UNIVERSITA' DEGLI STUDI DI TRENTO - DIPARTIMENTO DI ECONOMIA

SEMIPARAMETRIC EVIDENCE ON THE LONG-RUN EFFECTS OF INFLATION ON GROWTH

Andrea Vaona
and
Stefano Schiavo

Discussion Paper No. 20, 2005

The Discussion Paper series provides a means for circulating preliminary research results by staff of or visitors to the Department. Its purpose is to stimulate discussion prior to the publication of papers.

Requests for copies of Discussion Papers and address changes should be sent to:

Dott. Stefano Comino
Dipartimento di Economia
Università degli Studi
Via Inama 5
38100 TRENTO ITALY

Nonparametric and Semiparametric Evidence on the Long-Run Effects of Inflation on Growth *

A. Vaona† and S. Schiavo‡

Abstract

Two major findings of the empirical literature on the connection between inflation and output growth are that their relationship is non linear and that there exists a threshold inflation level below which inflation has a positive impact on growth and above which inflation has a negative impact on growth. In this paper we adopt both a nonparametric estimator and a semiparametric IV one to show that the first finding holds true even dropping the specification assumptions typical of parametric models. We also show that a threshold level does exist and it is around 12% for developed countries. Below this level inflation does not appear to have any substantial effect on growth.

Jel codes: E31, O49, C14.

Keywords: Inflation, Growth.

---

*The authors would like to thank Fabrizio Carmignani, Francesco Daveri and Abdelhak Senhadji for their helpful comments. The usual disclaimer applies.

†Corresponding author. Birkbeck College (University of London) and University of Verona, Department of Economic Sciences, Polo Zanotto, Viale dell'Università 4, 37129, Verona, Italy. Tel.: (+39)0458028102. E-mail: andrea.vaona@economia.univr.it

‡Department of Computer and Management Sciences, University of Trento, Via Inama 4, 38100 Trento. E-mail: sschiavo@economia.unitn.it, phone: (+39)0461882115, fax: (+39)0461882124.

1 Aim of the Paper and Literature Review

The aim of this paper is to reassess by means of both a nonparametric estimator and a semiparametric instrumental variable (IV) estimator the issue of the long-run relationship between inflation and economic growth.

The existing empirical literature uses spline models in the belief that a threshold level of inflation exists below which increasing inflation would foster output growth and above which more inflation would hamper it. However, first, the theoretical literature had considerable difficulties in matching this stylized fact (Temple, 2000) and, second, different empirical contributions have assumed different threshold levels without being able to test their assumptions (with the exception of Khan and Senhadji, 2001). For instance Fischer (1993) imposes a spline model with two breaks, one at 15% annual inflation rate and the other at 40%. Gylfason and Herbertsson (2001) find that the relationship between inflation and growth is non-linear and the threshold inflation rate to be around 10%. Ghosh and Phillips (1998) assume the kink of the spline to be at 2.5%, whereas Judson and Orphanides (1999) choose 10%.

A threshold effect is found also by Thirlwall and Barton (1971) at an annual inflation rate ranging from 8% to 10%. A similar value is suggested also by Sarel (1996). One notable contribution is Khan and Senhadji (2001) who find the threshold to be around 1% for industrialized countries and 11% for developing ones. However, the result for the industrialized countries is not completely convincing because the number of observations for which inflation is below 1% is rather small and in most cases they represents rare and temporary occurrences with little chance to impact on long-term growth. Hence, the paucity of observations, together with the assumption of the spline model, may drive the result.

Another major issue in this literature is the exact specified form of non-linearity necessary to better grasp the relationship between inflation and growth. The level of inflation rate π (Fischer, 1993) and its log (Khan and Senhadji, 2001) have been used as well as the log of $1+\pi$ (Harris, Gillman and Matyas, 2001 and Judson and Orphanides, 1999), $\frac{\pi}{1+\pi}$ and $(1-\gamma)\,\pi^{1-\gamma}$ (Ghosh and Phillips, 1998).

In order to take better care of these issues, we think that nonparametric and semiparametric estimators will allow to let as much as possible the data speak shedding further light on both the threshold level of inflation and its non linear relationship with output growth. Furthermore, by adopting a semiparametric IV estimator it will be possible to tackle the issue of the endogeneity of inflation, a problem that much of the above contributions neglect.

2 Model Specification and Data Issues

We test two model specifications both of which builds on Khan and Senhadji (2001). The dependent variable is the growth rate of GDP in constant local currency units. In Specification I controls include the level of inflation, gross fixed capital formation (or gross capital formation when the former is not available) as a share of GDP, the log of initial per capita GDP in PPP adjusted dollars, population growth, a measure of education and the share of government expenditures over GDP. In Specification II, the growth rate of the terms of trade and their 5-year standard deviation are also included. Inflation is instrumented by its first lag[1].

Data come from different sources: whenever possible we refer to the World Bank's World Development Indicators (WDI). For per capita GDP and the share of government consumption we revert to Penn World Tables (PWT), while our education measure (average schooling years in the total population aged 15 or more) comes from the Barro and Lee dataset on educational attainment. Last, terms of trade data are built from export and import unit value series taken from the IMF's International Financial Statistics (IFS).

The dataset covers the period 1960–1999, which is the maximum length common to all three data sources, and 167 countries, which again represents the intersection between WDI and PWT. Terms of trade data are available for a smaller set of (mainly developed) countries and they are therefore not included in our baseline specification, but only used as a robustness check.

As customary when focusing on long-term growth (Temple 2000), we divide all series into 8 equal periods of 5 years each and we consider 5-years means (or medians). The actual number of available observations is reduced due to the presence of missing data, especially for developing countries (whose IFS code is 200 or above). Moreover, we drop from the sample all observations for which the rate of inflation is above 40%: the semiparametric estimator is extremely sensitive to outliers, therefore we adopt the leave-one-out estimator (Pagan and Ullah, 1999) which brings us to trim observations for which inflation is above a certain threshold. We are not the first to recognize this problem: Temple (2000) warns against the risk of pooling together countries with very different inflation dynamics as few extremely high values may well drive the overall results. The 40% cutoff point is also employed in Khan and Senhadji (2001), while Gillman et al. (2004) show that using different truncation points

[1] Results about the validity of the instrument are available from the authors upon request.

generates negligible differences in the results.

In the end our sample contains 91 countries and 462 observations, 153 of which pertain to 24 industrial countries. Adding the terms of trade variables substantially reduces the sample size: while industrial countries are almost unaffected, the number of non industrial countries in the sample falls from 67 to 26 (112 total observations).

3 Estimation Method, Results and Conclusions

A nonparametric estimator is one of the tools that it is possible to use when the relationship between two variables is thought to be non-linear. Furthermore, in order to control for the effect of other covariates, it is possible to use a semiparametric estimator. In this contribution, we follow Park (2003) and we implement a semiparametric IV estimator.

The main assumption of Park (2003) is that in the following model

$$y_i = x'_{1i}\beta + \phi\left(x_{2i}\right) + u_i \tag{1}$$

$E\left[u_i|x_{2i}\right]$ is not null, where y is the dependent variable, x_{ji} for $j = 1, 2$ are two sets of independent variables, $\phi(\cdot)$ is a non linear function of unspecified form and i is the subscript for the i-th observation.

Let z_i be the set of instrumental variables: one first filters out the exogenous part of $\phi\left(x_{2i}\right)$ by computing $g(z_{1i}) = E\left[\phi\left(x_{2i}\right)|z_{1i}\right]$ and then obtains the model:

$$y_i = x'_{1i}\beta + g(z_{1i}) + v_i \tag{2}$$

where $E\left[v_i|z_{1i}\right] = 0$. At this stage, supposing x_{1i} to be exogenous, following Robinson (1988) it is possible to obtain estimates of beta as follows:

$$\hat{\beta} = \left[\sum_{i=1}^{n}\left(x_{i1} - \hat{m}_{12i}\right)\left(x_{i1} - \hat{m}_{12i}\right)'\right]^{-1}\left[\sum_{i=1}^{n}\left(x_{i1} - \hat{m}_{12i}\right)\left(y_i - \hat{m}_{2i}\right)'\right] \tag{3}$$

where $\hat{m}_{12i}$ and $\hat{m}_{2i}$ are the non-parametric estimators of $m_{12i} = E\left(x_{1i}|z_i\right)$ and $m_{2i} = E\left(y_i|z_i\right)$. More in detail, the nonparametric estimator of m_2 is:

$$\hat{m}_2 = \frac{\sum_{i=1}^{n} K\left(\frac{z_i - z}{h}\right) y_i}{\sum_{i=1}^{n} K\left(\frac{z_i - z}{h}\right)} \tag{4}$$

where h is the bandwidth and $K\left(\cdot\right)$ is the kernel function. Once having $\hat{\beta}$ in hand it is easy to find $\hat{g}\left(z_i\right)$:

$$\hat{g}\left(z_i\right) = \hat{m}_{2i} - \hat{m}_{12i}\hat{\beta} \tag{5}$$

In this contribution, we use a Gaussian kernel and Silverman's optimal bandwidth (Pagan and Ullah, 1999).

Table 1 shows the parameter estimates for the control variables. Figure 1 shows the result for a nonparametric estimation of the relationship between inflation and real GDP growth: the threshold inflation level is around 12 percent. Below it inflation does not appear to be particularly harmful to growth, while above it their relationship becomes markedly negative and steeper. Figure 2 shows the results for the semiparametric IV estimator. The continuous line traces $\hat{g}(z_i)$, whereas the dotted lines mark the 95% confidence interval. Overall, inflation does not appear to affect growth in a substantial way. The first box of Figure 3 shows that the same result would appear using 5 years medians instead of 5 years means, as suggested by Temple (2000). However, splitting the sample between developed and developing countries, as usual in the literature above (Khan and Senhadji, 2001), provides fruitful insights. The threshold level sticks to around 12% for developed countries, whereas no clear cut result emerges for the group of developing ones. This is probably the results of the very different experiences undergone by the economies grouped under this label: the relation between inflation and growth goes up and down for different inflation levels. Adding terms of trade data (Specification II) does not alter the results in any significant way.

This paper uses a nonparametric estimator and a semiparametric IV one to assess the issue of the non linear relationship between inflation and economic growth and the existence of a threshold effect within it. Our results point to the fact that inflation does not have a substantial effect on economic growth when it is below 12% in developed countries and that the high variability of growth performances in developing countries does not allow to find a precise threshold level for inflation. This tends to confirm that high inflation is detrimental to economic growth, but it highlights that spline models may have overstressed the benefits that can descend from moderate increases in long run inflation values at low inflation levels. Furthermore, whilst we do not address the issue of the allocative inefficency generated by inflation, our results also suggest that – from the standpoint of its impact on growth – the importance of low inflation targeting may have been overstated.

References

[1] Dotsey, M and Sartre, P. D. (2000), "Inflation Uncertainty and Growth in a Cash-in-Advance Economy", *Journal of Monetary Economics*, 45(3), 631-655.

[2] Fischer, S. (1993), "The Role of Macroeconomic Factors in Growth", *Journal of Monetary Economics*, 41, 485-512.

[3] Ghosh, A. and Phillips, S. (1998), "Inflation, Disinflation and Growth", *IMF Working Paper*, WP/98/68.

[4] Gillman, M., Harris M. N., and Matyas, L. (2001), "Inflation and Growth: explaining a Negative Effect", *Empirical Economics*, 29, 149 -167.

[5] Gylfason, T. and Herbertsson, T. (2001), "Does inflation matter for growth?", *Japan and the World Economy*, 13(4), 405 - 428.

[6] Judson, R. and Orphanides, A. (1999), "Inflation, Volatility and Growth", *International Finance*, 2(1), 117-138.

[7] Khan, S. and Senhadji, A. (2001), "Threshold Effects in the Relationship Between Inflation and Growth", IMF Staff Papers, 48 (1), 1-21.

[8] Park, S. (2003), "Semiparametric Instrumental Variable Estimation", *Journal of Econometrics*, 112, 381 - 399.

[9] Pagan, A. and Ullah, A. (1999), *Nonparametric Econometrics*, Cambridge University Press.

[10] Robinson, P. (1988), "Root-N-consistent Semiparametric Regression", *Econometrica*, 56, 931 - 954.

[11] Sarel, M., (1996), "Nonlinear Effects of Inflation on Economic Growth", IMF Staff Papers 43, 199-215.

[12] Temple, J. (2000), " Inflation and Growth: Stories Short and Tall", *Journal of Economic Surveys*, 14 (4), 395-426.

[13] Thirlwall, A. P. and Barton, C. A. (1971), "Inflation and Growth: The International Evidence", *Banca Nazionale del Lavoro Quarterly Review* 98, 263-275.

Table 1 – Coefficient estimates of the control variables

	Specification I				Specification II		
	All	Developed	Developing	Median	All	Developed	Developing
GDP per cap.	-4.40*	-6.02*	-4.26*	-4.01*	-6.53*	-5.66*	-5.93*
t-statistics	(-7.49)	(-4.56)	(-6.18)	(-6.47)	(-6.92)	(-4.00)	(-4.30)
Pop. growth	1.53*	0.02	1.73*	0.25	0.35	0.56	0.47
t-statistics	(9.13)	(0.05)	(8.63)	(0.84)	(1.03)	(1.17)	(0.87)
Investment/GDP	0.18*	0.16*	0.21*	0.14*	0.28*	0.11	0.37*
t-statistics	(7.06)	(2.64)	(6.34)	(5.56)	(7.35)	(1.59)	(5.55)
Gov.Consumption	-0.05	-0.10*	-0.02	-0.09*	-0.06	-0.12*	-0.01
t-statistics	(-1.77)	(-2.88)	(-0.52)	(-3.35)	(-1.62)	(-2.95)	(-0.11)
Education	0.10	0.37	0.01	0.08	0.23	0.41	0.22
t-statistics	(0.54)	(1.81)	(-0.03)	(0.38)	(0.93)	(1.76)	(0.41)
T. of Trade Growth	-	-	-	-	0.07*	0.11*	0.07
t-statistics	-	-	-	-	(2.08)	(2.30)	(1.23)
T. of Trade Stan. Dev.	-	-	-	-	0.78	-6.43	0.86
t-statistics	-	-	-	-	(1.90)	(-1.66)	(1.43)

*: significant at the 5% level

Figure 1 – Non-parametric estimation of the effect of inflation on real economic growth

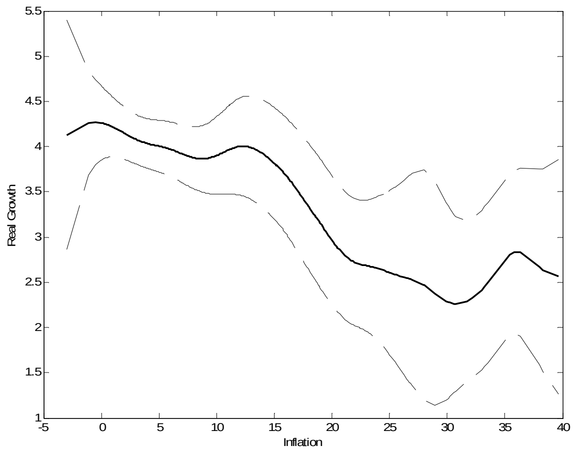


Figure 2 – Semi-parametric IV estimation of the effect of inflation on real economic growth

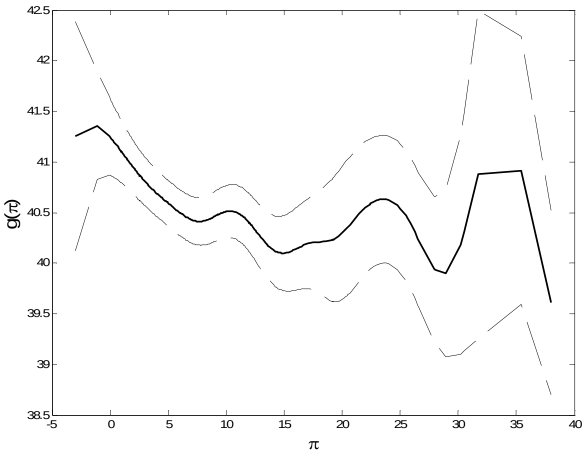
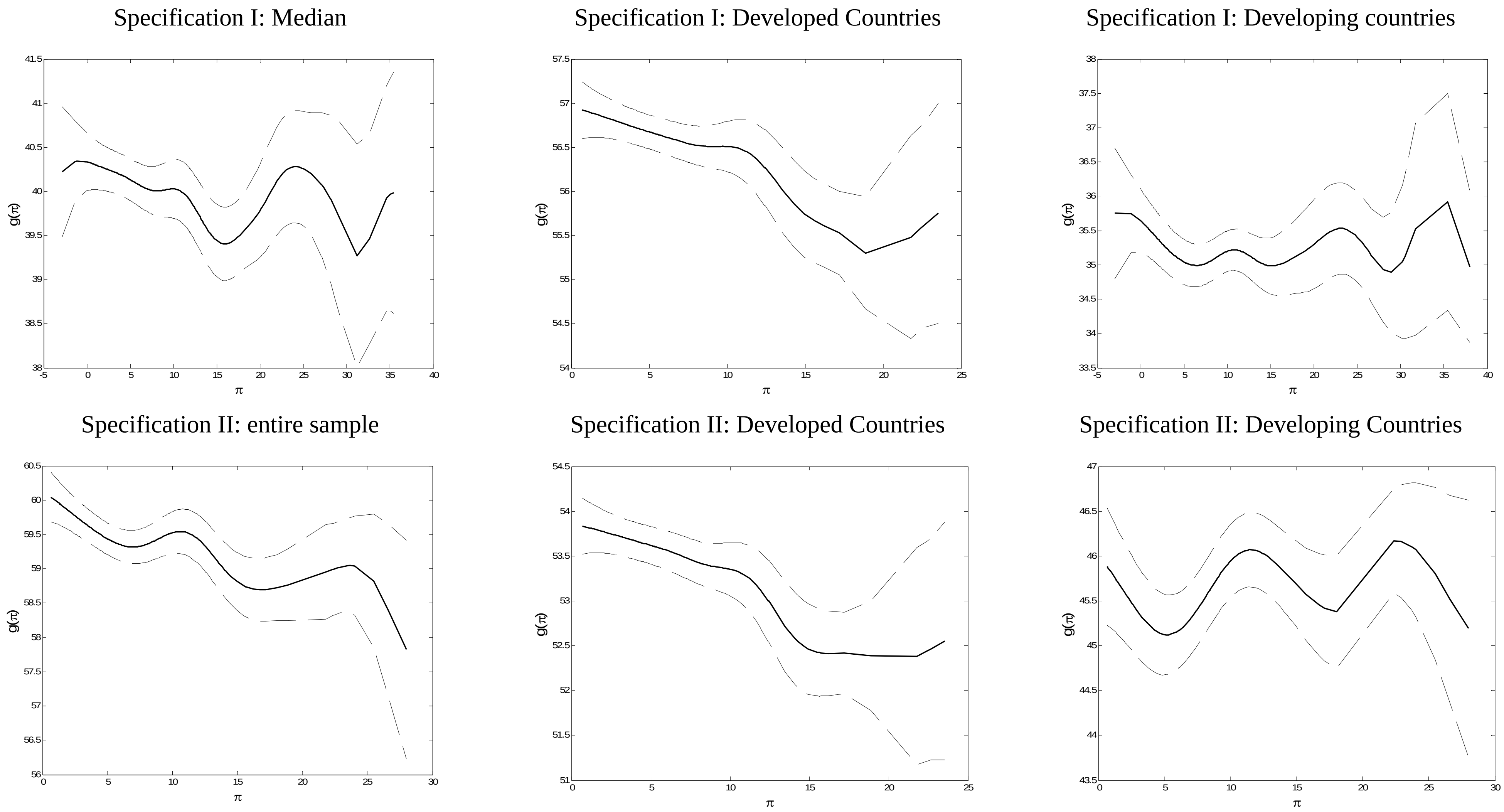


Figure 3 – Robustness checks for the Semiparametric IV estimation of the effect of inflation on real economic growth



Elenco dei papers del Dipartimento di Economia

2000.1 *A two-sector model of the effects of wage compression on unemployment and industry distribution of employment*, by Luigi Bonatti

2000.2 *From Kuwait to Kosovo: What have we learned? Reflections on globalization and peace,* by Roberto Tamborini

2000.3 *Metodo e valutazione in economia. Dall'apriorismo a Friedman ,* by Matteo Motterlini

2000.4 *Under tertiarisation and unemployment*. by Maurizio Pugno

2001.1 *Growth and Monetary Rules in a Model with Competitive Labor Markets,* by Luigi Bonatti.

2001.2 *Profit Versus Non-Profit Firms in the Service Sector: an Analysis of the Employment and Welfare Implications*, by Luigi Bonatti, Carlo Borzaga and Luigi Mittone.

2001.3 *Statistical Economic Approach to Mixed Stock-Flows Dynamic Models in Macroeconomics,* by Bernardo Maggi and Giuseppe Espa.

2001.4 *The monetary transmission mechanism in Italy: The credit channel and a missing ring,* by Riccardo Fiorentini and Roberto Tamborini.

2001.5 *Vat evasion: an experimental approach*, by Luigi Mittone

2001.6 *Decomposability and Modularity of Economic Interactions,* by Luigi Marengo, Corrado Pasquali and Marco Valente.

2001.7 *Unbalanced Growth and Women's Homework,* by Maurizio Pugno

2002.1 *The Underground Economy and the Underdevelopment Trap,* by Maria Rosaria Carillo and Maurizio Pugno.

2002.2 *Interregional Income Redistribution and Convergence in a Model with Perfect Capital Mobility and Unionized Labor Markets,* by Luigi Bonatti.

2002.3 *Firms' bankruptcy and turnover in a macroeconomy,* by Marco Bee, Giuseppe Espa and Roberto Tamborini.

2002.4 *One "monetary giant" with many "fiscal dwarfs": the efficiency of macroeconomic stabilization policies in the European Monetary Union,* by Roberto Tamborini.

2002.5 *The Boom that never was? Latin American Loans in London 1822-1825,* by Giorgio Fodor.

2002.6 *L'economia senza banditore di Axel Leijonhufvud: le 'forze oscure del tempo e dell'ignoranza' e la complessità del coordinamento,* by Elisabetta De Antoni.

2002.7 *Why is Trade between the European Union and the Transition Economies Vertical?,* by Hubert Gabrisch and Maria Luigia Segnana.

2003.1 *The service paradox and endogenous economic gorwth,* by Maurizio Pugno.

2003.2 *Mappe di probabilità di sito archeologico: un passo avanti,* di Giuseppe Espa, Roberto Benedetti, Anna De Meo e Salvatore Espa.
(*Probability maps of archaeological site location: one step beyond*, by Giuseppe Espa, Roberto Benedetti, Anna De Meo and Salvatore Espa).

2003.3 *The Long Swings in Economic Understianding,* by Axel Leijonhufvud.

2003.4 *Dinamica strutturale e occupazione nei servizi,* di Giulia Felice.

2003.5 *The Desirable Organizational Structure for Evolutionary Firms in Static Landscapes,* by Nicolás Garrido.

2003.6 *The Financial Markets and Wealth Effects on Consumption* An Experimental Analysis, by Matteo Ploner.

2003.7 *Essays on Computable Economics, Methodology and the Philosophy of Science,* by Kumaraswamy Velupillai.

2003.8 *Economics and the Complexity Vision: Chimerical Partners or Elysian Adventurers?*, by Kumaraswamy Velupillai.

2003.9 *Contratto d'area cooperativo contro il rischio sistemico di produzione in agricoltura,* di Luciano Pilati e Vasco Boatto.

2003.10 *Il contratto della docenza universitaria. Un problema multi-tasking*, di Roberto Tamborini.

2004.1 *Razionalità e motivazioni affettive: nuove idee dalla neurobiologia e psichiatria per la teoria economica?* di Maurizio Pugno.
(*Rationality and affective motivations: new ideas from neurobiology and psychiatry for economic theory?* by Maurizio Pugno.

2004.2 *The economic consequences of Mr. G. W. Bush's foreign policy. Can th US afford it?* by Roberto Tamborini

2004.3 *Fighting Poverty as a Worldwide Goal* by Rubens Ricupero

2004.4 *Commodity Prices and Debt Sustainability* by Christopher L. Gilbert and Alexandra Tabova

2004.5 *A Primer on the Tools and Concepts of Computable Economics* by K. Vela Velupillai

2004.6 *The Unreasonable Ineffectiveness of Mathematics in Economics* by Vela K. Velupillai

2004.7 *Hicksian Visions and Vignettes on (Non-Linear) Trade Cycle Theories* by Vela K. Velupillai

2004.8 *Trade, inequality and pro-poor growth: Two perspectives, one message?* By Gabriella Berloffa and Maria Luigia Segnana

2004.9 *Worker involvement in entrepreneurial nonprofit organizations. Toward a new assessment of workers? Perceived satisfaction and fairness* by Carlo Borzaga and Ermanno Tortia.

2004.10 *A Social Contract Account for CSR as Extended Model of Corporate Governance (Part I): Rational Bargaining and Justification* by Lorenzo Sacconi

2004.11 *A Social Contract Account for CSR as Extended Model of Corporate Governance (Part II): Compliance, Reputation and Reciprocity* by Lorenzo Sacconi

2004.12 *A Fuzzy Logic and Default Reasoning Model of Social Norm and Equilibrium Selection in Games under Unforeseen Contingencies* by Lorenzo Sacconi and Stefano Moretti

2004.13 *The Constitution of the Not-For-Profit Organisation: Reciprocal Conformity to Morality* by Gianluca Grimalda and Lorenzo Sacconi

2005.1 *The happiness paradox: a formal explanation from psycho-economics* by Maurizio Pugno

2005.2 *Euro Bonds: in Search of Financial Spillovers* by Stefano Schiavo

2005.3 *On Maximum Likelihood Estimation of Operational Loss Distributions* by Marco Bee

2005.4 *An enclave-led model growth: the structural problem of informality persistence in Latin America* by Mario Cimoli, Annalisa Primi and Maurizio Pugno

2005.5 *A tree-based approach to forming strata in multipurpose business surveys,* Roberto Benedetti, Giuseppe Espa and Giovanni Lafratta.

2005.6 *Price Discovery in the Aluminium Market* by Isabel Figuerola-Ferretti and Christopher L. Gilbert.

2005.7 *How is Futures Trading Affected by the Move to a Computerized Trading System? Lessons from the LIFFE FTSE 100 Contract* by Christopher L. Gilbert and Herbert A. Rijken.

2005.8 *Can We Link Concessional Debt Service to Commodity Prices?* By Christopher L. Gilbert and Alexandra Tabova

2005.9 *On the feasibility and desirability of GDP-indexed concessional lending* by Alexandra Tabova.

2005.10 *Un modello finanziario di breve periodo per il settore statale italiano: l'analisi relativa al contesto pre-unione monetaria* by Bernardo Maggi e Giuseppe Espa.

2005.11 *Why does money matter? A structural analysis of monetary policy, credit and aggregate supply effects in Italy*, Giuliana Passamani and Roberto Tamborini.

2005.12 *Conformity and Reciprocity in the "Exclusion Game": an Experimental Investigation* by Lorenzo Sacconi and Marco Faillo.

2005.13 *The Foundations of Computable General Equilibrium Theory*, by K. Vela Velupillai.

2005.14 *The Impossibility of an Effective Theory of Policy in a Complex Economy*, by K. Vela Velupillai.

2005.15 *Morishima's Nonlinear Model of the Cycle: Simplifications and Generalizations*, by K. Vela Velupillai.

2005.16 Using and Producing *Ideas* in Computable Endogenous Growth, by K. Vela Velupillai.

2005.17 *From Planning to Mature: on the Determinants of Open Source Take Off* by Stefano Comino, Fabio M. Manenti and Maria Laura Parisi.

2005.18 *Capabilities, the self, and well-being: a research in psycho-economics,* by Maurizio Pugno.

2005.19 Fiscal and monetary policy, unfortunate events, and the SGP arithmetics. Evidence from a *growth-gap* model, by Edoardo Gaffeo, Giuliana Passamani and Roberto Tamborini

2005.20 *Semiparametric Evidence on the Long-Run Effects of Inflation on Growth*, by Andrea Vaona and Stefano Schiavo.