Ageing and healthcare expenditure: a macroeconomic analysis

Luca Gerotto Luca Salmasi Gilberto Turati

Department of Economics and Finance, Faculty of Economics
Università Cattolica del Sacro Cuore

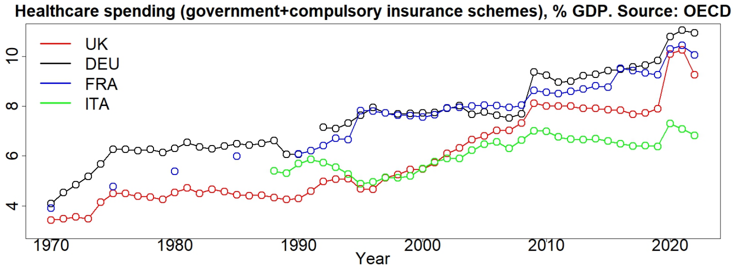
Health Needs and Resources:
Allocation and Measurement Issues
Urbino, November 9-10th, 2023

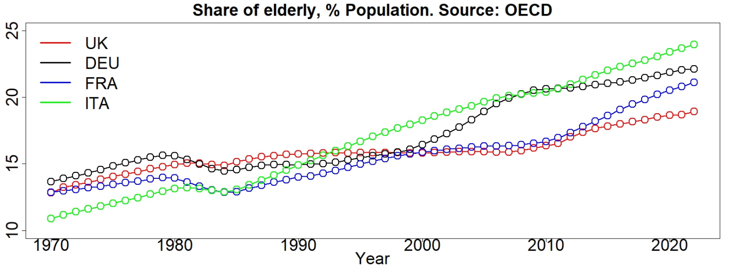
Motivation

Me: "How many elderly we have does not really determine spending"

Remuzzi (smiling): "What???"

Motivation


Healthcare spending (government+compulsory insurance schemes), % GDP. Source: OECD
UK
DEU
FRA
ITA
4
6
8
10
1970
1980
1990
2000
2010
2020
Year


Share of elderly, % Population. Source: OECD
UK
DEU
FRA
ITA
10
15
20
25
1970
1980
1990
2000
2010
2020
Year

Motivation

- Clear upward trends for both healthcare spending (HCE) and the share of the elderly across Western countries
- As the elderly consume more services than the young, an easy argument brings to the conclusion that the share of elderly determines the spending

Motivation

Me: "Well, let me be more precise: if you observe an increase in the share of elderly of, say, 1%, from one year to the next does this really imply an increase of spending from one year to the next because of that?"

Motivation

An extensive literature has highlighted several drivers of HCE. Some examples:

- Technological progress
- Organization (e.g., extension of coverage, ...)
- Baumol's cost disease
- Elasticity of per-capita HCE to per-capita income (rate of growth HCE higher than GDP growth)
- Demographics (e.g., age distribution, life expectancy)
- Political economy factors

In this paper, we focus on the role of the elderly as **end-users** and as **voters**, blending demographics and political economy issues

Elderly as end-users: theory

Literature mostly focused on elderly as end-users. Theoretically three possible effects of longer life expectancy on HCE:

- Compression of morbidity: lower number of years in bad health (Kramer, 1980) $\implies$ decrease in per-capita HCE, *ceteris paribus*;
- Postponement of morbidity: same number of years in bad health (Payne et al, 2007) $\implies$ (milder) decrease in per-capita HCE;
- Extension of morbidity: higher number of years in bad health (Olshansky et al., 1991) $\implies$ increase in per-capita HCE.

Elderly as end-users: empirical evidence

Empirical evidence on elderly as end-users is mixed:

- Positive correlation between share of elderly and per-capita HCE (*Crivelli et al., 2006; Di Matteo, 2005; Murthy and Okunade, 2016*);
- *Zweifel et al. (1999)*: ageing of the population might be a *red herring*: for *non-survivors*, the driver is time-to-death, not age. *Zweifel et al. (2004)*: yet, age affects HCE for *survivors*;
- *Seshamani and Gray (2004)* re-emphasize the role of ageing; positive, but moderate effect of ageing on HCE growth (*Breyer et al, 2010*); applying 'old' age-expenditure profiles to a 'new' longer life expectancy leads to an overstimation of future HCE (*Yang et al., 2003*)

Contribution

We consider the share of elderly, the main causes of death and political variables as HCE determinants in a macro model, using aggregate regional data from the Italian Regional Healthcare Services

We consider all twenty Italian regions for the period 1997-2018 (22 years $\times$20 regions).

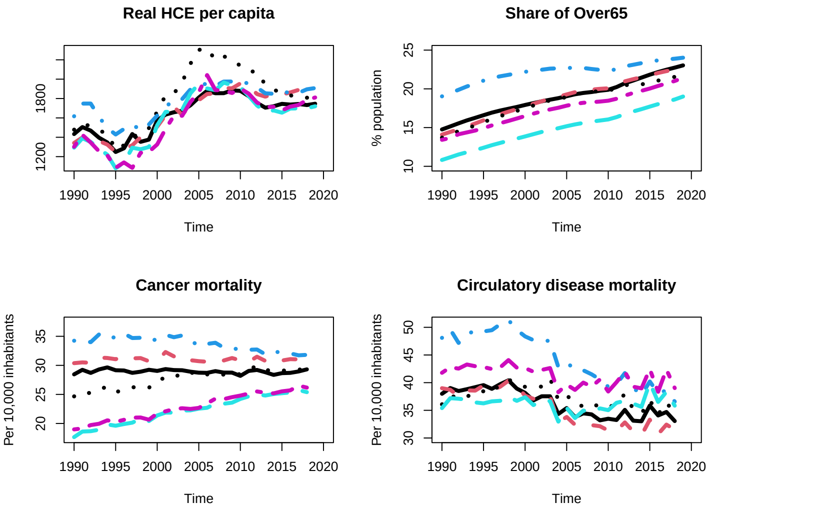
Results useful for policy making $\Longrightarrow$ improve forecasting

Italian National Health Service (NHS)

Italian NHS in a nutshell:

- Main characteristics: universal coverage and nondiscriminatory access to the health care services, tax financed by the State, regionally decentralized
- Central government is responsible for defining:
  - the minimum level of assistance that has to be provided in each Region
  - the level of funding, and the allocation to the different Regions
- Regions are responsible for organizing the local supply of healthcare services
- Regions that turn out to be *significantly* unable to either provide minimum services, or avoid budget deficits, undergo recovery plans (*Piani di Rientro*) imposed by the central government since 2007

Data: main variables, selected regions



Causes of death

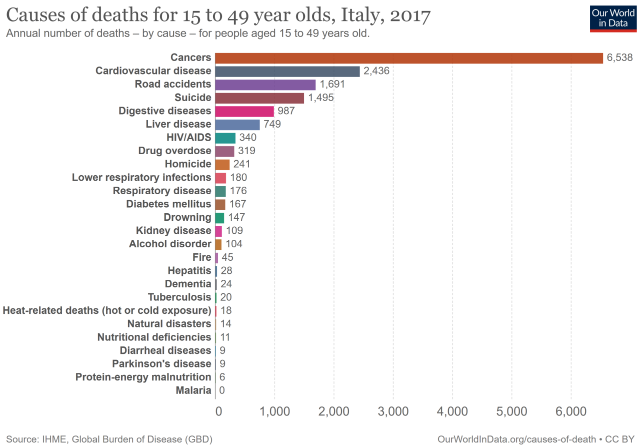


Figure: Causes of death in 15-49-year-olds (Source: Our World in Data)

Causes of death

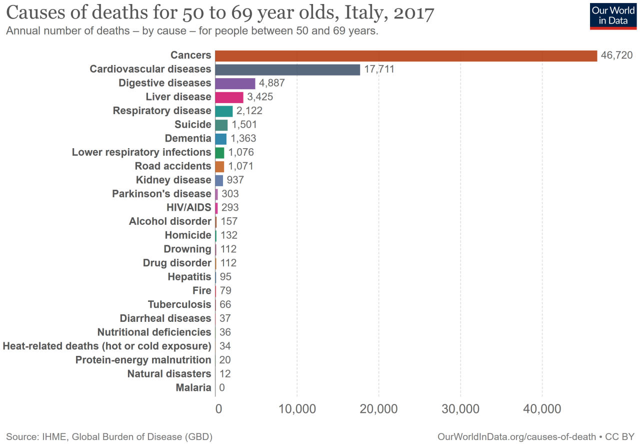


Figure: Causes of death in 50-69-year-olds (Source: Our World in Data)

Causes of death

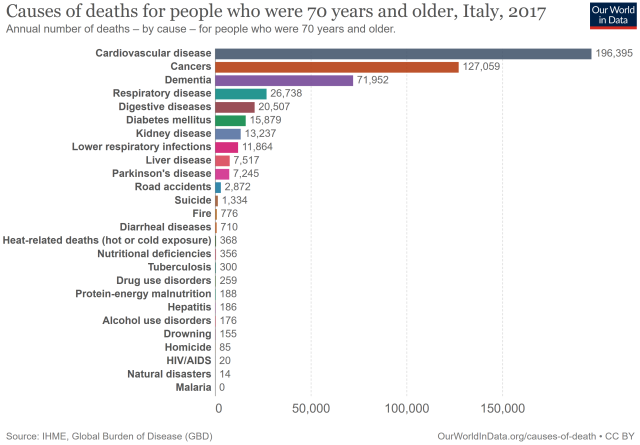


Figure: Causes of death in 70-year-olds and older ones (Source: Our World in Data)

Strategy

- Start with panel unit root testing
- Define appropriate model for data analysis

Panel unit root tests

We performed the following panel unit root tests based on the estimation of augmented Dickey-Fuller (ADF) regressions for each time series with different assumptions concerning cross-sectional dependence:

- Cross-sectional independence: Levin, Lin and Chu (2002), Breitung t-stat (2000), Im, Pesaran and Shin (2003), the ADF - Fisher Chi-Square and the PP - Fisher Chi-Square (Choi, 2001).
- Cross-sectional dependence: Pesaran CIPS (2007).

Panel unit root tests

We consider the levels and first differences of:

- $\ln(HCE)$: log of real per-capita public current healthcare expenditure (pp)
- E^{65-85}: share of population with age between 65 and 85 years (pp)
- E^{85}: share of the population with more than 85 years. (pp)
- M^{Cancer}: cancer mortality rates per 10k inhabitants.
- M^{Cardio}: cardiocirculatory mortality rates per 10k inhabitants
- $Beds$: rate of hospital beds per 10k inhabitants
- $\ln(GDP)$: log of real per-capita GDP. (pp)

We find that **the relevant time series are I(1)** and a Panel cointegration test suggests that **the variables are cointegrated**.

Empirical Strategy: First differences

$$\begin{aligned}\Delta \ln(HCE_{i,t}) =& \beta_0 + \beta_1 \Delta E^{65-85}_{i,t} + \beta_2 \Delta E^{85}_{i,t} + \beta_3 \Delta M^{Cancer}_{i,t+2} \\ &+ \beta_4 \Delta M^{Cardio}_{i,t+2} + \beta_5 \Delta Beds_{i,t} + \beta_6 \Delta \ln(GDP_{i,t}) \\ &+ \beta_7 TTE_{i,t} + \alpha_t + \epsilon_{i,t}\end{aligned}$$

White diagonal robust standard errors.
Clustered (region, period, two-way) s.e. yield more significant results.

Empirical Strategy: ECM

Given that variables in levels are I(1) and cointegrated, we implement an error correction model (ECM) first estimating the long-run relation with variables in levels:

$$\begin{aligned} \ln(HCE_{i,t}) = \beta_{0i} + \beta_{1i} t + \beta_2 E_{i,t}^{65-85} + \beta_3 E_{i,t}^{85+} + \beta_4 M_{i,t+2}^{Cancer} \\ + \beta_5 M_{i,t+2}^{Cardio} + \beta_6 \ln(GDP_{i,t}) + \beta_7 Beds_{i,t} + u_{it} \quad (1) \end{aligned}$$

and then implementing the error correction term (ECT) in the short run relation with first differenced variables:

$$\begin{aligned} \Delta \ln(HCE_{i,t}) = \gamma_0 + \gamma_1 \Delta E_{i,t}^{65-85} + \gamma_2 \Delta E_{i,t}^{85+} + \gamma_3 \Delta M_{i,t+2}^{Cardio} \\ + \gamma_4 \Delta M_{i,t+2}^{Cancer} + \gamma_5 \Delta \ln(GDP_{i,t}) + \gamma_6 \Delta(Beds_{i,t}) \\ + \gamma_7 TTE_t + \gamma_8 ECT_{i,t-1} + \alpha_t + \epsilon_{it} \quad (2) \end{aligned}$$

where

$$\begin{aligned} ECT_{i,t} = \hat{u}_{i,t} = \ln(HCE_{i,t}) - \hat{\beta}_{0i} - \hat{\beta}_{1i} t - \hat{\beta}_2 E_{i,t}^{65-85} - \hat{\beta}_3 E_{i,t}^{65-85} \\ - \hat{\beta}_4 M_{i,t+2}^{Cancer} - \hat{\beta}_5 M_{i,t+2}^{Cardio} - \hat{\beta}_6 \ln(GDP_{i,t}) - \hat{\beta}_7 Beds_{i,t} \quad (3) \end{aligned}$$

First difference model

Dependent variable: $\Delta log(RealHCE_t)$		
Variable	Coef.	p-value
Constant	1.865***	0.000
ΔE_t^{65-85}	2.436**	0.034
ΔE_t^{85}	-0.515	0.888
ΔM_{t+2}^{Cardio}	-0.061	0.653
ΔM_{t+2}^{Cancer}	0.148	0.477
$\Delta HospBeds_t$	0.078	0.300
$\Delta log(RealGDP_t)$	-0.014	0.779
Time to regional election	-0.233*	0.083
Cross-sectional F.E.		
Period F.E.	✓	
Sample (adjusted)	1997 2018	
Periods included:	22	
Cross-sections included:	20	
Total panel (balanced) observations:	440	
Adjusted R^2	0.552	
F-test (p-value)	0.000	

Comment on first-diff model

Statistically significant covariates:

- Share of "Elderly" (E^{65-85}) (positive sign)
- Time to following regional election (negative sign)

"Very elderly": an increase in the share of individuals older than 85 years is **not** associated with a higher growth rate of healthcare expenditure.

Potential explanations:

- Relatively younger patients are treated more aggressively. This intuition is supported by data: for example, according to the Ministry of Health spending yearly report (*Monitoraggio della Spesa Sanitaria*), per-capita spending for outpatient services increases up to 77-78 years and then decreases
- Very elderly patients need long term care (LTC) treatments, the spending for which is not included into HCE.

Error correction model: long run

Dependent variable: $log(HCE_t)$		
Variable	Coef.	p-value
E_t^{65-85}	2.134***	0.006
E_t^{85}	0.467	0.737
M_{t+2}^{Cardio}	-1.397***	0.000
M_{t+2}^{Cancer}	1.225***	0.002
$Beds_t$	-0.439***	0.000
$log(GDP_t)$	0.828***	0.000
Cross-sectional F.E.	✓	
Period F.E.		
Sample (adjusted)	1997 2018	
Periods included:	22	
Cross-sections included:	20	
Total panel (balanced) observations:	440	
Adjusted R^2	0.742	

Variance Inflation Factor (VIF)

- We also calculate the VIF to estimate the degree of multicollinearity among regressors in our model for the variables in levels.
- VIFs > 5 represent critical levels of multicollinearity where the coefficients are poorly estimated, and the p-values are questionable.
- **Results** from this analysis reveal that VIFs are always < 5.

Error correction model: short run

Dependent variable: $\Delta log(HCE_t)$		
Variable	Coef.	p-value
$Constant$	1.442***	0.001
ΔE_t^{65-85}	1.584	0.169
ΔE_t^{85}	0.991	0.790
ΔM_{t+2}^{Cardio}	-0.215*	0.096
ΔM_{t+2}^{Cancer}	0.202	0.289
$\Delta Beds_t$	-0.012	0.874
$\Delta log(GDP_t)$	0.076	0.284
TTE_t	-0.211*	0.077
ECT_{t-1}	-0.213***	0.000
Cross-sectional F.E.		
Period F.E.	✓	
Sample (adjusted)	1998 2018	
Periods included:	21	
Cross-sections included:	20	
Total panel (balanced) observations:	420	
Adjusted R^2	0.615	

Comment on ECM

- All selected variables, except the share of the very elderly, affect the long-run dynamics of healthcare expenditure (interesting differences in leads of mortality: + cancer, - cardio; beds: negative coeff, occupancy rates? better rotation?)
- Short-run dynamics, instead, are affected by political economy variables (expenditure increases faster closer to regional elections) and by the deviation from the long-term value.
- Exception: mortality rate for cardiocirculatory diseases, which is (barely) significant.

Elderly as voters

- Consider data about regional elections in Italy from 2005 to 2019.
- We estimate the following regression model

$$Votes_{mpt} = \alpha_0 + \alpha_1 E_{mt}^{65-85} + \alpha_2 E_{mt}^{85} + \alpha_3 fisc\_aut_{mt} + \iota_m + \omega_t + \epsilon_{mt}$$

- $Votes_{mpt}$ represents the share of votes obtained by candidates from coalition p (center-left, center-right, 5SM, other parties) in municipality m during year t.
- E_{mt}^{65-85} and E_{mt}^{85} are the same variables already described above at the municipality level
- We control for municipality (ι_m) and year ω_t of election FE and for an indicator of the level of fiscal autonomy

Elderly as voters

	Center-left		Center-right		5SM		Other parties	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
E^{65-85}	0.1523***		0.1152		-0.0135		-0.0248	
	(0.057)		(0.071)		(0.038)		(0.021)	
E^{85}	0.1753		0.1473		-0.0850		-0.0932**	
	(0.134)		(0.161)		(0.077)		(0.041)	
E^{65}		0.1538***		0.1162		-0.0218		-0.0294
		(0.056)		(0.070)		(0.037)		(0.021)
Fiscal autonomy	0.0000	0.0000	0.0004***	0.0004***	-0.0001*	-0.0001*	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.4141***	0.4142***	0.4108***	0.4110***	0.1266***	0.1257***	0.0224***	0.0222***
	(0.014)	(0.014)	(0.017)	(0.017)	(0.010)	(0.010)	(0.005)	(0.005)
Observations	21,339	21,339	21,332	21,332	12,815	12,815	18,645	18,645
R-squared	0.58	0.58	0.68	0.68	0.80	0.80	0.34	0.34
Municipalities	6,500	6,500	6,500	6,500	6,020	6,020	6,482	6,482
Mean of Y	0.357	0.357	0.416	0.416	0.108	0.108	0.0251	0.0251
SD of Y	0.164	0.164	0.191	0.191	0.0739	0.0739	0.0429	0.0429

Table: Share of elderly and votes to regional elections 2005-2019.

Conclusions

Me: "Let me be even more precise:

- the share of elderly matters in the long run
- it matters the share of elderly, not of the very elderly
- it matters in the short run for political reasons: they are many and they vote for center-left coalitions"

Panel unit root tests

Variable	Levin, Lin and Chu	Breitung t-stat	Im, Pesaran and Shin	ADF - Fisher	PP - Fisher
$ln(HCE)$	0.02	1.00	1.00	1.00	1.00
$\Delta ln(HCE)$	0.00	0.00	0.00	0.00	0.00
E^{65-85}	0.31	0.05	0.01	0.00	1.00
ΔE^{65-85}	0.03	0.00	0.00	0.00	0.21
E^{85+}	1.00	0.02	1.00	1.00	1.00
ΔE^{85+}	0.00	0.00	0.00	0.00	0.82
M^{Cancer}	0.00	0.00	0.00	0.00	0.00
ΔM^{Cancer}	0.00	0.00	0.00	0.00	0.00
M^{Cardio}	0.00	0.64	0.39	0.06	0.00
ΔM^{Cardio}	0.00	0.00	0.00	0.00	0.00
$Beds$	0.00	1.00	0.00	0.00	0.00
$\Delta Beds$	0.00	0.00	0.00	0.00	0.00
$ln(GDP)$	0.01	0.12	0.19	0.56	0.84
$\Delta ln(GDP)$	0.00	0.00	0.00	0.00	0.00

Table: Panel unit root tests - assuming cross-sectional independence

Panel unit root tests

Region	$ln(HCE)$	$\Delta ln(HCE)$	E^{65-85}	ΔE^{65-85}	E^{85+}	ΔE^{85+}
Abruzzo	≥ 0.10	< 0.01	≥ 0.1	≥ 0.1	< 0.05	≥ 0.1
Basilicata	≥ 0.10	< 0.01	≥ 0.1	≥ 0.1	< 0.10	≥ 0.1
Calabria	≥ 0.10	< 0.01	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Campania	< 0.01	< 0.01	≥ 0.1	< 0.10	< 0.10	< 0.01
Emilia-Romagna	< 0.10	< 0.05	< 0.05	< 0.10	< 0.05	< 0.10
Friuli Venezia Giulia	≥ 0.10	< 0.05	≥ 0.1	≥ 0.1	< 0.01	≥ 0.1
Lazio	< 0.10	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Liguria	≥ 0.10	≥ 0.1	≥ 0.1	< 0.05	≥ 0.1	< 0.01
Lombardia	≥ 0.10	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Marche	< 0.10	< 0.10	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Molise	< 0.05	< 0.01	≥ 0.1	≥ 0.1	≥ 0.1	< 0.05
Piemonte	< 0.01	< 0.01	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Puglia	≥ 0.10	< 0.05	≥ 0.1	≥ 0.1	≥ 0.1	< 0.01
Sardegna	≥ 0.10	< 0.05	< 0.05	≥ 0.1	≥ 0.1	< 0.05
Sicilia	≥ 0.10	≥ 0.1	< 0.10	≥ 0.1	< 0.05	< 0.10
Toscana	< 0.10	< 0.01	< 0.01	< 0.05	≥ 0.1	< 0.05
Trentino Alto Adige	≥ 0.10	0.05	< 0.05	≥ 0.1	≥ 0.1	≥ 0.1
Umbria	≥ 0.10	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1	≥ 0.1
Valle d'Aosta	< 0.10	< 0.01	≥ 0.1	< 0.10	≥ 0.1	≥ 0.1
Veneto	< 0.05	< 0.01	< 0.05	≥ 0.1	≥ 0.1	< 0.01

Table: Panel unit root tests - expenditure and ageing variables.

Panel unit root tests

Region	M^{Cancer}	ΔM^{Cancer}	M^{Cardio}	ΔM^{Cardio}
Abruzzo	≥ 0.10	< 0.01	≥ 0.10	≥ 0.10
Basilicata	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Calabria	< 0.10	< 0.01	≥ 0.10	< 0.01
Campania	≥ 0.10	≥ 0.10	≥ 0.10	< 0.01
Emilia-Romagna	≥ 0.10	< 0.01	< 0.01	< 0.01
Friuli Venezia Giulia	< 0.10	< 0.01	< 0.05	≥ 0.10
Lazio	≥ 0.10	< 0.05	≥ 0.10	< 0.01
Liguria	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Lombardia	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Marche	< 0.05	< 0.01	< 0.10	< 0.05
Molise	< 0.05	< 0.05	≥ 0.10	< 0.01
Piemonte	≥ 0.10	< 0.01	≥ 0.10	< 0.10
Puglia	< 0.05	< 0.05	< 0.01	< 0.05
Sardegna	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Sicilia	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Toscana	< 0.05	< 0.01	≥ 0.10	< 0.01
Trentino Alto Adige	< 0.01	< 0.01	< 0.05	< 0.01
Umbria	< 0.05	< 0.10	< 0.05	< 0.01
Valle d'Aosta	< 0.05	< 0.01	≥ 0.10	< 0.01
Veneto	≥ 0.10	< 0.01	≥ 0.10	< 0.01

Table: Panel unit root tests - mortality rates 2.

Panel unit root tests

Region	*Beds*	Δ*Beds*	*ln*(*GDP*)	Δ*ln*(*GDP*)
Abruzzo	≥ 0.10	< 0.10	< 0.10	< 0.05
Basilicata	≥ 0.10	≥ 0.10	≥ 0.10	< 0.01
Calabria	≥ 0.10	< 0.01	≥ 0.10	< 0.05
Campania	≥ 0.10	< 0.01	< 0.10	< 0.05
Emilia-Romagna	≥ 0.10	< 0.01	≥ 0.10	< 0.05
Friuli Venezia Giulia	< 0.10	≥ 0.10	≥ 0.10	< 0.05
Lazio	≥ 0.10	< 0.01	< 0.10	< 0.01
Liguria	≥ 0.10	≥ 0.10	< 0.05	≥ 0.10
Lombardia	≥ 0.10	≥ 0.10	< 0.01	< 0.01
Marche	≥ 0.10	< 0.10	< 0.05	< 0.05
Molise	≥ 0.10	≥ 0.10	≥ 0.10	< 0.05
Piemonte	< 0.05	≥ 0.10	≥ 0.10	< 0.01
Puglia	≥ 0.10	< 0.01	< 0.10	≥ 0.10
Sardegna	≥ 0.10	< 0.05	≥ 0.10	< 0.01
Sicilia	≥ 0.10	≥ 0.10	≥ 0.10	< 0.10
Toscana	≥ 0.10	< 0.01	< 0.01	≥ 0.10
Trentino Alto Adige	≥ 0.10	≥ 0.10	< 0.10	< 0.01
Umbria	≥ 0.10	< 0.01	< 0.10	≥ 0.10
Valle d'Aosta	≥ 0.10	< 0.01	≥ 0.10	< 0.01
Veneto	≥ 0.10	< 0.01	≥ 0.10	< 0.01

Table: Panel unit root tests - GDP and hospital beds.

VIF

Variable	Variance	VIF
E_t^{65-85}	0.596	4.147
E_t^{85+}	1.928	3.812
M_{t+2}^{Cardio}	0.052	2.245
M_{t+2}^{Cancer}	0.151	2.403
$Beds_t$	0.011	3.590
$ln(GDP)_t$	0.010	1.627

Panel cointegration test

Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-5.25	1.00	-6.66	1.00
Panel rho-Statistic	0.86	0.80	1.28	0.90
Panel PP-Statistic	-32.54	0.00	-33.50	0.00
Panel ADF-Statistic	-17.36	0.00	-14.44	0.00

Table: Pedroni Residual Cointegration Test. Alternative hypothesis: common AR coefs. (within-dimension)

Test	Statistic	Prob.
Group rho-Statistic	2.52	0.99
Group PP-Statistic	-57.85	0.00
Group ADF-Statistic	-18.03	0.00

Table: Pedroni Residual Cointegration Test. Alternative hypothesis: individual AR coefs. (between-dimension)

Null Hypothesis: No cointegration. Trend assumption: Deterministic intercept and trend. Automatic lag length selection based on SIC with a max lag of 2. Newey-West automatic bandwidth selection and Bartlett kernel.

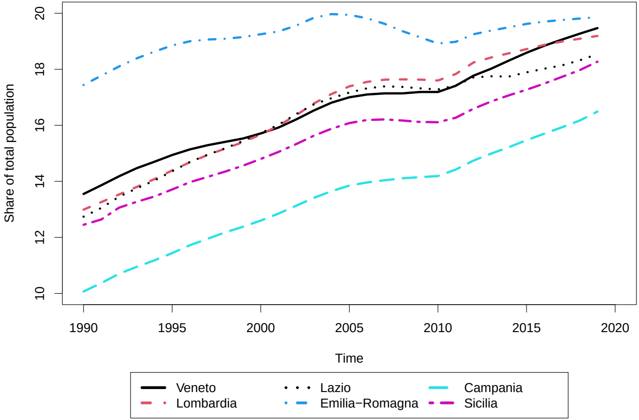


Figure: Percentage of the population between 65 and 85 years old, selected regions

Dependent variable: public per-capita nominal expenditure

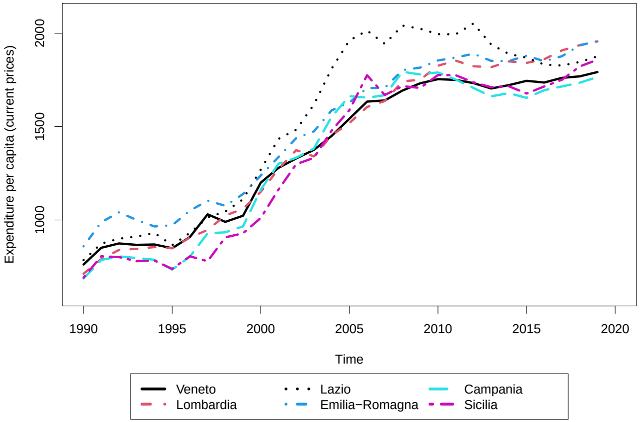


Figure: Healthcare public expenditure per capita at current prices, selected regions

Dependent variable: public per-capita real expenditure

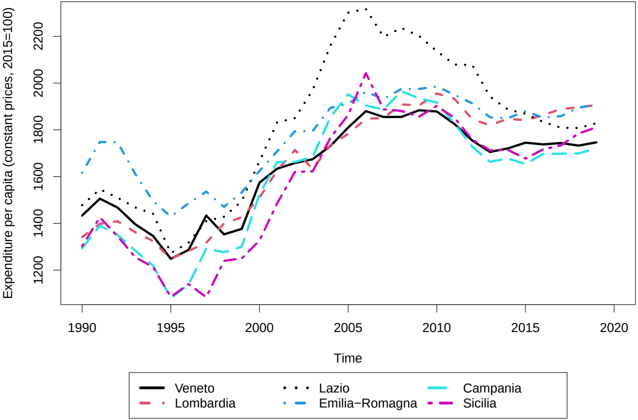


Figure: Healthcare public expenditure per capita at constant prices (2015=100), selected regions

Explanatory variable: share of elderly

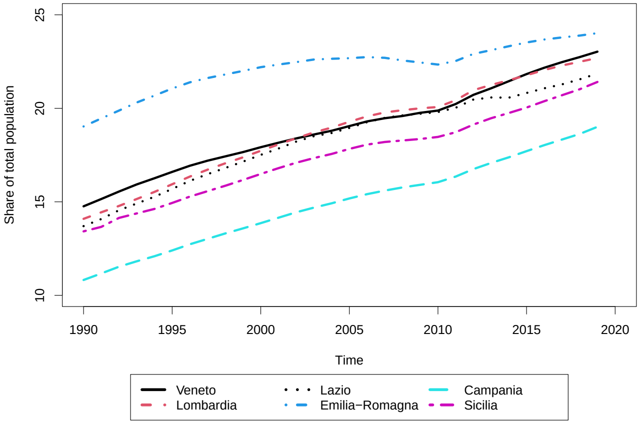


Figure: Percentage of the population older than 65 years, selected regions

Explanatory variable: share of elderly

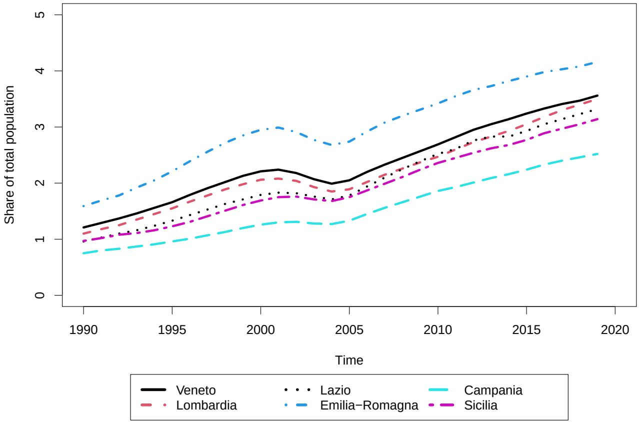


Figure: Percentage of the population older than 85 years, selected regions

Explanatory variable: mortality rate (cancer)

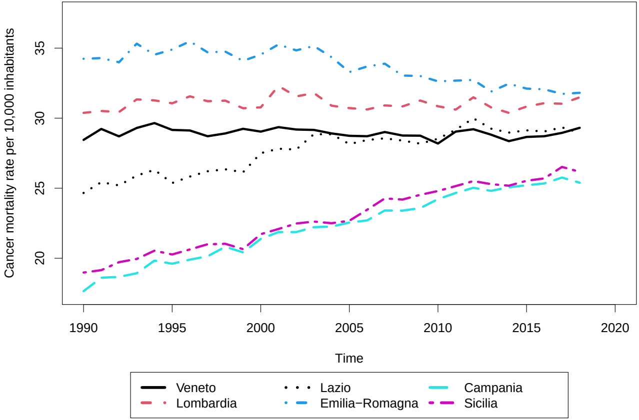


Figure: Cancer: mortality rate per 10,000 inhabitants, selected regions

Explanatory variable: mortality rate (circulatory diseases)

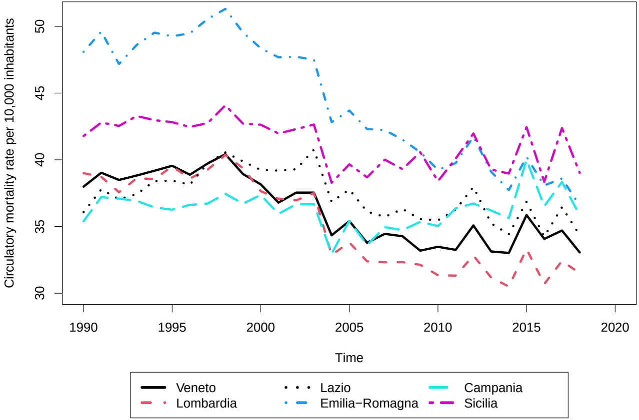


Figure: Circulatory diseases: mortality rate per 10,000 inhabitants, selected regions

Explanatory variable: hospital beds

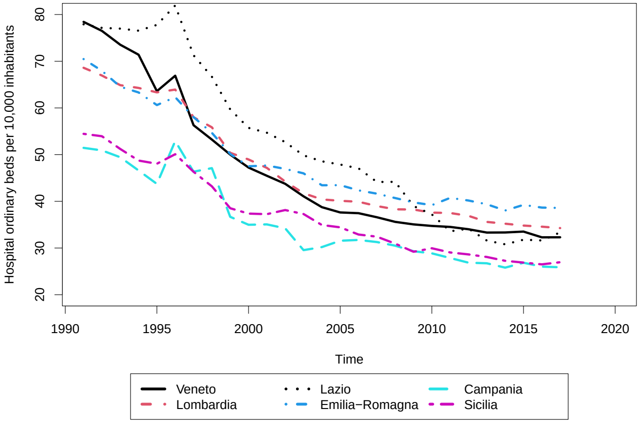


Figure: Rate of ordinary hospital beds per 10,000 inhabitants, selected regions