Estimating dynamic demand for outpatient antibiotics in Italy

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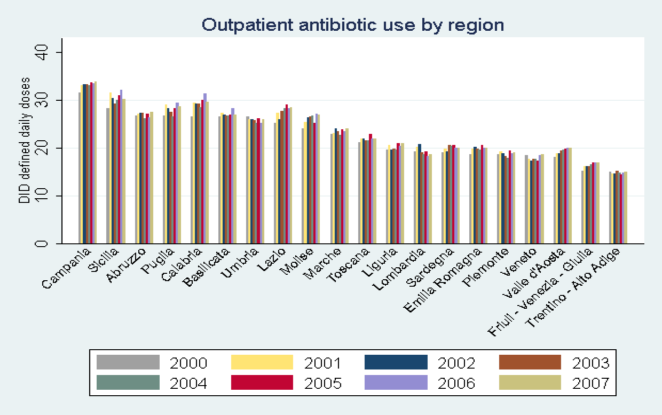
Outline

- Background
- The model
- Estimation method
- Results
- Conclusions

Objectives

- Empirical analysis of the demand for outpatient antibiotics in Italy (static and dynamic approaches)



Background

Empirical studies on the demand for outpatient antibiotics

- Determinants of regional variations in the use of antibiotics (Matuz et al., 2006; Filippini et al., 2006, 2009)

Antibiotic dynamics

- The economic dynamics of antibiotic efficacy (Herrmann and Gaudet, 2009)
- Theory of optimal antibiotic use (Laxminarayan and Brown, 2001; Ellison and Hellerstein, 1999; Elbasha, 2003; Rudholm, 2002)

Addiction models

- Empirical analysis of cigarette addiction ((McGuiness and Cowling, 1975; Becker et al., 1994)
- Rational addiction (Becker and Murphy, 1988)

The model

$$\ln a^*_{it} = f(Y_{it}, P_{it}, DPH_{it}, POP_{it}, EDU_{it}, MOR_{it}) \qquad (1)$$

where

a^*_{it}	=	desired amount of outpatient antibiotic consumption *per capita* (DID)
Y	=	income per capita
P	=	price/copayment
DPH	=	physicians' density
POP	=	population age structure
EDU	=	level of education
MOR	=	prevalence of infectious diseases (mortality as a proxy)

The partial adjustment model

$$\ln a_{it} - \ln a_{it-1} = \phi(\ln a^*_{it} - \ln a_{it-1}) + \eta_{it} \tag{2}$$

Estimated model

$$\begin{aligned} \ln a_{it} &= \alpha\phi + (1-\phi)\ln a_{it-1} + \beta_1\phi \ln Y_{it} + \beta_2\phi P_t + \\ &\quad \beta_3\phi DPH_{it} + \beta_4\varphi POP_{it} + \beta_5\phi POP_{3t} + \\ &\quad \beta_6\phi \ln MOR_t + v_{it} \end{aligned} \tag{3}$$

Estimation methodology

- Balanced panel covering the period 2000-2007 for 20 Italian regions (antibiotic sales as proxy of consumption)

Dynamic approach

- Bias-Corrected Least Squared Dummy Variable estimator (LSDVC)

Static approach

- LSDV estimator

Results

	Static model		Dynamic Model			
	LSDV		LSDVC (AB)		LSDVC (AH)	
	Obs 160		Obs 120		Obs 120	
	Wald χ^2 (7)	519.99				
Parameters	Coeff.	Std. Err.	Coeff.	(Bootstrap)	Coeff.	(Bootstrap)
Constant	0.427037	0.641338				
ln Y	0.258132****	0.052237	0.191399***	0.062426	0.195380	0.068741
POP_1	0.002746	0.004286	0.006758	0.004376	0.006812***	0.004832
POP_3	-0.000034	0.000075	-0.000003	0.000073	-0.000002	0.000074
PRIC	-0.010073***	0.003229	-0.007088*	-0.003941	-0.007170*	0.004222
DPH	0.076255	0.131373	0.172796	0.141240	0.174970	0.155954
MOR	-0.008865	0.015815	-0.015826	0.016163	-0.015481	0.016602
DID_{t-1}			0.173510**	0.082015	0.168158	0.105606

* significant at 10%, ** significant at 5%, *** significant at 1%, **** significant at 0.1%

Conclusions

- Outpatient antibiotic consumption in Italy exhibits a relatively weak persistence
- The process of adjustment to optimal levels of antibiotics use is relatively fast (1.2 years). Evidence of "rational-addicted behaviour"?
- Further research:
  - Expanding the panel to 2008
  - Testing "direct" indicators of the "stock of antibiotic efficacy", i.e. bacterial resistance
  - Spacial aspects to capture consumption and resistance effects across the areas

Appendix

Assume

$u_i(t) = u[c_i(t), a_i(t), R^{-1}(t)]$ through a process of "resource exhaustability"

$R^{-1}(t)$ = measure of the efficacy of antibiotic
$\rightarrow SIS : w(t) = \frac{I_w(t)}{I(t)}, \dot{w} = f($individuals treated, fitness cost of resistance$)$

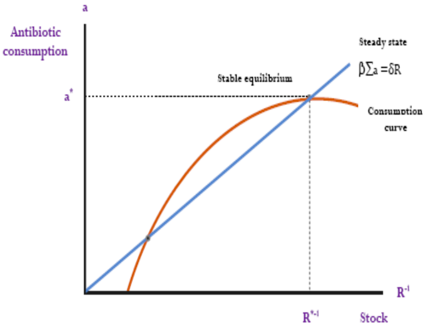
$$\dot{R}(t) = \beta \sum a_j(t) - \delta R(t)$$

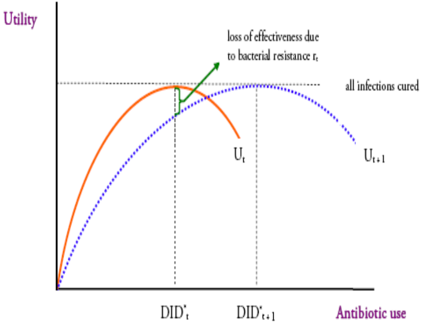
The utility function with a length of time equal to T is:

$U(0) = \int_0^T e^{-\sigma t} u[c_i(t), a_i(t), R^{-1}(t)] dt$ $s.t.$an expenditure constraint

Stable equilibrium: $(c^*, a^*, R^*(a^*))$

Appendix


a
Antibiotic consumption
a*
Stable equilibrium
Steady state
βΣa =δR
Consumption curve
R-1
R*-1
Stock


Utility
loss of effectiveness due to bacterial resistance rt
all infections cured
Ut
Ut+1
DID*t
DID*t+1
Antibiotic use

Appendix

$$\ln a^*_{it} = f(Y_{it}, P_{it}, DPH_{it}, POP_{it}, EDU_{it}, MOR_{it}) \qquad (4)$$

$$\ln a_{it} - \ln a_{it-1} = \phi(\ln a^*_{it} - \ln a_{it-1}) + \eta_{it} \qquad (5)$$

$$\ln a^*_{it} = \frac{1}{\phi} \ln a_{it} + (1 \ln - \frac{1}{\phi}). \ln a_{it-1} - \frac{1}{\phi} \eta_{it} \qquad (6)$$

Estimated model

$$\begin{aligned} \ln a_{it} \quad = \quad & \alpha\phi + \; (1 - \phi) \ln a_{it-1} + \beta_1 \phi \ln Y_{it} + \beta_2 \phi P_t + \\ & \beta_3 \phi DPH_{it} + \beta_4 \varphi POP_{it} + \beta_5 \phi POP_{3t} + \beta_6 \phi \ln MOR_t + v_{it} \end{aligned} \qquad (7)$$

Appendix

	Static Model						Dynamic Model			
	GLS AR(1)		PCSE		LSDV		LSDVC (AB)		LSDVC (AH)	
	Obs 160		Obs 160		Obs 160		Obs 120		Obs 120	
	Wald χ^2(6)	145.41	Wald χ^2(6)	147.02	Wald χ^2(7)	519.99				
Parameters	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	(Bootstrap)	Coeff.	(Bootstrap)
Constant	4.556521[d]	0.946904	4.011821[d]	1.074888	0.427037	0.641338				
ln Y	-0.242901[c]	0.075326	-0.230617[c]	0.085432	0.258132[d]	0.052237	0.191399[c]	0.062426	0.195380	0.068741
POP_1	0.020674[d]	0.005380	0.024218[d]	0.006117	0.002746	0.004286	0.006758	0.004376	0.006812[c]	0.004832
POP_3	-0.000113	0.000211	-0.000083	0.000216	-0.000034	0.000075	-0.000003	0.000073	-0.000002	0.000074
PRIC	-0.023435[d]	0.005423	-0.019252[c]	0.006348	-0.010073[c]	0.003229	-0.007088[a]	-0.003941	-0.007170[a]	0.004222
DPH	0.625997[c]	0.210222	1.012747[d]	0.245203	0.076255	0.131373	0.172796	0.141240	0.174970	0.155954
MOR	0.002174	0.020179	-0.002149	0.024194	-0.008865	0.015815	-0.015826	0.016163	-0.015481	0.016602
DID_{t-1}							0.173510[b]	0.082015	0.168158	0.105606

[a] significant at 10%, [b] significant at 5%, [c] significant at 1%, [d] significant at 0.1%

Appendix

	Static model (spatial interaction)							
	LSDV		GLS (AR1)		G2SLS		PCSE	
	Obs 160		Obs 160		Obs 160		Obs 161	
Parameters	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Constant	0.024248	0.054671	-0.114767	0.698454	-0.676987	0.779240	-0.545015	0.870143
ln Y	0.225972[d]	0.054672	0.017329	0.052971	0.135005[c]	0.056304	0.032940	0.066780
POP_1	0.004373	0.004340	0.009558[c]	0.003728	0.009082[c]	0.004342	0.013955[d]	0.004583
POP_3	-0.000023	0.000074	-0.000167	0.000200	-0.000003	0.000081	-0.000136	0.000203
PRIC	-0.008754[c]	0.003281	-0.005914	0.004071	-0.005791	0.003665	-0.001994	0.005546
DPH	0.043624	0.131440	0.193293	0.147713	0.030599	0.140820	0.465879[c]	0.200965
MOR	-0.004602	0.015848	0.001900	0.014194	0.006036	0.017239	0.009438	0.019940
DID_{-i}	0.225619	0.123021	0.856447[d]	0.065352	0.702789[d]	0.185949	0.832079[d]	0.083025

a significant at 10%, b significant at 5%, c significant at 1%, d significant at 0.1%

Appendix

	Dynamic Model (spatial interaction)			
	LSDVC (AB)		LSDVC (AH)	
	Obs 120		Obs 120	
Parameters	Coeff.	(Bootstrap)	Coeff.	(Bootstrap)
ln Y	0.152783[c]	0.067076	0.149959[a]	0.083276
POP_1	0.007428[a]	0.004303	0.007574	0.004695
POP_3	-0.000006	0.000072	-0.000008	0.000094
PRIC	-0.005970	0.004092	-0.005930	0.004274
DPH	0.127334	0.139386	0.124991	0.155317
MOR	-0.008980	0.016043	-0.009603	0.016624
DID_{t-1}	0.187160[c]	0.083962	0.207419[a]	0.120981
DID_{-i}	0.285037[a]	0.160182	0.296106[a]	0.167042

[a] significant at 10%, [b] significant at 5%, [c] significant at 1%, [d] significant at 0.1%