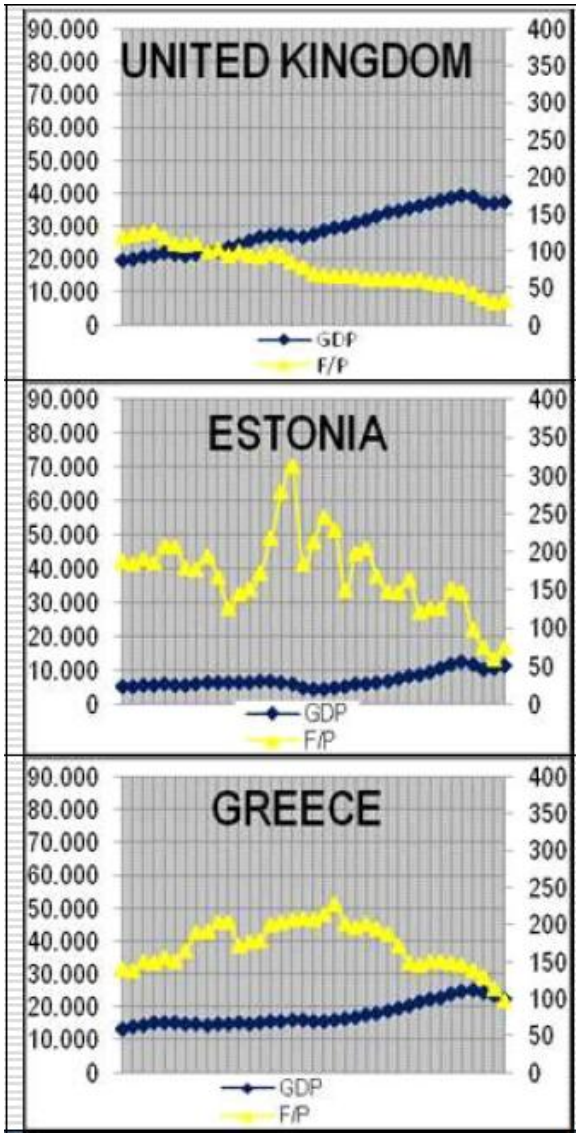
Background and objectives

- Annual or occasional changes in economic indicators may be associated with road safety changes
- During the last few years, road traffic fatalities exhibit important reductions in several countries in Europe
- These reductions may not be fully justified by policy efforts alone, and may be partly attributed to the global economic recession, affecting mobility



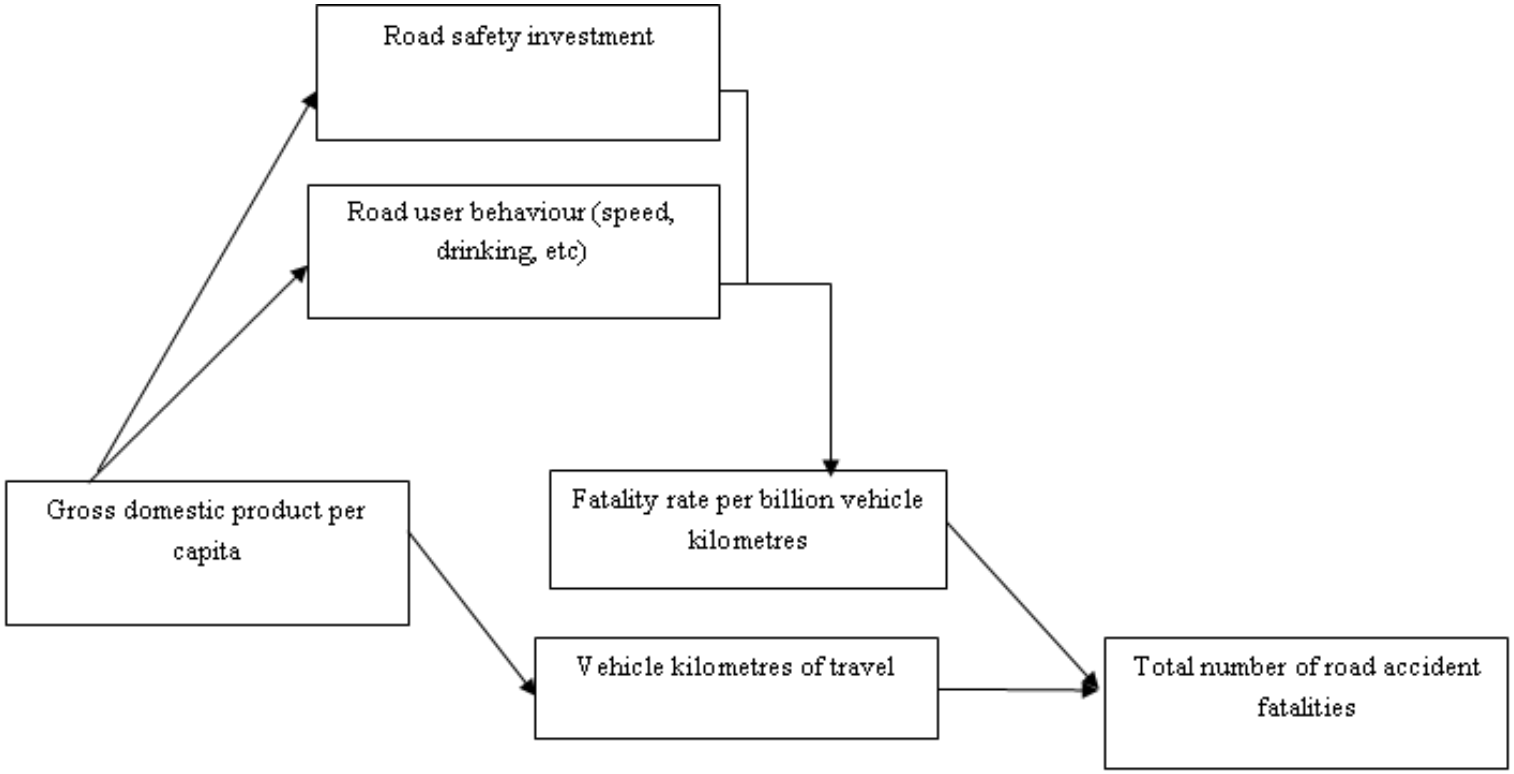
The current recession

	Fatalities					GDP per capita				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Belgium	1071	944	942	840	843	38.27	38.61	37.51	38.29	39.14
Czech Republic	1221	1076	901	802	769	13.80	14.15	13.58	13.91	14.29
Germany	4949	4477	4152	3648	4006	35.83	36.30	34.53	35.89	37.01
Estonia	196	132	100	79	101	12.48	11.92	10.33	10.58	11.31
Ireland	338	280	238	212	188	50.80	47.94	43.70	42.84	41.98
Greece	1612	1553	1456	1281	1100	24.79	25.01	24.46	23.34	22.16
Spain	3823	3100	2714	2478	2298	26.92	26.74	25.53	25.38	25.41
France	4620	4275	4273	3992	3969	35.11	34.88	33.73	34.05	34.42
Italy	5131	4725	4237	3934	3941	30.95	30.31	28.55	28.78	28.86
Lithuania	740	499	370	300	299	8.61	8.88	7.60	7.72	8.15
Hungary	1232	996	822	739	639	11.15	11.26	10.52	10.66	10.97
Netherlands	709	677	644	640	550	41.92	42.55	40.69	41.20	41.71
Austria	691	679	633	552	521	39.70	40.54	38.94	39.69	40.62
Poland	5583	5437	4572	3907	4164	8.95	9.41	9.57	9.94	10.36
Portugal	974	885	840	845	782	18.72	18.66	18.14	18.34	17.97
Finland	380	344	279	272	290	41.69	42.05	38.55	39.92	41.44
Sweden	471	397	358	266	311	44.22	43.87	41.47	43.70	45.55
United Kingdom	3059	2645	2222	1905	1998	39.29	39.02	36.90	37.15	37.32

Literature review

- Economic slowdown may lead to reduction in accidents and fatalities
  - Early 70's petrol crisis / reduced speed limits (Tihansky, 1974)
  - Early 80's economic recession (Wagenaar, 1984; Hedlund et al. 1984; Reinfurt et al. 1991)
  - Late 00's recession in the US / annual changes in unemployment rate and CPI (Consumer Price Index) (Kweon, 2011)

Economy and road safety



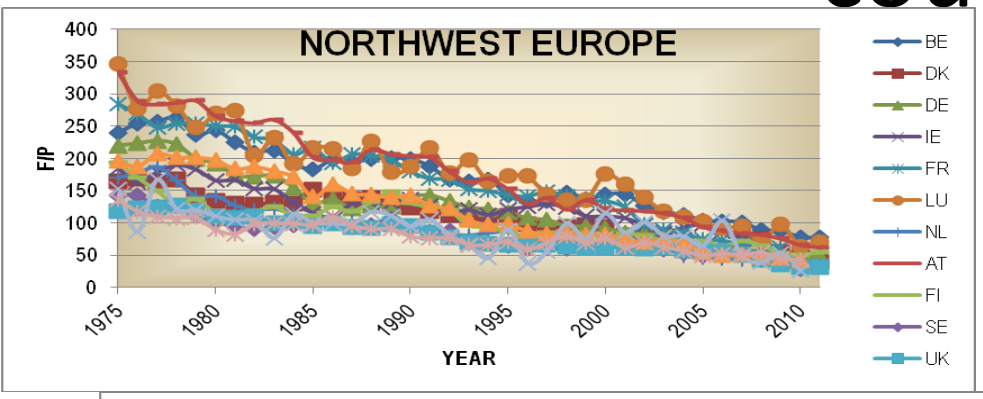
Analysis methods

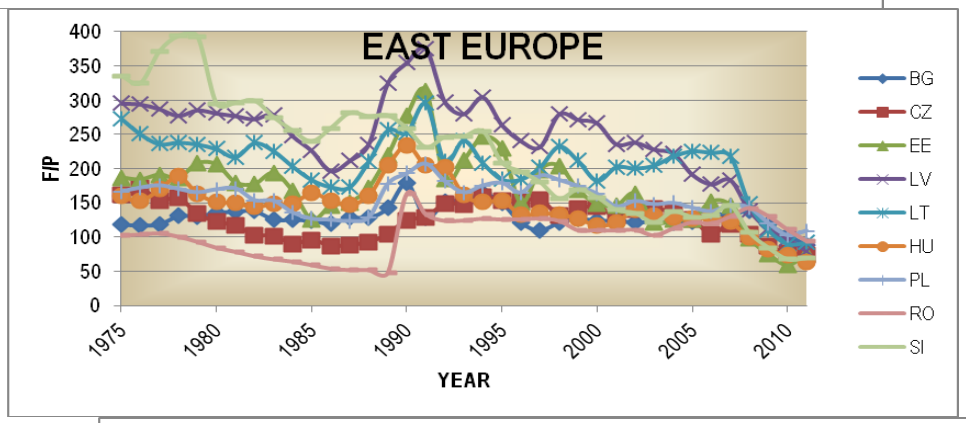
Country N \ Time T	Small (1 to 5)	Large (30)
Small (1)		Univariate time series model : autoregressive regression with linear trend, ARIMAX, structural model (bivariate)
Large (30)	Cross-sectional and micro panel analysis with (Poisson or NB) regression (+autoregression)	Macro-panel analysis with regression (cointegration)

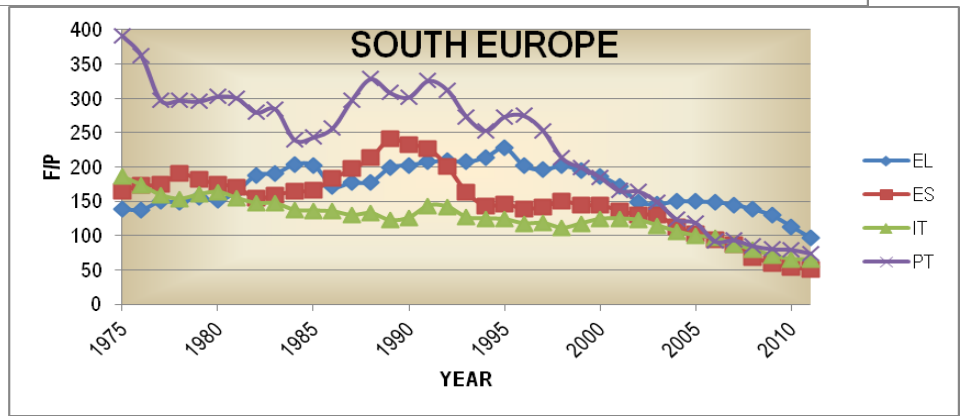
Data

- Annual number of fatalities for 27 European Union countries have been extracted from the IRTAD database (1975-2010) plus Norway, Switzerland, Iceland
- Main explanatory variable: the annual GDP per capita, deflated , US$ value 1985
- Interventions due to safety measures, data collection change or political change

Data exploration - groups of countries







- Northern / Western:

  A decreasing trend in the fatality rate spans the entire period

- Central / Eastern:

  the fatality rate shows more fluctuation, and the effect of the changes in political regimes of the early nineties is striking

- Southern:

  The decrease started somewhat later, following an initial increasing trend

Macro panel data
Three types of relationships (homogeneous)

- Long term between the levels (cointegration) (long run par.)

$$\log FAT_{it} = a_i + bt + \beta \log GDP_{it}$$

- Short term between the first differences (short run par.)

$$\log FAT_{it} - \log FAT_{it-1} = \%FAT_{it}$$

$$\log GDP_{it} - \log GDT_{it-1} = \%GDP_{it}$$

$$\%FAT_{it} = a_i + b\%GDP_{it}$$

- Combination of dynamics: Error correction model (ECM)

$$\log FAT_{it} - \log FAT_{it-1} = a_i + b_i(\log GDP_{it} - \log GDP_{it-1})$$

$$+ C(\log FAT_{it-1} - bt - \beta \log GDP_{it-1})$$

Static long-term equation

- As both time-series are I(1) integrated of order 1 over a macro-panel of 30 countries, the estimation of the slope which is the elasticity of the number of fatalities to the GDP requires to take into account various problems such as error cross-section dependence and persistent autocorrelation
- One of the most robust mean group type estimator is the Common Correlated Effects Mean Group estimator which is based on individual regression augmented by the mean value of both dependent and independent variables (Pesaran, 2006) (Coakley and al., 2006).

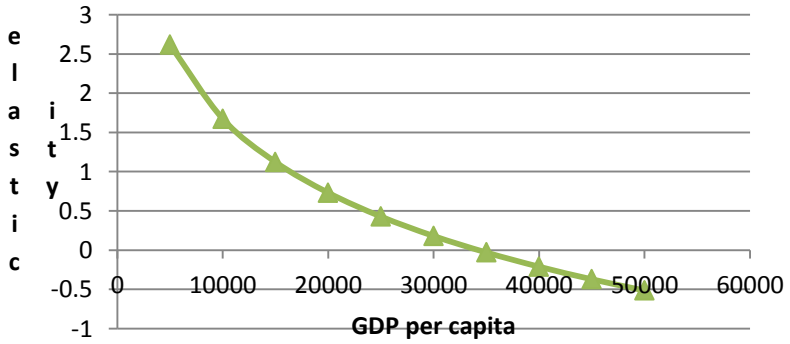
$$\log FAT_{it} = \beta_{0i} + f_i(t) + \beta_{1i} \log GDP_{it} + u_{it}$$
$$u_{it} = \rho_{ui} u_{it-1} + \lambda_{1i} f_t + \varepsilon_{uit}$$
$$\log GDP_{it} = \rho_{xi} \log GDP_{it-1} + \lambda_{2i} f_t + \gamma_i g_t + \varepsilon_{xit}$$

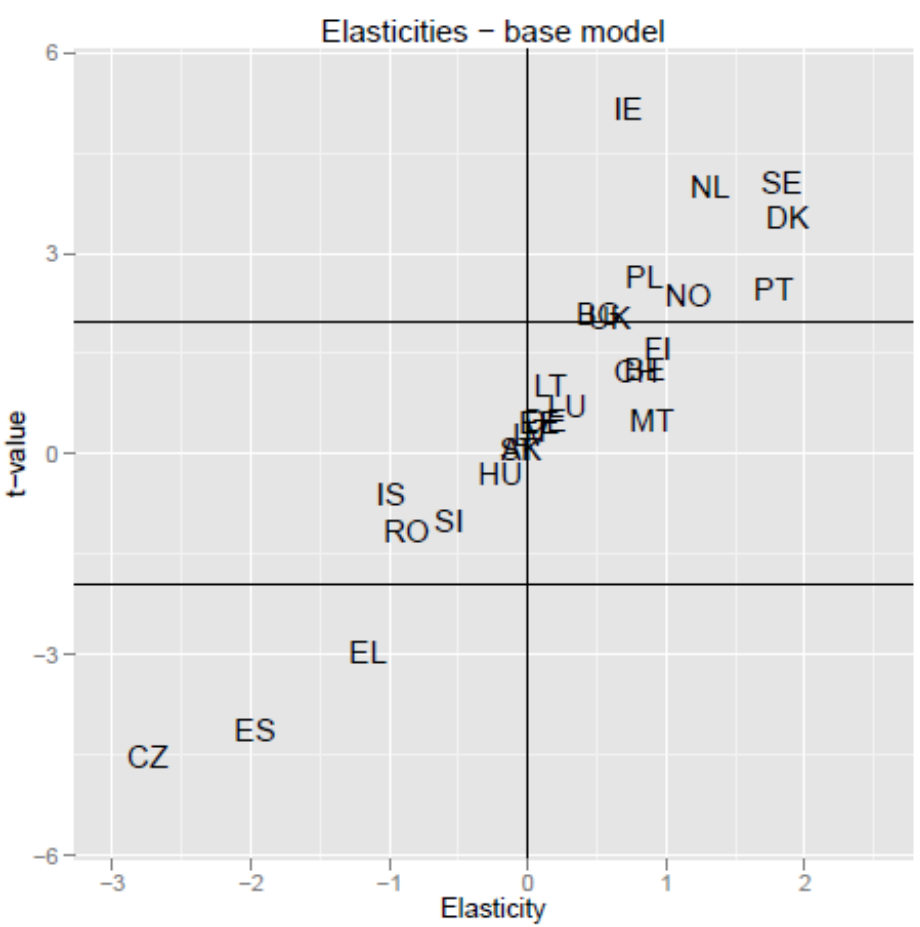
$$f_i(t) = a_i + b_i\, t + c_i\, t^2 + \omega_i\, I_{it}$$

Long-term elasticities

- Procedure xtmg Stata (elasticity = unweighted average of country elasticities)

		base	base+interventions	base	Kuznets
LGDP	coef	0.45	**0.69**	0.61	14.2
	std. err.	0.25	0.23	0.16	8.8
	z	1.81	2.79	3.82	1.62
t	coef	-0.008	-0 .019	0.11	-0.002
	std. err.	0 .008	0.008	0.14	0.014
	z	-1	-2.44	0.74	-0.16
t^2	coef			-0 .0005	
	std. err.			0.00028	
	z			-1.64	
$LGDP^2$	coef				-0.68
	std. err.				0.46
	z				-1.48




Elasticities − base model
t−value
Elasticity
6
3
0
−3
−6
−3
−2
−1
0
1
2
IE
NL
SE
DK
PL
NO
PT
EL
ES
CZ
IS
RO
SI
HU
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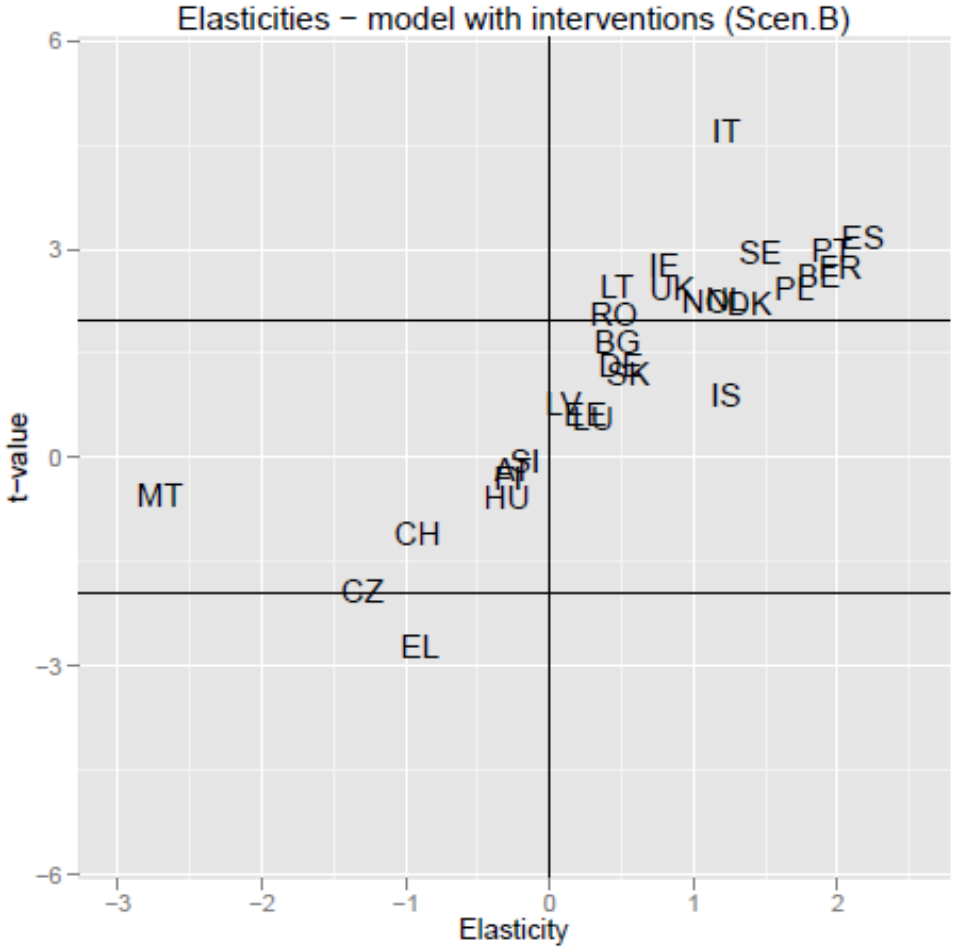
Elasticities − model with interventions (Scen.B)
t−value
Elasticity
6
3
0
−3
−6
−3
−2
−1
0
1
2
IT
SE
ES
IS
MT
CH
CZ
EL
HU

Dynamic equation

- From an autoregressive distributive lag (ARDL) and procedure stata xtpmg (common elasticity among countries)

$$\log FAT_{it} - \log FAT_{it-1} = a_i + b_i(\log GDP_{it} - \log GDP_{it-1})$$
$$+ C_i(\log FAT_{it-1} - bt - \beta \log GDP_{it}) + w_i \ (\mathbf{I}_{it} - I_{it-1})$$

- Presence of cointegration (error-correction <0 significant) and of short term effect (>0). Same elasticity as mean group (xtmg). The hypothesis of homogeneity between elasticities (and time trend) is accepted (Hausman test with MG)

- If homogeneous, elasticity = 0.118/0.115= 1.0

$$\log FAT_{it} - \log FAT_{it-1} = a_i + b(\log GDP_{it} - \log GDP_{it-1})$$
$$+ C(\log FAT_{it-1} - a + bt + \beta \log GDP_{it-1})$$

		xtmpg	xtmpg+interventions	Error-correction
LGDP	coef	0.59	0.59	-0.118
	std. err.	0.11	0.11	0.037
	z	5.5	5.4	-3.17
t	coef	-0.057	-0 .057	-0.003
	std. err.	0.003	0.003	0.0009
	z	-21.7	-20.6	-3.4
DLGDP	coef			0.63
	std. err.			0.13
	z			4.69
LFAT	coef			-0.115
	std. err.			0.019
	z			-6.1

Conclusion

- On european macro panel data, there is a significant linear long-term relationship between logGDP and logfatalities with a constant elasticity of 0.7 (No parabola curve like Kuznets and variable elasticity).
- The relationship is significant for half countries : 14 with >0 values :CY,IE,PT,PL,NL,IT,UK,NO,SE,FR,BG,LT,EL,DK and 1 with 0<: EL (due to special time trend).
- The time trend included in the long-term relationship is linear decreasing. Interventions improve the model.
- There is too a significant positive short-term effect of GDP on panel data and for 11 countries.
- Procedures and models xmpg (static) and xtmpg (dynamic) provide the same results for the long-term elasticity on panel data.
- For prediction, use error-correction models with a common long-term elasticity and time trend (procedure xtmpg) but country specific short-term elasticity and error-corrrection effect and interventions.