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X - XII

«ANGELO COSTA»
ECONOMICS UNDERGRADUATE
THESES AWARD
XIVth Edition

XIIth «ANGELO COSTA» LECTURE

A Series of Unfortunate Events: Common Sequencing Patterns in Financial Crises

Carmen M. Reinhart

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1911 - 2011

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Preface

In the year 2011, Rivista di Politica Economica (RPE) promoted the competition for the XIV^th^ edition of the «Angelo Costa» Economics Undergraduate Theses Prize consisting in the publication of the five most deserving papers taken from undergraduate theses in economics written by students who graduated in Italian universities between March 31st, 2009 and April 28th, 2010.

This issue collects the five papers winning the competition. The «Angelo Costa» Theses Prize aims at drawing attention to the most promising graduates in Economics awarding them with the publication of their paper in order to encourage studying and improve their post-graduate chances of admission to Master and/or Ph.D. programs. We also wish this Prize to bring the authors to the attention of a wider public, preventing that their works remain mere manuscripts with a limited and random circulation as it often happens.

The Prize is named in memory of Angelo Costa, the first President of Confindustria (the Confederation of Italian Industry) in the immediate post-war period. He was elected President in 1945 and guided the organisation throughout the reconstruction period until 1955. Angelo Costa was again elected to chair the board of Confindustria from 1966 to 1970. A free-market advocate, on several occasions Angelo Costa firmly opposed the constraints imposed by statism and stressed the key role played by small and medium-sized enterprises in Italy's economic and industrial growth.

Even for this 2011 edition the publication of the «Angelo Costa» Lecture – held on the awarding day by a Member of the International Scientific Committee or by an internationally renowned economist on a topic of economic interest – enriches the issue collecting the winning papers. The XII^th^ Lecture that we are here honoured to publish, is entitled: "A Series of Unfortunate Events: Common Sequencing Patterns in Financial Crises", and was held on October 5th, 2011 by Prof. Carmen M. Reinhart of the Peterson Institute for International Economics at "LUISS Guido Carli" University of Rome.

Twenty-two graduates from thirteen Italian universities submitted papers for this XIV[th] edition: four candidates were enrolled respectively at "Luigi Bocconi" University of Milan and the University of Bologna; two candidates were enrolled respectively at University of Cagliari, University of Florence and University of Siena; one candidate was enrolled in each one of the following universities: University of Bari, "Magna Graecia" University of Catanzaro, University of Macerata, University of Modena and Reggio Emilia, "Bicocca" University of Milan, "Federico II" University of Naples, "LUISS Guido Carli" University of Rome, University of Turin.

Each paper was submitted in anonymous form – as envisaged in the first stage of the competition – to the evaluation one of the following Italian referees:

Agar Brugiavini, Fabrizio Cacciafesta, Elena Carletti, Guido Cozzi, Luca De Benedictis, Giacomo Degli Antoni, Sonia Falconieri, Riccardo Fiorito, Paolo Ghirardato, Elena Granaglia, Luigi Guiso, Alberto Iozzi, Francesco Nucci, Domenico Mario Nuti, Sergio Ortobelli, Mario Padula, Loriana Pelizzon, Michele Pellizzari, Alberto Pozzolo, Riccardo Puglisi, Fabio Sabatini, Lorenzo Sacconi, Pasquale Scaramozzino, Giancarlo Spagnolo, Tommaso Valletti, Robert Waldmann.

On the basis of their opinions the authors who qualified for the second stage of the contest were the following (listed in alphabetical order):

Francesca Brusa, "Luigi Bocconi" University of Milan, Asset Pricing Puzzle: The Long Run Risks Model's Approach;

Rosella Carè, "Magna Graecia" University of Catanzaro, The Anomalies in Finance: the Behavior of Markets in the Presence of Black Swans;

Maddalena Cavicchioli, University of Modena and Reggio Emilia, Structural Macroeconomic Analysis for Dynamic Factor Models;

Giorgio Chiovelli, University of Bologna, Failed Democracies: Cross-Sectional Analysis on Economic Determinants of Democratic Transitions and on the Role of Electoral Authoritarianism During the Third Wave of Democratization;

Dario Gianluigi De Maio, University of Siena, Competition for Reputation: A Duopoly Predation Game;

Giuseppe Di Liddo, University of Bologna, The Effects of Immigration on PAYGO Pension System;

Marta De Philippis, "Luigi Bocconi" University of Milan, Media Impact on Native's Attitudes towards Immigration;

Ludovica Giua, University of Cagliari, The Effect of Social Capital on Environmental Quality: An Empirical Analysis on Italian Regions;

Alessandro Graniero, University of Turin, Life Cycle Finance with Habit Formation: A Simulation Approach;

Stefania Innocenti, University of Florence, Trade Negotiations and Lobbying Activity: Some Theoretical Reflections;

Simone Lombardini, "Bicocca" University of Milan, Migration Flow and Development: Effects on Educational Attainment in Mexico;

Rossana Morea, University of Bari, Systemic Risk in the Age of Financial Instability with an Empirical Investigation;

Cecilia Moretti, University of Siena, Stock Market Crash and Durable Goods: An Empirical Analysis Using US Data in Light of the 1929 Crisis;

Marco Giovanni Nieddu, University of Cagliari, Towards a Narrow Definition of Social Capital: Which Role on the Italian Regional Development and Well-Being?;

Jacopo Perego, "Luigi Bocconi" University of Milan, Modeling Fear;

Alessandro Silvestri, University of Bologna, Demand Saturation, Innovation and Economic Growth. How Aggregated Demand Drives the Real Economy;

Silvia Sorana, University of Macerata, Multidimensional Poverty in the Italian Families: An Analysis for 2004.

Each one of these papers was then submitted – again in anonymous form – to three different Members of the International Scientific Committee who finally defined the winners of the 2011 competition. The Members of the International Scientific Committee for this edition were:

Prof. Kyle Bagwell (Stanford University)
Prof. Richard Blundell (University College London)
Prof. Michael Brennan (University of California in Los Angeles)
Prof. Heinz Kurz (University of Graz)
Prof. Axel Leijonhufvud (University of California, Los Angeles)
Prof. Charles A. Mansky (Northwestern University)
Prof. Robert A. Mundell (Columbia University)
Prof. Lee E. Ohanian (University of California, Los Angeles)
Prof. Andrew Rose (University of California, Berkeley)
Prof. Stephen A. Ross (Massachusetts Institute of Technology)
Prof. Bertram Schefold (J.W. Goëthe Universität Frankfurt am-Main)
Prof. Jean Tirole (Université des Sciences Sociales de Toulouse)

The five authors who were awarded the 2011 "Angelo Costa" Undergraduate

Theses Prize are the following (listed in alphabetical order):

Francesca Brusa, "Luigi Bocconi" University of Milan, Asset Pricing Puzzle: The Long Run Risks Model's Approach;

Maddalena Cavicchioli, University of Modena and Reggio Emilia, Structural Macroeconomic Analysis for Dynamic Factor Models;

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Marco Giovanni Nieddu, University of Cagliari, Towards a Narrow Definition of Social Capital: Which Role on the Italian Regional Development and Well-Being?;

Jacopo Perego, "Luigi Bocconi" University of Milan, Modeling Fear.

Once again our initiative has received widespread and appreciative comments in Italian and foreign academic circles and we would like to sincerely thank all those who gave their contribution to spread information on the Prize. A special thanks for their personal direct and considerable commitment goes to the Italian referees and to the Members of the International Scientific Committee. The positive comments they expressed on the Prize and the notable skill of the candidates encourage us and testify that the prestige of the «Angelo Costa» Economics Undergraduate Theses Prize is considered today among the important events capable of fostering and encouraging young Italian economists in their scientific studies by making them known to a broader public.

The final choice of the winners, based on a criterion solely related to the quality of the manuscripts, is implemented by a doubleblind refereeing procedure made by Italian and international economists who have given important contributions to the science of economics and have acquired a rigorous capacity to evaluate scientific work over the years. Our guidelines for this Prize can be summed up with two terms: merit and competition. We believe these two characteristics have been and can be assured in the future by the rigour and transparency of the procedures adopted in the selection.

This issue of Rivista di Politica Economica also collects the profiles of the five winners of the XIVth edition, the announcement of the 2012 competition and a biographical update of the past-editions winners.

We take this opportunity to congratulate our young colleagues and wish them great success in their future studies and professional activities.

THE MANAGING EDITOR
PROF. GUSTAVO PIGA

XII^th^ «ANGELO COSTA» LECTURE

Prof. Carmen M. Reinhart during the XII[th] «Angelo Costa» Lecture, held at "LUISS Guido Carli" University of Rome on October 5[th], 2011.

A Series of Unfortunate Events: Common Sequencing Patterns in Financial Crises

Carmen M. Reinhart*

Peterson Institute for International Economics, CEPR and NBER

We document that the global scope and depth of the crisis the began 2007 is unprecedented in the post *World War II era and, as such, the most relevant comparison benchmark is the Great Depression of the 1930s. Some of the similarities are examined but the analysis of the aftermath of severe financial crises is also extended to the most severe* post-*WWII crises. We discriminate between root causes of the crises, recurring crises symptoms, and common features which serve as amplifiers of the boom-bust cycle. Recurring temporal patterns in the boom-bust cycle and their broad sequencing is analyzed.* [JEL Classification: E6; F3; N0].

Keywords: crisis, debt, cycle, financial regression.

* <*CReinhart@PIIE.com*>. This paper was prepared for the XIIth «Angelo Costa» Lecture, Rome, October 5, 2011. The material is drawn from Reinhart M.C. and Rogoff K.S. (2009) and Reinhart M.C., Kirkeegard J. and Sbrancia B. (2011). I wish to thank Vincent R. Reinhart and conference participants for helpful comments and suggestions.

1. - Introduction

> «*Over indebtedness simply means that debts are out-of-line, are too big relative to other economic factors. It may be started by many causes, of which the most common appears to be new opportunities to invest at a big prospective profit… such as through new industries… Easy money is the great cause of over-borrowing*».
>
> IRVING FISHER (1933)

The issues I address fall into three broad areas or sections. The next section takes stock of the collateral damage, in terms of the incidence of banking crises and currency and crashes around the world, which followed the financial turmoil that began as the subprime crisis in the United States in the summer of 2007. Following a common pattern in history, the financial crash has more recently morphed into full-fledged sovereign crises engulfing (to date), in varying degrees, Greece, Portugal, Ireland, Italy and Spain.[1] Apart from its impact on domestic and international financial flows, not to mention the changes in the landscape of the financial industry, that this crisis has produced, the toll on the real economy has been great. The evolution of world trade helps to illustrate the breadth and depth of the economic downturn. Global equity prices have also followed a roller coaster pattern since the onset of crisis about four years ago. The evidence presented here places these developments in a broader historical and international perspective that allows us to gauge the unusual severity of the unfolding global crisis. Section III dwells on the aftermath of severe financial crises, and speculates where we might be in the *post*-crisis cycle. The comparisons focus primarily on the housing and labor markets, where the aftereffects of the crises have tended to linger the longest. The fiscal implications and consequences of severe crises are discussed. Section IV poses the question of what causes these great crises and what factors make them more severe. The focus of this discussion is on causal factors that are common to severe financial crises across countries and across time rather than those that are idiosyncratic to the political and economic circumstances of the latest episode. The last section discusses on the high (and rapidly rising) levels of public sector indebtedness in nearly all the advanced economies and its implication for the "international financial architecture" in the form of financial repression in years to come.

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[1] REINHART M.C. and ROGOFF K.S. (2011*b*).

2. - Taking Stock: The Global Dimensions of the Crisis

2.1 *A Global Crisis Index*

So, where are we in a historical global context? We present an index which proxies of world economic turbulence. These aggregate crisis indices are the time series shown for 1900-2010 in Graph 1 for the "World". The indices shown are weighted by a country's share in world GDP, as we have done for debt and banking crises. The 66-country sample accounts for about 90 percent of world GDP. The country indices (without stock market crashes) are compiled from the time of independence (if after 1800) onward; the index that includes the equity market crashes is calculated based on data availability. While inflation and banking crises predate independence in many cases, a sovereign debt crisis (external or internal) is by definition not possible for a colony. In addition, numerous colonies did not always have their own currencies. The *BCDI index* stands for banking (systemic episodes only), currency, debt (domestic and external), and inflation crisis index. When stock market crashes are added (shown separately) to the *BCDI* composite, we refer to it as the *BCDI* +.

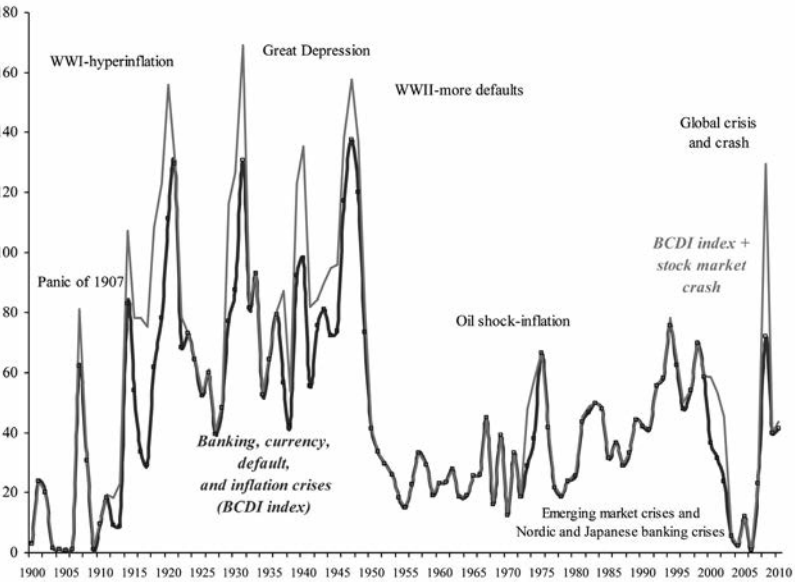
Graph 1 chronicles and summarizes the incidence, and to some degree the severity of varied crisis experience. A cursory inspection of the Graph reveals a very different pattern for the *pre*- and *post*-WWII experience. The *pre*-war experience is characterized by frequent and severe crises episodes ranging from the banking-crisis driven "global" panic of 1907 to the debt and inflation crises associated with World War II and its aftermath. The only period during the *post* war that we see as high an incidence of crises is the fifties where, during World War II big countries – Germany, Austria, Japan, Italy – were in a state of default and remained so through the early fifties. Plus, of course, there were a lot of countries that had gone into default in the thirties that were still in default. But since the immediate aftermath of World War II, we had not seen a crisis this global in scope.

The sharp rise in the heavy line (*BCDI index)* that we see in 2007 and more so in 2008 is mostly dominated by banking crises and also currency crashes. Indeed, a large share of countries in the fall of 2008 had sufficiently large depreciations to classify as a currency crash (*i.e.*, exchange rate depreciations exceeding 15 percent). The thin line adds stock market crashes – which were ubiquitous in 2008-2009. No doubt, when the index is updated to reflect year-end 2011 price levels, it will reveal yet another wave of stock market crashes.

GRAPH 1

VARIETIES OF CRISES: WORLD AGGREGATE, 1900-2010 A COMPOSITE INDEX OF BANKING, CURRENCY, SOVEREIGN DEFAULT, INFLATION CRISES, AND STOCK MARKET CRASHES

(Weighted by their share of world income)



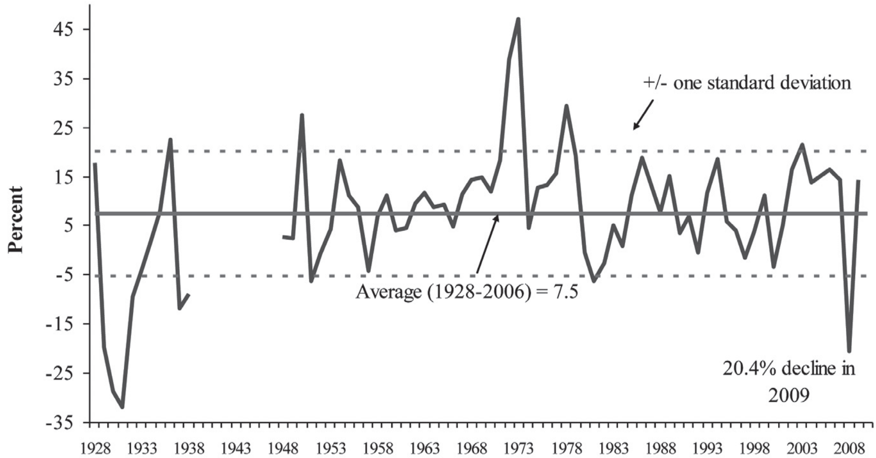
Notes: The banking, currency, default (domestic and external) and inflation composite (*BCDI* index) can take a value between 0 and 5 (for any country in any given year) depending on the varieties of crises taking place on a particular year. For instance, in 1998 the index took on a value of 5 for Russia, as there was a currency crash, a banking and inflation crisis, and a sovereign default on both domestic and foreign debt obligations. This index is then weighted by the country's share in world income. This index is calculated annually for the 66 countries in the sample for 1800-2010:6 (shown above for 1900-onwards). We have added, for the borderline banking cases identified LAEVEN L. and VALENCIA F. (2010) for the period 2007-2010. In addition, we use the BARRO R.J. and URSÚA J. (2008) definition of a stock market crash for the 25 countries in their sample (a subset of the 66-country sample-except for Switzerland) for the period 1864-2006; we update their crash definition through June 2010, to compile our *BCDI*+ index. For the United States, for example, the index posts a reading of 2 (banking crisis and stock market crash) in 2008; for Australia and Mexico it also posts a reading of 2 (currency and stock market crash).

2.2 *World Trade*

As to trade, we offer an illustration of the evolution of trade during two global crises. Graph 2 plots the value of World merchandise exports for 1928-2010. The estimate for 2009 uses the actual year-end level for 2008 as the average for 2009; this yields a 9 percent year-over-year decline in 2009, the largest one-year drop since 1938.[2] Other large *post*-WWII declines are in 1952, during the Korean War and in 1982-1983, when recession hit the United States and a 1930s-scale debt crisis swept through the emerging world. Smaller declines occurred in 1958, the bottom of a recession in the United States, 1998 during the Asian financial crisis and in 2001, after September 11.

Graph 2

WORLD EXPORT GROWTH, 1928-2010
(annual percent change)



Sources: Global Financial Data (GFD), League of Nations, *World Economic Survey* (various issues), International Monetary Fund, *World Economic Outlook,* and the authors (see notes).
Notes: The estimate for 2010 is from the *World Economic Outlook*. The 20.4 percent year-over-year decline in 2010, is the largest *post*-war drop.

[2] While we have reliable trade data for most countries during World War II, there are sufficient missing entries so as to make the calculation of the world aggregate not comparable to other years during 1940-1947.

2.3 *The "Big Picture"*

In sum, Graphs 1-2 highlight the breadth, depth, and internationally synchronous nature of the *post*-2007 financial crisis, especially in relation to the milder more scattered crises episodes of the *post* war landscape. Even "significant global" events, such as the break-down of the Bretton Woods system of fixed exchange rates, the oil shocks of the mid-1970s and the emerging market debt crisis of the early 1980s, pale in comparison in terms of the incidence of crises and impacts on the real economy. Indeed, the output declines registered in many advanced and emerging market economies in 2009 rank among the largest declines in the history of the national income accounts. In several countries, the declines in real GDP during the second great contraction (2008-2009) matched and even exceeded those recorded during severe "home grown" financial crises. This list includes such diverse countries (crisis year in parentheses) as Finland (1991); Mexico (1995); Singapore (1982); Spain (1977); Sweden (1991); Turkey (2001), among others.

Having suggested that the severity of this crisis is on a different scale from the *post*-war norm, it is logical sequel to expect that the aftermath of the crisis will, in all likelihood, also depart from the "standard" *post*-war recession-recovery pattern. To this end, the next section summarizes selected empirical findings of the Reinhart and Rogoff (2011*a*) study on the aftermath of severe financial crises.

3. - The Aftermath of Financial Crises

Let me begin by observing that, as to the present conjuncture in the United States, the *post*-war recession experience should not be seen as an instructive benchmark for where we are at present or what we should expect. The average NBER *post*-war recession lasts less than a year. The worst one lasted 16 months. We passed those milestones.

Broadly speaking, financial crises are protracted affairs. More often than not, the aftermath of severe financial crises share three characteristics. *First,* asset market collapses are deep and prolonged. Real housing price declines average 35 percent stretched out over six years. *Second*, the aftermath of banking crises is associated with profound declines in output and employment. The unemployment rate rises an average of 7 percentage points over the down phase of the cycle, which lasts on average over four years. *Third,* the real value of government debt tends to explode, rising an average of 86 percent in the major *post*-World War II episodes. Interestingly, the main cause of debt explosions is not the widely cited costs of bailing out and recapitalizing the banking system. In fact, the biggest driver of debt increases is the inevitable collapse in tax revenues that governments suffer in the wake of deep and prolonged output contractions.

3.1 *Unemployment*

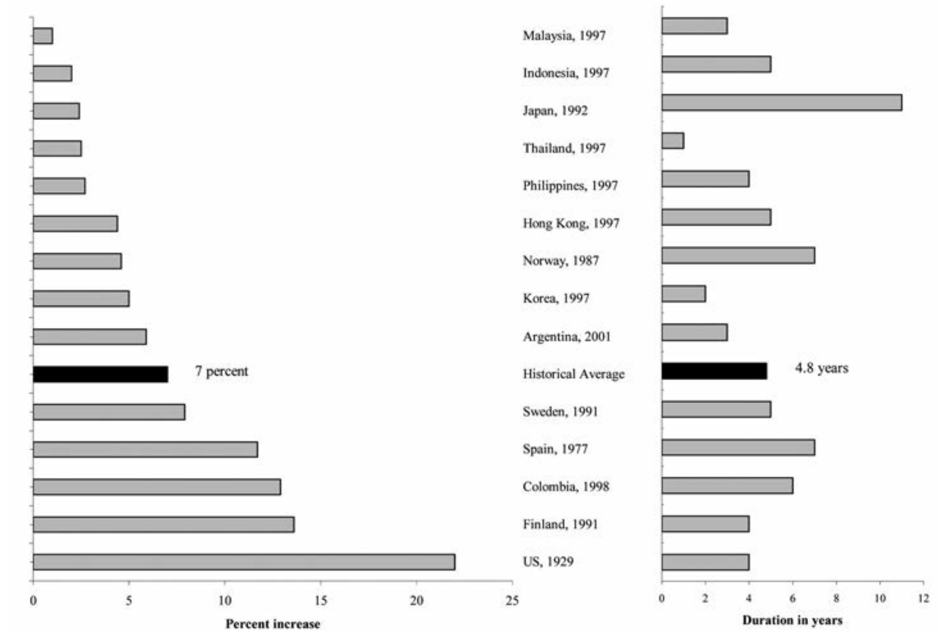
To illustrate, Graph 3 examines unemployment rates in the wake of the 14 worst financial crises in the *post* war. And what the left panel shows is the increase in the unemployment rate from the low point to the high point. So, it's the cumulative increase in unemployment for that particular crisis. What the right panel shows is the duration in years of the time it takes to go from the lowest unemployment level to the highest. On average from bottom to peak, unemployment increases by about 7 percentage points during the worst financial crises. In the US context, low point in unemployment in 2006 was around 4 percent - a 7 percentage point increase would take it to 11 percent. The average duration (bottom to peak) is 4.8 years.

These indices are the official unemployment rates; we are now all aware of more encompassing measures, such as U6 that are much higher than this when you take into account underemployment and so on. That's not reflected in these numbers.

To reiterate, recovery in the aftermath of severe financial crises are protracted affairs, in general.

Graph 3

PAST UNEMPLOYMENT CYCLES AND BANKING CRISES: TROUGH-TO-PEAK PERCENT INCREASE IN THE UNEMPLOYMENT RATE (LEFT PANEL) AND YEARS DURATION OF DOWNTURN (RIGHT PANEL)



Sources: OECD, IMF, Historical Statistics of the United States (HSOUS), various country sources, and authors' calculations.
Notes: Each banking crisis episode is identified by country and the beginning year of the crisis. Only major (systemic) banking crises episodes are included, subject to data limitations. The historical average reported does not include ongoing crises episodes.

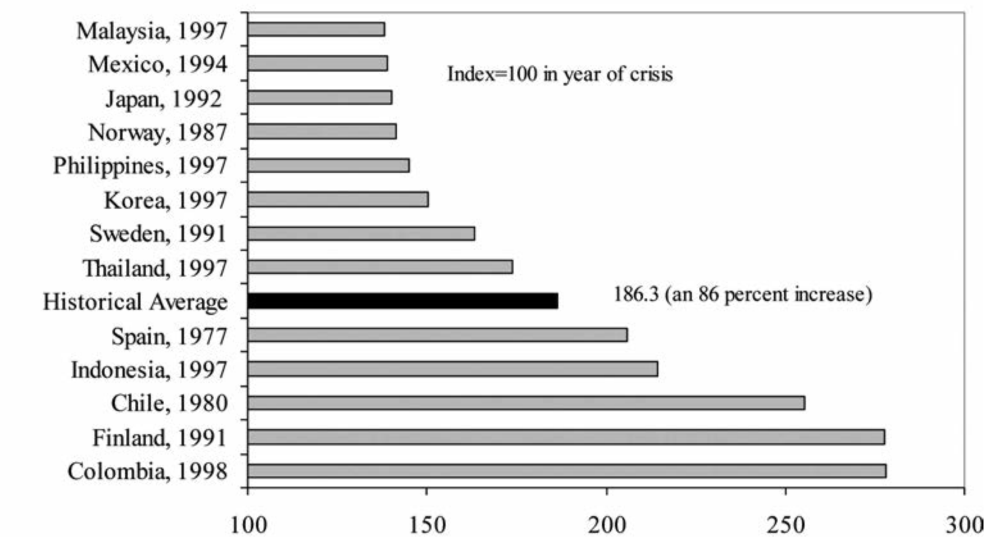
3.2 *Public Debt*

Where there is a substantial economic downturn, high and rising unemployment, and imploding real estate prices – major fiscal consequences should be expected. Not surprisingly, the true legacy of a major financial crisis is more government debt. Graph 4 shows the rise in real government debt in the three years following a banking crisis. The deterioration in government finances is striking, with an average debt rise of over 86 percent. We look at percentage increase in debt, rather than debt-to-GDP, because sometimes steep output drops would complicate interpretation of debt-GDP *ratios*. As Reinhart and Reinhart (2009) note, the characteristic huge buildups in government debt are driven mainly by sharp falloffs in tax revenue.

Importantly, however, another major contributor to the public debt buildup in past crises as well as the current one is the fact that private debts before a crisis become public debts afterwards. Nowhere is this pattern more evident in recent history that in Ireland, where the debt/GDP of general government stood at around 25 percent in 2007 and has since more than quadrupled.[3] In the United States, in early 2010 the transfer of the two mortgage giants, Fannie and Freddie, added 25 percent to the general government's debt-to-GDP *ratio*.

Graph 4

CUMULATIVE INCREASE IN REAL PUBLIC DEBT IN THE THREE YEARS FOLLOWING THE BANKING CRISIS



Sources: Reinhart M.C. and Rogoff K.S. (2009) and sources cited therein.
Notes: Each banking crisis episode is identified by country and the beginning year of the crisis. Only major (systemic) banking crises episodes are included, subject to data limitations. The historical average reported does not include ongoing crises episodes, which are omitted altogether, as these crises begin in 2007 or later, and debt stock comparison here is with three years after the beginning of the banking crisis.

[3] Reinhart M.C. (2010) documents numerous episodes where private debts ended up in the public sector balance sheet.

4. - Causes, Symptoms, and Amplifiers of Financial Crises

As to the causes of these great crises, we next focus on those factors that are common across time and geography; we discriminate between root causes of the crisis, its symptoms, and features such as financial regulation which serve as amplifiers of the boom-bust cycle. Pertinent to the globalization theme of this conference, the discussion begins with the link between financial liberalization (internal and external), the financial innovation and credit booms these spawn and banking crises.

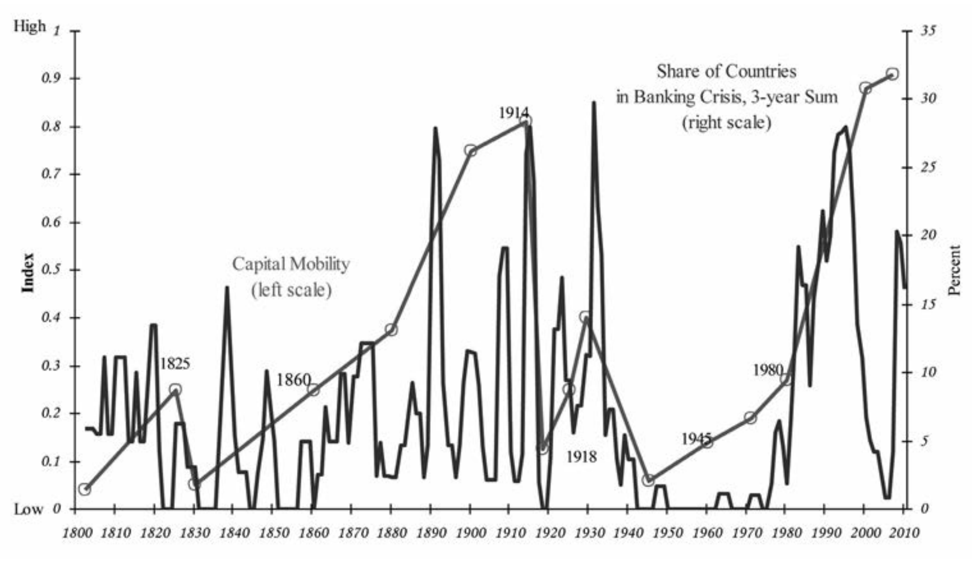
4.1 *The Roots*

There is a striking correlation between freer capital mobility and the incidence of banking crises, as shown in Graph 5. *Periods of high international capital mobility have repeatedly produced international banking crises, not only famously as they did in the 1990s, but historically.* The Graph plots a three-year moving average of the share of all countries experiencing banking crises on the right scale. On the left scale, we graph the index of capital mobility, due to Obstfeld and Taylor (2004), updated and back cast using their same design principle, to cover our full sample period. While the Obstfeld-Taylor index may have its limitations, we feel it nevertheless provides a concise summary of complicated forces by emphasizing *de facto* capital mobility based on actual flows.

For the *post*-1970 period, Kaminsky and Reinhart (1999) present formal evidence on the links of crises with financial liberalization. In 18 of the 26 banking crises they study, the financial sector had been liberalized within the preceding five years, usually less. In the 1980s and 1990s most liberalization episodes were associated with financial crises of varying severity. Only in a handful of countries (for instance, Canada) did financial sector liberalization proceed smoothly. Specifically, the paper presents evidence that the probability of a banking crisis conditional on financial liberalization having taken place is higher than the unconditional probability of a banking crisis.

GRAPH 5

CAPITAL MOBILITY AND THE INCIDENCE OF BANKING CRISES:
ALL COUNTRIES, 1800-2010



Sources: BORDO M. *et* AL. (2001); CAPRIO G. JR. and KLINGEBIEL D. (2003); CAPRIO G. *et* AL. (2005); KAMINSKY G. and REINHART C.M. (1999); LAEVEN L. and VALENCIA F. (2010); OBSTFELD M. and TAYLOR A.M. (2004) and these authors.

Notes: This sample includes *all* countries (even those not in our core sample of 66). The full listing of banking crises dates are shown in *APPENDIX* II. On the left scale, we updated our favorite index of capital mobility, admittedly arbitrary, but a concise summary of complicated forces. The smooth thin line shows the judgmental index of the extent of capital mobility given by OBSTFELD M. and TAYLOR A.M. (2004), back cast from 1800 to 1859 using their same design principle.

4.2 *The Setting*

Across countries and over the centuries, economic crises of all type follow a similar pattern. An innovation emerges. Sometimes it is a new tool of science of industry, such as the diving bell, steam engine, or the radio. Sometime it is a tool of financial engineering, such as the joint-stock company, junk bonds, or collateralized debt obligations. These usually accompany or are a direct result of financial liberalization, as described above. Investors may be wary at first, but then they see that extraordinary returns appear available on these new instruments and they rush in. Financial intermediaries – banks and investment companies – stretch their balance sheets so as not to be left out. The upward surge in asset prices continues, and that generation of financial market participants concludes that rules have been rewritten: risk has been tamed, and leverage is always rewarded. All too often, policy makers assert that the asset-price boom is a vote of confidence on their regime – that "this time is different". Only seldom, to my knowledge, do they protest that perhaps the world has not changed and that the old rules of valuation still apply. Marichal (1989), Winkler (1933) and Wynne (1951) all relate variants of this story in the chronicles of the crisis of the 19th and early 20th century.

But the old rules *do* apply. The asset price rise peters out, sometimes from exhaustion on its own or sometimes because of a real shock to the economy. This exposes the weaknesses of the balance sheets of those who justified high leverage by the expectation of outsized capital gains. Many financial firms admit losses, and some ultimately fail. All those financial firms hunker down, constricting credit availability in an effort to slim their balance sheets. With wealth lower and credit harder to get, economic activity typically contracts. Only after the losses are flushed out of the financial system and often with the encouragement of lagging monetary and fiscal ease does the economy recover.

4.3 *The Symptoms*

The recurring historical pattern described above is associated with some well-defined symptoms. I will focus here on a few of the symptoms or quantitative parallels (those listed in Table 1) that have been present during the current crisis in several countries and that we have seen systematically in numerous earlier crises in advanced and emerging market economies alike.[4] Specifically, large capital inflows, sharp housing and equity price run-ups lead the "leading indicator" group. So have been surges in private domestic and external debts. These symptoms are quantifiable, unlike the more nebulous amplifiers that are discussed in the remainder of this section.

TABLE 1

QUANTITATIVE ANTECEDENTS OF FINANCIAL CRISES:
THE "LEAD" OF THE LEADING INDICATORS

Large capital inflows
Sharp run-ups in equity prices
Sharp run-ups in housing prices
Inverted V-shaped growth trajectory
Marked rise in indebtedness

[4] These and other economic and financial indicators are analyzed in detail in KAMINSKY G. and REINHART C.M. (1999).

If we were to quantify periods of capital flow bonanzas – periods where *capital inflows* are unusually large – who comes up on the radar screen prior to the 2007-2009 crisis? As Reinhart and Reinhart (2009) document, in addition to the US and the UK, the other names that are listed there – Spain, Italy, Iceland, Ireland – are all countries that have had a period where the large capital inflows ended badly. Capital inflows facilitate domestic lending, fuel asset prices, and in most instances increase the indebtedness of the private sector, the public sector (if the government behaves procyclically), or both.

Table 2

CAPITAL INFLOWS TYPICALLY SURGE AHEAD OF FINANCIAL CRISIS

Countries with recent notable capital inflows	2006	2007	2008
Bulgaria	√	√	√
Iceland	√	√	√
Italy	√	√	√
Jamaica	√	√	√
Latvia	√	√	√
New Zealand	√	√	√
Pakistan	√	√	√
Romania	√	√	√
Slovenia	√	√	√
South Africa	√	√	√
Spain	√	√	√
Turkey	√	√	√
United Kingdom	√	√	√
United States	√	√	√

Source: Reinhart C.M. and Reinhart V.R. (2009).
Notes: For the full list of recent bonanza episodes see the paper.

There is a sense that the US *housing price bubble* during 2000-2006 (primarily) is both unique and unprecedented. The magnitude of the bubble is certainly unprecedented to the United States – at least during the past century for which we have comparable data. However, in a broader global context, the sub-prime bubble is neither unique to the US nor it magnitudes out of line with other real estate bubbles that have also ended equally lamentably in financial crises.

Graph 6 compares the run-up in housing prices. Period *T* represents the year of the onset of the financial crisis. By that convention, period *T-4* is four years prior to the crisis, and the graph in each case continues to *T+3*, except of course in the case of the US 2007 crisis, which remains in the hands of the fates.[5] The chart confirms the case study literature, showing the significant run-up in housing prices prior to a financial crisis. Notably, the run-up in housing prices in the United States exceeds that of the "Big Five" crises (Spain, 1977, Norway, 1987, Finland, 1991, Sweden 1991, and Japan 1992).

The boom in real housing prices (or real estate, and other asset prices, more broadly) is fueled by ample domestic credit availability, large capital inflows, and the easy liquidity environment that, and that this facilitates the boom. Coupling the ample liquidity environment with the presumption that *this time is different* and that the old rules of valuation do not apply, then you have the makings or the ingredients for a crisis.

As to *growth* (inverted V-shaped pattern) – growth does very well ahead of the crisis when credit is ample and wealth effects are positive (as asset prices climb) and falls subsequently. For further evidence the reader is referred to Reinhart and Rogoff (2011*b*).

I cannot stress enough the importance of the last entry in Table 1, *a marked rise in indebtedness*. Rising indebtedness can be domestic, external or both. In can be private, public or both. Any combination of these forms of rising indebtedness has been a hallmark of the *pre*-crisis period as far back as our data can take us. Perhaps Iceland illustrates this point in its most extreme form, as external debts rise from about 90 percent of GDP in 2000 to well over 900 percent of GDP in 2009. It is worth noting that stating that there are capital inflows is usually a different way of observing that a country is borrowing from the rest of the world.

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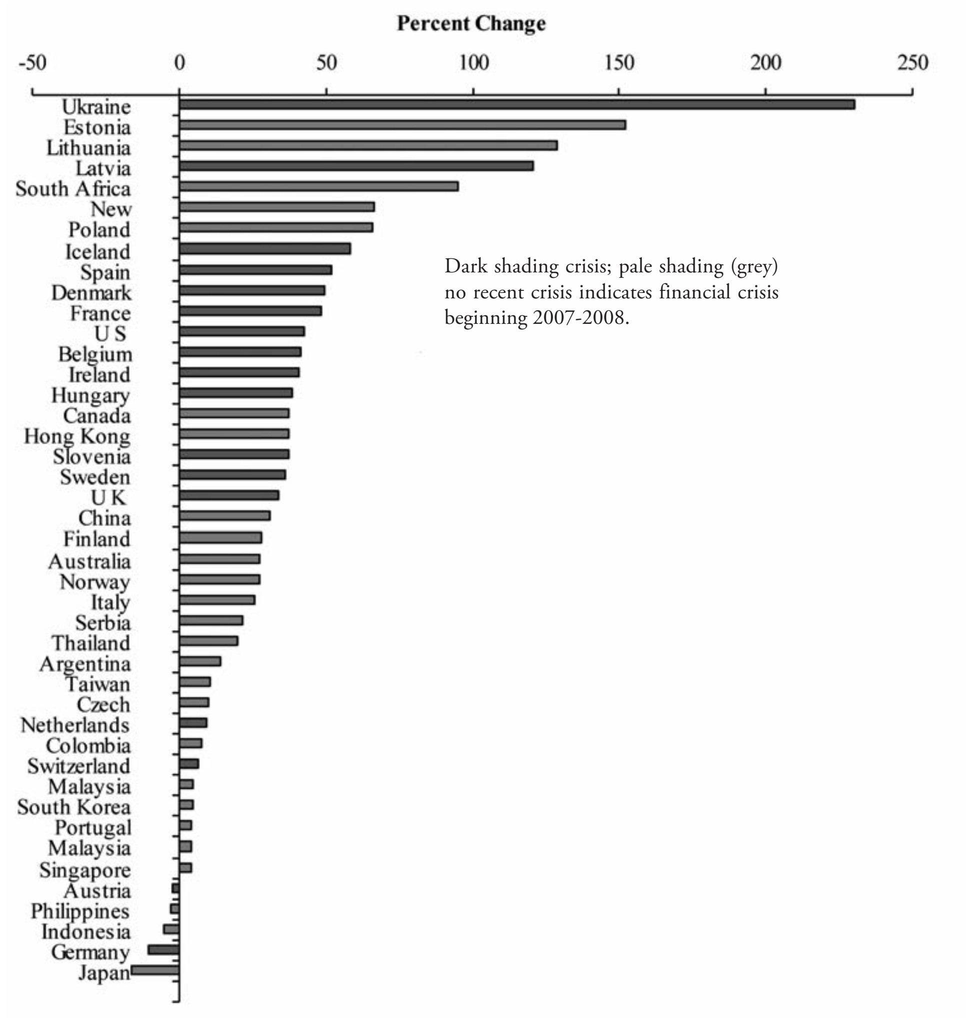
5 For the United States, house prices are measured by the Case-Shiller index, described and provided in SHILLER R. (2005).

GRAPH 6

PERCENT CHANGE IN REAL HOUSING PRICES (2002-2006)
AND BANKING CRISIS



Source: REINHART M.C. and ROGOFF K.S. (2009).

4.4 *The "Amplifiers"*

The list (shown on Table 3) of what I have dubbed the "usual suspects" (which ranges from pro-cyclical macroeconomic policies to overvalued currencies and myopic rating agencies) despite its breadth is not meant to be exhaustive. It is a list that has withstood the test of time, as several of these amplifiers come up on a recurring and it is those are not unique to the United States subprime crisis. Countless case studies of banking crises, across countries and time (see references in Reinhart and Rogoff, 2011*b*) list these factors on a recurring basis-often blamed as underlying causes of the crises. However, it is my view that these factors exacerbate both the boom and bust phases of the crisis cycle. For example, the stylized evidence presented in Caprio and Klingebiel (1996) suggests that inadequate regulation and lack of supervision at the time of the liberalization may play a key role in explaining why deregulation and banking crises are so closely entwined. But it is difficult to explain a cycle with a constant. Supervision may have always been lacking and the regulations ill defined. But such deficiencies may have limited consequences when credit conditions are tight (or in the case of emerging markets when access to international capital markets is not possible). If, on the other hand, financial liberalization (domestic and external) create lending possibilities that did not exist before, then inadequate supervision can make a bad lending scenario worse. Outright fraud, (often through connected lending) which crops up as another hardy perennial in studies of the run-up to crises works the same way.

The procyclicality of credit ratings (both at the sovereign and corporate levels, see Reinhart, 2002) also acts to amplify the cycle of lending and subsequent default and crash. Overvalued currencies are a magnet for capital inflows while procyclical fiscal policies add to the surge in borrowing during the boom phase of the cycle.

Far from being mutually exclusive many, if not most of the items in this list are present simultaneously in the most severe financial crises throughout history.

TABLE 3

AMPLIFIERS OF BOOM-BUST CYCLES: THE USUAL SUSPECTS

Procyclical macroeconomic policies
Hidden debts (implicit guarantees)
Overvalued currencies
Poor regulation
Even worse supervision
Outright fraud
Myopic credit rating agencies

4.5 *A Digression on the Sequencing of Crises*

Just as financial crises have common macroeconomic antecedents in asset prices, economic activity, external indicators and so on, *so common patterns appear in the sequencing (temporal order) in which crises unfold*. Obviously not all crises escalate to the extreme outcome of a sovereign default. Yet, advanced economies have not been exempt from their share of currency crashes, bouts of inflation, severe banking crises, and, in an earlier era, even sovereign default. The point of this short digression is to note that the long debt cycle we have discussed does not necessarily end with a banking crisis – more bad news usually follows – a stylized fact that should be kept in mind when trying to make sense of the current conjuncture.

Investigating what came first, banking or currency crises, was a central theme of Kaminsky and Reinhart's (1999) "twin crises" work; they also concluded that financial liberalization often preceded banking crises; indeed, it helped predict them. Demirgüç-Kunt and Detragiache (1999), who employed a different approach and a larger sample, arrived at the same conclusion. Gorton (1988) and Haberler (1937) also provide valutable insights into the business cycle-banking crisis genesis as shown in Graph 7. Reinhart (2002) examined the currency crash-external default link. Our work here has investigated the connections between domestic and external debt crises, inflation crises and default (domestic or external), and banking crises and external default.[6] Graph 7 maps out a "prototypical" sequence of events yielded by this literature.

As Diaz-Alejandro (1985) narrates in his classic paper about the Chilean experience of the late 1970s and early 1980s, financial liberalization simultaneously facilitates banks' access to external credit and more risky lending practices at home. After a while, following a boom in lending and asset prices, weaknesses in bank balance sheets become manifest and problems in the banking sector begin.[7] Often these problems are more advanced in the shakier institutions (such as finance companies) than in the major banks.

The next stage in the crisis unfolds when the central bank begins to provide support for these institutions by extending credit to them. If the exchange rate is

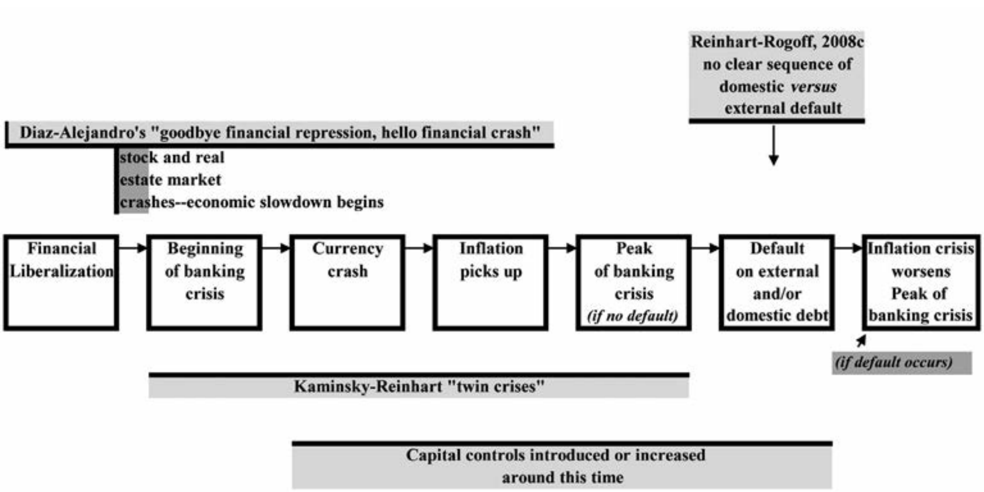
[6] Reinhart M.C. and Rogoff K.S. (2004) also examined the relationship between currency crashes and inflation as well as the currency crash–capital control (specifically, dual or multiple exchange rates) timing.

[7] In contrast to other studies of banking crises, Kaminsky G. and Reinhart C.M. (1999) provide two dates for each banking crisis episode – the beginning of a banking crisis and the later peak.

heavily managed (it does not need to be explicitly pegged), a policy inconsistency arises between supporting the exchange rate and acting as lender of last resort to troubled institutions[8]. The very numerous experiences in these studies suggest that (more often than not) the exchange rate objective is subjugated to the lender of last resort role of the central bank. Even if central bank lending to the troubled financial industry is limited in scope, the central bank may be more reluctant to engage in an "interest rate defense" policy to defend the currency than would be the case if the financial sector were sound. This brings the sequence illustrated in Graph 7 to the box labeled currency crash.

GRAPH 7

THE SEQUENCING OF CRISES: A PROTOTYPE



Sources: Authors' introspection based on empirical evidence from: DEMIRGÜÇ-KUNT A. and DETRAGIACHE E. (1998); DIAZ-ALEJANDRO C. (1985); KAMINSKY G. and REINHART C.M. (1999); KINDLEBERGER C.P. (1989); REINHART C.M. (2002); REINHART C.M. and ROGOFF K.S. (2004 and 2009), among others.

The depreciation or devaluation, as the case may be, complicates the situation in (at least) three dimensions: *(a)* it exacerbates the problem of the banks who have borrowed in a foreign currency, worsening currency mismatches; *(b)* inflation usually worsens (the extent to which the currency crisis translates into higher inflation is highly uneven across countries, as countries with a history of very high

[8] For an early model of this twin crisis sequence of banking and currenty crash, see VELASCO A. (1987).

and chronic inflation usually have a much higher and faster pass-through from exchange rates to prices); and *(c)* if the government has foreign currency–denominated debt, the currency depreciation increases the odds of an external and domestic default.

At this stage, the banking crisis either peaks following the currency crash, if there is no sovereign credit crisis, or keeps getting worse as the crisis mounts and the economy marches toward a sovereign default (the next box in Graph 7).

This is a very common pattern in the sequencing of crises. Notice the first entry there has financial liberalization. And financial liberalization is really not just liberalization proper, but big innovation, creations of new market. In the current conjuncture, the creation or the growth of securitization of mortgages is a big factor. Notice, perhaps more grimly, that the last entry is a debt crisis, which brings me to my remarks on debt resolution.

5. - From Goodbye Financial Repression, Hello Financial Crash to Goodbye Financial Crash-Hello Financial Repression?

Periods of high indebtedness have historically been associated with a rising incidence of default or restructuring of public and private debts. Sometimes the debt restructuring is subtle and takes the form of “financial repression”. In the heavily regulated financial markets of the Bretton Woods system, a variety of restrictions facilitated a sharp and rapid reduction in public debt/GDP *ratios* from the late 1940s to the 1970s. Reinhart, Kirkeegard, and Sbrancia (2011) document the resurgence of financial repression in the wake of the ongoing financial crises and the accompanying surge in public debts in advanced economies. This cycle in financial regulation is perhaps the last box in the flow chart shown in Graph 7.

In light of the record or near-record levels of public and private debt, deficit/debt reduction strategies are likely to remain at the forefront of policy discussions in most of the advanced economies for the foreseeable future.[9] Throughout history, debt/GDP *ratios* have been reduced by *(i)* economic growth; *(ii)* a substantive fiscal adjustment/austerity plans; *(iii)* explicit default or restructuring of private and/or public debt; *(iv)* a sudden surprise burst in inflation; and *(v)* a steady dosage of financial repression that is accompanied by an equally steady

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9 See Reinhart C.M., Kirkeegard J. and Sbrancia B. (2011).

dosage of inflation. (Financial repression is defined in Box 1) It is critical to clarify that options *(iv)* and *(v)* are only viable for domestic-currency debts (the euro area is a special hybrid case). Since these debt-reduction channels are not necessarily mutually exclusive, historical episodes of debt reduction have owed to a combination of more than one of these channels.

Financial repression is most successful in liquidating debts when accompanied by a steady dose of inflation. Low nominal interest rates help reduce debt servicing costs while a high incidence of *negative* real interest rates liquidates or erodes the real value of government debt. Inflation need not take market participants entirely by surprise and, in effect, it need not be very high (by historic standards).

5.1 *Financial Repression Defined*

Financial repression includes directed lending to the government by captive domestic audiences (such as pension funds or domestic banks), explicit or implicit caps on interest rates, regulation of cross-border capital movements, and (generally) a tighter connection between government and banks, either explicitly through public ownership of some of the banks or through heavy "moral suasion". Financial repression is also sometimes associated with relatively high reserve requirements (or liquidity requirements), securities transaction taxes, prohibition of gold purchases (as in the US from 1933 to 1974), or the placement of significant amounts of government debt that is nonmarketable.

In the current policy discussion, financial repression issues come under the broad umbrella of "macroprudential regulation".

We suggest that the combination of high public and private debts in the advanced economies (and the attendant pressures towards creating captive audiences for government debt) and the perceived dangers of currency misalignments and overvaluation in emerging markets facing surges in capital inflows (and, thus, the pressures towards currency intervention and capital controls) interact to produce a "home bias" in finance and a resurgence of financial repression. It is not called financial repression but unfolds in the context of "macroprudential regulation".

Succinctly, while emerging markets may increasingly look to financial regulatory measures to keep international capital "out" (especially as the expansive monetary policy stance of the US and others persists), advanced economies have incentives to keep capital "in" and create a domestic captive audience to facilitate the financing for the high existing levels of public debt. Concerned about potential overheating, rising inflationary pressures and the related competitiveness issues, emerging market economies are altering the regulatory frameworks that deter cross-border financial flows in their eternal quest for higher yields. This offers advanced and emerging market economies the common ground of agreeing to increased regulation and/or restrictions on international financial flows and, more broadly, the return to more tightly regulated domestic financial environment – often referred to as "financial repression".

5.2 *Negative Real Interest Rates during 1945-1980 and Again* Post-*2008*

One of the main goals of financial repression is to keep nominal interest rates lower than would otherwise prevail. This effect, other things equal, reduces the governments' interest expenses for a given stock of debt and contributes to deficit reduction. However, when financial repression produces negative real interest rates and reduces or liquidates existing debts, it is a transfer from creditors (savers) to borrowers (in the historical episode documented in Reinhart and Sbrancia, 2011 and summarized here – the government).

The financial repression tax has some interesting political-economy properties. Unlike income, consumption, or sales taxes, the "repression" tax rate (or rates) are determined by financial regulations and inflation performance that are opaque to the highly politicized realm of fiscal measures. Given that deficit reduction usually involves highly unpopular expenditure reductions and (or) tax increases of one form or another, the relatively "stealthier" financial repression tax may be a more politically palatable alternative to authorities faced with the need to reduce outstanding debts.

Liberal capital-market regulations and international capital mobility reached their heyday prior to World War I under the gold standard. However, the Great Depression, followed by World War II, put the final nails in the coffin of *laissez-faire* banking. It was in this environment that the Bretton Woods arrangement of fixed exchange rates and tightly controlled domestic and international capital markets was conceived. The result was a combination of very low nominal interest rates and inflationary spurts of varying degrees across the advanced economies.[10] The obvious results were real interest rates – whether on treasury bills (Graph 8), central bank discount rates, deposits or loans – that were markedly negative during 1945-1946.

[10] The advanced economy aggregate is comprised of: Australia, Belgium, Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, New Zealand, Sweden, the United States, and the United Kingdom. Interest rates for 2011 only reflect monthly observations through February.

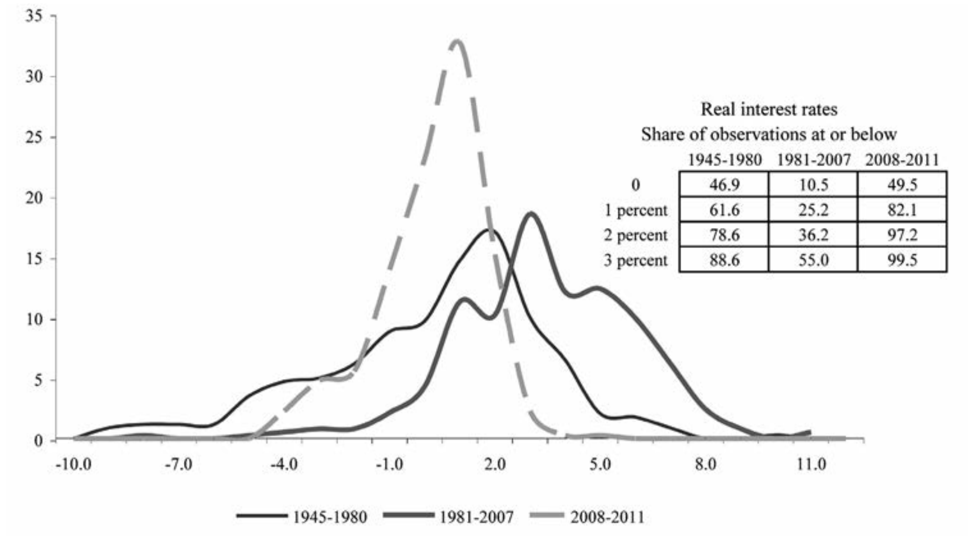
For the next 35 years or so, real interest rates in both advanced and emerging economies would remain consistently lower than the eras of freer capital mobility before and after the financial repression era. In effect, real interest rates were, on average negative. Binding interest rate ceilings on deposits (which kept real *ex-post* deposit *rates even more negative* than real *ex-post* rates on treasury bills) "induced" domestic savers to hold government bonds. What delayed the emergence of leakages in the search for higher yields (apart from prevailing capital controls) was that the incidence of negative returns on government bonds and on deposits was (more or less) a universal phenomenon at this time. The frequency distributions of real rates for the period of financial repression (1945-1980) and the years following financial liberalization shown in Graph 8, highlights the universality of lower real interest rates prior to the 1980s and the high incidence of negative real interest rates.

A striking feature of Graph 8, however, is that real *ex-post* interest rates (shown for treasury bills) for the advanced economies have, once again, turned increasingly negative since the outbreak of the crisis. Real rates have been negative for about one half of the observations and below one percent for about 82 percent of the observations. This turn to lower real interest rates has materialized despite the fact that several sovereigns have bee teetering on the verge of default or restructuring (with the attendant higher risk premia). Real *ex-post* central bank discount rates and bank deposit rates (not shown here) have also become markedly lower since 2007.

No doubt, a critical factor explaining the high incidence of negative real interest rates in the wake of the crisis in the aggressively expansive stance of monetary policy (and more broadly, official central bank intervention) in many advanced and emerging economies during this period. This raises the broad question of to what extent current interest rates reflect market conditions *versus* the stance of official large players in financial markets. A large role for non-market forces in interest rate determination is a key feature of financial repression.

Graph 8

REAL INTEREST RATES FREQUENCY DISTRIBUTIONS: ADVANCED ECONOMIES, 1945-2011
TREASURY BILL RATES



Sources: Reinhart C.M., Kirkeegard J. and Sbrancia B. (2011), *International Financial Statistics,* International Monetary Fund, various sources listed in the Data Appendix, and authors' calculations.
Notes: The advanced economy aggregate is comprised of: Australia, Belgium, Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, New Zealand, Sweden, the United States, and the United Kingdom.
Interest rates for 2011 only reflect monthly observations through February.

6. - Concluding Reflections

I have already discussed the consequences of high public and private debts in the advanced economies and the attendant pressures towards financial repression to ease the burden of debt servicing. Not discussed here but a re-enforcing trend is the perceived dangers of currency misalignments and overvaluation in emerging markets, and the attendant pressures towards currency intervention and capital controls – connected to the broader issue of "macroprudential regulation" – a part of the evolving trend toward greater financial repression.

The two sets of pressures on central banks, in the North and South, are complementary. While emerging markets may increasingly look to financial regulatory measures to keep international capital "out" (especially as the expansive monetary policy stance of the US and Europe persists as it is likely), advanced economies have incentives to keep capital "in" and create a domestic captive audience to facilitate the financing for the high existing levels of public debt. Concerned about potential overheating, rising inflationary pressures and the related competitiveness issues, emerging market economies may welcome changes in the regulatory landscape that keep financial flows at home rather than let them spill across borders. This offers advanced and emerging market economies the common ground of agreeing to increased regulation and/or restrictions on international financial flows and, more broadly, the return to more tightly regulated domestic financial environment – "financial repression".

The scenario sketched here entails both financial de-globalization (the re-appearance of home bias in finance) and the re-emergence of more heavily regulated domestic financial markets. As some of these trends are already unfolding in individual countries, it is a useful exercise to examine these developments as part of a broader global picture.

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WINNING PAPERS

Structural Macroeconomic Analysis for Dynamic Factor Models

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In this work we review some recent papers concerned with large dynamic factor model (LDFM) and its applications to structural macroeconomic analysis. Using this theory, we present a new empirical application on the effects of technology and non technology shocks on hours worked.
[JEL Classification: C01; C32; E32].

Keywords: dynamic factor model; fundamentalness; identification; estimation; consistency; (non) technology shocks; hours worked, productivity.

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* <*maddalena.cavicchioli@unive.it*>. This essay is taken from my M.Sc. thesis defended at the University of Modena and Reggio Emilia. I am especially grateful to my advisor, Prof. Mario Forni, for helpful suggestions and enlightening conversations as this work progressed. I would also like to thank the three anonymous *referees* of the *Rivista di Politica Economica* for their helpful comments and remarks which were most valuable in writing the final version of the paper. I also wish to thank the Managing Editor of the journal, Prof. Gustavo Piga, for his kind attention and consideration. Finally, I am the only one responsible for any possible mistake in this work.

1. - Introduction

Factor models have been used by several authors to address many different economic issues nowadays. Recent literature has focused on models specifically designed to handle a large amount of information: the *generalized dynamic factor models* (Forni, Hallin, Lippi and Reichlin, 2000; Forni and Lippi, 2001; Stock and Watson, 2002*a*, 2002*b*; Bai and Ng, 2002). Such models have been successfully used for forecasting and, recently, also for structural macroeconomic analysis (Forni, Giannone, Lippi, Reichlin, 2009, FGLR hereafter; Forni and Gambetti, 2010). The main idea underlying factor analysis is that a large set of variables can be explained by a small number of latent variables, the *factors*, which are responsible for all the relevant dynamics. Factor analysis is a technique of dimension reduction that takes the information contained in a large data set and summarizes it by means of a few unobservable variables. In this context, it is assumed that macroeconomic observable variables are represented as the sum of two unobservable components, called the *common component* and the *idiosyncratic component*.

The common component captures that part of the series which varies with the rest of the economy and the idiosyncratic component is the residual. The idiosyncratic components are not necessarily orthogonal to each other, and they are not of direct interest for the analysis since they arise from measurement errors or sectorial sources of variation. The vector of the common components is highly singular, *i.e.*, it is driven by a very small number of shocks (the "common shocks" or "common factors") as compared to the number of variables. Furthermore, the relation between the common part of the observable series and the factors is assumed to be linear. Structural analysis requires the identification of the macroeconomic shocks and their dynamic effect on macroeconomic variables.

The approach is a combination of structural vector autoregression (SVAR) analysis and large-dimensional dynamic factor models. More precisely, the factor model is used to consistently estimate common and idiosyncratic components of macroeconomic variables. Then the identification of the relationship between common components and macroeconomic shocks can be obtained just in the same way as in SVAR models, and the impulse response functions can be consistently estimated by means of a relatively simple procedure. In this paper we review some recent papers concerned with large dynamic factor model theory and its applications to structural macroeconomic analysis. Moreover, we present a new empirical application on the effects of technology shocks on hours worked. In detail, the paper is organized as follows. In Section 2 we describe the theory behind the dynamic factor model, its identification and estimation. We also consider the problem of nonfundamentalness and show how dynamic factor models can help to avoid it. In addition, we propose a new boot-strap procedure to obtain standard errors and confidence bands. In Section 3 we use the FGLR model and the related estimation procedure to analyze a controversial issue: the effects of technology shocks on hours worked. Our results turn out to be in contrast to the ones obtained from the well-known VAR of Galí (1999). We use 103 US quarterly macroeconomic series covering the period January 1959 - December 2007, and we identify assuming technology shocks as the only source of permanent shifts in labour productivity. Within a VAR model, such identification produces a negative correlation between hours and productivity rates. We find that in the dynamic factor model, the correlation is positive, meaning that hours worked increase in response to a positive technology shock. This discrepancy between VAR and factor model results could be due to overdifferentiation and unit root. In the Appendix we review some criteria to determine the number of factors and present the data set.

2. - A Dynamic Factor Model

In this section we illustrate the basic definitions and results concerned with a dynamic factor model, briefly called the *FGLR model*, introduced and studied by Forni *et* al. (2009).

1) THE MODEL. Denote by $\boldsymbol{x}_n^T = (x_{it})_{i=1,\dots,n;t=1,\dots,T}$ an $n \times T$ rectangular array of observations, and make two preliminary assumptions:

PA1. *The array $\boldsymbol{x}_n^T$ is a finite realization of a real-valued stochastic process*

$$X = \{x_{it} : i \in \mathbb{N}, t \in \mathbb{Z}, x_{it} \in L_2(\Omega, F, P)\}$$

where the n-*dimensional vector processes* $\{\boldsymbol{x}_{nt} = (x_{1t} \dots x_{nt})' : t \in \mathbb{Z}\}_{n \in \mathbb{Z}}$ *are stationary, with zero mean and finite second-order moments* $\Gamma^x_{nt} = E(\boldsymbol{x}_{nt} \boldsymbol{x}'_{n,t-k})$ *for every* $k \in \mathbb{N}$.

PA2. *For all* $n \in \mathbb{N}$, *the process* $\{\boldsymbol{x}_{nt} : t \in \mathbb{Z}\}$ *admits a Wold representation* $\boldsymbol{x}_{nt} = \sum_{k=0}^{\infty} C_k^n \boldsymbol{w}_{n,t-k}$ *where the full-rank innovations* $\boldsymbol{w}_{nt}$ *have finite moments of order four and the matrices* $C_k^n = (c_{ij,k}^n)$ *satisfy* $\sum_{k=0}^{\infty} |c_{ij,k}^n| < \infty$ *for all i, j,* $\in \mathbb{N}$.

The FGLR model is obtained by assuming that each variable x_{it} is the sum of two unobservable components $x_{it} = \chi_{it}+\xi_{it}$, where χ_{it} (resp. ξ_{it}) is called the *common* (resp. *idiosyncratic*) component. The common component χ_{it} is driven by *q common shocks* $\boldsymbol{u}_t = (u_{1t} \cdots u_{qt})'$ for q independent of n and $q<<n$. More precisely:

FM0. (*Dynamic factor structure of the model* FGLR) Defining $\boldsymbol{\chi}_{nt}=(\chi_{1t}\cdots\chi_{nt})'$ and $\boldsymbol{\xi}_{nt}=(\xi_{1t}\cdots\xi_{nt})'$, suppose that

(1.1) $$\boldsymbol{x}_{nt}=\boldsymbol{\chi}_{nt}+\boldsymbol{\xi}_{nt} = B_n(L)\boldsymbol{u}_t+\boldsymbol{\xi}_{nt}$$

where $\boldsymbol{u}_t$ is a q-dimensional orthonormal white-noise vector, that is, $E(\boldsymbol{u}_t\boldsymbol{u}_t')=\mathbf{I}_q$ for all t. The shocks $\boldsymbol{u}_t$ will be called *dynamic factors*.

Moreover, assume that

(1.2) $$B_n(L) = A_nN(L)$$

where:

i) $N(L)$ is an $r \times q$ absolutely summable matrix function of L, that is,

$$N(L) = \sum_{k=0}^{\infty} \Psi_k L^k \quad \sum_{k=0}^{\infty} \Psi_{jh,k} <\infty \quad \text{for all } j,\ h$$

where

$$\boldsymbol{\Psi}_k=(\Psi_{jh,k})_{j=1,\ldots,r;\ h=1,\ldots,q}$$

ii) $A_n=(a_{ij})_{i=1,\ldots,n;\, j=1,\ldots,r}$ is an $n \times r$ matrix, nested in A_m for all $m>n$.

Defining the $r\times1$ vector $\boldsymbol{f}_t=(f_{1t}\cdots f_{rt})'$, called the *static factor*, as

(1.3) $$\boldsymbol{f}_t=N(L)\boldsymbol{u}_t$$

Equation *(1.1)* can be rewritten in the static form

(1.4) $$\boldsymbol{x}_{nt}=A_n\boldsymbol{f}_t+\boldsymbol{\xi}_{nt}$$

From *(1.1)* and *(1.4)* we get

(1.5) $$\boldsymbol{\chi}_{nt}= A_n\boldsymbol{f}_t$$

hence

$$\chi_{it} = \sum_{j=1}^{r} a_{ij} f_{jt}$$

This means that all the variables χ_{it}, i=1,...,∞ belong to the finite dimensional vector space spanned by $f_t=(f_{1t} \cdots f_{rt})'$.

Following Forni *et* al. (2009), we are going to illustrate some conditions under which the shocks $\mathbf{u}_t$ can be identified and estimated by means of the observable variables x_{it}. First, we recall the assumptions necessary for the identification and the estimation of the common components χ_{it}.

FM1. (*Orthogonality of common and idiosyncratic components*)
For all n, the vector $\boldsymbol{\xi}_{nt}$ *is stationary, and* $E(\mathbf{u}_t \boldsymbol{\xi}'_{nt})=0$ *for any* $t,\tau \in \mathbb{Z}$ *and* $n \in \mathbb{N}$.

Let $\Gamma^x_{nk}=E(\mathbf{x}_{nt}\mathbf{x}'_{n,t-k})$, $\Gamma^x_{nt}=E(\boldsymbol{\chi}_{nt}\boldsymbol{\chi}'_{n,t-k})$ and $\Gamma^{\xi}_{nk}=E(\boldsymbol{\xi}_{nt}\boldsymbol{\xi}'_{n,t-k})$ be the k-lag covariance matrices of $\mathbf{x}_{nt}$, $\boldsymbol{\chi}_{nt}$ and $\boldsymbol{\xi}_{nt}$, respectively. Denote by μ^x_{nj}, μ^{χ}_{nj} and μ^{ξ}_{nj} the j-th eigenvalue, in decreasing order, of Γ^x_{n0}, Γ^{χ}_{n0} and Γ^{ξ}_{n0}, respectively.

FM2. (*Pervasiveness of common dynamic and static factors*)

a) *The complex matrix* $N(e^{-i\theta})$ *has* (*maximum*) *rank q for* θ *almost everywhere in* $[-\pi, \pi]$;

b) *There exist positive real constants* $\underline{c}_j<\overline{c}_j$, $j=1,\dots,r$, *such that* $\underline{c}_j>\overline{c}_{j+1}$, $j=1,\dots,r-1$, *and*

$$\underline{c}_j \le \liminf_{n\to\infty} \frac{\mu^{\chi}_{nj}}{n} \le \limsup_{n\to\infty} \frac{\mu^{\chi}_{nj}}{n} \le \overline{c}_j$$

Proposition 1.1 *Under assumption* FM2, *the r×r matrix* $A_n'A_n$ *has full rank r for n sufficiently large.*

Assumption FM2 also implies that the common components χ_{it} are identified (see Chamberlain and Rothschild, 1983), and that the number q is unique, *i.e.*, a representation of type *(1.1) - (1.4)* with a different number of dynamic factors is not possible (see Forni and Lippi, 2001).

FM3. (*Non-pervasiveness of the idiosyncratic components*)
There exists a real number d such that $\mu^{\xi}_{n1} \le d$ *for any* $n \in \mathbb{N}$. *This obviously implies that* $\mu^{\xi}_{nj} \le d$ *for any* $n \in \mathbb{N}$ *since such eigenvalues are in decreasing order.*

Assumption FM3, jointly with the identification of the common components χ_{it}, implies that the vector space spanned by the r static factors $f_{1t},\cdots,f_{rt}$ (in $\mathbf{f}_t$) is identified, or, equivalently, $\mathbf{f}_t$ is identified, up to non-singular linear transformation.

In conclusion, given a model of type *(1.1)-(1.4)*, then under assumption FM0-FM3 the integers q and r, the components χ_{it} and ξ_{it}, and the vector space spanned by $\mathbf{f}_t$ are identified.

2) FUNDAMENTALNESS. First we recall briefly some basic notions on fundamental representations of stationary stochastic vectors. Assume that the n stochastic vector $\boldsymbol{\mu}_t$ admits a moving average (MA) representation

$$\boldsymbol{\mu}_t = K(L)\mathbf{v}_t \qquad (2.1)$$

where $K(L)$ is an $n \times q$ square-summable filter and $\mathbf{v}_t$ is a q-dimensional white noise.

DEFINITION 2.1 If $\mathbf{v}_t$ belongs to the vector space spanned by present and past values of $\boldsymbol{\mu}_t$, then the MA in *(2.1)* is said to be *fundamental*, and $\mathbf{v}_t$ is called *fundamental* for $\boldsymbol{\mu}_t$.

Without loss of generality, we can suppose that $q \leq n$ and that $\mathbf{v}_t$ is full rank. Moreover, for our purposes, we can assume that the entries of $K(L)$ are rational functions of L and that the rank of $K(z)$, $z \in \mathbb{C}$, is maximal, *i.e.*, it is q except for a finite number of complex numbers.

PROPOSITION 2.1 *The MA representation in (2.1) is fundamental if and only if the rank of* $K(z)$ *is* q *for all complex numbers* z *such that* $|z|<1$.

For the proof see Rozanov (1967).

Fundamentalness plays an important role in the identification of the structural shocks in SVAR analysis. SVAR analysis starts with the projection of a full rank q-dimensional vector $\boldsymbol{\mu}_t$ on its past, thus producing a q-dimensional full rank fundamental white-noise $\mathbf{w}_t$. Then the structural shocks are obtained as a linear transformation $A\mathbf{w}_t$, where the matrix A arises from economic theory statements. This is equivalent to assuming that the structural shocks are fundamental. Here fundamentalness has the effect of enormously simplifying the identification problem (see Subsection 3 below). However, economic theory, in general, does not provide support for fundamentalness, so that all representations that fulfill the same economic statements, but are not fundamental, are ruled out in SVAR analysis with no justification. Such representations, although they imply the same autocovariance structure, cannot be obtained from inversion of estimated VARs.

The situation changes if the structural analysis is conducted assuming that n is large with respect to q. The fundamentalness is also required by dynamic factor models, but it is a condition less pressing than in VARs. The first reason is that non-fundamentalness of structural shocks arises when the econometrician's information set is smaller than the agent's. The second reason comes from a mathematical background. More precisely, a crucial step in our analysis is the dynamic specification of the common components $\boldsymbol{\chi}_{nt}$ as vector autoregression (VAR) driven by only q macroeconomics shocks $\mathbf{u}_t$, *i.e.*, $\boldsymbol{\chi}_{nt}=A_nN(L)\mathbf{u}_t$, where $q<n$. So the model contains only q variables; assume such variables are χ_{jt}, $j=1,\dots,q$, and they cannot ensure fundamentalness of $\mathbf{u}_t$. By Proposition 2.1, the rank of $B_n(z)$ is less than q for some complex numbers z with $|z|<1$, or equivalently, the polynomials $B_{nj}(z)$, $j=1,\dots,q$, have a common root. However, the informational advantage of the agents may disappear if the econometrician observes a large set of additional macroeconomic shocks. The generating process of χ_{jt}, $j=q+1,\dots,n$, contains parameters that do not belong to the generating process of χ_{jt}, $j=1,\dots,q$, and viceversa. Therefore, in all likelihood, their dynamic responses to $\mathbf{u}_t$ are sufficiently *heterogeneous*, with respect to the first q, to prevent the rank reduction of $B_n(z)$. Now Assumption FM2(b) implies that, for n sufficiently large, A_n has full rank r. Then $N(L)$ has full rank q and it is left-invertible. So the concept of fundamentalness can be adapted to our specification of the dynamic factor model, as follows:

FM4. (*Fundamentalness*) *The matrix function* $N(L)$ *in* (*1.2*) *is left invertible,* i.e.*, there exists a* $q\times r$ *square-summable filter* $G(L)$ *such that* $G(L)N(L)=\mathbf{I}_q$.

The following proposition shows that FM4, jointly with FM2, implies fundamentalness in the sense of Definition 2.1.

Proposition 2.2 *If* FM0-FM4 *are satisfied, then* $\mathbf{u}_t$ *is fundamental for* $\boldsymbol{\chi}_{nt}$ *for n sufficiently large, and therefore fundamental for* χ_{it}, $i=1,\dots,\infty$. *Moreover,* $\mathbf{u}_t$ *belongs to the vector space spanned by present and past values of* x_{it}, $i=1,\dots,\infty$, *that is, the shocks* u_{ht} *can be recovered as limits of linear combinations of the variables* x_{it}.

For the proof see Forni *et* al. (2009).

To introduce the last assumption, a VAR specification for $\mathbf{f}_t$, let us consider the orthogonal projection of $\mathbf{f}_t$ on the space spanned by its past values

$$\mathbf{f}_t = Proj(\mathbf{f}_t \,|\mathbf{f}_{t-1},\mathbf{f}_{t-2},\ldots)+\mathbf{w}_t \tag{2.2}$$

where $\mathbf{w}_t$ is the r-dimensional vector of the residuals. Under our assumptions, $\mathbf{w}_t$ has rank q. Moreover, by the same argument used to prove Proposition 3.1 in the next subsection, assumption FM4 implies that $\mathbf{w}_t = R\mathbf{u}_t$ where R is a maximum-rank $r\times q$ matrix. In the sequel we will adopt the VAR(p) specification:

FM4'. (*Fundamentalness: VAR*(*p*) *specification*)
The r*-dimensional static factors* $\mathbf{f}_t$ *admit a VAR*(*p*) *representation*

$$\mathbf{f}_t = D_1\,\mathbf{f}_{t-1}+\cdots+D_{\mathrm{p}}\,\mathbf{f}_{t-p}+R\mathbf{u}_t \tag{2.3}$$

where D_i *is* $r\times r$ *and* R *is a maximum-rank matrix of dimension* $r\times q$.

By *(2.3)* we have

$$\mathbf{f}_t = (I - D_1 L - \cdots - D_p L^p)^{-1}\, R\mathbf{u}_t$$

hence

$$\boldsymbol{\chi}_{nt} = A_n\,(I - D_1 L - \cdots - D_p L^p)^{-1} R\mathbf{u}_t$$

by *(1.5)*. So Equation *(1.1)* yields

$$B_n(L) = A_n\,(I - D_1 L - \cdots - D_p L^p)^{-1} R \tag{2.4}$$

called the *impulse-response function* (IRF) of the lags L.

3) Identification. As proved in Forni *et* al. (2009), Assumptions FM0-FM4 allow for the identification of shocks $\mathbf{u}_t$, up to a static rotation. More precisely, we have the following result

Proposition 3.1 *Let us consider the common components*

$$\boldsymbol{\chi}_{nt}=B_n(L)\mathbf{u}_t \tag{3.1}$$

of model (1.1), under assumptions FM0-FM4.

If

$$\boldsymbol{\chi}_{nt}=C_n(L)\mathbf{v}_t \tag{3.2}$$

for any $n \in \mathbb{N}$, where the function matrices $C_n(L)$ are nested and $\mathbf{v}_t$ is a q-dimensional fundamental orthonormal white noise vector, then representation (3.2) is related to (3.1) by

$$\mathbf{u}_t = H\mathbf{v}_t \qquad B_n(L)=C_n(L)H'$$

where H is a $q \times q$ orthonormal matrix, i.e., $HH'=I_q$.

For the proof see Forni *et* al. (2009).

Since fundamentalness of the structural shocks can be assumed in the dynamic factor model framework, identification is reduced to the choice of an orthogonal matrix H such that, without loss of generality, the economic restrictions concern the first $m \leq n$ variables for the matrix $B_m(L)H$ (just as in structural VARs). For instance, identification can be achieved by maximizing or minimizing an objective function involving $C_m(L)=B_m(L)H$. Notice that, under assumptions FM0-FM4, the number of economic restrictions we need to identify the shocks depends on q and not on n. This is an advantage for structural analysis, since, provided q is small, we need few restrictions for identification while we are not limited on the informational assumptions (that is, the size n of the panel).

4) Estimation. The following procedure of estimation can be found in Forni and Gambetti (2010) (see also Forni *et* al., 2009, Sect. 4.2).

STEP 1) First, we need to set value for the number r of the static factors $\mathbf{f}_t=(f_{1t}\cdots f_{rt})'$. Bai and Ng (2002) proposed some consistent criteria to determine an estimation of r. This method is described in details in Appendix A, Sect. 1. Let $\hat{r}$ denote an estimation of r obtained by such criteria.

STEP 2) We estimate the static factors $\mathbf{f}_t$, up to a non-singular linear transformation, by means of the first $\hat{r}$ ordinary principal components of the variables $\mathbf{x}_{nt}$ in the data set. Setting

$$\hat{\Gamma}_k^x = \frac{1}{T} \sum_{h=k+1}^{T} \mathbf{x}_{nt}\mathbf{x}'_{n,t-k}$$

and $\hat{\mu}_j^x$ the jth greatest eigenvalue of the sample variance matrix $\hat{\Gamma}_o^x$, the ordinary principal components method gives

$$\hat{\mathbf{f}}_t = (\hat{f}_{1t} \dots \hat{f}_{\hat{r}t})' = \hat{A}'_n \mathbf{x}_{nt} = \begin{pmatrix} \hat{a}_{11} & \cdots & \hat{a}_{n1} \\ \hat{a}_{12} & \cdots & \hat{a}_{n2} \\ \vdots & & \vdots \\ \hat{a}_{1\hat{r}} & \cdots & \hat{a}_{n\hat{r}} \end{pmatrix} \begin{pmatrix} x_{1t} \\ x_{2t} \\ \vdots \\ x_{nt} \end{pmatrix}$$

where $\hat{A}_n$ is the $n \times \hat{r}$ matrix having on the jth column the normalized eigenvector $\hat{a}_j = (\hat{a}_{1j} \hat{a}_{2j} \cdots \hat{a}_{nj})'$ corresponding to $\hat{\mu}_j^x$ for $j = 1, \cdots, \hat{r} \leq n$, hence

$$\hat{A}_n = \begin{pmatrix} \hat{a}_{11} & \cdots & \hat{a}_{1\hat{r}} \\ \hat{a}_{21} & \cdots & \hat{a}_{2\hat{r}} \\ \vdots & & \vdots \\ \hat{a}_{n1} & \cdots & \hat{a}_{n\hat{r}} \end{pmatrix} = \left(\hat{a}'_1 \hat{a}'_2 \cdots \hat{a}'_{\hat{r}} \right)'$$

STEP 3) We set a number of lags $\hat{p}$ and run a VAR($\hat{p}$) as in *(2.3)* with the estimated static factors $\hat{\mathbf{f}}_t$ to get estimates $\hat{D}(L)$ and $\hat{\boldsymbol{\varepsilon}}_t$ of the matrix function $D(L)$ and the residuals $\boldsymbol{\varepsilon}_t$, respectively. Recall that $\boldsymbol{\varepsilon}_t = R\mathbf{u}_t$ in *(2.3).*

STEP 4) We estimate the number q of the dynamic factors $\mathbf{u}_t = (u_{1t} \cdots u_{qt})'$ obtained by using three criteria which are summarized in Appendix A, Section 2. Denote this estimate by $\hat{q}$.

STEP 5) Now let $\hat{\Gamma}^{\varepsilon}$ denote the sample variance-covariance matrix of the estimated residuals $\hat{\boldsymbol{\varepsilon}}_t$. Having an estimate $\hat{q}$ of the number of dynamic factors $\hat{\mathbf{u}}_t = (u_{1t} \cdots u_{\hat{q}t})'$, we obtain an estimate of a non-structural representation of the common components by using the spectral decomposition $\hat{\Gamma}^{\varepsilon}$. More precisely, let $\hat{\mu}_j^{\varepsilon}$, $j=1, \dots, \hat{q}$, be the jth eigenvalue of $\hat{\Gamma}^{\varepsilon}$, taken in decreasing order, $|\hat{\mu}_1^{\varepsilon}| > \dots > |\hat{\mu}_{\hat{q}}^{\varepsilon}|$ Let $\hat{M} = Diag(\sqrt{\hat{\mu}_j^{\varepsilon}})$ be the $\hat{q} \times \hat{q}$ diagonal matrix with $\sqrt{\hat{\mu}_j^{\varepsilon}}$ as its (j,j)-entry, and

$\hat{K}$ the $\hat{r}\times\hat{q}$ matrix having on the columns the normalized eigenvectors corresponding to $\hat{\mu}_1^{\varepsilon},\dots,\hat{\mu}_{\hat{q}}^{\varepsilon}$. Then the spectral decomposition states

$$\hat{\Gamma}^{\varepsilon} = \widehat{K}\widehat{M}\widehat{M}'\widehat{K}' = \widehat{S}\widehat{S}'$$

where $\hat{S} = \hat{K}\hat{M}$.

Thus our estimated matrix of non-structural impulse-response functions in *(3.2)* is

$$\widehat{C}_n(L) = \widehat{A}_n(\widehat{D}(L)^{-1}\widehat{S}$$

Recall that by definition we have

$$C_n(L) = B_n(L)H \qquad B_n(L) = A_n D(L)^{-1} R$$

by *(2.4)* and Proposition 3.1. Of course, $R = SH'$.

STEP 6) Finally, we obtain $\hat{H}$ by imposing our identification restrictions on

$$\hat{B}_m(L) = \hat{C}_m(L)\,\hat{H}'$$

Thus we get estimates

$$(4.1) \qquad \hat{R} = \hat{S}\hat{H}' \qquad \hat{B}_n(L) = \hat{A}_n\,\hat{D}(L)^{-1}\,\hat{R}$$

5) CONSISTENCY. Consistency of $\hat{B}_n(L) = \hat{A}_n\,\hat{D}(L)^{-1}\,\hat{R}$ as estimator of the impulse-response function $B_n(L)$ for large cross-sections and large sample size, that is, $n,T\to\infty$ is proved in Forni *et* al. (2009), Proposition 3. For this, it is necessary to state a last assumption.

FM5. Denote by $\gamma_{ij,k}^{x}$ and $\hat{\gamma}_{ij,k}^{x}$ the (i,j)-entries of Γ_k^x and $\hat{\Gamma}_k^x$, respectively. There exists a positive real number ρ such that

$$TE[(\hat{\gamma}_{ij,k}^{x} - \gamma_{ij,k}^{x})^2] < \rho$$

for k=0,1 and for all positive integers i,j and T.

PROPOSITION 5.1 *Let* $\hat{b}_{ni}(L)$ *and* $b_{ni}(L)$ *denote the i-th rows of the matrix functions* $\hat{B}_n(L)$ *and* $B_n(L)$*, respectively. Under assumptions* PA1-2 *and* FM1-5, $\hat{b}_{ni}(L)$, *for a fixed i, is a consistent estimator of* $b_{ni}(L)$*, that is,*

$$\text{plim}_{\delta_{nt}\to\infty} \hat{b}_{ni}(L) = b_{ni}(L)$$

where δ_{nt}=min(*n*, *T*), *n is the number of variables, and T is the number of observations over time.*

For the proof see Forni *et* al. (2009).

Proposition 5.1 states that consistency is achieved along any path for (*n*, *T*) with *n* and *T* both tending to infinity. The consistency rate is given by $\sqrt{\delta_{nt}} = \min(\sqrt{n}, \sqrt{T})$. This implies that if the cross-section dimension *n* is large relative to the sample size *T*, that is, $T/n \longrightarrow 0$, the rate of consistency is $\sqrt{T}$, the same we would obtain if the common components were observed, that is, if the variables were not contaminated by idiosyncratic components. On the other hand, if $n/T \longrightarrow 0$, then the consistency rate is $\sqrt{n}$ reflecting the fact that the common components are not observed but have to be estimated.

6) STANDARD ERRORS AND CONFIDENCE BANDS. Here we present a new procedure to obtain confidence bands and standard errors. We modify the procedure described in Forni *et* al. (2009) to avoid the possible correlation among idiosyncratic components. We should underline that in the empirical application we use a standard block boot-strap procedure. However, it can sometimes lead to an estimation point line that lies outside the confidence bands. The new procedure involves the following steps:

i) Compute $\hat{\boldsymbol{\chi}}_{nt}$ and $\hat{B}_n(L)$ according to $\hat{\boldsymbol{\chi}}_{nt} = \hat{A}_n \hat{A}'_n \mathbf{x}_{nt}$ and (*4.1*), and $\hat{\boldsymbol{\xi}}_{nt} = \mathbf{x}_{nt} - \hat{\boldsymbol{\chi}}_{nt}$ by (*1.1*).

ii) To generate the new series of the idionsyncratic components, say $\boldsymbol{\xi}^*_{nt}$, we use the block boot-strap procedure. The sample period is partitioned into some intervals of equal length. Then such intervals (blocks) are taken of length large enough to retain relevant correlation. We draw *n* times reintroducing elements every times. In this way we produce fictitious data.

iii) Generate new simulated series for the shocks, say $\mathbf{u}^*_t$, white noise standard normal. Use this new series to construct

$$\boldsymbol{\chi}^*_{nt} = \hat{B}_n(L)\mathbf{u}^*_t$$

and subsequently

$$\mathbf{x}^*_{nt} = \boldsymbol{\chi}^*_{nt} + \boldsymbol{\xi}^*_{nt}$$

iv) Compute new estimates of the impulse-response functions $B^*_n(L)$ starting from $\mathbf{x}^*_{nt}$.

By repeating the two last steps N times we get a distribution of estimated values which can be used to obtain *standard errors* and *confidence bands*.

3. - An Empirical Application

This section is devoted to studying the effect of technology shocks on labour input. The main result of our investigation is that we contradict Galí (1999) by using the same de-trended variables but the dynamic factor model (DFM) instead of a structural VAR, which was considered by the cited author. Moreover, we confirm the results of Christiano *et* al. (2004) by making use of a larger data set containing more information. In Subsection 1 we present the theoretical status of this topic. In Subsection 3 we re-obtain the VAR results of the author cited above. Lastly, in Subsection 5 we present our new results with the DFM.

1) BACKGROUND. The dynamic effects of technology shocks and their role as a source of economic fluctuations have been the focus of growing interest among economists. Business cycles have long been associated with highly procyclical fluctuations of labour input measures. Standard real business cycle models imply that hours worked increase after a permanent positive shock to technology. This is a prediction of the theoretical model and its extensions. However, there is a large and growing literature that argues it is inconsistent with the data. Moreover, the prediction of a positive response of hours worked to technology shock is not only questioned from an empirical point of view. In fact, in the literature there are several theoretical models which predict a contraction of hours worked after the shock (for instance, Galí, 1999 and Francis and Ramey, 2005). When technology shocks are identified in a structural vector autoregression (SVAR) as the only source of permanent shifts in labour productivity, they generate a negative comovement between hours and productivity and, consequently, a long and protractive decrease in hours worked. Since the impact response of hours is negative, one can conclude that technology shocks have only a minor role for the business

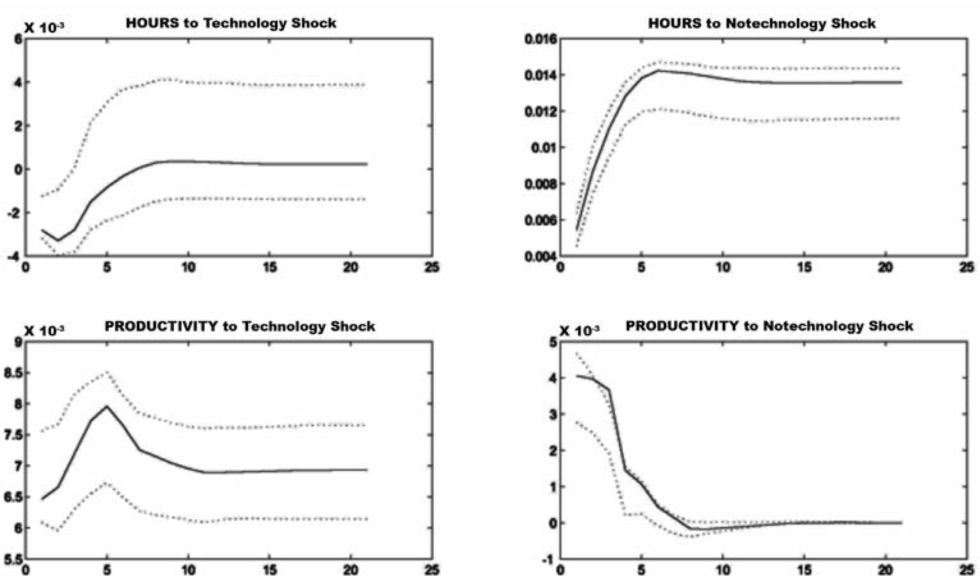
cycle. In fact, as remarked by Galí and Rabanal (2004), other shocks must play a predominant role in business cycles. This observation contrasts with the central role assigned to technology shocks as a source of business cycles in the RBC literature. In a later paper, Christiano, Eichenbaum and Vigfusson (2003) point out that the negative response of hours to a positive technology shock is not robust to using an alternative VAR specification that includes the level of (log) hours as a labour input measure. More specifically, when Christiano *et* al. (2003) re-estimate the VAR using the level of (log) hours, they find that a positive technology shock drives hours up, not down, and generates the positive comovement of hours and productivity, which confirms the prediction of the business cycle theory. Since they make the same fundamental identification assumption as Galí (1999) and Francis and Ramey (2005), the key question is: *what accounts for the difference in those findings*? A key culprit is how they treat hours worked, in particular the assumption of stationarity or non-stationarity of the time-series. Since the seminal work by Kidland and Prescott (1982), most business cycle models have adopted a "balanced growth" view consistent with some "stylized facts". In particular, in "balanced growth, consumption, investment and capital all grow at a constant rate, while hours stay constant" (Cooley and Prescott, 1995). This is why Christiano *et* al. (2004), for instance, adopted the level specification. In fact, if we assume that hours are stationary, differentiating can lead to major estimation problems. Moreover, it is widely agreed that the level specification avoids problems that come from possible cointegration among the variables, in addition to overdifferentiating problems mentioned above. In contrast to that view, Galí (2005) argues that stationarity of hours is not a necessary condition for a macro model to generate a balanced-growth path. As a matter of fact, from a theoretical point of view, one can think of many factors that could lead to non-stationary hours, including permanent shifts in government purchases or in labour and product market wedges, as well as permanent preference shifts. In fact, it is hard to imagine why some of those factors would remain unchanged or display only transitory fluctuations. More generally, modern economies are subject to a variety of frictions and distortions that can account for permanent shifts - and, thus, unit-root-like behaviour- in hours. In any case, it is a much debated question whether hours should be differentiated even if we believe in their unit-root behavior. We would shortly show that assuming the RBC point of view or a more keynesian one, could then lead to two opposite results. *Is there a way to overcome this difference*? Such a problem can be solved within the DFM.

2) Data. Our data set is made up of 103 US quarterly series, covering the period from 1959:Q1 to 2007:Q4. Most series are taken by the FRED (Federal Reserve Economic Data) database. The full list of variables along with the corresponding transformations (first differences of levels, first differences of logs or second differences of logs) is reported in Appendix B.

3) The benchmark VAR. Before showing the results for the structural factor model, we present for the sake of comparison the impulse response functions to a positive technology shock of bivariate VAR including the log of total employee hours in non-farm business sector and the log of total output for hours as measure of productivity. In this way, we reproduce the bivariate VAR as in Galí (1999). In particular, we use the same variables with the same treatment but the sample period is different. The 2-variables specification will help the comparison with our 2-shock factor model. Following Galí, identification is achieved by assuming technology shocks as the source of permanent shifts in labour productivity. The impulse response functions are reported in Graph 1 along with 68% confidence bands computed with standard block boot-strap (see Section 1, Sub-section 6). As showed in Galí (1999), the impulse responses based on the model with first-differentiated series show a persistent decline in hours. In particular, hours remain negative, at most close to zero, at all time horizons. As well known, the productivity shows an increase and then a negative comovement between the two variables. However, Christiano *et* al. (2004) objected that *pro capita* hours worked should not be differentiated and whether one works with the first differences or levels of hours has a substantial impact on the outcome of the analysis. In particular, those authors argued that the true sign of the response of hours worked is positive and the negative sign estimated in the difference VAR is a consequence of specification error due to first differencing. Among others have considered this issue, McGrattan (2004) and Chari, Kehoe and McGrattan (2005) pointed out that the VAR approach used by Galí *et* al. (2004) is misspecified because of the fact that capital is not included in the VAR. This means that the model is biased and inconsistent unless a potentially infinite order lag length is used. In conclusion, our goal is to study the time series in difference of total hours worked and productivity by means of a dynamic factor model. This leads us to contrasting results to the ones obtained by Galí (1999) concerning the reaction of hours to a technology shock.

GRAPH 1

IRF FROM A BIVARIATE FIRST-DIFFERENCED VAR



Response of hours worked and productivity to technology and non-technology shocks.
Solid line: point estimates; Dotted line: 68% confidence bands.

4) NUMBER OF STATIC AND DYNAMIC FACTORS. Let us come now to the factor model. To determine the number of static factors, $\hat{r}$, we use the criteria proposed by Bai and Ng (2002). We set to 25 the maximum number of factors and compute PC_{p1}, PC_{p2},PC_{p3} and IC_{p1}, IC_{p2},IC_{p3}. The most reliable information criterion, IC_{p2}, reaches an internal minimum in accordance with 10 factors. To determine the number of dynamic factors, we use the criteria proposed by Bai and Ng (2007), Stock and Watson (2005) and Onatski (2009). We first compute the residuals of a VAR(3) with the first 10 estimated factors, the number of lags being determined as the average of AIC (5 lags) and BIC (1 lag). Second, following Bai and Ng (2007), we find $\hat{q}_1$=6 and $\hat{q}_2$=8 when using the covariance matrix of such residuals (parameters δ=.4, m=1) and $\hat{q}_1$=9, $\hat{q}_2$=7 when using the correlation matrix (parameters δ=.4, m=1.25 for $\hat{q}_1$, m=2.25 for $\hat{q}_2$). Third, following Stock and Watson (2005) as described in *b*), Step 4, Section 4, we find 4 and 2 dynamic factors. Finally, using the criteria of Onatski (2009), we test a null hypothesis for

the number of dynamic factors up to a maximum of 6 (k_0) over an alternative hypothesis of k dynamic factors between k_0 to a maximum of 7 (k_1). The test produces 2 or 4 factors (see Table 1). We conclude, basing our decision mainly on Stock and Watson and Onatski criteria, that the number of dynamic factor is either 2 or 4.

TABLE 1

P-VALUES OF THE ONATSKI TEST STATISTIC

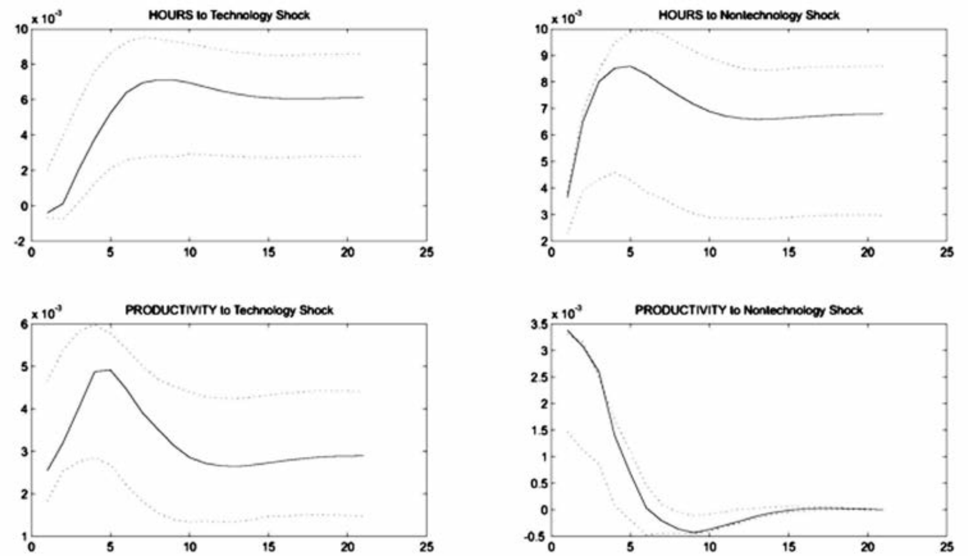
		k_1						
		1	2	3	4	5	6	7
	0	0.001	0.002	0.003	0.003	0.004	0.005	0.006
	1	0	0.011	0.019	0.026	0.033	0.039	0.046
	2	0	0	0.933	0.061	0.084	0.106	0.125
k_0	3	0	0	0	0.035	0.061	0.084	0.106
	4	0	0	0	0	0.915	0.970	0.815
	5	0	0	0	0	0	0.710	0.663
	6	0	0	0	0	0	0	0.381

ONATSKI A. test statistic (2009) tests the null hypothesis of k_0 factors against the alternative hypothesis of $k_1=k_0+1$.

5) MAIN RESULTS. Let us now come to the factor model. For the sake of comparison, the variables are the same used by Galí (1999) and identification is obtained just in the same way as the VAR model above. In addition, we use the same first difference specification as Galí. Graph 2 displays the impulse response functions of the dynamic factor model (with 10 static factors and 2 dynamic factors) of the two series included in the VAR. The dotted lines are the 68% confidence bands obtained with the block boot-strap procedure. We set the block length to 19 quarters, or 57 months, large enough to retain relevant autocorrelations. *Hours* reacts immediately to a technology shock and it increases for the first 7/8 quarters, showing a persistent positive level later on. Confidence bands are rather close to the point estimate, so that the effects is significant. In addition, productivity rises significantly after a positive technology shock for about 5 quarters and then it remains persistently at the level of the initial increase.

GRAPH 2

IRF FROM A DYNAMIC FACTOR MODEL
(10 STATIC FACTORS, 2 DYNAMIC FACTORS)



Response of hours worked and productivity to a positive technology and non-technology shocks.
Solid line: point estimates; Dotted line: 68% confidence bands.

The most striking result is that we reproduce the result in Christiano *et* al. (2004), *i.e.*, a positive reaction in hours to a positive technology shock, using detrended series. This arises from the fact that the DFM does not suffer from the possible existence of one or more roots on the unit circle. In fact, for large n we can always find an invertible square submatrix in A_n (see Proposition 1.1). This problem may happen in VAR analysis, then differencing can lead to misspecification of the model and to biased results. Here we calculate the roots of the polynomial and the corresponding confidence interval of the minimum one, that is 1.2231. Using the block boot-strap procedure with 500 repetitions we find that the 68% confidence interval is [0.9943 ; 1.2686] and the 80% one is [0.9091; 1.2918] that both could contain the unit modul. Let us now turning to the dynamic factor model with 4 dynamic factors, as suggested by the criteria presented previously (Section 3). The impulse response functions are displayed in Graph 3. Here the results are very similar to the 2-dynamic factor case, even if the response in hours turn out to be positive after 3 quarters. Furthermore, the response in productivity is somewhat more pronounced. This different specification suggests the robustness of the results to changes in the number of dynamic factors. In particular, we are able to re-confirm that a positive technology shock leads to an increase in hours. To conclude, we show the variance decomposition of hours and productivity in the DFM with 4 dynamic factors (Table 2). That means that we isolate the effects of the technology shock on both variables. First, on impact the percentage of variance in hours explained by the technology shock is extremely high (96%). The effects, however, decrease at longer horizons; after one year the shock explains 68% of the volatility of hours. Overall, results suggest a sizeable role of the technology shock in affecting both variables.

TABLE 2

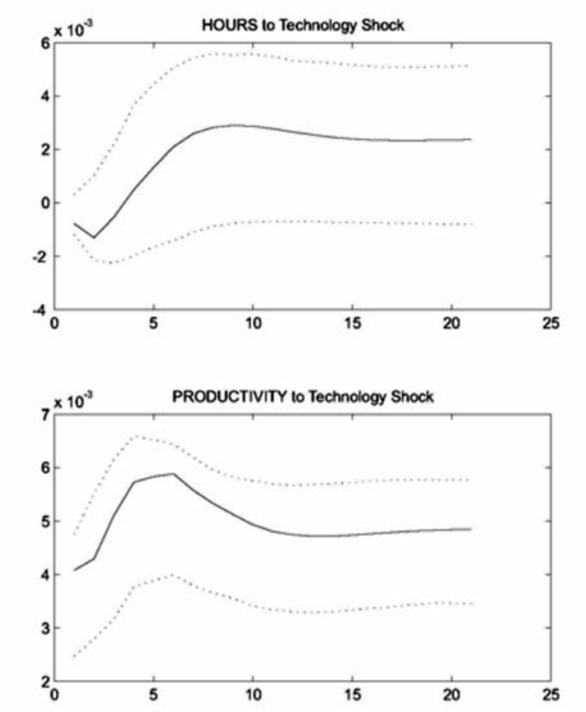
VARIANCE DECOMPOSITION DFM

Variance decomposition				
	k=0	k=2	k=4	k=16
Hours	0.9646	0.8428	0.6833	0.4293
Productivity	0.3329	0.2274	0.1276	0.0532

k are the quarters after the shocks.

GRAPH 3

IRF FROM A DYNAMIC FACTOR MODEL
(10 STATIC FACTORS, 4 DYNAMIC FACTORS)



Response of hours worked and productivity to a positive technology shocks.
Solid line: point estimates; Dotted line: 68% confidence bands.

4. - Conclusion

In this paper we study the effects of technology shocks on hours worked using a structural factor model approach. The results obtained with the dynamic factor model are in sharp contrast with those obtained with the VAR model. The factor model enables us to handle a large amount of information and, therefore, to avoid an important limitation of structural VAR models.

The most striking result is that we find a positive reaction of hours worked to a positive technology shock, while the response is negative using a detrended VAR. This arises from the fact that the dynamic factor model does not suffer from the existence of roots on the unit circle, as we confidently find in the VAR model. The presence of unit roots leads to incorrect estimation and thus misleading results. Finally, we remark that our results confirm those of Christiano *et* al.(2004) but contradict the work of Galí (1999).

APPENDIX A

Criteria to determine the Number of Factors

In this Appendix we present the methodology in estimating the numbers of static factors firstly and the numbers of dynamic factors afterwards.

1. Estimation of Static Factors - Bai and Ng Methodology (2002)

Bai and Ng estimate common factors in large panels by the method of asymptotic principal components firstly. The number of factors that can be estimated by this method is $min\{n, T\}$. But to determine which of these factors are statistically important, it is necessary to first establish consistency of all the estimated common factors when both n and T are large. Those authors start with an arbitrary number k, where $k<min\{n, T\}$. The superscript in $\mathbf{f}_t^{(k)}$ and $A_n^{(k)}$ signifies the allowance of k factors in the estimation. Let $F^{(k)} = (f_{jt}^{(k)})$ be the $k\times n$ matrix of the factors and $A^{(k)}=(a_{ij}^{(k)})$ the $n\times k$ matrix such that

$$x_{it} = \sum_{j=1}^{k} a_{ij}^{(k)} f_{jt}^{(k)} + \xi_{it}$$

for i=1,...,n and $t \in \mathbb{Z}$. Estimate of $A_n^{(k)}$ is obtained by solving the optimization problem for the sum of squared residuals (divided by nT)

$$V(k, \widehat{F}^{(k)}) = min_{A^{(k)}} \frac{1}{nT} \sum_{i=1}^{n} \sum_{t=1}^{T} (x_{it} - \sum_{j=1}^{k} a_{ij}^{(k)} \widehat{f}_{jt}^{(k)})^2$$

when k factors are estimated, subject to the normalization $A_n^{(k)\prime} A_n^{(k)} = nI_k$. This sum of squared residuals does not depend on which estimate of $F^{(k)}$ is used because they span the same vector space.

Now consider a loss function

$$V(k, \widehat{F}^{(k)}) + k\ g(n, T)$$

where $g(n, T)$ is the penalty for overfitting. This function can be used to determine k. The main results of Bai and Ng (2002) is to find the penalty functions $g(n, T)$ such that the class of criteria

$$PC(k) = V(k, \widehat{F}^{(k)}) + k\ g(n,T)$$

$$IC(k) = ln(V(k, \widehat{F}^{(k)})) + k\ g(n,T)$$

can consistently estimate *r*, under certain assumptions (see the quoted paper for more details). Moreover, these authors propose the following specific formulations of $g(n,T)$

$$PC_{p1} = V(k,\widehat{F}^{(k)}) + k\widehat{\sigma}^2\left(\frac{n+T}{nT}\right)ln\left(\frac{nT}{n+T}\right)$$

$$PC_{p2} = V(k,\widehat{F}^{(k)}) + k\widehat{\sigma}^2\left(\frac{n+T}{nT}\right)ln C_{nT}^2$$

$$PC_{p3} = V(k,\widehat{F}^{(k)}) + k\widehat{\sigma}^2\left(\frac{ln C_{nT}^2}{C_{nT}^2}\right)$$

$$IC_{p1} = lnV(k,\widehat{F}^{(k)}) + k\left(\frac{n+T}{nT}\right)ln\left(\frac{nT}{n+T}\right)$$

$$IC_{p2} = lnV(k,\widehat{F}^{(k)}) + k\left(\frac{n+T}{nT}\right)ln C_{nT}^2$$

$$IC_{p3} = lnV(k,\widehat{F}^{(k)}) + k\left(\frac{ln C_{nT}^2}{C_{nT}^2}\right)$$

where $C_{nT} = min\{\sqrt{n},\sqrt{T}\}$.

2. Estimation of Dynamic Factors - Three Different Methodologies

a) A first method to estimate *q* in a large panel of data was proposed by Bai and Ng in 2007. Their analysis is based on the residuals of a VAR in *r* static factors, where the factors are themselves obtained by applying the principal components procedure (see Appendix A). The obtained tests are based on a spectral decomposition of the covariance matrix Σ_ξ of the residuals ξ_t, and they are exact if the residuals were observable. To state the result of Bai and Ng, we need the following fact from matrix analysis.

LEMMA 4.1 *Let A be an r×r symmetric matrix, and write A=BCB′, where B is an r×r orthogonal matrix, and C is a diagonal matrix of eigenvalues of A. Let* $\mathbf{b}_j$ *be the jth column of B and* λ_j *the jth eigenvalue of A ordered such that* $\lambda_1>\lambda_2>\cdots>\lambda_r$. *Then the spectral decomposition of A is given by*

$$A=\sum_{j=1}^{r}\lambda_j\mathbf{b}_j\mathbf{b}'_j$$

The *j*th column $\mathbf{b}_j$ of B is the eigenvector associated with the *j*th largest eigenvalue of A. Let $A(k)$, $k\leq r$ denote the $r\times r$ matrix defined by

$$A(k)=\sum_{j=1}^{k}\lambda_j\mathbf{b}_j\mathbf{b}'_j$$

which is called the *k*th pseudomatrix of A.

Let $d_k=vech(A(k))$ be the half-vectorization of $A(k)$, that is, the $[r(r+1)/2]\times 1$ column vector obtained by vectorizing only the lower triangular part of $A(k)$. Of course, $d_r=vech(A)$, and we set $d_0=d_r$.

Define

$$D_{1,k}=\frac{\|d_{k+1}-d_k\|}{\|d_0\|}$$

$$D_{2,k}=\frac{\|d_k-d_0\|}{\|d_0\|}$$

If $rank\ (A)=q\leq r$, then $\lambda_k=0$ for $k>q$. This implies $d_k=d_q$ for $k\geq q$. Hence, if $rank(A)=q$, then $D_{1,k}=D_{2,k}=0$ for every $k\geq q$. Let now $A=\Sigma_\xi$ (the covariance matrix of a set of r innovations). Lemma 4.1 cannot be applied immediately because Σ_ξ is not observed but it can be estimated from the data. Considering its associated pseudo matrices yields the numbers $\widehat{D}_{1,k}$ and $\widehat{D}_{2,k}$.

Define

$$K_1=\left\{k:\widehat{D}_{1,k}<\frac{m}{T^{\frac{1}{2}-\delta}}\right\}$$

$$K_2=\left\{k:\widehat{D}_{2,k}<\frac{m}{T^{\frac{1}{2}-\delta}}\right\}$$

where $m>0$ and $0<\delta<1/2$, and set $\hat{q}_i=min\{k\in K_i\},i=1,2$.

The main result of Bai and Ng (2007) says that if $\hat{\Sigma}_{\xi}$ is a $\sqrt{T}$ consistent estimator of Σ_{ξ}, $0<m<\infty$, $0<\delta<1/2$, and *rank* $(\Sigma_{\xi})=q$, then $\hat{q}_i \xrightarrow{p} q$ as $T \longrightarrow \infty$. So the tests are accurate up to an error that vanishes asymptotically.

b) A second method to estimate the number q of the dynamic factors $\mathbf{u}_t$ was given by Stock and Watson (2005). Consider the model

$$\mathbf{x}_{nt} = B_n(L)\mathbf{u}_t + \boldsymbol{\xi}_{nt}$$

where

$$B_n(L) = A_n(I - D_1 L - \ldots - D_p L^p)^{-1}\ R = A(L)R$$

Then we have

$$tr\ E\left[B_n(L)\mathbf{u}_t\left(B_n(L)\mathbf{u}_t\right)'\right] = tr\left[R'\left(\sum_{j=1}^{\infty}\mathbf{a}_j\mathbf{a}'_j\right)R\right]$$

since $\Sigma_{\mathbf{u}}=I_q$. Here $\mathbf{a}_j$ denotes the jth column of the matrix $A(L)$, as usual. This implies that

$$tr\ \left(\Sigma_{\mathbf{x}}\right) = tr\left[R'\left(\sum_{j=1}^{\infty}\mathbf{a}_j\mathbf{a}'_j\right)R\right] + tr\left(\Sigma_{\xi}\right)$$

The criterion chooses R such that the dynamic factors $\mathbf{u}_t$ are uncorrelated and that they maximize the trace of $\Sigma_{\mathbf{x}}$, ordered so that the first dynamic factor makes the largest variance reduction, the second factor the second-largest, and so forth. But this is equivalent to choosing R to be the eigenvectors matrix of $\sum_{j=1}^{\infty}\mathbf{a}_j\mathbf{a}_j'$ that correspond to the largest q eigenvalues. The estimator $\hat{R}$ of R is the sample analog of this matrix of eigenvectors, computed using

$$\hat{A}(L) = \hat{A}_n(I - \hat{D}_1 L - \ldots - \hat{D}_p L^p)^{-1}$$

c) A recent method has been introduced by Onastki (2009). He developed a test of the null hypothesis of k_0 factors against the alternative hypothesis that the number of factors is larger than k_0 but no larger than $k_1>k_0$.

The test statistic equals

$$max_{k_0 < k \le k_1} \frac{(\gamma_k - \gamma_{k+1})}{(\gamma_{k+1} - \gamma_{k+2})}$$

where γ_i is the *i*th largest eigenvalue of the smoothed periodogram estimate of the spectral density matrix of data at a pre-specified frequency.

APPENDIX B

Data

Transformations:
1=levels;
2= first differences of levels;
3= first differences of logs;
4= second differences of logs.

No. Series	MNEMONIC	LONG LABEL	TRANSFORMATION
1	GDPC1	Real Gross Domestic Product	3
2	GNPC96	Real Gross National Product	3
3	NICUR/GDPDEF	National Income/GDP Deflator	3
4	DPIC96	Real Disposable Personal Income	3
5	OUTNFB	Nonfarm Business Sector: Output	3
6	FINSLC1	Real Final Sales of Domestic Product	3
7	FPIC1	Real Private Fixed Investment	3
8	PRFIC1	Real Private Residential Fixed Investment	3
9	PNFIC1	Real Private Nonresidential Fixed Investment	3
10	GPDIC1	Real Gross Private Domestic Investment	3
11	PCECC96	Real Personal Consumption Expenditures	3
12	PCNDGC96	Real Personal Consumption Expenditures: Nondurable Goods	3
13	PCDGCC96	Real Personal Consumption Expenditures: Durable Goods	3
14	PCESVC96	Real Personal Consumption Expenditures: Services	3
15	GPSAVE/GDPDEF	Gross Private Saving/GDP Deflator	3
16	FGCEC1	Real Federal Consumption Expenditures and Gross Investment	3
17	GEXPND/GDPDEF	Federal Government: Current Expenditures/ GDP deflator	3
18	GRECPT/GDPDEF	Federal Government Current Receipts/ GDP deflator	3
19	FGDEF	Federal Real Expend-Real Receipts	2
20	CBIC1	Real Change in Private Inventories	1
21	EXPGSC1	Real Exports of Goods and Services	3
22	IMPGSC1	Real Imports of Goods and Services	3
23	CP/GDPDEF	Corporate Profits After Tax/GDP deflator	3
24	NFCPATAX/GDPDEF	Nonfinancial Corporate Business: Profits After Tax/GDP deflator	3
25	CNCF/GDPDEF	Corporate Net Cash Flow/GDP deflator	3
26	IVIDEND/GDPDEF	Net Corporate Dividends/GDP deflator	3
27	HOANBS	Nonfarm Business Sector: Hours of All Persons	3
28	OPHNFB	Nonfarm Business Sector: Output Per Hour of All Persons	3
29	UNLPNBS	Nonfarm Business Sector: Unit Nonlabor Payments	3
30	ULCNFB	Nonfarm Business Sector: Unit Labor Cost	3

No. Series	MNEMONIC	LONG LABEL	TRANSFORMATION
31	WASCUR/CPI	Compensation of Employees: Wages and Salary Accruals/CPI	3
32	COMPNFB	Nonfarm Business Sector: Compensation Per Hour	4
33	COMPRNFB	Nonfarm Business Sector: Real Compensation Per Hour	3
34	GDPCTPI	Gross Domestic Product: Chain-type Price Index	4
35	GNPCTPI	Gross National Product: Chain-type Price Index	4
36	GDPDEF	Gross Domestic Product: Implicit Price Deflator	4
37	GNPDEF	Gross National Product: Implicit Price Deflator	4
38	INDPRO	Industrial Production Index	3
39	IPBUSEQ	Industrial Production: Business Equipment	3
40	IPCONGD	Industrial Production: Consumer Goods	3
41	IPDCONGD	Industrial Production: Durable Consumer Goods	3
42	IPFINAL	Industrial Production: Final Products (Market Group)	3
43	IPMAT	Industrial Production: Materials	3
44	IPNCONGD	Industrial Production: Nondurable Consumer Goods	3
45	AWHMAN	Average Weekly Hours: Manufacturing	2
46	AWOTMAN	Average Weekly Hours: Overtime: Manufacturing	2
47	CIVPART	Civilian Participation Rate	2
48	CLF16OV	Civilian Labor Force	3
49	CE16OV	Civilian Employment	3
50	USPRIV	All Employees: Total Private Industries	3
51	USGOOD	All Employees: Goods-Producing Industries	3
52	SRVPRD	All Employees: Service-Providing Industries	3
53	UNEMPLOY	Unemployed	3
54	UEMPMEAN	Average (Mean) Duration of Unemployment	3
55	UNRATE	Civilian Unemployment Rate	2
56	HOUST	Housing Starts: Total: New Privately Owned Housing Units Started	3
57	FEDFUNDS	Effective Federal Funds Rate	2
58	TB3MS	3-Month Treasury Bill: Secondary Market Rate	2
59	GS1	1-Year Treasury Constant Maturity Rate	2
60	GS10	10-Year Treasury Constant Maturity Rate	2
61	AAA	Moody’s Seasoned Aaa Corporate Bond Yield	2
62	BAA	Moody’s Seasoned Baa Corporate Bond Yield	2
63	MPRIME	Bank Prime Loan Rate	2
64	BOGNONBR	Non-Borrowed Reserves of Depository Institutions	4
65	TRARR	Board of Governors Total Reserves, Adjusted for Changes in Reserve	4
66	BOGAMBSL	Board of Governors Monetary Base, Adjusted for Changes in Reserve	4
67	M1SL	M1 Money Stock	4
68	M2MSL	M2 Minus	4

No. Series	MNEMONIC	LONG LABEL	TRANSFORMATION
69	M2SL	M2 Money Stock	4
70	BUSLOANS	Commercial and Industrial Loans at All Commercial Banks	4
71	CONSUMER	Consumer (Individual) Loans at All Commercial Banks	4
72	LOANINV	Total Loans and Investments at All Commercial Banks	4
73	REALLN	Real Estate Loans at All Commercial Banks	4
74	TOTALSL	Total Consumer Credit Outstanding	4
75	CPIAUCSL	Consumer Price Index For All Urban Consumers: All Items	4
76	CPIULFSL	Consumer Price Index for All Urban Consumers: All Items Less Food	4
77	CPILEGSL	Consumer Price Index for All Urban Consumers: All Items Less Energy	4
78	CPILFESL	Consumer Price Index for All Urban Consumers: All Items Less Food and Energy	4
79	CPIENGSL	Consumer Price Index for All Urban Consumers: Energy	4
80	CPIUFDSL	Consumer Price Index for All Urban Consumers: Food	4
81	PPICPE	Producer Price Index Finished Goods: Capital Equipment	4
82	PPICRM	Producer Price Index: Crude Materials for Further Processing	4
83	PPIFCG	Producer Price Index: Finished Consumer Goods	4
84	PPIFGS	Producer Price Index: Finished Goods	4
85	OILPRICE	Spot Oil Price: West Texas Intermediate	4
86	USSHRPRCF	US Dow Jones Industrial Share Price Index (EP) NADJ	3
87	US500STK	US Standard and Poor's Index of 500 Common Stocks (monthly ave NADJ)	3
88	USI62.F	US Share Price Index NADJ	3
89	USNOIDN.D	US Manufacturers New Orders for Nondefense Capital Goods	3
90	USCNORCGD	US New Orders of Consumer Goods and Materials (BCI 8) CONA	3
91	USNAPMNO	US ISM Manufacturers Survey: New Orders Index SADJ	1
92	USVACTOTO	US Index of Help Wanted Advertising Vola	3
93	USCYLEAD	US the Conference Board Leading Economic Indicators Index SADJ	3
94	USECRIWLH	US Economic Cycle Research Institute Weekly Leading Index	3
95	GS10-FEDFUNDS	US Economic Cycle Research Institute Weekly Leading Index	2
96	GS1-FEDFUNDS	US Economic Cycle Research Institute Weekly Leading Index	2
97	BAA-FEDFUNDS	US Economic Cycle Research Institute Weekly Leading Index	2
98	GEXPND/GDPDEF	Government Current Expenditures/ GDP deflator	3
99	GRECPT/GDPDEF	Government Current Receipts/ GDP deflator	3
100	GDEF	Government Real Expend-Real Receipts	2
101	GCEC1	Real Government Consumption Expenditures and Gross Investment	3
102	GS5	5-Year Treasury Constant Maturity Rate	2
103	GS5-FEDFUNDS	5-Year Treasury Constant Maturity Rate	2

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Failed Democracies: Cross-Sectional Analysis on Economic Determinants of Democratic Transitions and on the Role of Electoral Authoritarianism During the Third Wave of Democratization

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What are the economic and social factors behind the democratic transitions during the Third Wave of democratization? Do pre-transition political regimes affect the probability of democratization? This article attempts to answer these two questions for the period known as the Third Wave (1975-2006). With the use of a cross-sectional database of 152 countries and estimates obtained using a probit model, I identify human capital as the engine of democratization. Analyzing the role of electoral authoritarianism (regimes with elections but relying on authoritarian governance practices), I find that these regimes have a strong negative impact on the probability of democratization.
[JEL Classification: P16; O10].

Keywords: democratization; electoral authoritarian regimes; human capital; institutions.

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1. - Introduction

What are the economic and social factors behind the democratic transitions during the Third Wave of democratization? Do pre-transition political regimes affect the probability of democratization?

Before answering these questions, it is worth clarifying why democratization is economically relevant. Economists increasingly recognize that institutions, and in particular the establishment of democracies, matter for economic development. The recent literature in political economy suggests that democratization enhances economic growth. Papaioannou and Siourounis (2008*a*) document that permanent democratizations lead to annual real *per capita* GDP growth, which is up to one per cent larger. Democratization may also help to reduce social conflict. In Acemoglu and Robinson (2006), within a redistributive conflict framework, the choice of democratic transition represents a credible commitment made by the elite in order to avoid a revolutionary threat by the poor. Lizzeri and Persico (2004) argue that democratization may help to improve efficiency of economic policies by widening the electoral base and shifting economic policies towards public programs with wider benefits for the economy writ large.

A vast empirical literature in economics has investigated the economic and social determinants of democratic transitions. According to the traditional hypothesis of Lipset (1958), it is more likely that democratization emerges in more educated and developed societies (see also Bourguignon and Verdier, 2000; Glaeser *et* al., 2004). Others (like Weber, 1930 and Huntington, 1998) have underlined the role of social determinants such as religion, culture and ethnic fragmentation as the engine of successful democratic transition. Some recent works have pointed out the fundamental role of the endowment of natural resources for the emergence of democracy. Another perspective, following Friedman (1962), links democratization to economic liberalism and terms of trade openness. Finally, some authors (Acemoglu and Robinson, 2001) have stressed the role of colonial institutions, most of all for property rights protection, in order to create a path-dependency towards democratic institutions.

Economists have, so far, considered democracy, or the lack of it, essentially as a binary variable. Nonetheless, several political scientists have recently pointed out the emergence of electoral authoritarian regimes: regimes that combine peculiar characteristics of both democracies and non-democracies. Some authors (Levitsky and Way, 2002; Diamond, 2002; Schedler, 2006; Brownlee, 2009) document the *de facto* persistence of authoritarian practices along with a *de jure* extension of the franchise. Moreover, the emergence of these electoral authoritarian regimes has been anecdotally associated with a slowing down of the Third Wave of Democratization (from now on Third Wave) at the end of 1990s.

The goal of this paper is to study the economic and social determinants of democratization by extending the perspective beyond the binary classification adopted in economics so far. In particular, the paper addresses the question of whether the likelihood of a transition to a complete democracy depends on the regime which is present at the onset of democratization, and whether it is more or less likely that electoral authoritarian regimes, rather than full autocracies, democratize. A question that has not been addressed in the existing literature, so far, is about the possible effect of the type of the political regime in place on the likelihood of a country to democratize. Although no formal theories have been proposed on this side, some hypotheses can be derived from the existing literature. The fact that the type of political concessions, or reforms, implemented by elite facing a revolutionary threat may depend on the contingencies of such a threat has previously been studied from a theoretical point of view. For instance, Acemoglu and Robinson (2006) show that an elite facing a credible threat of conflict may have no other options than democratizing if the conflicts of interests between social groups are too large (for example, due to the large income inequality). However, in other cases the elites may face a credible threat but they may still be able to avoid democratization by implementing reforms that credibly transfer part of the income to the disenfranchised masses. Reinterpreting the same logical argument in terms of political concessions, rather than economic concessions, one could interpret the emergence or presence of an electoral authoritarian regime as the result of this attempt to avoid a full democratization. Hence, whether a regime with partial political freedom represents an intermediate step towards democratization or, instead, a process put in place precisely to avoid it, is essentially an empirical question. This paper sets out to provide a first attempt to address this question.

In order to answer these questions I create a cross-sectional dataset that identifies democratic transitions taking place in the period 1975-2006. That is, the so called Third Wave. The classification of democratization episodes follows previous works such as Papaioannou and Siourounis (2008*b*) and other authors (Przeworki, 2000; Golder, 2005). I use the dataset to test hypotheses of democratization by studying countries that were non-democratic regimes at the beginning of the Third Wave. In order to evaluate the effects on the probability of democratization, I introduce a set of covariates in 1975 (initial year of the Third Wave) in the same way as Papaioannou and Siourounis (2008*b*). This set of covariates is used as a *proxy* for some theories of democratization. By studying this set of countries I am able to mitigate the reverse causality problem of democratization: focusing only on non-democratic countries can be a way to "isolate the one-way effect of income, education, and other factors on democratization" (Papaioannou and Siourounis, 2008*b*). The econometric analysis is developed using a cross-sectional *probit* model with marginal effects.

In order to study the potential role of electoral authoritarian regimes on the likelihood of democratization, I introduce a new classification of pre-transition political regimes. Borrowing the concept of electoral authoritarianism from the political science literature, I control for the type of political regime before the transition, going beyond the binary cut-off of authoritarian *versus* democratic regimes that has been adopted so far in the economic literature. Using Brownlee's (2009) classification, I replace the classical definition of non-democratic regimes with this new regime's typology. Therefore, I include information in the econometric specification on the type of regime in place before the beginning of the observation period to test whether the existence of electoral authoritarian regimes increases or decreases the likelihood of a democratic transition.

The analysis delivers several interesting results. The estimates confirm the findings of the importance of the relation between democratization and human capital. Human capital is the most robust determinant of democratization. A one year increase in education increases the likelihood of democratization up to 50%. In other words, Modernization Theory is able to encapsulate the dynamics of democratization, as in Bourguignon and Verdier (2000) and Glaeser *et* al. (2004). Human capital is at the core of the so called Modernization Theory put forward by Lipset (1958) according to which increasing income, but most importantly, widespread education, are crucial for the emergence of democracy. Several recent contributions in the literature have pointed out reasons why the role of human capital may be the key for democratization. Increases in education can make individuals more aware of the opportunity cost of living in an environment in which civil and political rights are not fully guaranteed. Human capital can also help reducing the cost of collective action thereby making civil protests and opposition to undemocratic regimes more likely (see for instance Glaeser *et* al., 2004 and Acemoglu and Robinson, 2006).

Concerning the role of electoral authoritarian regimes, the estimates suggest that compared to closed authoritarianism, electoral authoritarianisms have a significant and negative effect on the probability of democratization. The result is in sharp contrast with the previous studies like Brownlee (2009). This result is relevant since 53 out of 152 countries in the period 1990-2006 were classified as electorally authoritarian. The results seem to suggest that electoral authoritarianism represents an autonomous political regime rather than an intermediate step in the transition from an oligarchy towards a democratic regime. Moreover the findings suggest that a more extensive consideration of the path towards democracy may be fruitful. Finally, given the presence of elections, the role of electoral authoritarian regimes claims the need of going beyond the extension of the franchise as the main element considered in the literature on democratization.

The paper has been organized as follows. In section one, I present some contributions by social sciences literature about determinants of democratization and electoral authoritarianisms. In section two, I show the methodology I follow in the creation of data set. In section three, I make a summary of countries by political regime and democratic transition. In section four, I report a descriptive analysis of the main variables. In the last section, I describe the results obtained with the *probit* model in order to determine which factors drive the Third Wave and in order to evaluate the role of electoral authoritarianism on democratization.

2. - Literature

This paper is closely related to two branches of literature: the branch of the economic and social determinants of democratization, and the branch of the study of democratic transitions. Concerning the first field of research, this paper studies the impact some socio-economic variables have on the likelihood of democratization. Many authors have highlighted the relation between democracy and the wealth and education of a given society (Lipset, 1959; Bourguignon and Verdier, 2000; Glaeser *et* al., 2004). These contributions have formed the *corpus* of what has been named Modernization Theory, in which a high level of wealth and education increases the possibility of democratization. This relation is the core of many contributions both on the theoretical (Bourguignon and Verdier, 2001; Glaeser *et* al., 2004) and the empirical side (Acemoglu and Robinson, 2001; Glaeser *et* al., 2004). Some authors, instead, have stressed the importance of the social environment in which democracy should take place. In this context, what is fundamental to the process of democratization is not income or education level. What matters is the level of religious and ethnic fragmentation. These considerations have been developed in the so-called Theory of the Social Structure. Additionally, other authors stress the importance of the relationship between democratic regimes and the abundance of natural resources. For these works it is significant to analyze the allocation of natural resources such as oil and other raw materials as determinants of the democratic processes. Another interpretation of democratization, relying on the contributions of Friedman (1962), sees economic liberalism, especially in trade openness, as the engine of democratic processes. Finally, in the literature (Acemoglu and Robinson, 2001) an explanation of democratic transitions has been proposed starting from analyzing the institutions that countries had at the date of their independence. In other words, this theory studies the impact of these early institutions, especially referring to the colonial era, on the ability of these countries to adopt democratic institutions.

Regarding the branch of studies on democratic transitions, this article relates to studies on electoral authoritarianisms and their influence on the processes of democratization (Brownlee, 2009). Over the past two decades, many authors have pointed out the emergence of these types of regimes, a widespread phenomenon during the Third Wave in which many states adopted electoral practices (proper of democracy) without abandoning practices of authoritarian governance. The conceptual debate was, and still is, very active over the definition of these regimes: in the literature, one may read terms such as "defective democracies", "hybrid regimes" and "electoral authoritarianism". All of these definitions refer to the same kind of regimes. Assuming that the election process is what distinguishes these authoritarian regimes by authoritarianism *tout-court* (such as military regimes, single party regimes, etc.), I will use the term electoral authoritarianism to identify these regimes. Schedler (2006) first characterized the electoral process of these regimes as an election which is widely inclusive (usually through universal suffrage), minimally pluralistic (opposition parties are allowed to participate in the electoral rounds), minimally competitive (opposition parties, although prevented from winning elections, may obtain votes and seats), and minimally open (opposition parties are not subject to repression, although repression may undergo treatment in a selective and intermittent way). Another major contribution for the purposes of this paper is the classification made by Diamond (2002) of electoral authoritarianism based on their electoral competitiveness. In other words, if there is a sound and effective multi-party presence, I can thus divide hegemonic authoritarianisms (where there is not competitiveness) from competitive ones. The former type, as defined by Howard and Roessler (2006), includes those regimes that, while announcing regular elections, do not allow opposition parties to compete, creating a *de facto* one-party state; while the latter type is defined by Levitsky and Way (2002) as regimes in which elections are an effective way to gain power, but at the same time there is fraud, such as violations of civil rights that make elections competitive but unfair.

TABLE 1

FEATURES OF ELECTORAL PROCESS IN ELECTORAL AUTHORITARIAN REGIMES

Electoral process	**Political regimes**			
	Closed authoritarism	Hegemonic authoritarism	Competitive authoritarism	Minimal Democracy
Elections	No	Yes	Yes	Yes
Minimally competitive elections	No	No	Yes	Yes
Free, fair and competitive elections	No	No	Yes	Yes

3. - Methodology

3.1 *Data Base Creation*

In this paper I use a cross-sectional database of 152 countries[1], obtained from the World Bank's World Development Indicators (2005). In selecting countries I remove all independent territories and small states[2]. It is worth clarifying two issues I deal with in selecting countries from two areas: Africa and Central-Eastern Europe (CEE). The first problem concerns the availability of certain data. Being a study that seeks to determine the impact of the initial conditions on the Third Wave, it was necessary to obtain observations for some variables in 1975. For many countries in those areas it is not possible to gather data, such as the level of *per capita* GDP or the average education level for this period. The second problem regards how to interpret the results obtained for the former Soviet countries. Indeed, by selecting 1975 as the benchmark for initial conditions, it is clear that the predictions one would find for these countries would not be very significant, since the liberalization of political and civil rights coincide with the fall of the

[1] Countries' narratives are available upon request to the author.

[2] Andorra, Aruba, Netherlands Antilles, American Samoa, Bermuda, Channel Islands, Faeroe Islands, Greenland, Guam, Hong Kong, Isle of Man, Liechtenstein, Macao, Maldives, Monaco, San Marino, Northern Marianna Islands, Mayotte, New Caledonia, Puerto Rico, French Polynesia, Timor-Leste, West Bank and Gaza, Virgin Islands, Cayman Islands, Marshall Islands, Palau, Samoa, the Solomon Islands, Micronesia, Vanuatu, St. Vincent and the Grenadines, St. Lucia, St. Kitts and Nevis.

Berlin Wall in 1989. This indeterminacy has led to the exclusion of some countries in these areas[3]. In any case, excluding these countries could lead to misleading interpretations of the results. In Appendix A, I provide evidence that results do not change qualitatively if I include Central-Eastern Europe[4] countries.

3.2 *Dependent Variable*

In order to identify democratization episodes, I use a dummy variable constructed by Papaioannou and Siourounis (2008*b*). This dummy is obtained by combining together three different indicators: the Polity Democracy Index (Gurr, 1990), Freedom House's Freedom in the World Index and the Przeworski's Index (2000) of political transition (updated by Papaioannou and Siourounis, 2008).

I present a brief description on the informational content of the different available indexes:

1. *Polity Index*: the index assigns scores from –10 to +10. A score of + 10 means the highest level of political freedom. This index is composed by the degree of competitiveness in political participation and the constitutional constraints on the executive.
2. *Freedom House's Freedom in the World*: the index assigns a score of political rights and a score of civil liberties protection. It assigns values from 1 to 7 to both scores with lower values indicating a higher level of protection. Moreover it assigns a threefold characterization of the countries based on the two scores: "free", "partially free" and "not free". The data is available from 1972.
3. *Przeworski* et *al. (2000) classification*: the data presents a binary regime classification (democratic *vs.* autocratic) which is based on whether contested elections are present or not.

As in Papaioannou and Siourounis (2008*b*), the dependent variable is derived by a combination of changes in the indexes presented above, in the way of the algorithm that follows (to which a stability constraint of five years is imposed):

1. Polity Index shifts from a negative to a positive value and *vice versa*;
2. Freedom House regime status characterization changes;
3. The Przeworski *et* al. (2000) classification moves from autocratic to democratic and *vice versa.*

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[3] Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Former Yugoslavian Republic of Macedonia (FYROM), Moldova, Russia, Serbia and Montenegro, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

[4] It is worth noticing that given the unavailability of controls in 1975, the regressions are unconstrained.

The use of a binary classification has been suggested by Przeworski *et* al. (1999) in view of the clear censoring of the democracy index around the extremes (most variables take values close to the lower and to the upper bound). Although considering that the switch from negative to positive is the most widely used convention alternative, more continuous definitions of democratic improvements has been shown to deliver qualitatively similar results (see Papaioannou and Siourounis, 2008*b*). To eliminate short term fluctuations in the democracy index that can be imputed to measurement errors, the data further impose a five year stability requirement (Papaioannou and Siourounis, 2008*b*).

3.3 *Independent Variables - Electoral Authoritarian Regimes*

In order to make operational the various definitions of electoral authoritarianism, I choose to use LIEC's (Legislative Index of Electoral Competitiveness) and EIEC's (Executive Index of Electoral Competitiveness) indexes as derived from Beck *et* al. (2006). Using these two indexes, as in Brownlee (2009), it is possible to get the electoral competitiveness of each country in terms of legislative and executive composition. Built on a range from 1 (meaning absence of competitiveness) to 7 (indicating regimes having a significant competitiveness), this ranking allows the identification of several levels of electoral competitiveness. This may be considered a *proxy* for the features of the regimes mentioned above. A regime that obtains a score from 1 to 4 is classified as a closed authoritarian regime; whereas a regime with a score between 5 and 7 is classified as an electoral authoritarianism. In this way I can create a dummy variable with value equal to 1 for electoral authoritarian regimes, and 0 for closed authoritarian regimes. Furthermore, it is possible to divide the group of electoral authoritarianism into hegemonic authoritarianism (for those countries that have scores between 5 and 6) and competitive authoritarianism (for those countries that achieve at least a 7 score in one of the two indexes). As before, it is now possible to create two more dummy variables. The first dummy is equal to 1 for hegemonic authoritarianisms and to 0 for all other types of regime. The second dummy, instead, with a value equal to 1 for competitive authoritarianisms and a value equal to 0 for all other regime's typologies.

Each country is classified into this ranking with the kind of regime it had in the previous year of democratic transition, or in the absence of democratization, with the latest available observation (year 2006).

3.4 *Economic Controls and the Problem of Reverse Causality*

The problem of reverse causality between democracy and income has been largely discussed in the literature; however it is not easily solvable. The recent paper by Ciccone and Bruckner (2011) addresses this issue by using variation in rainfalls as instrument for income in instrumental variables regressions where democratization is the dependent variable. However, this strategy can only be applied to Sub-Saharan African countries.

In this paper I follow the strategy by Papaioannou and Siourounis (2008*b*) to deal with (at least partially) this problem by considering only those countries that were non-democratic (that means either closed or electoral authoritarian) at the beginning of the Third Wave. Furthermore, the sample restricts attention only to countries that experience a permanently democratization. Studying this set of countries allows me to exclude the reverse effect on causality of democratization: focusing only on non-democratic countries helps to "isolate the one-way effect of income, education, and other factors on democratization" (Papaioannou and Siourounis, 2008*b*). Moreover, following the literature, I control for the level of income, education and social characteristic in 1975 (beginning of the Third Wave).

4. - Democratization and Electoral Authoritarianism

After presenting the methodology, I proceed to identify the democratization episodes and the way in which this process has been affected by electoral authoritarianisms during the Third Wave. [Table 2]

From the database, I identify 39 processes of democratization from 1975 to 2006. Concerning democratic transitions in countries with a closed authoritarian regime (without elections), they happened in 16 cases. Closed authoritarianisms have passed from 33 to 17 (year 2006). Dividing the Third Wave into two periods, *pre-* and *post-*1990, I notice that 11 out of 16 democratic transitions for closed authoritarianisms occurred after 1990. The decision to choose the year 1990 as a cutoff is two-fold. The first one is the fall of the Berlin Wall in 1989 and the disintegration of the Soviet bloc[5]. The second reason is that the emergence of electoral authoritarianism increases significantly during the decade 1990-2000.

[5] As already mentioned, although many former Central-Eastern European countries have experienced democratic transitions after that date, they are not included in this analysis given the difficulty in finding data about the initial conditions of the Third Wave (year 1975). See *APPENDIX* A, for some results on the probability of democratization after 1990 including CEE countries.

TABLE 2

COUNTRIES BY POLITICAL REGIME AND DEMOCRATIC TRANSITION (YEAR OF TRANSITION)

Closed Authoritarian	Democratization from Closed Authoritarian	Hegemonic Authoritarian	Democratization from Hegemonic Authoritarian	Competitive Authoritarian	Democratization from Competitive Authoritarian
Afghanistan	No	Burundi	No	Algeria	No
Albania	Albania 1991	Cambodia	No	Bangladesh	Bangladesh 1990
Angola	No	Cameroon	No	Botswana	No
Argentina	Argentina 1983	Central African Rep.	No	Brazil	Brazil 1985
Bahrain	No	Cote d'Ivoire	No	Burkina Faso	No
Benin	Benin 1991	Dominican Rep.	Dominican Rep. 1978	Chad	No
Bolivia	Bolivia 1978	Egypt, Arab Rep.	No	Congo, Rep.	No
Bulgaria	Bulgaria 1990	Haiti	No	El Salvador	El Salvador 1984
Chile	Chile 1989	Iran, Islamic Rep.	No	Equatorial Guinea	No
China	No	Iraq	No	Ethiopia	Ethiopia 2004
Congo, Dem. Rep.	No	Jordan	No	Gabon	No
Cuba	No	Kuwait	No	Ghana	Ghana 2000
Ecuador	Ecuador 1979	Lao PDR	No	Guinea	No
Guatemala	Guatemala 1985	Malawi	Malawi 1994	Guinea-Bissau	No
Honduras	Honduras 1981	Malaysia	No	Indonesia	Indonesia 1998
Hungary	Hung 1990	Morocco	No	Kenya	No
Korea, Dem. Rep.	No	Rwanda	No	Korea, Rep.	Korea Sud 1987
Libya	No	Singapore	No	Liberia	No
Mali	Mali 1991	Sudan	No	Madagascar	Madagascar 1993
Myanmar	No	Syrian Arab Rep.	No	Mauritania	No
Nepal	No	Tunisia	No	Mexico	Mexico 2000
Nigeria	Nigeria 1999	Turkey	Turkey 2004	Mozambique	Mozambico 2004
Oman	No	Yemen, Rep.	No	Nicaragua	Nicaragua 1990
Poland	Poland 1989			Niger	No
Qatar	No			Pakistan	No
Romania	Romania 1990			Panama	Panama 1989
Saudi Arabia	No			Paraguay	Paraguay 1993
Sierra Leone	No			Peru	Peru 2000
Somalia	No			Philippines	Philippines 1986
United Arab Emirates	No			Senegal	Senegal 2000
Uruguay	Uruguay 1984			South Africa	S. Africa 1994
Vietnam	No			Spain	Spain 1979
Zambia	Zambia 1991			Tanzania	Tanzania 2004
				Thailand	Thailand 1988
				Togo	No
				Uganda	No
				Zimbabwe	No
Total	**Total**	**Total**	**Total**	**Total**	**Total**
34	16	24	3	36	20

Considering electoral authoritarianisms, there has been 23 episodes of democratization. Thus the number of these regimes has decreased from 60 to 37 countries. Dividing electoral authoritarianisms into hegemonic and competitive authoritarian regimes, I observe that, from 1975 to 2006, only 3 out of 23 hegemonic authoritarian regimes have become democratic regimes. This number is reduced to just one transition when I consider the *post*-1990 period. At the same time competitive authoritarianisms have decreased from 37 to 17 during the Third Wave. This leads to 20 democratic transitions cases (15 for the period *post*-1990).

After identifying the dynamics of democratization and country-specific cases, it remains to be determined which socio-economic factors may drive the democratization process described above. I therefore attempt to investigate the effect of an electoral authoritarian regime on the probability of democratizing for a given country.

5. - Determinants of Democratic Transition - Descriptive Analysis

In this section I present the controls selected to study the determinants of the Third Wave. Through the descriptive analysis that follows (Table 3), I try to provide some insights in order to show the explanatory power of democratization theories. The theories I consider in this section are five: Modernization Theory, Social Structure Theory, Endowment of Natural Resources Theory, Trade Openness Theory, and Early Institution Theory. The next table summarizes the values of the control variables for each type of political regime. For this reason, I introduce two additional variables for political regimes. The first one specifies democratic countries that were already democracies before the Third Wave. The second one includes all those countries experiencing a democratic transition process during the Third Wave. Introducing these variables may provide a useful benchmark for comparisons among political regimes. [Table 3]

Regarding the variables of Modernization Theory, I show how the predictions of this theory are respected. Countries classified as "always democratic" have a *per capita* GDP of nearly five times higher than that of countries belonging to electoral authoritarianism and closed authoritarianism as well.

For levels of average education for the population older than 25 years, the results are likewise significant. "Always democratic" countries are much more educated, in terms of years of schooling, than any other type of regime. In fact, electoral authoritarian regimes achieve an average education level equal to one-third that of democratic countries. Isolating hegemonic authoritarianisms, the gap increases to one-quarter compared to the level of "always democratic" countries.

Concerning life expectancy (as proxy of country development), I further consider information for the Central-Eastern European countries in addition to the benchmark sample. The reason of the above inclusion is that this is the only control available for this set of countries in 1975 (data are from the Indexes of World Bank). In this way I am able to control for the well documented differences between the life expectancy of these countries compared with other authoritarian regimes. Nevertheless, life expectancy in 1975 has higher levels in democratic countries than in any other regimes. Even introducing CEE countries and comparing the level of development between "always democratic" countries and electoral authoritarianisms, the latter ones have an average life expectancy lower than 14 years with respect to the former ones.

Analyzing the Theory of Social Structure, the table reports average values of ethnic and religious fragmentation. Descriptive analysis suggests that "always democratic" countries have lower levels of ethnic fragmentation than other regimes, reaching a 29% probability that two people belong to two different ethnic groups. The electoral authoritarianism has, instead, a fragmentation index equal to 55%. Regarding the countries that democratize during the Third Wave, they have levels of ethnic fragmentation similar to that of the electoral authoritarianisms. Religious fragmentation has even more ambiguous results. "Always democratic" countries present an index of religious fragmentation higher than that of the electoral authoritarianism and closed authoritarianism group.

What about the Theory of Endowment of Natural Resources? How many countries that democratize have a value equal to one for the oil-exporters variable? There are two countries that are oil-exporters, namely Indonesia and Nigeria. In total, among electoral authoritarianisms, there are seven countries over sixty that are oil exporters, while for closed authoritarianisms they are eight out of thirty-three.

The liberal hypothesis assumes trade openness as the fundamental factor for democratization. Taking into account the variable for trade openness in 1975 (sum of exports and imports as a percentage of GDP), I see that electoral authoritarian regimes have more openness to trade than "always democratic" ones. The group of hegemonic authoritarianisms has higher levels of trade openness compared with the average of the group of electoral authoritarianisms. Instead for countries that democratize during the Third Wave, the level of trade openness is even lower than in "always democratic" countries.

The last theory I analyze is the so-called Theory of Early Institution. In order to summarize the message of this theory I choose a variable able to identify differences in protection of property rights to the date of independence of a given

TABLE 3

DESCRIPTIVE ANALYSIS OF THEORIES AND POLITICAL REGIME

	Always democratic	Democratization	Closed Authoritarianism	Electoral Authoritarianism	Hegemonic Authoritarianism	Competitive Authoritarianism
			Modernization Theory			
GDP *p.c.* in 1975	10538,89	3334,418	2942,61	2805,264	2696,19	2856,772
	(5494,932)	(2708,978)	(2544,92)	(2248,821)	(1833,56)	(2442,981)
	35	48	18	53	17	36
Education in 1975	6.3	3.29	3.12	2.18	1.81	2.43
	(2.472)	(2.119)	(2.58)	(1.407)	(1.115)	(1.539)
	36	45	26	50	20	30
Life expectancy in 1975*	68,407	58,059	57,525	54,226	54,019	54,336
	(7,447)	(9.663)	(10,943)	(9,395)	(9,517)	(9,427)
	41	66	38	75	26	49
			Social Structure Theory			
Ethnic Fragmentation	29,972	48,268	50,39	55,294	48,187	59,52
	(21,750)	(25,754)	(26.86)	(24,591)	(23,763)	(24,406)
	41	54	33	59	22	37
Religious Fragmentation	47,214	38,242	37.52	43,129	40,385	44,835
	(22,668)	(25,097)	(21,24)	(25,746)	(28,559)	(24,085)
	41	55	33	60	23	37
Islam	2.51	23.35	31.97	37.59	51.82	28.74
	(5.16)	(35.98)	(41.87)	(40.47)	(42.76)	(36.84)
	41	55	33	60	23	37
Confucian/Buddhist	4.05	3.93	5.42	5.72	9.73	3.23
	(18.09)	(18.20)	(19.14)	(19.81)	(24.67)	(15.96)
	41	55	33	60	23	37
			Endowment of Natural Resources Theory			
Oil-exporters	0.049	0.054	0.242	0.116	0.13	0.108
	(0.218)	(0.229)	(0.435)	(0.324)	(0.344)	(0.314)
	45	55	33	60	23	37

			Trade Openness Theory			
Share of trade in 1975	62,262 (44,012) 35	61,511 (52,512) 49	55,83 (44,88) 19	63,039 (40,968) 53	68,631 (44,914) 17	60,398 (39,358) 36
			Early Institutions Theory			
Executive constraints at indipendence	0.664 (0.419) 32	0.269 (0.273) 51	0.244 (0.272) 33	0.311 (0.291) 60	0.269 (0.263) 23	0.337 (0.307) 37

* Usual sample plus CEE countries: Armenia, Azerbaijan, Belarus, Croatia, Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Former Yugoslavian Republic of Macedonia (FYROM), Moldova, Russia, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

Table reports mean, standard deviation and number of available observations for each variable by political regime.

Variables

GDP *p.c.* in 1975 : real *per capita* GDP based on PPP in 1975 (HEASTON A. *et* AL., 2002);

Education in 1975: Average year of education for the population >25 (BARRO R.J. and LEEJ., 2001); missing values integrated with data SOTO M. *et* AL. (2005);

Life expectancy in 1975: Number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same in 1975 (WORLD BANK, 2005);

Ethnic/Religious Fragmentation: Index of ethnic/religious heterogeneity, constructed as one minus the Herfindahl index of the share of the largest ethnic/religious groups. It reflects the probability that two randomly selected individuals follow different ethnic/religious beliefs. (ALESINA A. *et* AL., 2003);

Religion (Muslims, Confucian/Buddhist): Share of each religious group in total population (ALESINA A. *et* AL., 2003);

Oil (dummy variable): variable equal to 1 for countries that are members of OPEC or classified by the IMF as exporters of fuel (PAPAIOANNOU E. and SIOUROUNIS G., 2008).

Trade openness in 1975: A zero-one variable for trade openness based on five individual dummies for specific trade related policies (WACZIARG R. and WELCH K.H., 2003).

Executive constraint at independence: Average value during the first ten post-independence years. If data for the first 10 years after independence is missing, I average over the first ten years of available data. The measure is normalized to lie between 0 and 1 (MARSHALL M.G. and JAEGGERS K., 2004).

country, as in Marshall and Jaeggers (2004). I notice that "always democratic" countries have, on average, a level of protection of property rights higher than that of both closed and electoral authoritarianism. Nevertheless, it should be recognized that for countries democratizing during the Third Wave, levels of protection of property rights are lower to that of countries experiencing the democratic process before the Third Wave.

6. - Empirical Findings

Following the descriptive analysis, I introduce the econometric model I use in order to test both the impact of electoral authoritarianism on the probability of democratization, and to control which of the theories presented above can best explain the determinants of democratic transition.

The regression is a cross-sectional probabilistic model[6]

$$P(D=1|R^P, X_{i,1975}, Z_i) = G(\alpha + R_i^P\beta_1 + x_{i,1975}\beta_2 + z_i\beta_3)$$

The model is estimated employing a *probit* model with marginal effects: the reported coefficients are therefore interpretable as the impact on the probability of democratization of a small change in the control variables (considering the average values for all the controls). The *p-values* are calculated using heteroskedasticity-adjusted standard errors and are reported in brackets. Using this approach I try to identify which is the effect of the control variables on the probability of a country to become democratic (D_i) in the period 1975-2006. This model is a nonlinear function of type of previous political regime (R^P) and initial time-varying factors ($X_{i,1975}$), such as education and trade openness, and characteristics that do not vary over time (Z_i), such as ethnic and religious fragmentation. As shown by descriptive analysis, Modernization Theory is the one that presents less ambiguity in terms of interpretation. I decide to select it as a benchmark of my analysis (as in Barro, 1999; in Przeworski *et* al., 2002; Glaeser *et* al., 2004; Acemoglu *et* al., 2005 and Papaioannou and Siourounis, 2008). Given the collinearity problem, the three Modernization Theory's variables cannot be simultaneously included into the same regression. Thusly, three different regressions are presented for every model. Moreover, I include in the model all the variables presented in the descriptive analysis in order to assess the significance of these theories as well.

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[6] This model is similar to that used by PAPAIOANNOU E. and SIOUROUNIS G. (2008*b*) with the introduction of a dummy that takes account of political regime changes.

The first regression (Table 4) is designed to evaluate the role of electoral authoritarianism on democratic transitions during the Third Wave. Columns 1A, 2A and 3A show the results for the dummy electoral authoritarianism on the likelihood of democratization. Columns 1B, 2B and 3B show estimates for the subset of hegemonic and competitive authoritarian regimes. [Table 4]

Testing electoral authoritarian regimes, as opposed to closed authoritarian regimes, I see how the impact on the probability of democratization is negative, but not statistically significant. Specifically, an electoral authoritarian regime has a negative effect around 45%, *ceteris paribus*, on the probability of becoming a democracy with respect to a closed authoritarianism. This result may seem counter-intuitive, given the existing literature that considers the extension of the franchise as a first step towards democracy. But as it has been highlighted in this paper, the electoral process that characterizes electoral authoritarian regimes does not seem driven by improving the efficiency of policies. It seems simply due to mechanisms of legitimization for the regime itself. This result is consistent also after controlling for all three variables of modernization theory.

With regard to these three variables, I notice how *per capita* GDP in 1975 is not significant, albeit positive. In contrast, both the initial level of education and life expectancy are positive and significant. In particular, the level of education seems to have a very important effect on the likelihood of democratization. *Ceteris paribus*, the marginal effect of education is equal to an increase in the likelihood of democratization around 20% (significant at 1%). This result seems to confirm the fundamental role of human capital for democratization processes as confirmed by Bourguignon and Verdier (2000) and Glaeser *et* al. (2004). So, one additional year of education for electoral authoritarianism in 1975 increases the probability of democratization up to 43% (2.18*0.20). In order to interpret this result, I have to consider the following: the implementation of such a policy, which could increase the average education of the population over 25 years, is not one which is available in the short-run.

Concerning other controls, I observe that religious fragmentation has a negative (around 7%) and significant impact in a consistent way, regardless the control of Modernization Theory that is chosen. This result is in line with the literature stating that democracy is less likely to emerge in countries with high religious fragmentation. When controlling for human capital, ethnic fragmentation and Confucian and Buddhist controls become significant. An increase of 20% ethnic fragmentation improves the chances of democratization by 6%; while a 20% increase in the presence of individuals belonging to religions Confucian/Buddhist leads to a decrease in probability of democratization by 7%.

The next step is to test the two subsets hegemonic and competitive authoritarianisms against the group of closed authoritarian regimes. The impact of these two types of regime on democratization goes in the same direction: countries belonging to these two regimes experience a negative effect on the probability of democratize. Again, the result of previous regression is confirmed: the extension of voting rights and the partial liberalization of political rights do not induce an increase in the probability of democratization. As a matter of fact, the opposite is true.

The result obtained for hegemonic authoritarianism is surprising. In fact, it predicts a negative impact on the probability of democratization between 40% and 46% when I compare it with closed authoritarian regimes, with a significance of 5% (in case I control for GDP and life expectancy) and 10% (in case I control for education). Regarding the variables of the Modernization Theory, as noted above, the effect of *per capita* GDP is positive but not statistically significant. The education variable, instead, is still highly significant. Again human capital seems to be the main driver of democratization. In this case, a one year increase in the average education level in 1975 (1.81 years to 2.43 years for authoritarian hegemonic and competitive ones) predicts an increase in the probability of democratization of 36% for hegemonic and 48% for competitive authoritarian regimes.

TABLE 4

CROSS-COUNTRY ESTIMATES ON THE LIKELIHOOD OF DEMOCRATIZATION FOR ELECTORAL AUTHORITARIANISM AND INITIAL CONDITIONS (PERIOD 1975-2006)

Dependent variable = d_ev1	**Model 1A**	**Model 1B**	**Model 2A**	**Model 2B**	**Model 3A**	**Model 3B**
Electoral Authoritarian	-.231		-.149		-.213	
	(.132)		(.140)		(.134)	
Hegemonic Authoritarian		- .456**		-.400*		- .466**
		(.181)		(.223)		(.194)
Competitive Authoritarian		- .178		-.054		- .142
		(.158)		(.184)		(.160)
Ln GDP *p.c.* in 1975	.102	.118				
	(.087)	(.089)				
Schooling in 1975			.200***	.205***		
			(.053)	(.052)		
Life Expectancy					.017*	.021**
					(.009)	(.009)
Ethnic Fragmentation	.003	.002	.006*	.005	.005	.004
	(.003)	(.003)	(.003)	(.003)	(.004)	(.003)
Religious Fragmentation	-.007*	-.005	-.007*	-.005	-.007*	-.005
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)
Muslim	-.003	-.002	-.001	- .0003	-.003	-.002
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Confucian – Buddhist	-.0005	-.00006	-.006*	- .006**	-.003	-.003
	(.004)	(.003)	(.003)	(.003)	(.004)	(.003)
Oil	-.122	- .161	.003	- .052	-.076	-.122
	(.247)	(.249)	(.197)	(.231)	(.225)	(.231)
Trade share in 1975	-.001	-.001	-.001	-.001	-.002	-.001
	(.002)	(.002)	(.001)	(.002)	(.002)	(.002)
Executive constraints at independence	.109	.045	-.432*	- .548**	.036	-.055
	(.232)	(.238)	(.234)	(.250)	(.239)	(.247)
Pseudo *R*-squared	0.152	0.185	0.305	0.352	0.178	0.220
Countries	72	72	65	65	72	72

Table reports the estimated probit marginal effects on probability of democratization. The dependent variable equals one for countries that democratize during the Third Wave. All specifications show the values of standard deviation in brackets under the marginal effect. The table shows the Pseudo *R*-square MacFadden.

* Statistical significance at 10% ** *Idem* 5% *** *Idem* 1%.

Finally, the life-expectancy variable has a significance of 10%, although the coefficient is very small (2%). When controlling for other theories of democratization in this regression, they do not have predictive power. Only when I control for human capital, variables concerning the presence of members of the Buddhist religion and the protection of property rights at independence become significant and negative. These estimates, however, differ greatly on the extent of their coefficient: the first one presents a negative coefficient around 6%, while the second one is around 54%.

The regressions just described take into account the period 1975 to 2006. In other words, they assess the impact electoral authoritarianism has on democratization for this time interval. However, as previously recognized by many political scientists, these regimes are a phenomenon that has assumed growing importance in the last phase of the Third Wave. In my database, for the period 1990 to 2006, there are 53 countries that fall under the classification of electoral authoritarianism. Thus, it may be useful to assess what impact electoral authoritarian regimes have in the late part of Third Wave. If Brownlee (2009) was correct in stating that electoral authoritarian regimes have become the new forms of governance in developing countries, I judge necessary to establish to what extent these regimes are resilient to democratization. To this purpose, I use a dummy variable that identifies countries experiencing democratic transition by 1990. This allows me to estimate the likelihood of democratization for the period 1990 to 2006. [Table 5]

Let me now describe this model and the estimates generated by it. The first regression is similar to that of Table 4, except that the analysis sample is restricted to countries that could potentially democratize only after 1990. Columns 1C, 2C and 3C show the results for the dummy variable on the democratization probability of electoral authoritarianisms. Columns 1D, 2D and 3D, instead, describe the results for the dummy variables of hegemonic and competitive authoritarian regimes.

Running the regression for electoral authoritarianism, I find that the coefficient of this variable is negative but not significant after controlling for the three variables of Modernization Theory. This result is consistent with the findings of the previous regressions. Considering the period from 1990 to 2006, the electoral authoritarianisms have a negative effect on the probability of democratize with respect to closed authoritarian regimes. Moreover, electoral authoritarian regimes have an even greater negative impact on the probability of democratization during *post*-1990 period.

Concerning Modernization Theory, the non-relevance of *per capita* GDP is confirmed, albeit having a positive coefficient. Unlike the regression that considered the period from 1975 to 2006, the life-expectancy variable also loses significance.

The only variable of the Modernization Theory that is still important and meaningful is education. Indeed, human capital always has a positive impact on likelihood of democratization that is around 43%. Regarding other controls, I note that religious fragmentation still has a negative impact on democratization, when controlling for *per capita* GDP. By the way, when human capital is included into the regression, ethnic fragmentation becomes significant (with positive effects on the likelihood of democratization), as well as protection of property rights around independence (with negative effect on the probability of democratic transition).

Examining the effects of the two subsets of electoral authoritarianisms, I show that the most important result found in the previous regression (period 1975-2006) is confirmed. The hegemonic authoritarianisms have a lower chance (around 46-48%) of becoming democracies if compared with closed authoritarian regimes. This important result, which has an even greater impact for the considered time interval, it is significant at 5%, controlling for *per capita* GDP and life expectancy; while it has significance at 10%, when I control for human capital. Modernization Theory has significance only when I introduce the variable of education. C*eteris paribus*, human capital has a positive impact on the likelihood of democratization around 22% (statistically different from zero at 1%). The other two variables, *per capita* GDP and life expectancy, although having positive coefficients, are not statistically significant.

Controlling for the other theories, ethnic fragmentation shows the same results as before: a significant negative effect when controlling for *per capita* GDP. However, this effect disappears when introducing the other two variables of Modernization Theory. Checking for subgroups of electoral authoritarian and the educational level, only the protection of property rights at independence shows a coefficient statistically different from zero. The coefficient implies that this variable, *ceteris paribus*, has a negative effect on the probability of democratization (minus 79%) and is statistically different from zero at 5%.

6.1 *Theoretical Interpretation*

The results show that electoral authoritarian regimes have a lower transition-into-democracy probability with respect to closed authoritarian regimes. How can one try to empirically interpret this result? One possible interpretation of the result is that the political regimes that were flexible and adaptable enough have a higher probability of lasting; while the more rigid ones cracked and collapsed.

TABLE 5

CROSS-COUNTRY ESTIMATES ON THE LIKELIHOOD OF DEMOCRATIZATION FOR ELECTORAL AUTHORITARIANISM AND INITIAL CONDITIONS (PERIOD 1990-2006)

Dependent variable = d_ev1	Model 1C	Model 1D	Model 2C	Model 2D	Model 3C	Model 3D
Electoral Authoritarian	-.261		-.151		-.248	
	(.152)		(.183)		(.151)	
Hegemonic Authoritarian		-.471**		-.468*		-.482**
		(.166)		(.215)		(.171)
Competitive Authoritarian		-.189		-.003		-.158
		(.170)		(.212)		(.168)
Ln GDP *p.c.* in 1975	.029	.060				
	(.106)	(.110)				
Schooling in 1975			.205***	.227***		
			(.076)	(.079)		
Life Expectancy					.012	.017
					(.010)	(.011)
Ethnic Fragmentation	.004	.002	.008**	.007	.006	.005
	(.003)	(.004)	(.004)	(.005)	(.004)	(.004)
Religious Fragmentation	-.007*	-.005	-.006	-.002	-.006	-.004
	(.004)	(.004)	(.005)	(.005)	(.004)	(.005)
Muslim	-.003	-.002	-.0008	.002	-.002	-.0005
	(.002)	(.003)	(.003)	(.003)	(.002)	(.003)
Confucian – Buddhist	-.0007	.0006	-.005	-.004	-.002	-.002
	(.004)	(.004)	(.004)	(.004)	(.004)	(.003)
Oil	-.118	-.138	.021	-.027	-.097	-.119
	(.237)	(.237)	(.237)	(.262)	(.226)	(.227)
Trade share in 1975	-.0007	-.0006	-.002	-.001	-.001	-.0009
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Executive constraints at independence	.141	.033	-.525*	-.790**	.062	-.075
	(.245)	(.249)	(.307)	(.359)	(.260)	(.269)
Pseudo *R*-squared	0.097	0.137	0.228	0.304	0.115	0.164
Countries	60	60	53	53	60	60

Table reports the estimated probit marginal effects on probability of democratization. The dependent variable equals one for countries that democratize during the Third Wave. All specifications show the values of standard deviation in brackets under the marginal effect. The table shows the Pseudo *R*-square MacFadden.

* Statistical significance at 10% ** *Idem* 5% *** *Idem* 1%.

This interpretation appears indeed compatible with the anecdotic evidence resulting from the analysis of the historical narratives of process of democratization in the countries in the sample (Papaioannou and Siourounis, 2008*b*; Karatnycky and Ackerman, 2005). Some common patterns emerge in many countries belonging to the same regime classification. In the following paragraph let me just briefly add some details regarding some countries from each type of regime which can be used as prototypical illustrative examples.

Two quite clear recurring patterns are identifiable for the closed authoritarian regimes that do not democratize: the absence of a strong, and cohesive, civic opposition and the elite's large effectiveness to repress opposition. These two factors may have allowed closed authoritarian regimes to perpetuate themselves without being subjected to the sufficient political pressure to be forced to further extend the political rights. Some common patterns emerge in the closed authoritarian regimes which managed to resist democratization. For instance, the mid-1970s, Fidel Castro started implementing economic reforms in Cuba but the government kept arresting and imprisoning a large number of civil activists (a period known as the "Black Spring" in 2003). Despite the very different background some Arab countries similarly managed to resist democratization pressure (for the moment). Saudi Arabia (an absolute monarchy) remains the only Arab Nation where no elections have ever taken place, since its creation. Similarly no strong opposition can be detected in the case of the United Arab Emirates where the Supreme Council elected new rulers (in 2004 and 2006) which essentially represented a mere dynastic change in leadership.

The evidence for those closed authoritarian regimes that collapse and eventually experience democratization is quite different. A consistent pattern can be detected. These regimes face a strong military opposition which they are not able to repress. In some countries of the sample, along with military opposition there is a role for civic opposition which is nonetheless weak or moderate. An example is Benin, which was ruled by the military since independence in 1960. After almost thirty years of military dictatorship, a new democratic constitution, which institutionalized multi-party democracy, was drafted and approved by a National Conference in December 1990. While the long ruling president Kerekou accepted to hand power to the opposition, he managed to be democratically re-elected in the two subsequent voting rounds until 2001. Despite the very different historical and cultural background also Bolivia, after its independence from Spain in 1825, was subject to a long series of *coups* (about 180) before free elections were finally held in 1978 despite having been far from fair. After a strike that brought the country just a step before civil war, the military decided to step down and reconvene the 1980 Congress.

A common pattern in the electoral authoritarian regimes that managed to resist a full democratization is the presence of a potentially violent, but substantially divided opposition which in many cases has created windows of opportunity for the electoral authoritarian regime to avoid a full democratization by co-opting a part of the opposition through a democratic facade. One significant example is Burundi, where after two genocides and the mass killing of very different groups of Hutus, the Tutsi-dominated army signed a cease-fire in 2003 with the largest Hutu rebel group. This allowed them to keep controlling power despite the concessions.

A partial political freedom was conceded also in Kenya after a failed and strongly repressed *coup d'état*, following a rising *climax* of a very undemocratic regime that generated widespread agitation and demand for constitutional reform which failed to lead to a full democratization.

Finally, behind the emergence of a fuller democratization out of electoral authoritarian regime is the presence of a cohesive civic opposition. The fact that cohesion is hard to achieve (for instance due to the well-known problem of collective action) may help explaining the low probability of democratize from these electoral authoritarian regimes. Examples of these types of transition include the flee of president Ferdinand Marcos from the Philippines after a huge opposition from both internal protests and pressure from the international community. Similarly in Alberto Fujimori's Peru, mounting civic pressure forced him to resign prematurely in November 2000 and steered the nation toward free and fair national election; while in Senegal large support for the long term leader of the opposition Wade eventually allowed to overcome repeatedly fraudulent voting rounds and to lead to free elections.

7. - Conclusion

In this paper I tried to answer the following question: what are the economic and social determinants that drive the Third Wave of democratization and what role is played by political regimes in relation to democratic transition. In order to answer this question, I, first, analyzed some of the main theories of democratization with respect to the Third Wave (1975-2006). Secondly, I wanted to abandon the distinction between non-democratic regime (or oligarchy) and democracy. To do this, I used a new classification of non-democratic regimes which has become increasingly important in the political science literature, over the last fifteen years: the electoral authoritarian regimes. Given the stagnation undergone by processes of democratization since the mid-nineties, such regimes seem to represent a barrier to the continuation of the Third Wave. The presence of elections without democracy is the fundamental characteristic of these regimes: regular elections for the executive offices and legislative power, which are, however, heavily influenced by widespread and systematic manipulation by the regime. Those findings seem to contradict the proposition stating that the larger is the political participation in a regime, the greater the possibility of democratization. It is worth noticing that these elections are partial concessions and that they comply with the trio postulated by Levitsky and Way (2002): inclusion of a large part of the population, elections minimally competitive and minimally opened. I therefore find interesting to conceive electoral authoritarianism as a new starting point for democratic transitions and to try to assess the effect on the likelihood of democratization given these types of regime.

The work yields two main results. The first is the confirmation of the well-known relation between democratization and human capital. Considering the average level of education in 1975, this variable predicts an effect on the probability of democratization which is always positive and significant for all the specifications of the model. However, if one considers the level of *per capita* GDP and the life expectancy, I observe that these two factors do not show significance levels for all specifications of the model, while showing positive coefficients. Therefore, empirical evidence seems to suggest that the real engine of democratic processes seems to be the average level of education, as already shown by much of the previous literature (Bourguignon and Verdier, 2000; Glaeser *et* al., 2004). Among the other theories, Social Structure has some ambiguous results. On one hand, the religious fragmentation has a negative effect on the probability of democratization; on the other hand, ethnic fragmentation has the opposite effect. Nevertheless, it is worth noticing how these results are not consistent for all the specifications of the model. Therefore, their interpretation is still not clear. Finally, Early Institutions Theory seems to have an impact on democratization as well. For some specifications of the model, countries that have experienced high levels of protection of property rights, after ten years from the independence, have a negative effect on the probability of democratization.

The second result shows how electoral authoritarianisms, especially hegemonic authoritarianisms, appear to be wayward to the process of democratic transition, compared to closed authoritarian regimes. So far, 37 countries are electorally authoritarian (respectively 20 hegemonic authoritarianisms and 17 electoral authoritarianisms) and they have almost half the chance to democratize with respect to closed authoritarian regimes. This negative result for hegemonic authoritarian regimes had already emerged in Brownlee (2009). However, for Brownlee (2009) the result was not significant and was offset by the positive effect of competitive authoritarianisms. This result is not confirmed by estimates of my research. Competitive authoritarianisms always predict a negative effect on the probability of democratization, and never a significant one. How can I explain the vast discrepancies between my own results and that of Brownlee's (2009)? I am most likely to find the cause of these discrepancies in the choice of dependent variable. The dependent variable in Brownlee (2009) only takes into account changes in the Freedom in the World Index (Freedom House); while in this paper the dependent variable is generated by an algorithm taking into account changes in three different indexes, as in Papaioannou and Siourounis (2008*b*). Another difference lies in the economic and social factors used as controls. Given the results presented in this paper, it is worth emphasizing that Brownlee (2009) does not control for the level of human capital, which clearly may have led to a bias in his model to such an important omitted variable. For the sake of transparency, if I replaced the dependent variable I used with the one chosen by Brownlee (2009), the results would still not be confirmed within my model.

The impact of hegemonic authoritarian regimes on the likelihood of democratization is an intricate, multidimensional proposition. Although the causes of resistance to democratization by electoral authoritarian regimes need much further investigation, I believe this result offers crucial evidence for the hypothesis that these regimes do not evolve into democracies, but are fully-formed political systems employing the façade of transition.

APPENDIX A

In this appendix I show the result I obtain when Central-Eastern European countries are included in the sample. Given the lack of data on the economic and social characteristic of the countries in 1975, I run a regression without covariates. Nevertheless, this kind of regression can provide a hint about the effect of including these countries into the database used in this paper.

The countries included in this appendix are: Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Former Yugoslavian Republic of Macedonia (FYROM), Moldova, Russia, Serbia and Montenegro, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

Table 6

CENTRAL-EASTERN EUROPEAN COUNTRIES BY POLITICAL REGIME AND DEMOCRATIC TRANSITION (YEAR OF TRANSITION)

Closed Authoritarian	Democratization from Closed Authoritarian	Hegemonic Authoritarian	Democratization from Hegemonic Authoritarian	Competitive Authoritarian	Democratization from Competitive Authoritarian
Czech Rep.	Czech Rep. 1990	Belarus	No	Armenia	Armenia 1998
Estonia	Estonia 1993	Latvia	Latvia 1993	Azerbaijan	No
Macedonia	Macedonia 1991	Moldova	Moldova 1994	Bosnia	No
Slovak Rep.	Slovak Rep. 1990			Croatia	Croatia 2000
Turkmenistan	No			Georgia	Georgia 2003
				Kazakhstan	No
				Kyrgyzstan	No
				Lithuania	1993
				Russia	No
				Tajikistan	No
				Ukraine	No
				Uzbekistan	No
Total	**Total**	**Total**	**Total**	**Total**	**Total**
5	4	3	2	12	3

The results below show that the inclusion of these countries does not dramatically change the previous results.

TABLE 7

CROSS-COUNTRY ESTIMATES ON THE LIKELIHOOD OF DEMOCRATIZATION FOR ELECTORAL AUTHORITARIANISM (PERIOD 1975-2006)

Dependent variable = d_ev1	Sample + CEE countries	Sample	Sample + CEE countries	Sample
Electoral Authoritarian	- .851 (.098)	-.065 (.108)		
Hegemonic Authoritarian			- .270** (.115)	- .305** (.121)
Competitive Authoritarian			.012 (.107)	.080 (.119)
Pseudo *R*-squared	0.004	0.003	0.004	0.07
Countries	114	93	114	93

Table reports the estimated probit marginal effects on probability of democratization. The dependent variable equals one for countries that democratize during the Third Wave. All specifications show the values of standard deviation in brackets under the marginal effect. The table shows the Pseudo *R*-square MacFadden.
* Statistical significance at 10% ** *Idem* 5% *** *Idem* 1%.

TABLE 8

CROSS-COUNTRY ESTIMATES ON THE LIKELIHOOD OF DEMOCRATIZATION FOR ELECTORAL AUTHORITARIANISM (PERIOD 1990-2006)

Dependent variable = d_ev1	Sample + CEE countries	Sample	Sample + CEE countries	Sample
Electoral Authoritarian	- .073 (.104)	-.051 (.114)		
Hegemonic Authoritarian			- .265** (.114)	-.302** (.118)
Competitive Authoritarian			.029 (.112)	.099 (.125)
Pseudo *R*-squared	0.004	0.002	0.05	0.08
Countries	102	81	102	81

Table reports the estimated probit marginal effects on probability of democratization. The dependent variable equals one for countries that democratize during the Third Wave. All specifications show the values of standard deviation in brackets under the marginal effect. The table shows the Pseudo *R*-square MacFadden.
* Statistical significance at 10% ** *Idem* 5% *** *Idem* 1%.

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Asset Pricing Puzzle: The Long-Run Risks Model's Approach

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*The magnitude of risk compensation in equity markets is an enduring puzzle in the field of the Economics of Finance. Bansal and Yaron (2004) and Bansal, Kiku and Yaron (2007*a,b*) have recently addressed the topic by picking out the long run growth prospects and the level of economic uncertainty in the economy as the key drivers of risks. Although their "Long-Run Risks" model successfully defines a solid theoretical framework within the ongoing debate, on the empirical side this work reveals the existence of a non-negligible model specification problem that should be addressed by further research.*

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1. - Introduction

A long-running debate in the field of the Economics of Finance regards the solution of the so-called *Asset Pricing Puzzle*: data clearly reveal the existence of a low risk free rate and a large equity premium making a serious puzzle the magnitude of risk compensation in equity markets. Bansal and Yaron (henceforth BY, 2004) have recently emphasized the crucial role played by the long-run growth prospects and the level of economic uncertainty in the economy arguing that changes in these fundamentals are the determining factors of risks and volatility in asset prices. Their "long-run risks" model (henceforth LRR model) has attracted a great deal of attention and their ideas have provided incentives for further research. Outstanding achievements, in this regard, are ascribable to Bansal (2004); Bansal, Khatchatrian and Yaron (2005); Bansal, Kiku and Yaron (2007*a*,*b*); Bansal, Dittmar and Kiku (2008); Hansen, Heaton and Li (2008) and Pakoŝ (2008). Moreover, a noteworthy and exhaustive review of the LRR model has been recently carried out by Beeler and Campbell (henceforth B&C, 2009): their work offers an accurate empirical assessment of the BY calibration and its subsequent improvements as they evaluate them along a number of dimensions.

Three aspects are crucial in the BY calibration: *(1)* consumption and dividend growth rates are modelled as containing a small persistent expected growth rate component; *(2)* the consumption process incorporates time-varying consumption volatility (*i.e.* economic uncertainty); *(3)* the model relies on the standard Epstein and Zin (1989) preferences. The persistence in the growth prospects plays not only a fundamental role in terms of the theoretical findings but it is also supported by the empirical evidence. Bansal and Lundblad (2002) and BY (2004) address this issue. Due to such a component the long-run risks are able to cause a revision in agents' expectations. This leads to changes in asset prices and concomitantly lowers agents' consumption and wealth. In other words, even if the variance of the predictable component of the growth rate process is tiny but its persistence is fairly high, a current shock to the expected growth can alter future expected prospects. These prospects can change not only in the short run but also for very long horizons thus justifying the demand for a high risk compensation. This reasoning clearly relies on the well-known belief that asset prices reflect expectations of future growth rates. The second important aspect of the LRR model is the assumption of time-varying volatility that allows time variation in expected excess of returns. The key intuition here is embodied by the awareness that asset markets dislike economic uncertainty: according to BY, a reliable model should suggest a decline in asset prices as a consequence of rising economic uncertainty or declining economic growth prospects. A rigorous calibration and an *ad hoc* choice of the preference parameters' size allow the BY model to satisfy these requirements. Finally, the representative agent has Epstein-Zin preferences that generalize power utility. While the latter forces the elasticity of intertemporal substitution (EIS) to be the reciprocal of the coefficient of relative risk aversion (RRA), Epstein-Zin preferences treat them as separate free parameters thus allowing both to be larger than 1. The results depend crucially on this assumption: an EIS larger than 1 is required for the asset valuation to rise along with an improvement in the expected consumption growth and/or a fall in the economic uncertainty, while a RRA larger than one ensures high risk premia.

Even if the evidence suggests that the BY calibration performs better than several alternative models, their work fails to address all issues. BY stock prices seem less responsive to lagged consumption growth and more predictive of future consumption growth than the empirical evidence implies. To overcome this issue, Bansal, Kiku, and Yaron (henceforth BKY, 2007*a*) revised this calibration by reducing the importance of persistent shocks to consumption growth and increasing the role of persistent shocks to volatility. B&C (2009) show that the BKY specification really improves the BY specification even if new empirical difficulties arise.

This work reinforces these results by providing new evidence. The analysis stems from B&C (2009), but crucially implements a different methodology. While the population moments approach is followed by the former, the Monte Carlo simulations' approach is adopted throughout this paper. On the ground that the persistence of the volatility process differs significantly in the BY and the BKY calibrations, the empirical section focuses on its setting and assesses the impact of such a choice on the model's performance.

The remainder of the paper is organized as follows. Section 2 reviews the LRR model literature. Section 3 provides an empirical assessment of the original calibration. Section 4 focuses on the revised calibration of the LRR model, analyses it along a number of dimensions and provides evidence for new potential problems. Section 5 concludes.

2. - Long-Run Risks Model

2.1 *Overview: Preferences and General Setting*

Under the assumption of Epstein-Zin (1989) recursive preferences, the representative agent maximizes the following objective function:

$$V_t = \left[(1-\delta)C_t^{\frac{1-\gamma}{\theta}} + \delta\left(E_t\left[V_{t+1}^{1-\gamma}\right]\right)^{\frac{1}{\theta}}\right]^{\frac{\theta}{1-\gamma}} \qquad (1)$$

Where C_t is consumption at time t,$0<\delta<1$ is the time-discount factor, $\gamma \geq 0$ is the risk-aversion (sensitivity) parameter, $\psi \geq 0$ is the intertemporal elasticity of substitution (IES) and the parameter $\theta = \frac{1-\gamma}{1-1/\psi}$. Note that the sign of θ depends crucially on the size of the preference parameters: the choice $\gamma > 1$ and $\psi > 1$ made in BY leads to a negative θ. Utility maximization is subject to the intertemporal budget constraint that requires to the wealth next period to be equal to the portfolio return time reinvested wealth:

$$W_{t+1} = (W_t - C_t)\ R_{a,t+1} \qquad (2)$$

Epstein and Zin have shown, using dynamic programming arguments that, for any asset i, the first-order condition yields the following asset pricing Euler condition,

$$E_t\ [exp(\theta\ \log\delta - \tfrac{\theta}{\varphi}\ g_{t+1} + (\theta-1)\ \ r_{a,t+1} + r_{i,t+1})] = 1 \qquad (3)$$

Where $g_{t+1} = \ln(C_{t+1}/C_t)$ stands for the log growth rate of aggregate consumption and $r_{a,t+1}$ is the log of the return (*i.e.* continuous return) on an asset that delivers aggregate consumption as its dividends each time period.

According to these preferences, the logarithm of the Intertemporal Marginal Rate of Substitution (IMRS) or the log stochastic discount factor for the economy is

$$m_{t+1} = \theta\ \log\ \delta - \tfrac{\theta}{\varphi}\ g_{t+1} + (\theta-1)\ r_{a,t+1} \qquad (4)$$

Remember that under the assumption θ equals one the above recursive preferences collapse to the standard case of power utility thus leading to the general setting discussed in Mehra and Prescott (1985)[1].

[1] Note that θ=1 and γ=1 yield the standard case of log utility.

The clear distinction between $r_{a,t+1}$ and $r_{m,t+1}$ discussed in BY is a noteworthy remark: the former represents the return to the aggregate consumption claim that being unobservable in the data has to be derived endogenously, while the latter stands for the return on the dividend claim, easily observable in the data in the form of market portfolio return. As in Campbell (1996), BY implicitly define the agent's labour income process by treating aggregate dividends and aggregate consumption as two separate processes.

The BY model is solved both via approximate analytical solutions and numerically: the first approach allows us to catch the key intuitions and the main mechanisms working in the model while the second one provides the key-qualitative results. To derive the BY analytical solutions, we rely on the standard approximations defined in Campbell and Shiller (1988):

$$r_{a,t+1}=\kappa_0+\kappa_1 z_{t+1}-z_t+g_{t+1} \tag{5}$$

Where $z_t=\log(P_t/C_t)$ is the log price-consumption ratio and κ_0 and κ_1 are parameters of linearization that depend only on the average level of z[2]. By analogy, we can define the continuous return on the dividend claim as

$$r_{m,t+1}=\kappa_0+\kappa_1\ z_{t+1}-z_t+g_{d,t+1} \tag{6}$$

Where $z_t=\log(P_t/D_t)$ is its log price-dividend ratio. Defining the agent's wealth to consumption *ratio* as $\frac{P_t+C_t}{C_t}$ it is straightforward to notice that the price-dividend *ratio* is its main determinant.

From equation *(4)*, it follows:

$$m_{t+1}-E_t\ [m_{t+1}]=(\theta-1)[r_{a,t+1}-E_t(r_{a,t+1})]-\frac{\theta}{\varphi}\ [g_{t+1}-E_t(g_{t+1})] \tag{7}$$

The IMRS measures the willingness to substitute consumption over time. As shown, its innovation is driven by the innovations in the growth rate of aggregate consumption and in the return on the consumption claim, g_{t+1} and $r_{a,t+1}$ respectively. As asset returns and the IMRS in this economy are assumed conditionally lognormal, covariation with the innovation in *(7)* governs the risk premium. In this economy the continuous risk premium on any asset *i* is given by:

2 Refer to the section *Linearization parameters* in the *APPENDIX* for a detailed discussion on this topic.

$$(8) \qquad E_t\ [r_{m,t+1} - r_{f,t}] = -\,Cov(m_{t+1}, r_{i,t+1}) - \frac{1}{2}\ Var(r_{i,t})$$

According to the LRR literature, long-run growth prospects and the level of economic uncertainty are the key determinants of risk compensation in the equity market. In order to better understand the mechanism working in the model and the importance of both risks, we start by discussing the specification proposed in BY (2004).

2.2 *LRR Model: Long Term Economic Growth and Uncertainty*

Solving the model requires derivation of the endogenous consumption return $r_{a,t+1}$ *(5)*, which is a crucial element of the pricing kernel *(4)*. The risk compensation on all assets relies on this return which itself is determined by the process for consumption growth. In order to determine the return on the market portfolio $r_{m,t+1}$ *(6)*, the dividend process is needed. BY suggest the following joint dynamics for consumption and dividends:

$$(9) \qquad \begin{aligned} & g_{t+1} = \mu + x_t + \sigma_t \eta_{t+1} \\ & x_{t+1} = \rho x_t + \varphi_e \sigma_t e_{t+1} \\ & g_{d,t+1} = \mu_d + \phi x_t + \varphi_d \sigma_t u_{t+1} \\ & \sigma^2_{t+1} = \sigma^2 + \upsilon_1(\sigma^2_t - \sigma^2) + \sigma_w w_{t+1} \\ & e_{t+1}, u_{t+1}, \eta_{t+1}, w_{t+1} \sim \ N.i.i.d\,(0,1) \end{aligned}$$

Where g_{t+1} and $g_{d,t+1}$ are the growth rate of consumption and dividends respectively, σ_{t+1} represents stochastic volatility of consumption growth, σ^2 is its unconditional mean and the four shocks e_{t+1}, u_{t+1}, η_{t+1}, w_{t+1} are assumed to be mutually independent. In the BY calibration consumption and dividends are strictly linked but are not the same: even if they share the same small and persistent component x_t, dividends are more volatile. BY introduce this feature in the model by incorporating the parameters φ_d>1 and ϕ>1 in the dividend process. The first one, φ_d, makes the conditional volatility of dividend growth proportional to the conditional volatility of consumption growth. The second one, ϕ, can be interpreted as the leverage ratio on expected consumption growth (Abel, 1999); in other words dividends, relative to consumption, display larger reactions to changes in economic prospects. The standard deviation of the long-run innovations is equal to the volatility of consumption growth times the long-run volatility multiple, that is $\varphi_e \sigma_t$, while the standard deviation of dividend growth innovations is equal to the volatility of consumption growth times the volatility multiple for dividends growth, that is $\varphi_d \sigma_t$. The time varying component of the expected rate, x_t, is a key feature of the model as it allows capturing long-run risks in consumption growth. The parameter ρ determines its persistence. By relying on fluctuating consumption volatility, BY introduce economic uncertainty into the model thus allowing the second long-run risks channel to affect the equity premium.

To solve for $r_{a,t+1}$ *(5)*, BY express the log price-consumption ratio z_t and the log price-dividend ratio $z_{m,t}$ as a linear function of the relevant state variables, namely the expected growth rate of consumption x_t and the time varying consumption volatility. Therefore, both conjectured long-run risks are able to directly affect asset prices within the boundaries of the rational expectations. BY assume the asset valuations follow,

$$z_t = A_0 + A_1 x_t + A_2 \sigma_t^2 \quad \text{and} \quad z_{m,t} = A_{0,m} + A_{1,m} x_t + A_2 \sigma_t^2$$

Exploiting the Euler equation *(3)*, the dividends and consumption dynamics *(9)* and the return equation *(5)*, the solution coefficients can be easily derived. The effect of the expected growth rate x_t on the price-consumption *ratio* is embodied by the coefficient A_1 According to computations:

$$\text{(10)} \qquad A_1 = \frac{1 - \frac{1}{\psi}}{1 - \kappa_1 \rho} \qquad A_{1,m} = \frac{\phi - \frac{1}{\psi}}{1 - \kappa_{1,m} \rho}$$

The sign of A_1 clearly depends on the preference parameters of the model. Setting $\psi > 1$ yields A_1 positive thus implying the dominance of the intertemporal substitution effect over the wealth effect. In the BY calibration, asset prices increase along with the improvements in expected growth prospects (*i.e.* higher future returns), because the new investment opportunity induces the representative agent to buy assets today and to postpone consumption in the future. Note that an increase in x_t provides concurrent incentives to boost current consumption (*i.e.* income effect); however, the result is not large enough to overcome the previous one. Working under standard power utility with risk aversion larger than one yields opposite results: in this case the IES is forced to be lower than one thus leading to a negative A_1. Hence, the wealth effect dominates the substitution effect. Again, the BY calibration suggests that dividends are more volatile then consumption: if ϕ>1 then $A_{1,m}$>A_1, which means that the price of the dividend claim reacts more than the price of the consumption claim to fluctuations in the long-run risks. The sensitivity of asset valuations to fluctuating volatility is embodied by the coefficients A_2 and $A_{2,m}$. With regard to the latter refer to the section *Dividend claim* in the Appendix, the solution for A_2 is

$$\text{(11)} \qquad A_2 = \frac{0.5\left[\left(\theta - \frac{\theta}{\psi}\right)^2 + \left(\theta A_1 \kappa_1 \varphi_e\right)^2\right]}{\theta\left(1 - \kappa_1 \upsilon_1\right)}$$

Two noteworthy remarks are needed. Firstly, setting ψ>1 and γ>1 yields A_2 negative, as θ is negative. Since asset markets dislike economic uncertainty, the model suggests a decline in asset prices and an increase in the risk premia on all assets as a consequence of rising economic uncertainty. Setting IES larger than 1 is crucial to capture this intuition. Secondly, not only an increase in the persistence of the expected growth rate news but also an increase in the persistence of the volatility shocks, that is υ_1, induces the investors to perceive shocks as being long lasting. In both cases, the required risk compensation to hold equity increases. The endowment process implies that both the equilibrium return for $r_{a,t+1}$ and the pricing kernel together with its innovations are affected by consumption volatility. The equilibrium return for $r_{a,t+1}$ *(5)* allows us to define the pricing kernel *(4)* and its innovations:

$$\text{(12)} \qquad m_{t+1} - E_t\ [m_{t+1}] = \lambda_{m,\eta}\sigma_t\eta_{t+1} - \lambda_{m,e}\sigma_t e_{t+1} - \lambda_{m,w}\sigma_w w_{t+1}$$

Where $\lambda_{m,\eta} \equiv [-\frac{\theta}{\psi}+(\theta-1)]=-\gamma$ and $\lambda_{m,e} \equiv (1-\theta)\ \kappa_1 A_1 \varphi_e$

match the market prices of risk for the expected growth rate shock e_{t+1} and the independent consumption shock η_{t+1} respectively, while $\lambda_{m,e}$ matches the market price of risk for the consumption volatility shock. Even if the conditional volatility and expected growth rate processes are assumed independent, Epstein-Zin preferences allow both long-run growth and uncertainty risks to be priced. Again, working under standard power utility with risk aversion larger than 1 yields an opposite result: the condition θ=1 yields to $\lambda_{m,w}$=0 and $\lambda_{m,e}$=0, that means that both long-run risks are here not priced. In the light of these findings, we expect both long-run risks to be mirrored by the equity premium of the market portfolio. Handling all previous results follows:

$$(13) \qquad E_t[\,r_{m,t+1} - r_{f,t}\,] = \beta_{m,e}\lambda_{m,e}\sigma_t^2 + \beta_{m,w}\lambda_{m,e}\sigma_w^2 - \frac{1}{2}Var_t(\,r_{m,t+1}\,)$$

Where $\beta_{m,v} \equiv \kappa_{1,m}A_{2,m}$; λ_i, $i=\{w,e\}$ represents the price of risk i, while β_i, $i=\{w,e\}$, corresponds to the exposure to risk i. Specifically, e_t is the long-run risk and w_t is the volatility risk. From the assumption that the conditional volatility of consumption growth is time-varying, it follows that the conditional risk premium and its conditional volatility fluctuate, too. As the maximal Sharpe *ratio* in this economy is driven by the stochastic volatility, all risk premia will rise along with a rising economic uncertainty.

Exploiting the Euler equation *(3)*, the consumption dynamic *(9)* and the return equation *(5)*, it is straightforward to derive the risk free rate[3]. The risk-less return increases with the average growth rate of consumption and decreases with ψ, namely IES. Its volatility is mainly driven by the volatility of expected consumption growth rate and it increases in inverse proportion to ψ, too.

Although the LRR theoretical implications depend crucially on the IES parameter, its empirical magnitude is troublesome. BY (2004) provide empirical evidence that the existence of stochastic volatility in the model leads to a sizeable downward bias in its estimates using the regression approach pursued in Hall (1988)[4]. Hence, the extremely small value of ψ suggested by this methodology should be considered as misleading. This justifies the assumption ψ>1 on which the LRR model crucially relies.

[3] For the analytical solution refer to the *APPENDIX* in Beeler J. - Campbell J. (2009).

[4] Hall R.E. (1998) used an instrumental variables (IV) approach to estimate the IES from the homoskedastic Euler Equation. The IES is measured by the slope coefficient from regressing date t+1 consumption growth rate on the date t risk-free rate. Bansal R. - Yaron A. (2004) argue that this projection would recover the IES, if no fluctuating uncertainty affected the risk-free rate. However, the LRR model crucially incorporates time varying volatility and this causes time-variation in the intercept of the Euler Equation. Bansal R. - Yaron A. (2004) conclude that the projection is misspecified and creates a downward bias.

3. - An Empirical Assessment: The US as a Benchmark

This section aims to assess the performance of the LRR model. The calibration proposed by Bansal and Yaron (2004) is used to solve the model numerically. Then, 1,000 Monte Carlo simulations are run to evaluate to what extent that calibration matches the data. The mean across the simulations is always reported. As in the original work and in its further developments, the US historical series are used as a benchmark.

3.1 *Empirical Findings*

Data are annual and cover the period from 1930 to 2006, which is the longest available sample. Working with long-run series ensures that the measurement errors are minimized which in turn supports the achievement of reliable results. However, some discrepancies can arise across sub-samples. The literature on the LRR model highlights a considerable concern over sample biases: the available number of observations is fairly low and the Great Depression data are potential outliers after all. For consumption, data are based on seasonally adjusted *per capita* series from NIPA tables available on the Bureau of Economic Analysis website. Aggregate consumption is defined as personal consumption expenditure on non-durables and services; chained (2005) dollars data are used. For financial data, following B&C(2009) I rely on Shiller S&P 500 composite data: real dividends and real prices used here are downloadable from Shiller's website. The real riskless asset is constructed by subtracting realized annual inflation from the annualized yield on the 3-month Treasury bill; both series are taken from the CRSP US Treasury databases.

Table 1 - Column 1 reports the main descriptive statistics of the variables involved in the BY specification. All entries are annual and are expressed in real percentage terms. As in B&C (2009), the mean equity premium is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate. The outcomes show that the selected sample does a decent job of pointing out the standard features of the data: the risk free rate and the consumption volatility are small while the equity premium is large. The real *per capita* consumption growth mean is about 2 percent and its standard deviation is about 2.2 percent; as far as the autocorrelation function is concerned, the first order autocorrelation is quite large – about 0.45 – while the second one is very small, about 0.16. Over the period 1930-2006 the data reveal that the risk free rate is lower than 1 percent, the

stock market return is about 6 percent and the mean equity premium is close to 7 percent. All the results are consistent with B&C (2009). With regard to BY (2004), slight divergences are due to the different sources of data.

3.2 *Bansal and Yaron Parameter Configuration*

The numerical solution of the LRR model requires the parameter configuration at first. Table 2 reports the calibration proposed by BY (2004); the entries are chosen to allow the model to match the key features of data reported in Table 1 - Column 1.

Setting the preference parameters means assigning a value to the risk aversion γ, to the discount factor δ and to the IES ψ. In BY the time preference equals 0.998 and the risk aversion parameter is 10. Mehra and Prescott (1985) support the latter by arguing that a value of 10 or below looks reasonable. As discussed above, the third choice is really troublesome and divergent views coexist in the literature. BY state that setting ψ higher than 1 is essential to deal with results consistent with the economic theory. Due to this assumption, in BY the asset valuations rise with the expected consumption growth and decrease with the economic uncertainty, thus supporting one of the main features of the LRR model. Even if Hansen and Singleton (1982, 1983); Attanasio and Weber (1989); Guvenen (2001) and Attanasio and Vissing-Jorgensen (2003) provide evidence of ψ over 1 in their works, the estimates of Hall (1988) and Campbell (1999) suggest that IES is well below 1. However, Bansal and Yaron criticize this literature by arguing that it ignores time-varying volatility. This critique supports the choice ψ=1.5 in the BY specification. Even if the data to match are annual, BY calibrate the model *(9)* at the monthly frequency. To evaluate their calibration, annual time-aggregated series have to be derived from the monthly model. All entries in Table 2 are expressed in monthly terms. BY set the persistence of the growth rate process ρ at 0.979 so that its half-life is between two and three years. The basic idea is to deal with a stationary process and to allow a large reaction of asset valuations and equity risk premia to changes in the expected growth rate *(10)*. On the grounds that the volatility shocks show a slow decay, the persistence of conditional volatility v_1 is set at 0.987 thus resulting in half-life somewhat over four years.

3.3 *BY: Implied Dynamics and Asset Pricing Implications*

The following analysis aims to assess whether the original calibration of the LRR model performs well. The configuration parameters reported in Table 2 are used to solve the model numerically. With regard to the methodology, each experiment consists of 1,000 Monte Carlo simulations each with 924 monthly observations that correspond to the 77 annual observations available in the dataset. For each experiment, I reported the mean across the simulations. The same approach is adopted by BY (2004). Table 1 - Column 2 reports my results.

The BY calibration seems to match data quite well, even if room for further improvements still exists. Overall, the LRR model is able to generate sizeable risk premia, market volatility and fluctuations in price-dividend ratios thus matching the key-features of equity market. However, the matching of the risk free-rate's behavior and that of the standard deviation of the price-dividend ratio seem to be troublesome. With regard to the former, the model clearly understates its standard deviation: it predicts 1.22 and not 4.15 as the empirical evidence suggests. B&C (2009) highlight this issue, too, but they argue that it could be a strength rather than a weakness of the model. As a matter of fact, the data record the *ex post* real return on a short-term nominally risk-less asset while the model matches the *ex ante* (equal to the *ex post*) real return on a real risk-less asset. Hence, volatile inflation surprises are able to affect (upward) the volatility of the series but are not able to affect it in the model. The second bias, instead, seems to be more serious. According to the BY calibration the standard deviation of the price-dividend *ratio* is around 0.15, but the data reveal that 0.43 is the proper value. As a matter of fact, the existence of persistent high stock prices at the end of the sample period (1930-2006) pushes the standard deviation upward.

Increasing the number of simulations does not affect the results: the estimates are stable. Table 1 - Column 3 displays values for the same moments as published in Beeler and Campbell (2009). They rely on the same calibration, but opt for a different approach: their moments are generated from an independent 1.2 million month simulation. Comparing the values in Column 2 with those in Column 3, there is evidence that the results match. Although the standard deviations are usually lower in my simulations, the bias seems to be negligible.

3.4 *BY: Sensitivity to Preference Parameters*

As the parameter configuration could be debatable, Table 3 analyses the main asset pricing properties of the LRR model along with 9 alternative combinations of the preference parameters. The risk aversion parameter can be set at 5, 10 or 15, while the elasticity of intertemporal substitution can be equal to 0.5, 1.5 or 2. The standard case γ=10 and ψ is reported, too.

Table 3 - Panel A clearly reveals that the classical configuration is able to match data better than the other ones. As expected, the relative risk aversion parameter mainly affects the equity premium: *ceteris paribus*, the higher RRA, the higher the equity premium. The entries clearly show this mechanism: just fix EIS and allow γ to vary. In line with the remarks provided in Section one, the choice of the EIS is crucial. As expected, the higher IES, the higher the volatility of the price-dividend *ratio*, the equity premium and its volatility. Under the assumption $\psi < 1$, the opposite is true: the income effect overcomes the substitution effect and the representative agent prefers to flatten the consumption path, thus increasing consumption in all periods. Again, the entries are consistent: the risk-free rate is high and volatile and the equity premium is considerably low.

Table 3 - Panel B focuses on the role played by the leverage parameter. The study relies on the standard parameter configuration but sets ϕ at 3.5 rather than at 3. As expected, the equity premium is considerably higher than before. As ϕ increases, the riskiness of dividends increases, and $A_{1,m}$ rises. It follows that the price-dividend ratio is more volatile and the equity premium rises.

Table 3 - Panel C assumes *i.i.d* consumption and dividend growth rates. As the BY calibration does not allow the independent consumption shocks η_{t+1} to affect the dividend process, the new assumptions lead to $Cov(g_{t+1}, g_{d,t+1})$ around zero. It follows that the equity premium is zero, too[5]. In other words, with *i.i.d* consumption and dividend growth rates, the long-run risks are not able to exercise any influence and the model has troubles explaining the asset market data. Even if it is often argued that consumption growth is close to being *i.i.d*, the BY calibration provides evidence that allowing for a persistent predictable component produces consumption and dividend moments that are largely consistent with data. This asserts the reliability of this assumption.

In conclusion, a parameter configuration with an IES larger than 1 and the assumption of a persistent but small predictable component in the consumption dynamics seem to be crucial to explain successfully the asset market data. As a matter of fact, these assumptions allow the BY calibration to perform better than several alternative models proposed in the literature.

[5] By defining the equity premium as: $E(r_m - r_f) + \frac{1}{2} Var(r_m - r_f)$

4. - A Further Advancement: The BKY Calibration

4.1 *BKY: The Literature*

Even if the empirical evidence suggests that the BY calibration is able to explain key-features of asset market data quite well, further research pointed out that BY stock prices seem less responsive to lagged consumption growth and more predictive of future consumption growth, than the empirical evidence implies. In the light of this remark, Bansal, Kiku and Yaron (2007*a*) revised the original LRR model by reducing the importance of persistent shocks to consumption growth and increasing the role played by the persistence of shocks to volatility. This means that discount-rate news, namely news about future economic uncertainty, are supposed to affect asset prices more than in the previous calibration while the relevance of cash-flow news for stock prices is considerably reduced.

BKY (2007*a*) suggest the following joint dynamics for consumption and dividends:

$$
(14)\qquad
\begin{aligned}
& g_{t+1} = \mu + x_t + \sigma_t \eta_{t+1} \\
& x_{t+1} = \rho x_t + \varphi_e \sigma_t e_{t+1} \\
& g_{d,t+1} = \mu_d + \phi x_t + + \pi \sigma_t \eta_{t+1} + \varphi_d \sigma_t u_{t+1} \\
& \sigma_{t+1}^2 = \sigma^2 + v_1(\sigma_t^2 - \sigma^2) + \sigma_w w_{t+1} \\
& e_{t+1}, u_{t+1}, \eta_{t+1}, w_{t+1} \sim N.i.i.d\,(0,1)
\end{aligned}
$$

Where the parameter π allows the independent consumption shocks η_{t+1} to affect the dividend process. Note that this contemporaneous correlation of consumption shocks and dividend shocks is absent in the BY calibration. It follows that there are three candidates for risk compensation in equity markets: the "short run" risk, η_t, the long-run risk, e_t, and the volatility risk, w_t. Solving the model as before, it comes out that the equity premium on the market portfolio carries three sources of risk. That is:

$$
(15)\qquad E_t[r_{m,t+1} - r_{f,t}] + \frac{1}{2} Var_t(r_{m,t+1}) = \beta_{m,\eta}\lambda_{m,\eta}\sigma_t^2 + \beta_{m,e}\lambda_{m,e}\sigma_t^2 + \beta_{m,w}\lambda_{m,w}\sigma_w^2
$$

Where $\beta_{m,h} = \pi$ represents the exposure to the "short run" risk η_t.

BKY modified the configuration parameters proposed by BY (2004) to increase the importance of discount-rate news at the expense of cash-flow news.

Table 2 reports the new calibration parameters and allows a comparison with the previous one. The persistence of the predictable component of consumption growth is lower than before: it is 0.975 rather than 0.979, implying half-lives of 27 months rather than 33 months. As in BY, dividends are less predictable than consumption. However, the BKY model emphasizes the difference between the respective processes by decreasing the exposure of dividends to long-run risks (from $\phi = 3$ to $\phi = 2.5$) and by increasing the long-run volatility multiple (from $\varphi_d = 4.5$ to $\varphi_d = 5.96$). With regard to the volatility process, the divergences are even more accentuated. BKY set the persistence of volatility at 0.999 while it is 0.987 in BY. Hence, the half life of volatility differs substantially in the two calibrations, either 58 years or 4 years. After 60 years a volatility shock in the BY model decays to $\frac{1}{2^{15}}$ of its magnitude while that number is just $\frac{1}{2}$ in the BKY model. Although the standard deviation of volatility shocks is similar in both calibration (0.0000023 in BY and 0.0000028 in BKY), the remarkable difference in the persistence of these shocks allows them to play a bigger role in BKY than in BY.

Finally, a noteworthy remark concerns the importance of the censoring of negative volatility realisations. Both in BY and in BKY, the variance process can take negative values. As B&C (2009) pointed out, it happens with small probability if the mean is high enough relative to the volatility of variance. With regard to this issue, the alternative calibrations differ substantially. I simulated 1,000 times the volatility process and I compared the results provided by both calibrations. In both scenarios, I considered 924 months that correspond to 77 years: the idea is to match the length of the sample on which all the simulations of this paper rely. I found clear evidence that the probability of dealing with at least one negative realisation is around zero under BY but it is around 50% under BKY. Moreover, the proportion of negative realisations to positive ones is not stable: in my simulations, that percentage varies from 0.22% to 15% but even higher values cannot be excluded. BY (2004), BKY (2007*a*) and B&C (2009) replace negative realisations of the conditional variance with a very small positive number. In the following, I use the same method, too. However, the previous findings suggest that the process of the replacement for volatility could have non-negligible consequences on the results.

4.2 *BKY: Implied Dynamics and Asset Pricing Implications*

The following analysis aims to assess whether the BKY calibration performs better than the original one or it creates new problems[6]. B&C (2009) will be considered as a benchmark, as they provide an accurate empirical assessment of both calibrations. A noteworthy remark concerns the difference in the methodologies. As I mentioned above, B&C always report the population moments generated from an independent 1.2 million month simulation. On the contrary, all my experiments consist of 1,000 Monte Carlo simulations each with 924 monthly observations that correspond to the 77 annual observations available in the dataset. For each experiment, I reported the mean across the simulations. From a statistical point of view, both analyses should yield the same outcomes. With regard to the calibration, both analyses rely on the configuration parameters reported in Table 2. With regard to the initialisation of the variance process, both works set vol(1)=σ^2, that is a convention in the literature.

Table 1 - Column 4 displays my results for the implied dynamics and asset pricing implications under BKY, while Column 5 shows the values for the same moments as published in B&C (2009). Both analyses rely on the standard preference parameters. The BKY calibration seems to match many basic properties of data (Column 1) better than the BY model (Column 2). With regard to the mean risk-free rate, the improvement is sizeable: it is 0.82 in the data, 2.58 under BY and 1.16 under BKY. If we consider the growth rate of dividends, we can easily come to a similar conclusion: it is 1.00 in the data, 1.62 under BY and 1.30 under BKY. As before, we can seriously question the ability of the long-run risk model to match the standard deviation of the log price-dividend ratio. Both BY and BKY greatly understate it: they assume 0.15 as the right value while it is around 0.43 in the data. The matching with the standard deviation of the risk-free rate is troublesome, too. Both calibrations imply a lower value, 1.22 and 0.97 respectively, than the empirical evidence suggests, that is 4.15. On the other hand, there is clear evidence that my results differ from those reported in B&C. Firstly, the standard deviations are always lower in my simulations and the discrepancies are sizeable. Secondly, both the mean risk-free rate and the mean market return are biased, too. Thirdly, it is still true that the BKY calibration understates the standard deviation of the log price-dividend ratio, but my code performs really worse than the one used by B&C (0.15 *vs.* 0.26, 0.43 in the data). Compared to

[6] With regard to the BKY "new issues", I am grateful to Jason Beeler for helpful discussion.

the BY calibration, my results suggest that the BKY calibration does not allow remarkable improvements in this regard. Thus, the LRR model's deficiency in this matching seems to be more serious than B&C's state. One may object that my simulations lead to lower standard deviations not only under BKY but also under BY. However, the magnitude of the divergence is not comparable: the standard deviation of the market return can be considered as the best example.

In conclusion, Table 1 suggests that something could work not properly under the BKY calibration. The next sections aim to address this issue by detecting the potential sources of divergence between my results and those provided in B&C.

4.3 *BKY and New Issues: Sensitivity to the Replacement for Volatility*

The outcomes discussed in Section 3 seem to suggest that my code works properly under BY calibration. Therefore, finding the source of potential bias between my results and those provided in B&C may require scanning the differences between the original and the revised model. As pointed out above, the persistence of volatility differs significantly in the two calibrations. Moreover, the main discrepancies concern the values of the standard deviations and the bias affects all the considered time-series. These remarks suggest that the BKY extreme setting of the persistence of volatility might be troublesome. Ruling out any difference in terms of calibration, the source of divergence should be found somewhere else. I am forced to conclude that the focus should be stuck on the volatility process.

Table 4 aims to assess the sensitivity of the BKY calibration to different treatments of negative realisations of the variance process. As I discussed before, the probability of dealing with negative realisations of the conditional variance is not negligible under BKY: it is about 50%. To overcome the problem, the negative values have to be replaced. In principle, this process should not bias the outcomes significantly. Note that the replacement procedure is not a novel in the literature, both BY and B&C used it and I followed them, too. In this regard, all the quoted researchers suggest that the negative realisations should be replaced by "a very small positive number". However, what exactly does it mean? I repeated the exercise proposed in Table 1, but I considered four different replacement values: 0.0001 (Column 1), 0.0000000000001 (Column 2), 0.00000001 (Column 3) and 0.00000000001 (Column 4). The second value is used in B&C while my analysis in Section 3 relies on the third one. Column 1 and Column 2 provide evidence that under BKY calibration the replacement for volatility matters. The standard deviation of all variables displays variability and the divergence is sizeable in the case of the market return. Only the mean of the consumption growth and all the first autocorrelations are stable. Interestingly, when the sensitivity to the replacement is clear, the divergence between my results and those provided in B&C is noticeable. As the probability to deal with negative realisations of the conditional variance is around zero under BY calibration, the exercise is not run. However, at this point several objections can be raised and I will try to address all of them in the following paragraphs.

First objection: on the grounds that 0.0001 is too high compared to 0.0000000000001, the previous analysis makes no sense. Not only using 0.0001 biases the results, but also this choice makes the distortion predictable. Second objection: the discrepancies exist but they are not accentuated enough to charge the model. Maybe these results are not stable across the simulations and the gap can easily disappear by repeating the same experiment several times.

With regard to the first objection, the comparison between Column 1 and 2 (the highest *vs*. the lowest replacement value) clearly spots the divergence, even if the results are quite stable across other columns (*i.e.* by setting vol=10^{-8} and vol=10^{-11}). However, the first experiment (*i.e.* under vol=10^{-4}) matches B&C's results better than any other case. When I analysed these outcomes for the first time, I guessed that B&C used vol=10^{-4} as a replacement value, despite that it looked striking. Nothing was mentioned in their paper about it. Later, Jason Beeler ensured me that the replacement value is vol=10^{-13} in his work. This finding supports the idea that some drawbacks may exist under BKY calibration.

With regard to objection 2, it is reasonable to assess the stability of the Monte Carlo results provided in Table 4. For a given replacement value of negative realisations of the variance process, I repeated the same experiment three times. Again, each experiment is based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. The reported values are the means across the simulations. Under stability, replicating the same experiment should yield similar outcomes. Table 5 displays the results. Columns 1-3 refer to the experiments in which the negative realisations are replaced by 0.0001. Columns 4-6 refer to the ones in which the replacement value is 0.0000000000001. The table provides evidence for stability under the extreme scenarios. It follows: when the replacement for volatility leads to discrepancies, these discrepancies are stable and are not due to the randomness of the simulations. Technically, Columns 4-6 display the results that my code generates under B&C's setting. If the model worked properly, these values should match B&C, while the moments reported in Columns 1-3 should be biased. However, the opposite is true. One can question that the results under 0.0001 are biased, too. However, this choice performs better and the discrepancies are visibly small.

Table 5 - Columns 7-9 display the outcomes when the same exercise is run under the BY calibration. As in B&C, the negative realisations are replaced by 0.0000000000001. The table provides evidence for the stability of the Monte Carlo results reported in Table 4, thus confirming that the divergence with B&C is limited to the BKY calibration.

In conclusions, the ability of the BKY calibration to perform well might be questionable. The new specification seems to depend too much on the choice of the replacement value of volatility, even if it is expected to be a minor assumption. Volatility censoring issues might be important, as they suggest that the linearization is not that accurate. Furthermore, my moments differ significantly from those reported in B&C, even if no evidence of divergence between the codes has been found yet. The extreme setting of the persistence of volatility seems to be the main matter of concerns.

4.4 *BKY and New Issues: Sensitivity to Preference Parameters*

As in Section 3, the analysis of the sensitivity to preference parameters may provide useful remarks. Table 6 - Panel A reports my results when negative variances are replaced by vol=10^{-13}, while Panel B displays the outcomes for the same exercise as published in B&C. With regard to the initialisation of the variance process, both works set vol(1)=σ^2. In line with BY, in both cases there is evidence that the EIS matters. Furthermore, the high persistence of volatility can lead to a worrisome issue: the consumption claim can have an infinitive price. This happens if the representative agent is sufficiently risk averse: high uncertainty about future growth prospects can lead to precautionary savings that can push the equilibrium real interest rate towards negative values. Along with these common agreements, huge disparities also exist. My methodology leads always to a lower standard deviation and this statement is true for all the considered variables. By comparing the alternative scenarios with the standard case, it follows that the direction of the change is usually the same in both works, although its magnitude can vary considerably. This should suggest that both methodologies agree on the role of the preference parameters in the LRR model, even if they did not agree on the magnitude of the changes across alternative scenarios. However, two interesting cases are noteworthy: γ=5 and ψ=1.5, γ=5 and ψ=2. When the risk aversion is quite low and the elasticity of substitution is sufficiently high, the risk-free rate's behavior seems puzzling. According to B&C, the mean risk-free rate should increase considerably compared to the standard case and its standard deviation should display the same trend. However, my methodology suggests the opposite. With regard to the standard case, the moments are biased but comparable; with regard to the special cases, the results clearly diverge. For example, if γ=5 and ψ=1.5, then $E(r_f)$ = 4.62 and $\sigma(r_f)$ = 3.40 in B&C but $E(r_f)$ = 2.04 and $\sigma(r_f)$ = 0.93 in my work. Moreover, in the latter one all the other moments are biased and the mean price-dividend ratio is higher (5.02 *vs*. 3.79). As an excess of sensitivity to the replacement value for volatility might exist under BKY, Table 7 display the results when the negative realisations are replaced by vol=10^{-4} (Panel A) and vol=10^{-8} (Panel B). Table 8 - Panel A repeats the exercise under vol=10^{-11}, while Panel B displays the corresponding moments from the 1930-2006 yearly dataset. New evidence seems to arise to corroborate previous remarks. Again, the highest replacement value (*i.e.* 0.0001) allows overall the best matching with B&C. In principle, the opposite should be true. With regard to the risk-free rate's behavior, in all scenarios the cases γ=5 and ψ=1.5, γ=5 and ψ=2 strongly disagree with B&C and the price-dividend *ratio* is always upward biased.

In line with the LRR literature, both methodologies make clear that the suitable parameter configuration is γ=10 and ψ=1.5 and agree that setting EIS>1 is crucial to match the level of the equity premium and the volatility of the stock prices. Nevertheless, the LRR model still seems to encounter difficulties in the proper matching of the standard deviation of the log price-dividend *ratio*.

In conclusion, the assessment of the sensitivity to preference parameters questions further the ability of the BKY calibration to perform well. As a matter of fact, there is still evidence that under BKY calibration the population moments and the finite sample moments could be not equal in limit. However, a further evidence comes to light. The analysis in subsection 4.3 suggests that both methodologies agree on the role of the preference parameters in the LRR model, even if they did not agree on the magnitude of the changes across alternative scenarios. Instead, in this subsection a new evidence arises: when γ=5 and ψ=1.5, γ=5 and ψ=2 the methodologies strongly disagree on the behavior of the risk-free rate. This puzzling evidence should be addressed by further research.

4.5 *BKY and New Issues: Sensitivity to the Size of the Monte Carlo*

All the remarks discussed in Section 4 rely on the clear evidence that my estimates do not match those published in B&C. Although there is no room to debate it, this evidence looks striking. Noticeably, under BY the outcomes are consistent and the alternative calibrations differ slightly in terms of codes. Ruling out the possibility of code-mistakes, the idea is to provide a rational explanation for this fact and to try to support it on statistical grounds, too. The choice of the methodology could play a crucial role. As discussed above, B&C follow the population moments approach: their moments are generated from an independent 1.2 million month simulation. To minimise the importance of the initial condition of the volatility process, they run the simulation for 120 months before they use the data. My analysis, however, could not overcome this issue, as it adopts the Monte Carlo simulations' approach. This choice follows BY (2004). Every experiment consists of 1,000 Monte Carlo simulations, each with 924 monthly observations. Given that in each simulation the sample size matches the number of observations in the dataset, I cannot reduce the sample further. It is worth mentioning that this approach requires the variables to be reset to their initial condition in each simulation. With regards to the initialisation of the variance process, I set vol(1) = σ^2, that is a convention in the literature. In principle, both methodologies should yield the same results. When the number of available samples tends to infinity, the population mean and the finite sample average converge precisely to the same value. As a matter of fact, this statement is true under BY. However, we can consider an interesting example. Suppose we are interested in the variance of a variable with a near unit root. In this context, the unconditional variance can be very different from the conditional variance. While the former tends to be close to the population value, the latter is likely to be close to the finite sample average. As I stressed several times, the persistence of the volatility process is very high in the BKY calibration (v_1=0.999). Hence, the volatility is a variable with a near unit root there. It follows that there is a possibility of finding a divergence between my results and those reported in B&C. In principle, my outcomes are expected to tend to the finite sample average, while those of B&C are supposed to tend to the population value. If these two outcomes are not equal, divergence arises. It is straightforward to check whether this happens under BKY. If this speculation were correct, my moments should tend to those of B&C as the horizon increases gradually. Therefore, my results should not be stable and are expected to approach the population values.

Table 9 - Panel A displays the results; six new scenarios are considered. The horizon of the simulations increases gradually from Column 1 (the original sample) to Column 7 (100 times the original sample). The negative variances are replaced by vol=10^{-13}. The outcomes well support previous speculation. A clear convergence is spotted as we increase the sample size. The moments of the last column exactly match those reported in B&C[7], except for a minor deviation in the standard deviation of the market return which is slightly higher.

To further enhance these findings, the same exercise is run under BY. In principle, the estimates should be stable as the horizon increases gradually. In other words, the population value and the finite sample average should overlap as required by basic statistics. Panel B displays the outcomes. As expected, the results are quite stable: the mean risk-free rate and the mean price-dividend are constant as the sample size increases, while the other moments display little variability. Slight changes are due to small adjustments around the limit of the values. By comparing Panel A and Panel B, the convergence dynamics look even stronger. The behavior of the standard deviation of the price-dividend ratio seems to be the best example[8].

In conclusion, simulating a volatility with a near unit root seems to be troublesome. Under this setting, working with the population moments means finding the unconditional mean, whereas working with finite sample estimates means finding the conditional variance. Given that the focus should be on the conditional rather than the unconditional variance, under BKY it seems more reasonable to work with finite sample estimates rather than population values. On these grounds, Beeler and Campbell's work bring out suspicion; their moments are potentially biased and their conclusions may be questionable. It could be that there are more issues concerning the BKY calibration than their analysis suggests. These remarks could open doors for further research.

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[7] Refer to Table 1 - Column 5.

[8] The findings in Table IX may be strengthened by considering the average realized variance as the sample size increases gradually. Furthermore, looking at the frequency distributions of the variance (over all months and simulations) from the 924 month simulation and the 92,400 month simulations could enhance them further, as these distributions are expected to be somewhat different. Many thanks to an anonymous referee for these precious comments; they will be addressed via a future development of this work.

5. - Conclusions

Although the solution of the so-called *Asset Pricing Puzzle* is still a matter of concern among academics, the contribution of the long-run risks model to the literature is remarkable. Bansal and Yaron (2004) and Bansal, Kiku and Yaron (2007*a*,*b*) successfully address the question of the magnitude of risks compensation in equity markets by defining a solid theoretical framework within the ongoing debate. However, the empirical section of my work reveals the existence of a non-negligible model specification problem.

Firstly, as under the BKY calibration the probability to get negative realisations of the conditional volatility is high, the censoring of these values seems to be non-negligible. Even if the variance process can take negative values in both calibrations, I found clear evidence that the probability of dealing with at least one negative realisation is around zero under BY but rises dramatically to 50% under BKY. Moreover, the proportion of negative realisations to positive ones is not stable: in my simulations that figure varied from 0.22% to 15% but even higher values cannot be excluded. Secondly, I showed that the new specification seems to depend too much on the choice of the replacement value of volatility, even if it is expected to be a minor assumption. Thirdly, the assessment of the sensitivity to preference parameters questioned further the ability of the BKY calibration to perform well: under the revised framework I detected two combinations of the preference parameters that result in a puzzling behavior of the risk-free rate. Fourthly, I showed that the Monte Carlo method and the population moments approach do not provide equivalent outcomes under the BKY calibration, as the volatility is a variable with a near unit root. In light of these remarks, Beeler and Campbell (2009) can be called into question: it could be the case that there are more issues concerning the BKY calibration than their analysis suggests. Furthermore, along with these "new issues", several open questions still exist in the literature. The proper level of the IES and the existence of a persistent predictable component in the consumption dynamic are outstanding examples.

This work suggests that focusing on the BKY extreme setting of the persistence of volatility could be the key to develop a better calibration of the LRR model thus opening the door for further research.

APPENDIX A

Linearization Parameters

All returns are given by the approximation of Campbell and Shiller (1998):

(A.1) $$r_{a,t+1}=\kappa_{0,i}+\kappa_1 z_{t+1} - z_t+g_{t+1}$$

For any asset, the linearization κ_0 and κ_1 are determined endogenously by the following system of equations:

(A.2)
$$\bar{z}_i = A_{0,i}(\bar{z}_i) + A_{2,i}(\bar{z}_i)\sigma^2$$
$$\kappa_{1,i} = \frac{exp(\bar{z}_i)}{1+exp(\bar{z}_i)}$$
$$\kappa_{0,i}=ln(1+exp(\bar{z}_i)) - \kappa_{1,i}\bar{z}_i$$

The procedure is discussed in Campbell and Koo (1987) and Bansal, Kiku, Yaron (2007*b*). The solution is determined numerically by iteration until reaching a fixed point of $\bar{z}_i$. The solution coefficients for the price-consumption ratio and the price-dividend ratio are needed to solve the previous system. Note that Bansal and Yaron (2004) and Bansal, Kiku, Yaron (2007*a*) impose model consistency between the average price-consumption ratio $\bar{z}_i$ and the approximation κ's, which themselves depend on the average price-consumption ratio. It is important to impose this consistency, as any change in the model parameters will affect $\bar{z}_i$ and thus the approximation κ's.

Dividend Claim

In order to derive $A_{2,m}$, two steps are needed. Firstly, starting from the asset pricing condition

(A.3) $$E_t[M_{t+1}R_{i,t+1}] = 1$$

the Euler Equation can be rewritten as:

(A.4) $$1=exp\ [E_t(m_{t+1})+ E_t(r_{m,t+1})+ \frac{1}{2}\ Var_t\ (m_{t+1}+ r_{m,t+1})]$$

Where

(A.5) $$Var_t\ (m_{t+1}+ r_{m,t+1})=Var_t[(m_{t+1} - E_t(m_{t+1}))+ (r_{m,t+1}- E_t(r_{m,t+1}))]$$

Exploiting the innovations in m_{t+1} and in $r_{m,t+1}$ yields:

(A.6) $$Var_t(m_{t+1}+r_{m,t+1}) = H_m\sigma_t^2 + [-\lambda_{m,w}+\beta_{m,w}]^2\sigma_w^2$$

Where

(A.7) $$H_m = [(\pi+\lambda_{m,\eta})^2 + (\beta_{m,e}-\lambda_{m,e})^2 + \varphi_d^2]$$

Secondly, *(A.6)* can be plugged in *(A.4)* to obtain:

(A.8) $$A_{2,m} = \frac{(1-\theta)\ A_2\ (1-\kappa_1\upsilon_1)+\frac{1}{2}H_m}{(1\text{-}\kappa_{1,m}\upsilon_1)}$$

APPENDIX B

Tables

TABLE 1

IMPLIED DYNAMICS AND ASSET IMPLICATIONS

MOMENT	1930-2006 (1)	BY (2)	B&C (BY) (3)	BKY (4)	B&C (BKY) (5)
$E(\Delta c)$	1.97	1.82	1.79	1.82	1.82
$\sigma(\Delta c)$	2.17	2.86	2.92	2.54	2.96
$AC1(\Delta c)$	0.45	0.46	0.51	0.39	0.44
$E(\Delta d)$	1.00	1.62	1.66	1.30	1.85
$\sigma(\Delta d)$	10.72	11.41	11.57	14.30	16.42
$AC1(\Delta d)$	0.14	0.35	0.40	0.25	0.29
corr(c,d)	0.44	0.29	–	0.45	–
$E(r_f)$	0.82	2.58	2.56	1.16	0.99
$\sigma(r_f)$	4.15	1.22	1.30	0.97	1.28
$AC1(r_f)$	0.62	0.80	0.85	0.78	0.86
$E(r_m)$	6.10	6.72	6.62	6.15	6.58
$\sigma(r_m)$	18.03	16.90	16.88	18.82	21.35
$AC1(r_m)$	0.04	0.01	0.03	-0.00	0.02
epremium	6.89	5.50	–	6.95	–
$\sigma(r_m - r_f)$	18.03	16.57	–	18.92	–
$E(p\text{-}d)$	3.30	3.01	3.00	3.11	3.04
$\sigma(p\text{-}d)$	0.43	0.15	0.16	0.15	0.26
$AC1(p\text{-}d)$	0.88	0.72	0.77	0.83	0.95

Table 1 displays moments for the analytical solutions of the Long-run Risks model with the BY calibration in Column 2 and the BKY calibration in Column 4. The statistics for both models are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. The reported moments are the means across the simulations. The consumption growth rate and the dividend growth rate are computed by taking the first difference of the corresponding log series. The market return and the risk-free rate are aggregated to a yearly level by adding log returns within a year. *epremium* is the mean equity premium that is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate. For the price-dividend ratio the yearly value is taken from the last month of the year. Column 1 displays the moments from the 1930-2006 yearly dataset. Column 3 and Column 5 display moments for the BY calibration and the BKY calibration as published in Beeler and Campbell (2009) (B&C). Their statistics are calculated from a simulation of 1.2 million months.

TABLE 2

BY AND BKY CONFIGURATION PARAMETERS

PREFERENCE PARAMETERS

Model	Risk Aversion	EIS	Discount factor
BY	γ =10	ψ =1.5	δ = 0.998
BKY	γ =10	ψ =1.5	δ = 0.9989

CALIBRATION OF MONTHLY CONSUMPTION GROWTH:

$$g_{t+1}=\mu+xt+\sigma_t\eta_{t+1}$$

$$x_{t+1}=\rho x_t+\varphi_e\sigma_t e_{t+1}$$

Model	Mean Growth	Persistence	LR Vol Multiple
BY	μ = 0.0015	ρ = 0.979	φ_e = 0.044
BKY	μ = 0.0015	ρ = 0.975	φ_e = 0.038

CALIBRATION OF MONTHLY DIVIDEND GROWTH RATES:

$$g_{d,t+1}=\mu_d+\phi x_t+\varphi_d\sigma_t u_{t+1}+\pi\sigma_t\eta_{t+1}$$

Model	Mean Growth	Leverage	Div Vol Multiple (1)	LR Vol Multiple (2)
BY	μ_d = 0.0015	ϕ = 3	φ_d = 4.5	–
BKY	μ_d = 0.0015	ϕ = 2.5	φ_d = 5.96	π = 2.6

VOLATILITY PARAMETERS:

$$\sigma_{t+1}^2=\sigma^2+\upsilon_1(\sigma_t^2-\sigma^2)+\sigma_w w_{t+1}$$

Model	Base SD	Vol of Volatility	Vol Persistence
BY	υ_1 = 0.0078	σ_w = 0.0000023	υ_1 = 0.987
BKY	υ_1 = 0.0072	σ_w = 0.0000028	υ_1 = 0.999

Table 2 displays the model parameters for Bansal and Yaron (2004) (BY) and Bansal, Kiku and Yaron (2007) (BKY). All parameters are given in monthly terms. The standard deviation of the long-run innovations is equal to the volatility of consumption growth times the long-run volatility multiple (LR Vol Multiple 1). The standard deviation of dividend growth innovations is equal to the volatility of consumption growth times the volatility multiple for dividend growth (Div Vol Multiple). LR Vol Multiple 2 is the magnitude of the impact of the one period consumption shock on dividend growth. Leverage is the exposure of dividend growth to long-run risks.

TABLE 3

BY - SENSITIVITY TO PREFERENCE PARAMETERS

PANEL A: ϕ = 3.0, ρ = 0.979

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
(5 & 0.5)	5.86	3.62	0.73	13.08	3.22	0.065
(10 & 0.5)	6.09	3.55	2.00	12.94	2.92	0.063
(15 & 0.5)	6.55	3.61	3.44	13.07	2.61	0.063
(5 & 1.5)	3.11	1.21	2.77	17.17	3.65	0.160
(10 & 1.5)	2.58	1.21	5.57	16.69	3.01	0.150
(15 & 1.5)	2.03	1.23	8.30	16.26	2.64	0.141
(5 & 2)	2.73	0.89	3.02	17.77	3.71	0.169
(10 & 2)	2.12	0.92	6.10	17.19	3.02	0.160
(15 & 2)	1.44	0.96	8.68	16.74	2.64	0.154

PANEL B: ϕ = 3.5, ρ = 0.979

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
(10 & 1.5)	2.58	1.21	6.58	18.13	2.86	0.18

PANEL C: ϕ = 3.0, $\rho = \varphi_e$ = 0

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
(10 & 1.5)	3.01	0.12	0.023	12.19	5.39	0.02

PANEL D: DATA

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
Data	0.82	4.15	6.89	18.03	3.30	0.43

Table 3 - Panel A displays moments for the BY calibration for different levels of the EIS and RRA. Panel B relies on the standard parameter configuration but sets the leverage parameter at 3.5. Panel C assumes *i.i.d.* consumption and dividend growth rates. The standard configuration (10 & 1.5) is always reported. All the statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations. Panel D displays the corresponding moments from the 1930-2006 yearly dataset. *epremium* is the mean equity premium that is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate.

Table 4

BKY - SENSITIVITY TO REPLACEMENT FOR VOLATILITY

Moment	if vol< 0, vol= 10^{-4} (1)	if vol< 0, vol= 10^{-13} (2)	if vol< 0, vol= 10^{-8} (3)	if vol< 0, vol= 10^{-11} (4)
$E(\Delta c)$	1.83	1.82	1.82	1.81
$\sigma(\Delta c)$	2.94	2.53	2.56	2.56
$AC1(\Delta c)$	0.39	0.39	0.39	0.39
$E(\Delta d)$	1.33	1.37	1.32	1.36
$\sigma(\Delta d)$	16.64	14.30	14.41	14.52
$AC1(\Delta d)$	0.25	0.25	0.25	0.26
corr(c,d)	0.45	0.45	0.45	0.45
$E(r_f)$	0.95	1.17	1.18	1.19
$\sigma(r_f)$	1.12	0.97	0.98	0.97
$AC1(r_f)$	0.79	0.79	0.79	0.78
$E(r_m)$	6.32	6.14	6.25	6.19
$\sigma(r_m)$	21.86	18.80	19.03	18.84
$AC1(r_m)$	-0.00	-0.01	-0.00	-0.00
$E(p\text{-}d)$	3.02	3.11	3.11	3.11
$\sigma(p\text{-}d)$	0.17	0.15	0.15	0.15
$AC1(p\text{-}d)$	0.81	0.82	0.83	0.83

Table 4 displays moments for the BKY calibration for different treatments of negative realisations of the variance process. Four different replacement values are considered: 0.0001 (Column 1), 0.0000000000001 (Column 2), 0.00000001

(Column 3) and 0.00000000001 (Column 4). All the statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations.

TABLE 5

STABILITY OF THE MONTE CARLO RESULTS

	BKY calibration						BY calibration		
Moment		if vol< 0, vol= 10^{-4}			if vol< 0, vol= 10^{-13}			if vol< 0, vol= 10^{-13}	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$E(\Delta c)$	1.82	1.82	1.82	1.79	1.80	1.82	1.80	1.80	1.83
$\sigma(\Delta c)$	2.94	2.94	2.94	2.56	2.58	2.54	2.87	2.88	2.87
$AC1(\Delta c)$	0.39	0.39	0.39	0.40	0.39	0.40	0.46	0.47	0.46
$E(\Delta d)$	1.34	1.34	1.31	1.22	1.43	1.40	1.64	1.65	1.67
$\sigma(\Delta d)$	16.61	16.58	16.79	14.38	14.55	14.39	11.41	11.37	11.46
$AC1(\Delta d)$	0.25	0.25	0.26	0.26	0.25	0.26	0.36	0.36	0.36
corr(c,d)	0.45	0.45	0.45	0.45	0.45	0.45	0.29	0.29	0.29
$E(r_f)$	0.92	0.96	0.95	1.16	1.16	1.17	2.59	2.55	2.59
$\sigma(r_f)$	1.13	1.11	1.13	0.98	0.98	0.99	1.21	1.22	1.22
$AC1(r_f)$	0.79	0.78	0.79	0.79	0.79	0.79	0.80	0.80	0.80
$E(r_m)$	6.36	6.43	6.26	6.14	6.10	6.27	6.75	6.70	6.72
$\sigma(r_m)$	22.00	21.87	22.00	18.89	18.82	19.00	16.83	16.92	16.92
$AC1(r_m)$	-0.01	-0.01	-0.00	-0.00	-0.01	-0.00	0.01	0.01	0.01
$E(p\text{-}d)$	3.02	3.02	3.02	3.11	3.11	3.10	3.01	3.01	3.01
$\sigma(p\text{-}d)$	0.18	0.17	0.17	0.15	0.15	0.15	0.15	0.15	0.15
$AC1(p\text{-}d)$	0.82	0.81	0.81	0.83	0.83	0.83	0.72	0.72	0.72

Table 5 displays moments for the analytical solutions of the Long-run Risks model with the BKY calibration from column 1 to 6 and the BY calibration from column 7 to 9. In each column all the statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. The reported moments are the means across simulations. For a given replacement value of negative realisations of the variance process, the same experiment is repeated three times. The replacement value of volatility is 0.0001 from Column 1 to 3 and 0.0000000000001 from column 4 to 9.

Table 6

BKY - SENSITIVITY TO PREFERENCE PARAMETERS (1)

Panel A: if vol < 0, vol = 10^{-13} - My results

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
(5 & 0.5)	4.71	2.76	1.03	12.24	3.75	0.08
(10 & 0.5)	NA	NA	NA	NA	NA	NA
(15 & 0.5)	NA	NA	NA	NA	NA	NA
(5 & 1.5)	2.04	0.93	2.22	18.32	5.02	0.09
(10 & 1.5)	1.16	0.98	6.93	18.97	3.10	0.15
(15 & 1.5)	0.13	1.05	11.43	18.92	2.64	0.16
(5 & 2)	1.64	0.71	2.34	18.53	5.30	0.10
(10 & 2)	0.54	0.78	7.32	19.39	3.13	0.17
(15 & 2)	-0.60	0.87	11.97	19.24	2.54	0.18

Panel B: if vol < 0, vol = 10^{-13} - Beeler J. and Campbell J. (2009)

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p-d)$	$\sigma(p-d)$
(5 & 0.5)	4.65	3.32	1.33	19.50	3.79	0.15
(10 & 0.5)	NA	NA	NA	NA	NA	NA
(15 & 0.5)	NA	NA	NA	NA	NA	NA
(5 & 1.5)	4.62	3.40	1.36	19.93	3.79	0.14
(10 & 1.5)	0.97	1.32	7.85	21.45	3.03	0.27
(15 & 1.5)	-0.18	1.51	13.22	21.45	2.42	0.30
(5 & 2)	4.63	3.31	1.39	19.42	3.79	0.14
(10 & 2)	0.29	1.12	8.60	22.13	3.04	0.30
(15 & 2)	-0.99	1.37	13.88	22.27	2.43	0.33

Table 6 displays moments for the BKY calibration for different levels of the EIS and RRA. The standard configuration (10 & 1.5) is reported, too. In Panel A all the statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations. Panel B displays Beeler and Campbell, (2009)'s moments. The statistics are calculated from a simulation of 1.2 million months. *epremium* is the mean equity premium. In both panels *epremium* is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate. The negative realisations of the variance process are always replaced with 10^{-13}. NA represents cases where the price of the consumption claim is infinite.

TABLE 7

BKY - SENSITIVITY TO PREFERENCE PARAMETERS (2)

PANEL A: if vol < 0, vol = 10^{-4}

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p - d)$	$\sigma(p - d)$
(5 & 0.5)	4.56	3.18	1.47	19.95	3.80	0.09
(10 & 0.5)	NA	NA	NA	NA	NA	NA
(15 & 0.5)	NA	NA	NA	NA	NA	NA
(5 & 1.5)	1.91	1.07	2.77	21.15	5.02	0.10
(10 & 1.5)	1.15	0.92	7.83	22.01	3.02	0.18
(15 & 1.5)	-0.21	1.22	13.12	22.01	2.40	0.19
(5 & 2)	1.51	0.82	3.09	21.73	5.28	0.11
(10 & 2)	0.31	0.90	8.65	22.45	3.04	0.20
(15 & 2)	-1.00	1.03	13.69	22.64	2.43	0.21

PANEL B: if vol < 0, vol = 10^{-8}

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p - d)$	$\sigma(p - d)$
(5 & 0.5)	4.75	2.78	0.93	17.33	3.75	0.08
(10 & 0.5)	NA	NA	NA	NA	NA	NA
(15 & 0.5)	NA	NA	NA	NA	NA	NA
(5 & 1.5)	2.05	0.95	2.17	18.40	5.02	0.09
(10 & 1.5)	1.17	0.99	6.77	18.82	3.10	0.15
(15 & 1.5)	0.16	1.04	11.49	18.64	2.51	0.16
(5 & 2)	1.62	0.71	2.47	18.67	5.30	0.10
(10 & 2)	0.57	0.77	7.44	19.12	3.14	0.17
(15 & 2)	-0.59	0.88	11.96	19.22	2.55	0.18

Table 7 displays moments for the BKY calibration for different levels of the EIS and RRA. The standard configuration (10 & 1.5) is reported, too. In both panels all the statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations. *epremium* is the mean equity premium that is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate. In Panel A the negative realisations of the variance process are replaced with 10^{-4}. In Panel B the negative realisations of the variance process are replaced with 10^{-8}. NA represents cases where the price of the consumption claim is infinite.

Table 8

BKY - SENSITIVITY TO PREFERENCE PARAMETERS (3)

Panel A: if vol < 0, vol = 10^{-11}

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p - d)$	$\sigma(p - d)$
(5 & 0.5)	4.69	2.75	1.06	17.19	3.75	0.08
(10 & 0.5)	NA	NA	NA	NA	NA	NA
(15 & 0.5)	NA	NA	NA	NA	NA	NA
(5 & 1.5)	2.04	0.93	2.06	18.15	5.02	0.09
(10 & 1.5)	1.16	0.98	6.85	18.77	3.1	0.15
(15 & 1.5)	0.13	1.05	11.44	18.88	2.51	0.16
(5 & 2)	1.63	0.70	2.39	18.51	5.30	0.10
(10 & 2)	0.54	0.78	7.24	19.14	3.14	0.17
(15 & 2)	-0.59	0.88	11.90	19.08	2.55	0.18

Panel D: Data

(γ & ψ)	$E(r_f)$	$\sigma(r_f)$	*epremium*	$\sigma(r_m - r_f)$	$E(p - d)$	$\sigma(p - d)$
Data	0.82	4.15	6.89	18.03	3.30	0.43

Table 8 - Panel A displays moments for the BKY calibration for different levels of the EIS and RRA. The standard configuration (10 & 1.5) is reported, too. The statistics are based on 1,000 simulations each with 924 monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations. *epremium* is the mean equity premium that is computed by adding one-half the variance of excess stock returns to the mean log stock return (a Jensen's Inequality correction) and subtracting the mean log interest rate. The negative realisations of the variance process are replaced with 10^{-11}. NA represents cases where the price of the consumption claim is infinite. Panel B displays the corresponding moments from the 1930-2006 yearly dataset.

TABLE 9

SENSITIVITY TO THE SIZE OF THE MONTE CARLO

PANEL A: BKY calibration

Moment	smplx1 924m (1)	smplx2 1848m (2)	smplx4 3696m (3)	smplx8 7392m (4)	smplx20 18480m (5)	smplx50 46200m (6)	smplx100 92400m (7)
$E(r_f)$	1.16	1.11	1.02	1.00	0.99	0.99	0.99
$\sigma(r_f)$	0.98	1.08	1.17	1.23	1.27	1.28	1.28
$E(r_m)$	6.22	6.37	6.47	6.46	6.55	6.55	6.56
$\sigma(r_m)$	19.10	19.82	20.73	21.06	21.30	21.42	21.43
$E(p\text{-}d)$	3.10	3.08	3.05	3.05	3.04	3.04	3.04
$\sigma(p\text{-}d)$	0.15	0.18	0.21	0.24	0.25	0.26	0.26
epremium	6.93	7.27	7.62	7.68	7.81	7.83	7.84
$\sigma(r_m - r_f)$	18.97	19.68	20.58	20.91	21.16	21.28	21.30

PANEL B: BY calibration

Moment	smplx1 924m (1)	smplx2 1848m (2)	smplx4 3696m (3)	smplx8 7392m (4)	smplx20 18480m (5)	smplx50 46200m (6)	smplx100 92400m (7)
$E(r_f)$	2.58	2.58	2.58	2.58	2.58	2.58	2.58
$\sigma(r_f)$	1.21	1.26	1.29	1.30	1.31	1.31	1.30
$E(r_m)$	6.71	6.70	6.75	6.75	6.76	6.74	6.74
$\sigma(r_m)$	16.90	16.98	17.00	17.03	17.04	17.05	17.06
$E(p\text{-}d)$	3.00	3.00	3.00	3.00	3.00	3.00	3.00
$\sigma(p\text{-}d)$	0.15	0.15	0.16	0.16	0.16	0.16	0.16
epremium	5.50	5.49	5.55	5.56	5.57	5.55	5.55
$\sigma(r_m - r_f)$	16.64	16.61	16.66	16.67	16.69	16.70	16.70

Table 9 displays moments for the analytical solutions of the Long-run Risks model with the BKY calibration in Panel A and the BY calibration in Panel B. The statistics are based on 1,000 simulations each with the same amount of monthly observations that are time-aggregated to an annual frequency. Reported moments are the means across the simulations. Each column relies on a different number of monthly observations; the length of the samples is displayed at the top. In both panels Column 1 reports the standard case: each simulation has 924 monthly observations that correspond to the 77 annual observations available in the dataset. The horizon of the simulations increases gradually from Column 1 to Column 7 (100 times the original sample). In both panels the negative variances are replaced with 10^{-13}.

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Towards a Narrow Definition of Social Capital: Which Role on the Italian Regional Development and Well-Being?

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The concept of social capital still suffers from its "original sin", the historical process that led it to an excessively broad definition. The aim of this study is to isolate some of the key components – interpersonal relationships – from other concepts that are usually improperly pooled into them. A coherent measure allows analyzing some of the possible outcomes of social capital, that is growth and well-being: results confirm a positive association between social capital and well-being only. Also, an explorative investigation puts forward the creation of trust as a crucial stage in the process through which social capital generates its outcomes.
[JEL Classification: Z13; O11; R11].

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1. - Introduction

Concept or praxis? Social capital is undoubtedly one of the most popular themes in the economic debate of the last twenty years, but it is still a sort of mysterious object. Many authors claim that the concept of social capital is born as a reaction, even historically justified, to the approach of modern economics that has excluded from analysis all those aspects, variables, contexts related to the society. Using Fabio Sabatini's (2007, page 77) words we can say that such approach has "deprived the economic interactions of their social content".

In this reaction it could be found the success and, at the same time, the "original sin" of the concept of social capital. To describe the process that has seen the label "social capital" as a protagonist in the scientific debate, it is often used the metaphor of an "umbrella". Several disparate phenomena have been accommodated under this umbrella, despite the fact that they were different from each other in kind and causal link and that their unique common element is of being neglected as economic factors. For these reasons, social capital risked to become "not a concept but a praxis, a code word used to federate disparate but interrelated research interests and to facilitate the cross-fertilization of ideas across disciplinary boundaries" (Durlauf and Fafchamps, 2004, page 1642).

The present paper can be ideally divided into two phases. Firstly, we will try to "empty" the umbrella of social capital, redefining its boundaries and identifying its key components. Secondly, we will exploit a new definition in order to choose the consistent explanatory variables for various empirical tests. In this phase, we will explore the possible outcomes – growth and well-being – of social capital for the Italian regions, comparing our results with the estimates of some other most known works on the role of social capital in Italy.

The paper is organized as follows. Section 2 is devoted to the redefinition of the concept of social capital. In section 3 and 4 we measure the endowments of social capital in Italy and its stability over time. Section 5 deals with the social capital-trust nexus. In section 6 and 7 we analyze the relationship between social capital and its possible outcomes, such as growth and well-being. The last section is let to concluding remarks.

2. - Towards a Redefinition of the Concept of Social Capital

The summary of the “state of the art” of the concept of social capital is the first step of our analysis.

Firstly, we report some of the most popular definitions of the last two decades:

> «*Social capital is defined by its function. It is not a single entity, but a variety of different entities, having two characteristics in common: they all consist of some aspect of a social structure, and they facilitate certain actions of individuals who are within the structure*» (Coleman 1988, page 98).
>
> «*Social capital refers to features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit*» (Putnam, 1995, page 67).
>
> «*Social capital can be defined simply as a set of informal values or norms shared among members of a group that permits cooperation among them*» (Fukuyama, 1995, page 10).
>
> «*Social capital refers to the norms and networks that facilitate collective action*» (Woolcock, 1998, page 151).
>
> «*Social capital refers to connections among individuals-social networks and the norms of reciprocity and trustworthiness that arise from them. In that sense social capital is closely related to what some have called* “*civic virtue*”» (Putnam, 2000, page 19).

From this very short review, it emerges a positive convergence towards a closer and less elusive definition. Moreover, it should be noted that in these definitions there are recurrent keywords like trust, social norms and relations.

The second step is to see which variables are commonly chosen to match with these definitions. Table 1 shows the most common indicators used to define social capital in some recent works. Among them, there have been several studies that focused on different possible outcomes of social capital for the case of Italian regions. Some examples of such outcomes are reduction of poverty and social exclusion (Andriani and Karyampas, 2010), financial development (Guiso, Sapienza and Zingales, 2004) and growth (Degli Antoni, 2006).

It may be really useful to build a scheme like the one presented, because of the fact that the problem of the theoretical definition of social capital is close to the one of the choice of the “operative” variables. In fact, despite of a common definition which is becoming more and more precise, the absence or the difficulty to find adequate data leads to test for variables that are weakly correlated with this definition.

Overall, we need a double effort. On one hand, we have a theoretical problem, that is to identify which concepts, from those included in the definitions reported above, could be part of social capital. On the other hand, we face the recurrent challenge of finding adequate proxies of social capital that do not betray the results of the first step.

TABLE 1

SUMMARY OF THE MOST COMMON VARIABLES USED TO MEASURE SOCIAL CAPITAL IN SOME INFLUENTIAL WORKS

	Nr. of associa-tions	Nr. of newspa-per readers	Elector-al partic-ipation	Trust *(WWS, EVS)*	Civic-ness (survey)	Mem-bership (surveys)	Inten-sity of familiar ties (survey)	Inten-sity of friend-ship ties (survey)	Blood dona-tions	Institu-tional perfor-mances	Satis-faction	Offen-ces and protest-ed bills
Putnam *et* al. (1993)	X	X	X									
Helliwell, Putnam (1995)	X	X	X							X	X	
Knack, Keefer (1997)				X	X							
La Porta *et* al. (1997)				X								
Beugelsdijk, Smulders (2003)						X	X					
Guiso *et* al. (2004)			X						X			
Micucci, Nuzzo (2004)	X	X	X			X	X	X		X	X	
Sabatini (2007*a*, 2008)	X	X				X		X			X	
Degli Antoni (2006)												X
Andriani, Karyampas (2010)	X					X						

2.1 *Social Capital as Social Networks*

To begin our redefinition process we start from the key work of Dasgupta (2001) that explores the process for generating trust.

«*Trust is the key for cooperation, social capital is merely one of the means to creating trust*» (Dasgupta, 2001, page 20).

The starting point is the analysis of a mutually advantageous agreement between a group of people, and in particular the problem of its abiding by the parties. Which conditions or situations could ensure that the parties will keep their side of the bargain? To be more precise, how is it possible that the strategy (*keep the bargain*) could be a part of an equilibrium strategy? Since the behaviors of other people are not observable, beliefs about one another play key role in determining the equilibrium.

Dasgupta identifies four situations that strengthen the reliability of the agreement, since they allow to an equilibrium belief. These situations, that lead to trust and trustworthiness, are:

- Mutual affection;
- Pro-social disposition;
- Mutual enforcement;
- External enforcement.

Each of these situations comes from a particular pre-existing or a new relationship between the parties.

With respect to mutual affection, beliefs arise from strong and weak ties due to the fact that people care about each other. This situation is common in families and friendship.

The second situation concerns a pro-social disposition to reciprocate, both being trustworthiness in response to trusting people and punishing an opportunistic behavior. As pointed out by Dasgupta (2001), there are some psychologists that argue that this kind of disposition develops in childhood and adolescence accordingly to education, community life and systems of rewards and punishments.

Mutual enforcement is the third situation. The reliability of the deal is enforced by the implicit norms that underpin repeated long-term relationship. In this situation, the key elements are not mutual care or a disposition to reciprocate, but reputation and honorability.[1] Equilibrium strategies that allow for cooperative outcomes in repeated games are usually defined "social norms". They enclose the possibility of imposing sanctions on those who break the deal and on those who do not punish the latters, and so on.

1 One of the most known examples is the market of the diamonds of New York, where the merchants exchange diamonds without any formal contracts.

The last situation, external enforcement, is related to institutions. The agreement is translated into an explicit contract "and enforced by an established structure of power and authority; which is to say that the agreement is enforced by a "third" party. This may be the State" (Dasgupta, 2001, page 15). In this case, beliefs play a key role as well: the parties will keep the agreement "if the Authority can be trusted" (Dasgupta, 2001, page 15) to enforce them.

Here is a first fact that comes out from our redefinition process: institutions seem to be out of the boundaries of social capital, they are just another channel to build cooperation.[2]

But can we, on the contrary, delimit the sets of social capital and of trust? One of the explicit aims of this survey is to thin out the social capital "umbrella" consistently with a system of casual links and of structural definitions. At the same time, it is essential to avoid falling into a sort of simplifying fury that forces the phenomena related to social capital into excessively narrow labels. The categories of cognitive and structural social capital, as suggested by Uphoff (1999), can help to clarify the role of the concepts of trust, norms and relationships with respect to that of social capital. Relationships are an observable, structural dimension of social capital which facilitates the *mutually beneficial collective action* (MBCA) together with social norms, which govern and drive relationships themselves. Members of these networks, in turn, are willing to cooperate because they carry forms of cognitive and structural individual social capital, a sort of Kantian *Form*.[3] This has to do – among the others – with the predisposition to trust and reciprocity, which Dasgupta calls *pro-social disposition*.

It is conceptually arduous to state the existence of a sharp distinction between predisposition to trust and trust itself, that is, the discrimination between trust as prerequisite and trust as outcome. This is the reason why, from a purely theoretical point of view, trust stays in the *limbo* between an exclusive outlook and an inclusive one when redefining the concept of social capital. Yet, it seems inappropriate to consider trust as social capital when dealing with an empirical

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[2] There is a large debate on the relationship between social capital and institutions: are they complementary or substitute? HELLIWELL J.F. (2001, page 47) highlights that «a legal system with defined and enforceable rules is more necessary in the absence of personal ties». This assumption suggests that greater social networks allow preventing costly interventions of the institutions.

[3] It does not mean that such structures are innate and unmodifiable. We will see that the aptitude to trust others could be an outcome of social capital as well.

analysis on the outcomes of social capital because such an approach would lead to encompass other kind of sources of trust as well.

Consequently, we choose to embrace an operative perspective and to exclude trust from the core components of social capital.

The recurrent keywords in the definitions of social capital reported above are "trust", "norms" and "relationships". Up to this point it is possible to clarify the *scenario*: the core concept of social capital encompasses the various forms of social networks, whereas social norms are on an halfway point.[4] We can define them as the informal rules that lead some social structures to cooperative equilibria.

But what are exactly these relationships? The main element is the creation of a link between subjects or groups. However, it is not only a simple quantitative phenomenon, but we should treat the social networks as a real structure that has its own rules and social norms. These norms manage the relationships and lead to cooperation, whether social capital is effectively related to trust.

There are several classifications of the various forms of relationships. Putnam distinguishes between bonding social capital – relationships within small groups as families – and bridging social capital – relationships within large and differentiated groups – and between horizontal and vertical relationships. Various findings in the existing literature highlight the importance of bridging and horizontal connections, since they can really lead to cooperation. On the contrary, bonding social capital seems to be related to familism and to be a potential obstacle to development and growth.

2.2 *The Representative Variables of Social Capital*

Table 1 shows that one of the most common variables used to represent social capital is the trust index (or, more properly, the trustworthiness index). This index is obtained by aggregating answers to a question of the World Value Survey.[5]

In the previous sections we discussed the necessity of excluding trust from the main definition of social capital, since trust could be considered as an outcome of such networks. Moreover, there are further doubts in using this variable, espe-

[4] This definition is consistent with the work of "purification" of the concept of social capital carried out by several economists: among them Sabatini F. (2007); Woolcock M. (2001); Ponthieux S. (2004).

[5] For a more detailed discussion of this index see section 5.

cially regarding the legitimacy of aggregating data (Sabatini, 2007*b*).[6]

Anyway, many variables other than trust are presented in Table 1, and some of them represent indirect measures of social capital. These concern, for instance, electoral participation, blood donation, the number of newspaper readers, and that could be essentially related to the concept of civicness. In regard to these indirect indicators, Sabatini (2007*b*, page 86) claims:

> «*Of course, from a lexical point of view, it is possible to attribute the "social capital" label to every aspect of the economy's social fabric providing a favorable environment for production and well-being. However, such definition poses a "logic" problem: if social capital is everything can make agents cooperate or markets work better, then any empirical analysis will find that social capital causes cooperation among agents and improves the efficiency of markets. This approach simply "sterilizes" the social capital literature, making it unable to foster the explanatory power of economic studies addressing the socio-cultural factors of growth*».

This is the problem that affects several works – reported in the previous section – on the role of social capital in the Italian regional development. Guiso *et* al. (2004) choose blood donations and electoral participation as proxies in order to show how social capital increases financial development by fostering trust. The same indicators have been chosen, among others, by Helliwell and Putnam (1995) and Putnam (1993).

Once again, we cope with a cause-and-effect problem, since these civicness indicators should represent the evidences of the spillover process fostered in the society by a rich associational life. Therefore, it seems that such variables should be treated as possible outcomes of social capital and not as a part of it.

The same argument could be made for the measures of the number of offences and protested bills. These data have been used by Degli Antoni (2006) in order to test if social capital fosters economic growth. However such variable, despite of being "outcome-oriented", seems to be more coherent with the underlying theoretical hypothesis. It could be in fact interpreted as a measure of trustworthiness, which represents for Degli Antoni the key for the promotion of regional growth by social capital. Thus we can say that the choice of this proxy allows – at least partially – to avoid the risk of selecting other indicators which are just de-

[6] Again, for or a more detailed discussion of this point see section 5.

scribing other form of structural weaknesses of the considered regions. On the contrary, such risk is strong when selecting generic proxies of civicness.

Nevertheless it should be noted that the concepts of social norms and civicness have some degree of overlapping.[7]

Indirect indicators and the related concept of civicness represent border themes on the scenario of social capital. On the one hand, they are possible results of social networks, on the other hand they are complementary to such networks.

Our choice will be to exclude civicness from the core components of social capital, because of its dubious role and of our awareness that this theme would need a separate analysis.

The main point is to state, once more, the identity between social capital and relationships. This identity must be kept also in the choice of the variables.

There are two kinds of data on social connections: the "subjective" ones, coming from surveys on use of time and social structures[8], and the "objective" ones, coming from surveys on the number of associations and on demography.

It would be better to use the first kind of data. The report of the Commission on the Measurement of Economic Performance and Social Progress (2009), in fact, recognizes that these subjective variables have better capacities to describe the various dimensions of social capital than the objective ones. Moreover, the reliability of these objective data is questionable. It can often happen that name and address correspond to an "empty box" and not to a working association or organization.

Our data on social networks, therefore, mainly comes from various surveys on the behavior of individuals and on the frequency and the intensity of their relations with relatives, friends and acquaintances and with other members of the associations to which they belong. In addition to these data, we insert a few objective variables related to demography, like the average dimension of families and the number of children.

An interesting perspective on this theme has been suggested by Andriani and Karyampas (2010) about the role of social capital in reducing poverty and social exclusion. They select as an index of social capital a measure of the density of as-

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7 We refer to the social norms that are linked to the concepts of pro-social disposition, described in section 2.1 and of structural (shared norm) and cognitive (individual process) described in the same section.

8 Those data are available both for Italian regions (ISTAT) and for European regions (European Value Study). They are available also worldwide (World Value Survey).

sociational activity in the Italian industrial districts. Their contribution is relevant since the choice of the variable is strictly coherent – and we saw that it is not a common practice – with the hypothesis to control for: social capital may help reduce poverty by improving the circulation of information and innovations and by reducing opportunistic behaviors.

We are not suggesting that a better choice of the various social capital measures could represent a *panacea* for all the common problems of reverse causation, nor that it will remove all doubts about interpreting the estimation results. However a narrow choice – as we see in Andriani and Karyampas – of the social capital index could at least reduce the space for such problems to bite.

2.3 *From "Umbrella" to Multidimensionality*

We have totally rejected the view of social capital as praxis, as an "umbrella" for grouping together all social phenomena that could lead to cooperation and growth. Therefore, the core components of social capital are social networks and the related implicit norms that constitute the rules for such networks. Moreover, frequency, intensity and the number of these connections are the correct variables to be used in an empirical analysis of the phenomenon.

That being so, we need to make an important methodological remark. Sabatini (2004) correctly defines social capital as a "multidimensional" concept. Although the borders of the definition are tightened, in fact, it is true that it still encompasses a wide range of aspects of social connections. This remark suggests that we have to be careful when creating indexes with the purpose of summarizing information.

As suggested by Sabatini (2008, 2007), we can classify social connections in four different dimensions:

- Familiar networks;
- Friendship ties, or networks of weak bridging ties;
- Voluntary membership networks;
- Political participation networks.

In order to respect the multidimensionality of social capital we need to process each one of these dimensions on the whole. In the following steps we will run separate principal components analysis for each dimension of social capital. Such an approach, for its own features, perfectly describes a complex and multidimensional phenomenon, since it allows identifying the most correlated variables in the whole set that contain complementary information.

3. - Social Capital Endowment in Italy

In this section we follow the approach proposed by Sabatini (2007) and Micucci and Nuzzo (2004) for the Italian regions. Data are extracted from the system of multipurpose surveys conducted by the Italian National Institute of Statistics (ISTAT) over the period 2003-2006.

The multipurpose surveys provide information on the answers of a large sample of people – about 20,000 individuals – to questions regarding the use of time, the family structure and their personal activities. We select the proposed variables in order to build a dataset on intensity and frequency of family and friendly relationship and membership.

Apart from the possibility to generate a synthetic indicator, principal component analysis allows to rank regions basing on their coordinates on the first factorial axes. Therefore, it allows ranking regions on the basis of their stock of various kinds of social capital. As we have already noted, we analyze the four dimensions of social capital separately by building a separate ranking for each of them.

Familiar social capital

The social capital index of this dimension comes from two groups of variables: the family structure (average number of components, number of children, geographical distances between members) and the frequency and intensity of the relationships.

The first factorial axes explain about 70% of total variability. In its negative part it describes small families, whose members do not see and hear frequently each other, while in its positive part there are large families characterized by frequent relations.

As expected, the ranking shows the regions of Southern Italy (Campania, Basilicata, Apulia e Calabria) at the top and the regions of Northern Italy, in particular Liguria, Friuli and Emilia at the bottom (see Table 2 and Graph 1).

TABLE 2

RANKING OF THE ITALIAN REGIONS BASED ON THEIR ENDOWEMENT OF FAMILIAR SOCIAL CAPITAL

	Regions	First principal component
1	Campania	5.487404778
2	Basilicata	4.486934343
3	Apulia	4.436925958
4	Calabria	4.268142013
5	Sicily	3.311213491
6	Sardinia	3.071500431
7	Abruzzo	1.950298409
8	Molise	1.738545848
9	Umbria	0.335146156
10	Marche	-0.226998985
11	Veneto	-0.411351832
12	Trento	-0.562135008
13	Bolzano	-0.772127692
14	Lombardy	-1.49547217
15	Tuscany	-2.10583739
16	Lazio	-2.19671933
17	Piedmont	-3.34971315
18	Aosta Valley	-3.798868567
19	Emilia Romagna	-3.826109721
20	Friuli Venezia Giulia	-4.745774411
21	Liguria	-5.59500317

GRAPH 1

MAP OF FAMILIAR SOCIAL CAPITAL IN ITALY IN 2006. DARKER GREY INDICATES HIGHER STOCK OF SOCIAL CAPITAL

Connection with friends

The "informal networks of weak ties" (Sabatini, 2007*a*) index is made of a set of variables describing several aspects of the informal relational life, such as frequency and intensity of the relationships with friends, neighbors, acquaintances, and the attendance to particular meeting-places.

Principal component analysis highlights a complex phenomenon, since frequency of relationships seems to be uncorrelated with intensity. The first component describes the dimension of intensity, a set of variables related to the number of close friends which one can rely on.

The ranking made from this first component shows a reversed *scenario* compared to that one of familiar dimension of social capital. It is presented in Table 3 and Graph 2. In the first places there are the regions of Centre-North Italy, while in the last ones the Southern regions. Trentino Alto Adige and Aosta Valley hold the highest stock of this kind of bridging social capital. We find the same results also for the membership dimension, and so these regions seem to be the most virtuous in terms of the type of social capital commonly considered "positive".

Social capital related to memberships

The membership dimension has been considered as the core of the concept of social capital.

Putnam (1993) assigns the role of "school of democracy" to associations which are social structures that not only lead to the creation of ties among members, but also to a process of diffusion of shared values (partially ascribable to the concept of civicness) throughout society.

Our variables measure intensity of membership in different forms, as cultural, ecological or voluntary associations. We excluded religious and trade union membership from the analysis, since these kinds of associations have particular aims and features that could cover the relationship component. While trade union membership could probably shift into the political dimension of social capital, religious participation should be treated aside, as done by Barro and McCleary (2003).

Since the first component, that explains 77% of total variability, is negatively correlated with the membership variables, regions with a negative coordinate are those with higher stock of this type of social capital. Once again, as shown in Table 4 and Graph 3, the North-South dualism bites.

As pointed out before, the autonomous Provinces of Trento and Bolzano are more "virtuous" than the other Italian regions in general and also than the rest of the North-East. Their eigenvalues indicate that these Provinces are potential outliers. On the contrary, Campania, Abruzzo, Calabria and Sicily have little associational life.

TABLE 3

RANKING OF THE ITALIAN REGIONS BASED ON THEIR ENDOWEMENT OF FRIENDSHIP TIES

	Regions	First principal component
1	Trento	-3.966858535
2	Aosta Valley	-3.312621605
3	Bolzano	-3.166015513
4	Friuli Venezia Giulia	-1.954141104
5	Emilia Romagna	-1.823503344
6	Piedmont	-1.660952652
7	Veneto	-1.651695435
8	Marche	-1.019186398
9	Umbria	-0.870690793
10	Molise	-0.757361308
11	Sardinia	-0.619363917
12	Lombardy	-0.486309076
13	Tuscany	-0.277908694
14	Abruzzo	0.505407217
15	Basilicata	1.317511723
16	Liguria	1.782158606
17	Lazio	2.072148345
18	Calabria	2.48931819
19	Sicily	4.063174553
20	Apulia	4.550750459
21	Campania	4.786139283

GRAPH 2

MAP OF FRIENDSHIP TIES IN ITALY IN 2006. DARKER GREY INDICATES HIGHER STOCK OF SOCIAL CAPITAL

Table 4

RANKING OF THE ITALIAN REGIONS BASED ON THEIR ENDOWEMENT OF SOCIAL CAPITAL RELATED TO MEMBERSHIP

	Regions	First principal component
1	Bolzano	-7.146508973
2	Trento	-5.510642766
3	Veneto	-1.218202014
4	Lombardy	-1.141989546
5	Tuscany	-0.585306863
6	Emilia Romagna	-0.564368974
7	Aosta Valley	-0.247122405
8	Friuli Venezia Giulia	-0.162031958
9	Umbria	-0.120580729
10	Basilicata	0.253563075
11	Sardinia	0.573357243
12	Piedmont	0.619419022
13	Marche	0.800997784
14	Liguria	1.212373435
15	Lazio	1.259305707
16	Molise	1.587017217
17	Apulia	1.650266135
18	Sicily	1.932167817
19	Calabria	1.968710805
20	Abruzzo	2.208726247
21	Campania	2.630849743

Graph 3

MAP OF SOCIAL CAPITAL RELATED TO MEMBERSHIP IN ITALY IN 2006. DARKER GREY INDICATES HIGHER STOCK OF SOCIAL CAPITAL. THE PROVINCES OF BOLZANO AND TRENTO ARE IN BLACK BECAUSE THEY COULD BE CONSIDERED AS OUTLIERS

Political social capital

We do not find evidence of dualism analyzing political participation. It is a particular form of social capital and this makes it hard to find a correct interpretation. It is likely, in fact, that such associations are based on explicit structures and vertical hierarchies rather than implicit and shared norms. Furthermore it could be that within political parties the relationships among members are driven by processes like *do ut des*. If it was true it could be unlikely that the process of spillover and of enforcement of trust and trustworthiness among members can happen. The variables used for this dimension of social capital represent the degree of active involvement of people in politics, especially in parties. There is a slight predominance of this form of associational life in the South, except for the case of the Province of Bolzano, that again at the first place. For this Province it is possible to explain the intense political activity with the strength and the weight of the autonomist parties such as the Südtiroler VolksPartei.

Overall, this short overview suggests a clear separation: while Southern regions are richer in strong familiar ties, Northern regions hold a greater stock of bridging social capital, both as membership and friendship.

4. - Stability of Social Capital over Time

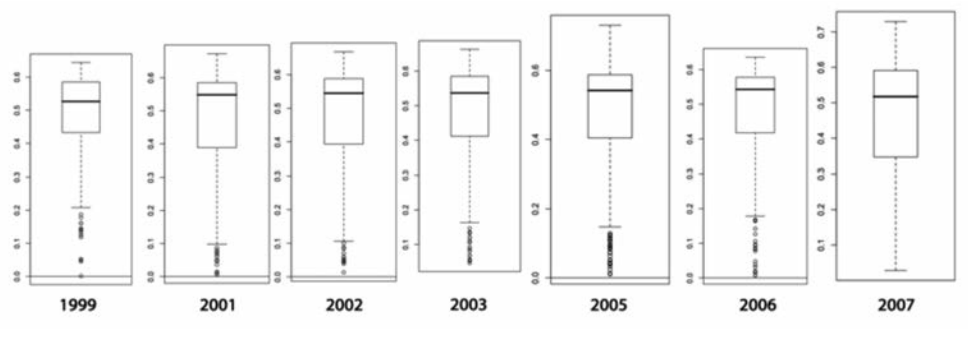
This *atlas* of social capital updated to 2006 has been built using the system of Multipurpose analysis, that are carried out yearly by ISTAT. Data are available from 1999 to 2007. Therefore it is possible, renouncing to only a few variables, to analyze if and how our measures of social capital vary over time. We run several principal component analyses for each year to study variation of the first component over time.

We conduct this analysis on the dimension of associational life, since it is probably the most interesting and potentially productive form of social capital.

Following some of the existing literature, our hypothesis is a strong stationariety. Putnam and Helliwell (1995, 2004) bring the differences in the amounts of social capital between North and South Italy back to historical reasons, in particular the absence, for the South of Italy, of the communal experience and the backwardness due to centuries of Borbonic domination.

GRAPH 4

BOXPLOTS OF EIGENVALUES OF FIRST PRINCIPAL COMPONENT RELATED TO ASSOCIATIONALS ACTIVITIES FOR THE YEARS 1999, 2001, 2002, 2003, 2005, 2006, 2007



The years taken into account are 1999, 2001, 2002, 2003, 2005, 2006, 2007 (data for 2000 and 2004 are not available). To overcome the sample size problem, we resample the data with a size of bootstrap resample of 50. This is a nonparametric method for which eigenvalues of the first principal component are repeated randomly in absolute value.

Graph 4 shows resampled eigenvalues as a series of boxplot, one for each year. Eigenvalues are quite stable over time: the black line represents the median, the extension of the boxplot correspond to the variability.

The short-term stability of social capital raises an interesting problem. As pointed out by Dasgupta (2001), different types of variables should be expected to change at different speeds and adapt at different speeds to changing circumstances. Can a slow-adapting variable constitute a parameter for short-run analysis? The practical answer to this question contrasts with the lack of adequate datasets. In fact, there are not available data responding to the assumptions and definitions stated in the sections above to allow for extending the analysis of evolution of social networks and of its impact over growth and development.

5. - The Nexus Social Capital-Trust

Given a measure of the stock of social capital for the Italian regions, we will investigate its possible outcomes, especially its relationship with growth. To this end, we need to go deeper into the nexus social capital-trust.

The starting point, following Dasgupta (2001), is the fact that, under particular relational situations, cooperative outcomes (*trust, trustworthiness*) are enforced.

Specifically, we are in the presence of a complex and interrelated process leading to the generation of cooperation. According to a considerable branch of the literature (*e.g.* Andriani, 2010 and Burt, 2000, in addition to Dasgupta, 2001), networks affect trust both with a better circulation of information, which reduces uncertainty and improves people's capability to foresee responses from others, and with the establishment of norms that punish opportunistic or free-riding behaviors.

Tracing this process back to the theoretical fundamentals cited in section 2.1, it is easy to see how the three crucial elements are networks, propensity to trust and the social norms that support this relationship. But the links among these concepts are not univocal. The higher density of particular forms of networks may induce individuals with high pro-social disposition to interact more, to share certain social norms, to exchange more information and to behave in a more virtuous way, fearing exclusion or, in a positive view, developing aversion towards free-riding. At the same time, though, thick networks can enhance the propensity to trust which is both a prerequisite and a possible outcome of the social capital-fiducia mechanism. As we stated earlier, in fact, this propensity is a cognitive component of social capital but this does not mean it is innate.

But, in practice, which types of relationships are encompassed in these situations? Are associational life, for example, or weak friendship ties forms of social capital capable to promote trust and trustworthiness and to generate cooperative equilibria? In order to test this hypothesis it is necessary to identify a measure of trust. Aggregate responses to a question of World Value Survey represent the most common attempt in measuring trust[9]. The question is the following:

> «Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?».

and it has two possible answers:

- «People can be trusted»;
- «Cannot be too careful».

Data like these are also available at regional level for the European regions, through the European Value Study (EVS).

We consider the third wave of the Survey, the 1999/2000 one.

Throughout our analysis, we generically refer to the concept of trust, while we acknowledge that it should be more appropriate to address that of perceived trustworthiness.

As Degli Antoni (2006) underlines, in fact, "it is the degree of trustworthiness that reveals the probability for the cooperative processes that can foster growth in a certain community to be fulfilled". In practice, according to this view – of the same mind as ours but largely debated upon in the literature – perceived trustworthiness represents the agents' expectations with respect to the probability of observing opportunistic behaviors in the relative network or community.

Another important issue concerns which aspect is being captured by the measure of trust here considered – replies to the so-called "Rosenberg's question". Is it an

[9] There exist several evidences supporting this measure of trust. One of them is the high correlation (0.67) between this index and the percentage return of wallets in many lost wallet experiments performed in various cities around the world. However, despite the fact that this index is widely used, there remain serious doubts about its reliability, mainly related to framework and contingency of answers problems.

approximation of the "cognitive" propensity to trust or an evaluation of the degree of trustworthiness in the social environment? Although rather slight, the difference between the two aspects is not irrelevant and it is the subject of analyses and empirical evaluations by, for instance, Glaeser *et* al. (2000). The authors examine the correlation between this measure of trust and the results of two lab experiments, a trust game and an envelope game, in which cooperation is achieved when the first and the second player decide to trust and to be trustworthy, respectively.

Their results confirm that attitudinal questions about trust, like the one here considered, actually predict trusting behavior, but weakly. On the contrary, an important conclusion is that "in order to determine if an individual is trustworthy, ask him if he trusts others" (Glaeser *et* al., 2000 page 840). Rosenberg's question, then, seems to approximate trustworthiness rather than trust. This result partially supports the theoretical proposition illustrated in this section and the use of replies to EVS as variable of interest. If, then, replying affirmatively to the question "do you think you can trust others" predicts a trustworthy behavior, this may imply that we are not measuring the "cognitive" component of social capital but one of its possible outcomes, that is a result of the functioning of networks: «I trust others, therefore I am trustworthy».

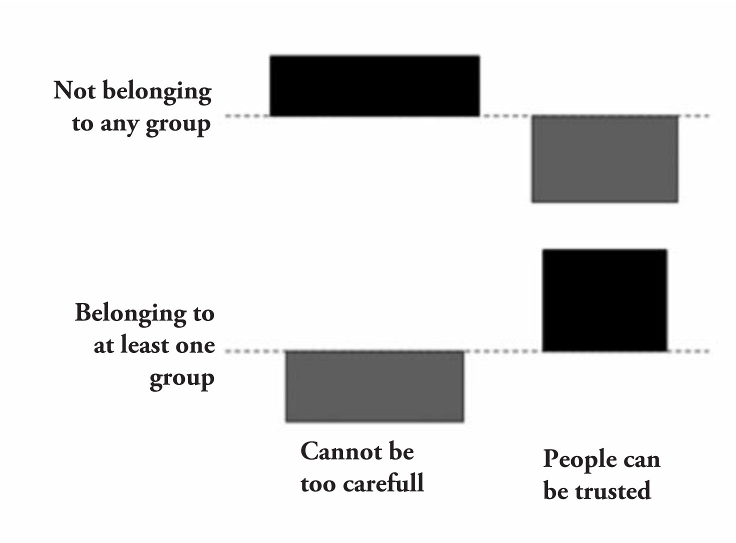
Nevertheless, we must emphasize that this is just one of the possible interpretations and that there is no unanimous consensus as to this outlook and the role of Rosenberg's question in the literature.

Yet, the issue we address in this section does not require a more detailed analysis in this sense. What should be investigated is whether the people who belong to certain networks believe more that you can trust others with respect to those who belong to other networks. This approach is consistent with the awareness of the ambiguity of the direction of this relation. It is not a matter of verifying whether the propensity to trust (or to trustworthiness) is an outcome or a prerequisite of the functioning of networks, rather stating the existence of a link between a particular form of network, the associational life, and a greater trust in the environment.

The sample size poses a significant methodological problem: 2,000 respondents are enough for data at a micro level, but not at an aggregate regional level. For this reason we only run an association test to explore the relationship between individual behaviors and beliefs.

GRAPH 5

ASSOCIATION PLOT BETWEEN THE VARIABLES "TRUST IN OTHER PEOPLE" AND "MEMBERSHIP"



Such a restriction on the possibility to aggregate data at regional level, however, not only does not constitute an obstacle, but rather it allows empirical investigation to escape one of the critical point in the literature, that is to investigate cross-section based on the index of confidence. Sabatini (2007*b*) highlights the fact that in the transition from micro to macro level, the data lose a part of the explanatory power, *i.e.* the link with contingent factors that may have influenced the responses.

We analyze both the whole sample and a restricted sample, excluding individuals (54 out of 2,000) that answered *I don't know* or *No answer*. Results are presented in Table 5.

We carry out a χ^2 association test on several pairs of qualitative variables, as membership in various forms of associations and stated trust in others. The choice of the association test as investigation device, in place of other more "rigorous" means, is consistent with the explorative approach earlier described. The EVS data, in fact, do not allow evaluating which direction prevails in the relation associational life-trust. Nevertheless, this is not necessarily to be intended as a limit:

we already argued that on a theoretical level the concept of trust is partially hanging in between being in or out the umbrella of social capital. Once more, the relevant point of this section is not investigating trust as an outcome of social capital. It is more the confirmation of trust as part of the virtuous mechanism that leads to cooperation.

TABLE 5

ASSOCIATION BETWEEN MEMBERSHIP IN VARIOUS FORM OF ASSOCIATIONS AND ANSWERS TO THE QUESTION (1) ABOUT TRUSTING OTHERS

Belonging to groups related to:	**"I don't know" and "No answer" included** χ^2	**"I don't know" and "No answer" not included** χ^2
Social welfare services for elderly, handicapped or deprived people	8.0546**	5.4363**
Religious or church organisations	6.3287*	5.4011**
Education, arts, music or cultural activities	59.1467***	51.2046***
Trade unions	12.1965***	10.2834***
Political parties or groups	16.6969	14.8343***
Local community action on issues like poverty, employment, housing, racial equality	16.3662***	9.6989***
Third world development or human rights	13.6053***	11.3601***
Conservation, the environment, ecology, animal rights	23.3088***	21.5244***
Professional associations	17.5756***	15.1713***
Youth work (*e.g.* scouts, guides, youth clubs etc.)	12.6689**	10.6401***
Sports or ricreations	12.839***	11.906***
Women's groups	0.5384	0.0304
Peace movement	17.2842**	8.534***
Voluntary health organisations	7.5969*	6.1232**
Other groups	1.9754	0.3163
None	59.2886***	57.2616

Asterisks denote significance at 1%(***), 5%(**) and 10% (*).

For the whole sample we can reject the null hypothesis of independence for almost all types of associations: those who trust more are those who belong to some associations.

This is not true for religious, voluntary health and women organizations and "other groups", that seem to be an exception. When we carry out the χ^2 test on the restricted sample, however, we can reject the null hypothesis also for religious and voluntary health organizations. Only women groups and "other groups" seem to be not associated with stated trust. Since for some variables the approximation of χ^2 test could be inaccurate and the *p*-value not reliable, we also run some χ^2 test with a bootstrap approximation of the *p*-value, replicating the contingency table from the marginals.

Membership in general seems to be associated to the perceived trust of the society. In Graph 5 we study the direction of this association relative to answers to "belonging to at least one group or not" and to question about trust.

In this graph, the areas of the rectangles result from summation of statistical test χ^2. If a rectangle is above the dotted line, it means that there is a positive association. There are more people who do not belong to any group and who think that in general we should not trust others than those expected in the assumption of independence. Similarly, there are more people who belong to at least one group and who think that most people can be trusted than those expected assuming that the variables are independent.

Undoubtedly, the analyses suffer from strong problems of possible reverse causation. It could happen, in fact, that associations "self-select" people who *ex ante* have a greater tendency to trust others. In this case trust would not be the outcome of associational social capital.

The existing literature provides several analysis of the relationship between social capital and trust. Knack e Keefer (1997) run a regression between the World Value Survey index and a measure of intensity of membership, built as the average number of groups to which each respondent belong. They find a strong bivariate relationship between trust and membership, not statistically significant when controlling for income and education. These finding confirm the difficulty in interpreting this association, since the risk of a selectioning process by associations and group of trusting people is very high. Glaeser *et* al. (2000) also deal with the link between trust and networks, but they refer to the latter in a generic sense and not specifically as associational life. Their results seem to confirm the existence of a strong influence of relationships on trustworthiness and a weak one on trust.

6. - Social Capital and Growth

Since its appearance to the top of the scientific debate, social capital has been related to a wide range of economic outcomes: growth, investments, financial development, well-being, health, environmental quality, reduction of suicide numbers. Often, a statistical association has been found between these outcomes and something else than social capital: trust, for example. After the hard work of redefinition started in the economic debate, the main point is to verify whether the "purified" concept of social capital is still a positive determinant of these outcomes or whether it remains only a sort of "empty box".

Putting all together, at a theoretical level the relationship between social capital and economic development runs through the concept of trust. A necessary consequence is that in a trustful environment people can avoid transaction costs related to uncertainty, such as insurance or explicit contracts. Another possible channel through which social capital enforces growth is by spreading innovation. Several authors have found a link between social capital and economic and institutional performances.[10]

Our hypothesis is that these results are biased by the problems related to a too broad definition of social capital and to a wrong choice of the proxies. Supporting our idea, Knack e Keefer (1997) provide evidence that there is a positive relationship between trust and growth but not between membership and growth. Moreover, Beugelsdijk e Smulders (2003) show that there is a strong connection between growth and active membership only. The latter is an ambiguous proxy of social capital that seems not to be relevant with social connections.

If, as earlier stated, it is inappropriate to clearly exclude trust from the concept of social capital, it is also true that trust is not the most suitable indicator for social capital, as it is one of its potential outcomes – although intermediate. According to this, our measure of social capital is consistent with the theoretical redefinition of the concept described above. We test the relationship between the indexes for the four dimension of social capital obtained from principal component analysis and growth of Italian regions over the period 1996-2007. The same approach has been followed by Tabellini (2005) in his analysis of the nexus culture–growth.

This kind of cross-section analysis suffers from three main drawbacks, which must be considered when interpreting the results. Firstly, the undoubtedly limited sample size that restricts the number of regressors: we only have 21 regions.[11] Sec-

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[10] Among them, PUTNAM R.D. *et* AL. (1993) and PUTNAM R.D. and HELLIWELL J.F. (1995) for the case of Italian regions, KNACK S. - KEEFER P. (1997) in a cross-country analysis. An interesting recent paper by BEUGELSDIJK S. and SMULDERS S. (2003) shows evidences on the relationship social capital-growth for the case of European regions.

[11] We consider the autonomous Provinces of Bolzano and Trento separately.

ondly, the high risk of endogeneity. Thirdly, the process of economic convergence between Italian regions. As pointed out by Helliwell (2001, page 45):

> «*It is doubtful that anyone steeped in the recent growth history of subnational regions in Europe would find anything to support such links, since the predominant post-war pattern of convergence among the regions of Europe saw the poorer regions of Italy, which also tended to have lower levels of social capital, growing faster than the richer regions*».

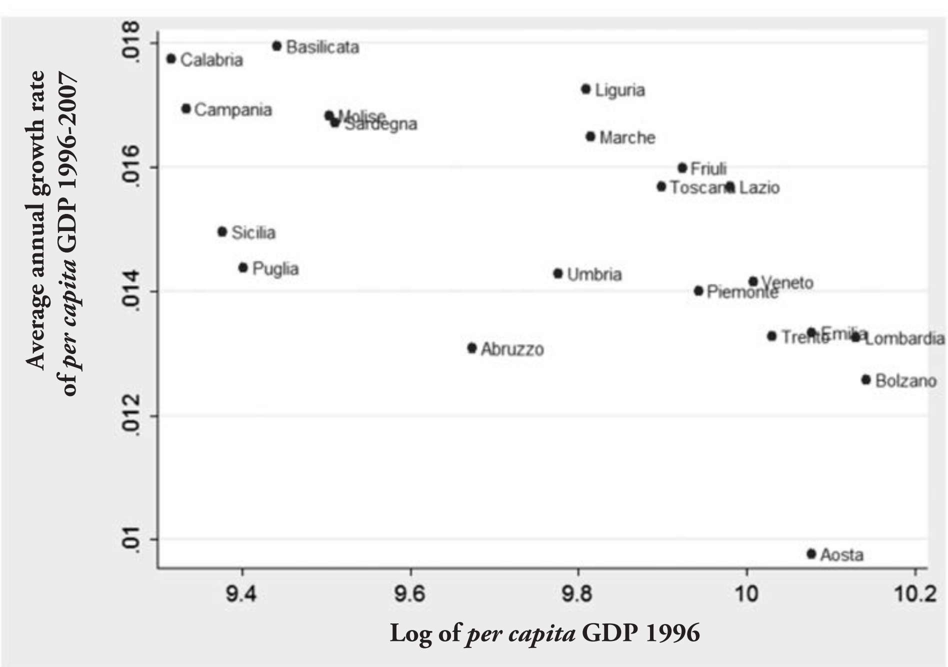
Our social capital variables are the first principal components obtained from four different dimensions of social capital: family relationship (*pc_fam*), political membership (*pc_pol*), voluntary membership (*pc_vol*), (friendship relations) (*pc_ami*). We multiply by -1 the eigenvalues of the last three dimensions to facilitate the interpretation of coefficients: higher values of the first principal component indicate higher stocks of social capital.

We study the relationship between growth over the period 1996-2007 and our measure of social capital by OLS estimates.

To allow for convergence, initial *per capita* output in logs (*pil1996*) is included among the regressors. For each dimension of social capital we run four regressions. Results are presented in Table 6. The coefficients of *pil1996* are always positive and significant and confirm that a convergence process has been working: regions with lower *per capita* GDP in 1996 grew at a greater rate than the ones that were richer at the beginning. Graph 6 offers further evidence of the convergence process: regions with lower levels of *per capita* GDP at the starting period are those with higher growth rates (Campania, Calabria, Molise and Sardinia).

Graph 6

GRAPH OF CONVERGENCE OF THE ITALIAN REGIONS FROM 1996 TO 2007



Both autonomous Provinces of Bolzano and Trento, which had a greater density of social capital, were richer than others in term of *per capita* GDP in 1996 and grew slower.

We also control for education (*lowedu*). This variable is built on the percentage of people aged between 18 and 64 who only attended middle school. The estimate coefficient of *lowedu* has the expected (negative) sign, although it is statistically significant only for equations *(1)*, *(2)*, and *(4)*. The most interesting results concern social capital variables: for each of its dimensions the estimated coefficients are not significant. Familiar and friendship social capital seem to be negatively associated with growth, although coefficients are not statistically significant.

The considered set of regressors is, with no doubt, limited, as well as the explanatory capacity of the equation of convergence. The introduction of additional explanatory variables, *e.g.* investments, would be appropriate and essential if the purpose was that of investigating the major determinants of the Italian regional growth in the short or medium run.

Table 6

ESTIMATION RESULTS FOR AN OLS CROSS-SECTION MODEL
OF CONVERGENCE FOR DIFFERENT FORMS OF SOCIAL CAPITAL

Dependent variable: growth of *per capita* GDP 1996-2007

OLS estimates

	(1)	(2)	(3)	(4)
Constant	0.1603508***	0.1666748***	0.191033***	0.1538869***
	(0.0311576)	(0.0419028)*	(0.0419662)	(0.0432287)
pil1996*	-0.0119399***	-.0126133***	-0.0153959***	-0.0113743**
	(0.0027793)	(0.0038474)	(0.0041885)	(0.0041045)
lowedu	-0.0002779*	-0.0002728*	-0.0002157	-0.000259*
	(0.00014)	(0.0001399)	(0.0001353)	(0.0001335)
pc_pol	0.0001741			
	(0.0004638)			
pc_vol		0.0001071		
		(0.0004015)		
pc_fam			-0.0004115	
			(0.0003777)	
pc_ami				-0.000075
				(0.0004262)
	R^2=0.5220	R^2=0.6675	R^2=0.5495	R^2=0.5189
Observations	N=21	N=21	N=21	N=21

**per capita* GDP of 1996 is in logs.

Asterisks denote significance at 1%(***), 5%(**) and 10% (*). Standard errors are in parentheses.

However, the aim of the analysis is to verify whether the conclusions of the previous leading empirical works in the literature on social capital and its macroeconomic effects still hold after adopting a measure of social capital that is consistent from both the logic and the causal point of view – that is, substantially cleansed from its outcomes. As a consequence, also in view of the sample size issue described earlier, we choose to sharply limit the set of explanatory variables and in particular to replicate the one suggested at cross-country level by Knack and Keefer (1997).

In contrast to their results, social capital does not appear to be an important determinant for short-term economic growth. This supports the view that estimates of previous works would be biased by a too broad definition of the concept of social capital. Any kind of conclusion must be treated with the greatest caution, in view of the major endogeneity problems described earlier.

7. - Social Capital and Well-Being

Beside the part of economic literature that explores social capital as a factor of growth, there are many studies covering a wide range of possible outcomes. Many of these are related to the concept of well-being.

In the Report of the Commission on the Measurement of Economic Performance and Social Progress (2009) chaired by J. Stiglits, social capital is listed among the features of high quality of life, along with health, education, personal activities (including paid and unpaid work), environmental conditions and safety, but at the same time it is a determinant of many of them.

Helliwell e Putnam (2004) run an empirical analysis on the determinants of well being and they find that social capital, both as trust and as social connections, has a significant impact on health and features of subjective well-being like life satisfaction and happiness.

This section continues the same approach carried out in relation to growth: we will explore the relationship between the indexes of social capital obtained with principal components analysis and a measure of subjective well-being.

Since there does not exist a complete and exhaustive indicator of subjective well-being for Italian regions, but only a few incomplete datasets that suffer from low representativeness limits, we choose a measure that is just a proxy for a true index of well being.

To build the selected dataset we use several multipurpose surveys carried out by the Italian National Institute of Statistics (ISTAT). We use data on the degree of satisfaction expressed by people on various features of quality of life.

These data are treated again by principal components analysis in order to obtain a single measure of well being.

Table 11 shows the correlation matrix between these variables: satisfaction with income (*soddeco*), health (*soddsal*), leisure (*soddtl*), friendship (*soddami)* and family relationships*, soddfam*).

Table 7

CORRELATION MATRIX BETWEEN THE VARIOUS DIMENSIONS OF SUBJECTIVE SATISFACTION

	soddeco	*soddsal*	*soddfam*	*soddami*	*soddtl*
soddeco	1.000				
soddsal	0.877	1.000			
soddfam	0.494	0.645	1.000		
soddami	0.808	0.753	0.738	1.000	0.904
soddtl	0.924	0.824	0.662	0.904	1.000

Analyzing the correlation matrix, in Table 7, we find a strong correlation between satisfaction with income, friendships, health and leisure. Satisfaction with family relationship, on the contrary, seems to be slightly correlated with the other variables. That is why the first principal component, explaining 88% of total variability, is a suitable index in representing only the first four dimension of satisfaction. The last one, satisfaction with family relationship, will be treated separately.

Similar to what we do with the social capital stock analysis, it is possible to classify Italian regions according to their eigenvalues. We obtain a ranking based on the amount of our measures of satisfaction (see Table 8 for details). At this point we can begin to explore the relationship between social capital and well being.

The correlation circle in Graph 7 displays the high correlation of friendly and voluntary social capital with our measure of satisfaction, *pc_sodd,* while political participation is not much correlated.

Table 8

RANKING OF THE ITALIAN REGIONS BASED ON ENDOWMENT OF LIFE SATISFACTION

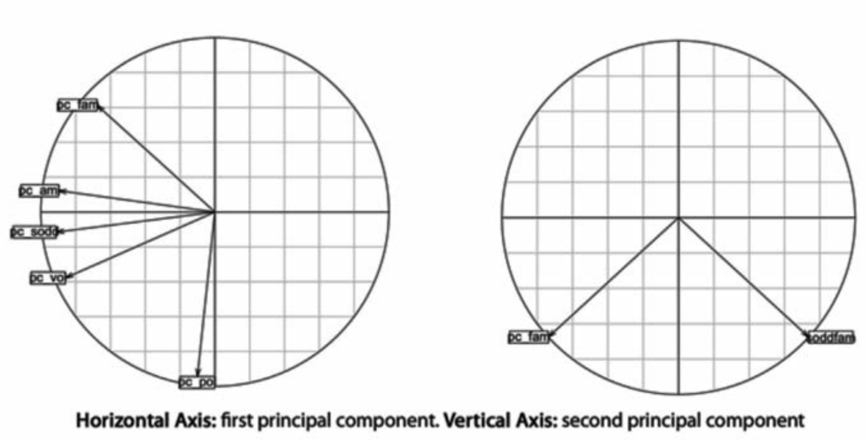
	Regions	First principal component
1	Bolzano	-5.086295449
2	Aosta Valley	-2.22188712
3	Trento	-2.090924501
4	Lombardy	-1.576494318
5	Liguria	-1.445966109
6	Emilia Romagna	-1.000222677
7	Marche	-0.708194545
8	Piedmont	-0.612779281
9	Abruzzo	-0.39921249
10	Umbria	-0.179980283
11	Veneto	-0.161115824
12	Tuscany	-0.058831547
13	Basilicata	0.37249341
14	Molise	0.858670479
15	Friuli Venezia Giulia	1.033740227
16	Campania	1.812666131
17	Apulia	1.833013514
18	Lazio	2.034981858
19	Sardinia	2.060215911
20	Calabria	2.359535377
21	Sicily	3.176587238

In order to understand this result, however, it should be noted that this dimension has been considered as secondary and ambiguous compared to the core components of social capital. We carry out an investigation on the relationship between familiar social capital (*pc_fam*) and satisfaction with family (*soddfam*).

Graph 8 illustrates how *pc_fam* and *soddfam* are uncorrelated, as they are perfectly orthogonal. This means that frequent meetings with relatives do not lead to a greater satisfaction, nor a worse quality of life.

Graph 7 and 8

CORRELATION CIRCLE BETWEEN SOCIAL CAPITAL INDICATORS AND OUR MEASURE OF OVERALL SATISFACTION (7) AND CORRELATION CIRCLE BETWEEN FAMILIAR SOCIAL CAPITAL AND SATISFACTION WITH FAMILY RELATIONSHIPS (8)



On the contrary, Sabatini (2007*a*) finds a negative association between familiar ties and satisfaction for connections with relatives.

This kind of analysis, however, does not take into account the effect of income on the measures of well-being. Moreover, for a correct interpretation of the results it should be noted that our proxy of subjective satisfaction cannot be treated as a measure of overall well-being: it comes from self-reported satisfaction levels only for some aspects of the quality of life.

The index is usually built from responses to the question

«All things considered, how satisfied are you with your life as a whole these days?».

on a scale from 1 to 10. Such data are available for Italy, both in the European Value Study survey and in the Survey on Household Income and Wealth (SHIW), carried out by the Bank of Italy, but they cannot be used as they are based on a sample that is either too small or not representative.

TABLE 9

OLS ESTIMATIONS ON THE RELATIONSHIP BETWEEN SOCIAL CAPITAL AND SATISFACTION

Dependent variable: *Pc_sodd.*
Ols Estimations

	(1)	(2)	(3)	(4)
Constant	-2.889524*	-3.202486*	-6.760725**	-5.900654***
			(2.949779)	(1.215779)
pilmed_0206	.0001269**	.0001406*	.0002968**	.0002591***
				(.0000519)
pc_vol	.4268404***			
pc_ami		.3216642*		
pc_fam			.1059895	
pc_pol				.3514954*
	R^2=0.6726	R^2= 0.5977	R^2=0.5239	R^2=0.5944

Asterisks denote significance at 1%(***), 5%(**) and 10% (*).
Standard errors are in parentheses.

In order to test the social capital – well-being relationship we estimate four different regressions, one for each dimension of social capital, controlling for the average (2002-2006) *per capita* GDP. The estimated coefficients are reported in Table 9.

Per capita GDP has the expected positive coefficient, always significant, and it seems to be a positive determinant of life satisfaction. Social capital coefficients are consistent with what is expected: while voluntary, friendly and political social capital exhibit a positive significant coefficient, familiar social capital seems not to be associated with our measure of well-being.

Our estimates still show the role of social capital, seen as the network of horizontal relationships, being a determinant of well-being. This results confirm the findings of the Report of the Commission on the Measurement of Economic Performance and Social Progress and of Helliwell's (2001) cross-country analysis for the Italian regions.

A further step would be to verify the relationship in compliance to a measure of overall well-being, if and when available.

8. - Concluding Remarks

Despite its history has been influenced by trends and too broad interpretations, the economic concept of social capital still is a significant theme in the literature on growth and well-being.

Social networks are an exceptional device when it comes to spreading information and trust. The relationship between social capital and trust is the key to revaluate the role of social capital and its capability to generate cooperative equilibria through the propagation of a higher level of perceived trustworthiness.

A new trust in the concept of social capital could rise thanks to its abilities to promote trust. Quoting a Nobel Prize:

> «*Trust is an important lubrificant of a social system (…) much of the economic backwardness in the world can be explained by the lack of mutual confidence*» (Arrow, 1972, pages 357).

Then, networks, as means that allow people to move closer to each other, get in touch, ease the exchange of information that reduces uncertainty and discourages opportunistic behaviors, can have a crucial role in economic development.

Nevertheless, our analysis highlights that some of the existing results are biased by a too broad definition of social capital or by the choice of unfitting variables. Frequently, although the social capital label is used, what is actually estimated is the well-known relationship between trust and growth, without analyzing one step backward the determinants of trust as social networks.

Our estimates on the association between social capital and growth and social capital and well being would confirm only a positive relationship between the latter.

We need to take into account two important risks. Firstly, the convergence process that could hide the benefits coming from high stocks of social capital. Secondly, the fact that we only carry out a short-term analysis, because of the lack of larger datasets. This short term horizon contrasts with the stationariety of social capital over time.

Furthermore, there exist issues concerning the aggregating process of data. We have already discussed Sabatini's (2007*b*) point on the lack of legitimacy of any index of trust that is obtained by aggregating some answers separated from the context. But is it true for all the data coming from surveys? Does the data on use of time that we (and Sabatini) use to build the measures of social capital suffer from the same problem? To reject such aggregating process would mean to confine analysis on social capital only to a microeconomic and behavioral level, abandoning the possibility of exploring its role in determining growth.[12]

[12] A well-known exemple of a micro approach to social capital is the work of Guiso L., Sapienza P. and Zingales L. (2004) on the relationship between social networks (and civicness) and financial development.

One last remark concerns the recurrent risks of inverse causality and endogeneity in general, which are very common in the socio-economic literature and particularly in that on social capital. This work does not cope with the endogeneity problem, which is undoubtedly strong and may undermine the interpretability of the results. However, we believe that an important contribution has already been suggested: the approach to social capital itself. Rather than the pursuit of a "magical" instrument aiming at purifying the existent indicators from the correlation problems, we believe that the redefinition of social capital and the choice of progressively less inclusive approximations will bring to more interesting results. In practice, it is necessary to solve the endogeneity problem *ex ante* in order to obtain a more consistent definition of social capital and to find out how it affects the dependent variable, may this be growth, wellbeing or any other macroeconomic variable. And that is what we try to do in this analysis, even if encountering several and clear limits.

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Modeling Fear

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This paper provides a decision theoretic framework in which agents can possibly experience fearful emotional states. In particular, I axiomatize a lexicographic maxmin *framework, throughout called* Lexicographic Multiple Priors *model, which accounts for different levels of fear, pessimist and conservativeness. Using infinitely less likely events as a motivation for the enlargement of the set of beliefs over the state space, I show how the realization of previously unexpected events can be a condition for fear to arise and to exacerbate.*
[JEL Classification: C44; C72].

Keywords: fear; ambiguity; lexicographic multiple priors model; unawareness.

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* *<jacopo.perego@nyu.edu>*. I express all my deep gratitude to Pierpaolo Battigalli and Massimo Marinacci for their precious guidance. Also, I thank three anonimous *referee* for usefull comments. All errors are mine only.

1. - Introduction

This work is about fear and how it influences the way we understand the world, how we form beliefs over it and, as a consequence, how we behave. To an inattentive observer, fear could seem something which normally leads people to behave irrationally. At the same time, however, fear is something we wouldn't never want to live without since the evolutionary role it plays is admittedly fundamental for our own survival. Extreme extents of fear-driven pessimism can certainly come with a cost, sometime very high, but they nonetheless secure our well-being in those times in which we feel threatened by something or someone. In this sense, fear is a rational response to a state of ignorance which cannot be easily and timely unveiled. It is true that ignorance usually pervades our daily lives, but there are instances in which being ignorant about something is just unbearably dangerous. Those are the cases in which fear do play a role. It can be argued that ignorance may extinguish with a cognitive analysis. Unfortunately, the latter, as all cognitive processes, requires plenty of time at hand and, sometime, waiting is just more costly than behaving instinctively. From a psychological perspective, it can be argued that fear is the most time-efficient response which our brain is able to provide in such states of ignorance. Immediacy could come at the cost of impreciseness, but that's exactly the price we want to pay for our endangered safety. In this sense, it just cannot be deemed as irrational.

Consistently, in many instances, neuroscience categorizes human behavior not as being deliberative, but, more precisely, as being the result of automatic processes which are faster than conscious deliberation and that occurs with negligible or absent awareness[1]. Evolutionary psychology identifies these types of processes as those designed by natural selection to solve adaptive problems: in these processes scarcity of time is a relevant issue since deliberation needs time to become effective. These automatic brain processes generally coincides with those involving *emotions.* From a psychological perspective, emotions are defined as an ordinate "program" whose function is to direct the activities and interactions of the subprograms governing perception. These includes a diversified set of processes such as attention, inference, learning, memory, goal choice, motivational priorities, categorization and concep-

[1] In psychological literature, the concept of unawareness is mostly unrelated with the one used in economic literature and in modal logic (FAGIN R. *et* AL., 1988). The latter has be discussed extensively in my thesis, but is not part of this excerpt. Here, instead, we use unawareness as synonym for unconsciousness, that is a state in which the agent doesn't know that she knows. As a matter of fact, in any modal logic axiomatizations this epistemic state would be ruled out by the so called *positive introspection.*

tual frameworks, communication processes, recalibration of probability estimates, situation assessments, values and regulatory variables such as self-esteem (Cosmides, Tooby, 2000). These "programs" have a very persistent structure and don't vary upon the needs of the individual or her circumstances. As a matter of fact, they were designed by nature to generate responses that worked well in ancestral situations, regardless of their consequences in the present.

Fear is an example of emotion which involve many of these subprograms. A fearful individual, relative to a control group of non-fearful peers, is the one with increased attention and modified priorities. Under fearful emotional states, immediate present becomes much more valuable than before, *i.e.* discount rate increases since survival is endangered (Gray, 1987). Goals are quickly reordered, safety becomes a far higher priority (Cosmides, Tooby, 2000) and communicational signals are reverted into quick, poorly structured and easily recognizable sounds. More importantly, *probability assessments are recalibrated* (Loewenstein *et* al. 2005), making worse and previously ignored scenarios becoming more likely. Taken as a whole, these responses have an ambiguous effect on behavior. On the one hand, an increased level of attention might make the agent better off but, on the other, a diminished verbal ability might cause her troubles to communicate effectively. Furthermore, the net effect of recalibrating the probability assessment clearly depends on whether or not the recalibration is justified and accurate. In the first case, final outcomes are positively affected, and *vice versa* in the second one.

In financial environments, it is widely recognized that fear may play a major role in determining final outcomes (Lo *et* al. 2002). Traders constantly deal with emotions such as fear, greed, exuberance, hope, etc. Fear impacts daily activity of individuals in a way which is not necessarily negative or positive and, for the variety of implications on behavior explained so far, it is worth taking it in consideration when analyzing both individual and collective decision problem. In principle, modeling fear requires to solve two distinct problems, both of them being extremely complicated. On the one side, agents must be endowed with a decision rule that accounts for fear in a non-trivial way, that is without invoking *ad hoc* assumptions. In particular, fear should be regarded as a rational response to a changed environment and therefore modeled consistently. Since fear arises and fosters by means of beliefs, these will be the main object of the present analysis. On the other hand, however, we must be able to give sufficient conditions triggering fear. Once again, no exogenous approach will be worth discussing. On the contrary, we should find inner reasons for which fear could arises within the above mentioned decision rule.

Throughout, we fit fear in subjective beliefs. We avoid the use of *ad hoc* assumptions in the decision rule, such as external parameters accounting for fear or time-varying utility functions that, under fearful emotional states, penalize certain consequences more than others. In Section 2, we will motivate this choice. For the time being, it suffices to notice that fear affects not exactly the way we evaluate worst consequences, but, more intimately, the way we contemplate at possible worlds we might face. In particular, it makes the agent believe that previously impossible scenario are now becoming likelier.

The paper unfolds as follows. Section 2 gives a psychological backing to our main assumption, that is the interconnection between fear and ambiguity over our own state of ignorance. Section 3 introduces the decision theoretical framework which will be used throughout. In particular, it adapts a standard *maxmin* framework to account for fear, gives definition of comparative fear and prove some monotonicity results on the set of multiple beliefs. Section 4 addresses the main controversial question of this work, namely what triggers fear. In this regard, we present an approach relying on *infinitely less likely events*. Section 5 brings together some conclusions and it opens the field for future research. All proofs are relegated in the Appendix.

2. - Fear, a Psychological Perspective

2.1 *Towards a Definition of Fear*

In order to handle the problems outlined above, I need to clarify what definition of fear I will use throughout. Indeed, there is a good extent of ambiguity among terms such as fear, panic, anxiety and phobias. Unfortunately, there is no unique definition of fear, despite many characters are commonly recognized by psychologists as being necessary conditions. One of them is *unpleasantness,* that is, fear inherently has a negative valence. As a matter of fact, no fear can properly be pleasant. Oddly enough, one could argue that horror movies may be scary and at the same time pleasant to watch. The same holds for some extreme sport activity, such as parachuting, which are risky and may sometimes generate fearful emotional states in the individual. However, the mild fear induced by a horror movie can be controlled almost completely, for example just by turning the television off. On the contrary, an authentic fearful emotional response requires to be triggered by a situation which is fully out of our control. Indeed, a victim of fear is the one who experiences it as a total *lack of control* (Ortony, Clore, Collins, 1990). A third element, also related to the previous one, is the *surprise* generated by a phenomenon which is still unprocessed, unfamiliar and loosely predictable. Saliba (1980) argues that "an induced element of surprise keeps the perceiver emotionally off-balance so that *she cannot construct a set of mental expectations* and thereby reimpose a control. With a similar intuition, in their model of financial traders Caballero *et* al. (2008) stress the importance of surprise and unpreparedness generated by fast financial innovation.

From an evolutionarily perspective, fear and death go arm-in-arm. As a matter of fact, fear is biologically a warning signal of the imminence of either death or injury. It is designed to cause the individual deviating from his previous activity in order to avoid the – perceived – dangerous event. In this respect, for a fearful response to arise, the perceiver must simply *believe* his well-being is endangered. Clearly, a physical dimension – in the sense of death and injury – of the threat is not required. Returning to the previous example, a trader may experience actual fear, *i.e.* amygdala activation, of losing money or being fired not because such a scenario will induce his physical death, but because he might perceive his worsened financial situation, or the connected signal of low-abilities, affecting his self-esteem, as a dreadful and unbearable outcome. For this reason, material outcomes (losing money) as well as psychological outcomes (losing self-esteem) produces the same brain activation of physical ones and can elicit fear to the same extent. In this sense, a physical dimension is not necessary to trigger fear.

There are occasions in which fear can be *self-enhancing,* thereby creating vicious cycles which facilitate the beginning of a panic reaction. This is due to a distorted use of subprograms involved in the emotional arousal. For example, an exaggerate level of attention induced by a fearful state can make an individual considering signals, which normally neglects, as being relevant. For example, a man in a dark room may interpret insignificant sounds in the background as the signal of another person in the room. Again, a trader, subject to a fearful emotional state, could interpret unimportant signals in stock markets as the evidence of an imminent crash. In turn, contemplating these previously ignored signals may worsen the fearful emotional state of the agent, so as to create panic loops. Another example of distorted use of subprograms induced by fear concerns memory. An individual having a fearful experience recalls past events which she would normally not consider as informative. Sometimes, the recalling of these memories can be made unconsciously: in such cases, it is the fearful stimulus which is responsible of the recalling, since the individual, in a normal state, would simply be unable to remember the particular episode. That of unconscious brain activity is a recurrent topic in psychological literature, and it cannot be easily linked with *unawareness* (see footnote 1).

From a broader perspective, this signifies that the decision maker's emotional state can affect cognitive evaluation of risk (Johnson, Tversky, 1983) and, in turn, these evaluations can affect the agent's emotional state. That this, there is a feedback between the emotional and the cognitive region of the brain, which generate a self-confirming effect of fear (Lang, 1995). Feedback processes of this type can generate unstable situations in which a relatively mild fear rapidly degenerates into a panic reaction.

The complexity of the relationships between the emergence and the decline of fear can be acknowledged by noticing that repeated exposures to fear stimuli may sometimes exacerbate the state of fear, s.c. *fear sensitization,* and other times ameliorate it, s.c. *fear habituation.* The equilibrium between the former and the latter, if it exists, will depend on the type of exposure, intensity of the stimulus and on the characteristics of the subject.

Finally, we can identify two basic kinds of fear stimuli. The first one is called *environmental,* since it is unambiguously induced by the physical environment. The second one is *psychological,* since it is driven by beliefs, not by actual observation, and poses no direct real threats. In the psychological literature, the former is often referred as a rational fear and the latter as an irrational one. We find this distinction misleading. Indeed, it rests on a definition of rationality which does not account for the fact that a rational behavior is such only with respect to oneself's beliefs, namely that oneself's actions must be consistent with her own belief structure. Even though the distinction is imprecise, we learn from psychologists that agents may fear something also without having a proper assessment of the plausibility of the threat. In other words, fear can be solely enforced and maintained through beliefs. Summing together all the above mentioned characters of fear, we can try to give an exhaustive definition.

Fear is an unpleasant emotional state which causes a sometimes healthy other times debilitating response to an unexpected and possibly dangerous situation going out of oneself's control.

This is the definition which will be used throughout whenever we will speak of fear.

2.1.1 *Fear and Risk Aversion*

An important distinction to make is the one between fear and risk aversion. Indeed, one could question the convenience of modeling an additional character of human behavior, *i.e.* fear, when already having risk aversion to control for a quite natural phenomenon, *i.e.* people disliking and thus avoiding potential bad outcomes. In respect, one could think of fear as a high degree of risk aversion. In this respect, it is convenient to account for emotions such as fear, but also panic and anxiety, only if they add something to the standard risk aversion set-up. The first thing to notice is that we can distinguish the different brain regions in which risk aversion and fearful response take place. Camerer *et* al. (2005) point out how risk aversion is characterized as a cognitive process, therefore taking place in the prefrontal cortex, while fear activates the automatic affective region of the brain, in particular amygdala and the hippocampus. In principle, for efficiency reasons, if two distinct brain regions are responsible for different phenomena, *we could expect them to produce* – at least – *partially different responses in behavior.* As a second matter of distinction, fear is inherently a temporary phenomenon. Indeed, a flight-or-fight response is meant to end the stress as soon as possible. Moreover, when the individual gets used to the stimulus, fear can extinguish and her response become less and less instinctual and emotional.

Oddly, as Camerer *et* al.(2005) point out, economists use to classify individual risk preference as something which is both constant over time and consistent across activities. Caballero *et* al. (2008) arrive to the same conclusion, by saying that accounting for fear response is different than endowing the agent with an utility function that all of the time gives bad outcomes to a certain set of unpleasant consequences. By doing that, indeed, one makes agents become extremely risk averse directly through the utility functions, the latter predicting that agents will *always* fear certain particular consequences. On the contrary, we would like to make such a case happening sometimes, precisely only when the agent is experiencing a fearful emotional state. There are several empirical evidences showing precisely that risk preferences are not fixed characteristics of utility function. For example, in Isaac and James (2000), such risk-taking behaviors often appear to be highly inconsistent across domains and situations. This variability is attributed to the changing of emotional states which are influenced by situational variables that play only a minor role in cognitive evaluations. In this view, Lowenstain *et* al. (2001) assert that emotions "respond to the two central variables of cognitive consequentiality account of risk-related perception and behavior – *i.e.* probabilities and outcomes – in a way which differs from cognitive evaluation of riskiness. There is a paradigmatic example of how affects, *i.e.* emotional states, influence the perception of risk independently to standard cognitive evaluation. Many neurologists, for example LeDoux (1996), showed experimentally how risk averse behavior can be fully triggered by fear, without any cognitive involvement. In the experiment, a rat is "fear-conditioned", that is, by pairing a naturally unpleasant event, the unconditioned stimulus (US), with a previously neutral stimulus (CS), it learns a conditioned fear response (CR). In LeDoux (1996)'s experiment, as in a plenty of others, the CS is a signal, that is a – not necessarily noisy – tone. By itself, this conditioned stimulus is *neutral* in the sense that doesn't provoke any particular response in the rat. The unconditioned stimulus (US) is an electric shock which is administered few seconds after the tone. By repeatedly pairing CS with US, the rat starts to relate them consequentially. Once the rat learns the experiment, it fearfully responds to the tone even when no electric shock is administered. That is, the rat became fear-conditioned to the CS. After a number of repetitions of CS with absent shock the fearful reaction extinguishes. We can be led to think that the rat has unlearned the connection, but reality is more complicated. Indeed, when neural connections between the cortex and the amygdala are externally damaged by the experimenter, the original fear response to the tone reappears. This is to say, the rat had *cognitively* learned not to fear the signal, but once cortex connections are severed and the rat's cognitive abilities impaired, it lets amygdala override on prefrontal cortex, *letting automatic affects dominate on cognitive evaluations.*

In conclusion, fear and risk aversion are not antithetical, but precisely the former, in addition with cognitive process, is something which shapes the latter. In this view, behavioral evidences confirm that, in those cases when emotions and cognitive processes are dissociated in their influence on risky choices, risk preferences are often determined by the former (Lowenstain *et* al., 2001). Accounting for fear is to getting closer to real human behavior facing risk preferences. A framework which incorporates affects allows for diversified types of behavioral responses without necessarily assuming an exaggerate degree of risk aversion - something which occurs, for example, in some equity premium puzzle explanations. Moreover, it allows to control for different responses in different times and situations.

2.2 *Modeling Fear with Ambiguity Aversion: Psychological Reasons*

In this part of the paper, I want to relate decision problems under ambiguity with fearful emotional states, both by saying that (*a*) ambiguity triggers fearful emotional states and (*b*) by showing how a fearful individual behaves "as if"she is facing ambiguity. In line with Ghirardato *et* al. (2002) and Ghirardato *et* al. (2004), we handle the definitions in the following way: we use the word "uncertainty"to describe those instances in which the decision maker is able to assign a unique subjective probability measure over the state space. On the other hand, we call decisions under ambiguity those in which, not being able to recover a unique probability assessment, the agent ignores which probability measures, among a class of them, she should use. These definition are purposely loose, in order to facilitate the readability of the argument below. We will provide more thorough definitions and we will explain why and how subjective probability or probabilities arise in the next Section.

The first implication is straightforward. Indeed, we already have empirical evidences showing how ambiguity may induce fear responses. For example, Rustichini *et* al. (2002) shows that risk and ambiguity generate responses in different regions in the brain. As for fear and risk aversion, if two distinct regions are activated, it is very likely they end up with different response behavior. In the experiment, subjects are faced with risky and ambiguous choice and report mild extent of fearful emotional states. More interestingly, in Hsu *et* al. (2005), brain imagining techniques are used to map brain region activation, showing that ambiguous choices activate the amygdala, that is the region responsible for fearful responses, up to a considerable extent. Summing up, faced with an ambiguous decision problem, the decision maker feels as if she has no control over the possible outcomes for she cannot assess probabilities in an clear way. For these reason, she experiences an emotional state which has characteristics similar to those of fear, namely unpleasantness, lack of control and so on.

The inverse implication, namely that fear can make the DM believe and act "as if"she is facing an ambiguous choice problem, has not yet been tackled directly by the literature. However, there are many reason to believe it is plausible. Indeed, we have already seen which are the implications on behavior of a fearful emotional state. For simplicity, we could reduce them to three dimensions, the others being less important or irrelevant to our problem. These three are a shift in the level of attention, a change in the probability assessment (Loewenstein *et* al. 2001) and a reordering of personal goals (Cosmides, Tooby, 2000). As it appears, they all work in the same direction.

Suppose that the DM faces a known set of states of the world over which she can assess a unique belief. During normal times, she uses a standard SEU framework to discriminate among behaviors by choosing the one which leads the higher expected utility given her belief. Once she experiences a fearful emotional state, she is no more certain that her belief correctly describes reality and she starts wondering whether or not others should be considered. By doing this, she extends her class of probability assessments, including those who gives positive probability to previously ignored states. She convinces herself that other previously zero-probability states are now likely to occur. The ancestrally recurrent situation is being alone at night: coupled with fear, the agent can start considering situations, *i.e.* states, which she would normally deem as impossible. Being chased by someone, ripped off, killed, kidnapped are events which she begins to take into account. In a non-fearful condition, she would rationally disregard them as being the outcome of a childish imagination. The same happen in the other recurrent example, *i.e.* financial markets. Traders under a panic crises start to believe that previously ignored states of the world are now becoming likely. Meltdown, terrorist attack, defaults, government interventions are examples.

However, there is an important clarification which has to be made. Fear is not the only trigger which can initiate this process. Indeed, the agent can receive signals leading her to *cognitively* consider previously ignored states of the world. This is the result of the coexistence of both cognitive and affective components in the determination of behavioral response (Camerer *et* al. 2005). Assume there are actually some evidences that a market crash is going to occur. The implied response, *e.g.* a selling off, is not the result of a fearful emotional state, but simply the consequences of Bayesian updating. On the contrary, a fearful agent does not necessarily need any realistic signal to trigger her response, since fear will do the job. Moreover, if she fears a crash, she will probably underweight signals telling her that no such a thing is going to happen and, *vice versa,* overweight pessimistic signals (Loewenstein *et* al. 2005). In some sense, also in line with the psychological game literature, the agent will seemingly choose not to receive some pieces of information.

Caballero *et* al. (2008) consider a similar model in which the uncertainty is triggered by unusual events and untested financial innovations that lead agents to question their view of the world. Consistently with the psychological backing given above, they find that these (Knightian) investors most commonly respond by reevaluating their models, becoming conservative and disengaging from risky activities. They note how, in such cases, the emphasis on tail outcomes and worst-case scenarios in agents decision rules suggests ambiguity aversion. Consistently with the arguments presented above, we intend to model fear and its resulting conservative behavior by means of a standard *maxmin* device to describe agents expected utility, by which they choose a worst case among a class of beliefs. During normal times, the belief is unique and therefore the *maxmin* framework is equivalent to a standard SEU one. On the other hand, under fearful emotional states, the class of beliefs is extended and the agents become conservative; in this sense, safety becomes a far higher priority (Cosmides, Tooby, 2000).

3. - A Decision Theoretic Framework

The intuition behind the choice of the framework was introduced extensively in the previous Section. In what follows, it is justified from a decision theoretical point of view.

Decision making under neutral (*i.e.* non-fearful) emotional states are perfectly described by the contribution of standard behavioral models in decision theory. In particular, the axiomatization of *Anscombe-Aumann,* despite some criticisms, does its job extremely well. By assuming the DM respects a small set of behavioral axioms, we are able to derive, as a direct consequence, a powerful way to formally describe choices by means of utilities and subjective probabilities. On the contrary, we feel at least embarrassed trying to account for fearful emotional states within the same model. This is both because a definition of fear is easily objectionable and because its modeling under SEU necessarily obliges us to make *ad hoc* assumptions. For example, a simple way to work around the problem is to let the utility function vary through time, possibly by exploiting some gain-loss asymmetries in the payoff function. Although intuitive and descriptively powerful[2], such a way of *ad hoc* modeling doesn't offer any satisfactory explanations to the following questions: why and how does the DM switch from one utility function to the other? On what grounds does she choose a particular "fearful utility function"? Does it makes any behavioral sense to assume the DM actually reasons by means of a multiplicity of utility functions? This is clearly not the way one would like to proceed. For this reason a more thorough approach is necessary, one which neither requires time varying utility functions nor lacks a solid behavioral foundation.

[2] As a matter of fact, it fits within the so called Prospect Theory by Kahneman and Tversky.

3.1 *Fear, Ignorance and Bayesian Updating*

After reviewing a good extent of psychological literature[3], a reasonable and compelling connection between *fear* and *ambiguity* arose. It turns out that, other than being compelling, such a way of modeling is also powerful since it goes in the direction of fitting fear into a behavioral model only by means of subjective probabilities, leaving untouched both the utility structure and the decision rule. By doing so, it avoids many (clearly not all) the objectionable assumptions, nonetheless maintaining a good descriptive power. The reasoning unfolds as follows. During fearful emotional states, the DM is principally subject to three psychological reactions: *(i)* she experiences an increased level of attention. That is, she may start considering signals which would normally neglects as being irrelevant. *(ii)* She reorder her personal goals, in a way that induces her to become more conservative and to consider safety as a higher priority. *(iii)* She recalibrates her probability assessments, *i.e.* she is no more certain that her prior belief correctly describes reality and she starts wondering whether or not other probability measures should be considered. In a way, it is "as if"the DM *puts herself* in a situation of ambiguous choice in which a set of beliefs is considered in place of a unique one.

The immediate question which comes to our mind is why the DM enlarges her set of beliefs, instead of simply updating the pre-existing one, possibly by giving positive probabilities to previously null-events. The answer is simple: that is, the DM simply can't do that, because she lacks sufficient information. Bayesian updating works perfectly when it has to do with knowledge, but it becomes problematic when ignorance prevails.[4] Nonetheless, as a matter of fact, fear and ignorance are strictly linked together. This is indeed how fear and risk aversion differ from each other. We cannot talk about fear, in those cases in which the DM *knows* which are the states of the world she should be concerned about and *how* to assess a probability among them. Rather, we would say she is possibly risk averse and behaves consistently. As a matter of fact, this is a fully cognitive process. On the contrary, emotional processes governing fear are such that the DM ignores what class of events she should be concerned with. She can only speculate on that. Fear differs from mere risk aversion exactly because one cannot uniquely determine to what extent the probability of a given event has changed. Taken to

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3 ÖHMAN A. (2006); LOEWENSTEIN G.F. *et* AL. (2005); HSU M. *et* AL. (2005); CAMERER C. *et* AL. (2003); LO A.W. *et* AL. (2002); LOEWENSTEIN G.F. (2001); LEDOUX J. (1996).

4 I am stealing this concept from a seminar GILBOA I. held at "Luigi Bocconi" University of Milan in 2009.

the extreme, a fearful agent might start considering states of the world as becoming more and more likelier even when she has not received yet any signal justifying this new belief.

Loosely speaking, for a September 10th 2001 investor, the subjective probability of a terrorist attack in following 24 hours is possibly a zero probability event. One day after, she fears previously ignored states of the world are likely to occur - chemical and nuclear attacks, wars, economic crash being examples. The problem is how much likelier than before? Are the probabilities of a nuclear attack higher than those of a chemical one? Ignorance prevails and we cannot prohibit the DM to just remain silent. Since at the end of the day an action will be taken by the DM, and we don't want to think she will choose randomly among her set of possible actions, we could assume she will conservatively choose an action which performs well enough among a multiplicity of beliefs over the states of the world she might have. The stronger the ignorance, the larger the set of beliefs she considers. Behaviorally, this can be justified in two equivalent ways: either the fearful agent, in evaluating the likelihood of states of nature, uses capacities, that is non-additive measures, or she develops a sort of ambiguity aversion induced by her emotional state. In both cases, the outcome is the same: she becomes more cautious and conservative and she behaves as an expected utility *max-minimizer* decision maker.

3.2 *A Time-Varying Preference Ordering*

As in a standard framework, an agent faces a known set of states of the world S, either countable or not, and she chooses acts among a set of functions $\mathscr{F} = \{f \mid f : S \longrightarrow X\} = X^S$, mapping from the state space to a set of consequences X, a convex subset of a vector space. In the *Anscombe-Aumann* framework, in which the DM has access to an "objective" independent randomizing device, this set X is the set of all the lotteries on a set of prizes. S, X and, hence, $\mathscr{F}$ are constant through time and therefore we avoid the time index. Furthermore, we let (S,Σ) be a measurable state space, with Σ being an algebra of events $A \in \Sigma$. Acts $f,g \in \mathscr{F}$ are Σ-measurable and bounded. Customarily, we will endow $\mathscr{F}$ with a mixture operation performed pointwise, such that for every pair of acts $f,g \in \mathscr{F}$, and every constant $\alpha \in [0,1]$, the mixed act $\alpha f + (1-\alpha)g \in \mathscr{F}$ is defined as

$$\forall s \in S,\ (f + (1-\alpha)g)(s) = f(s) + (1-\alpha)\, g(s)$$

Finally, we abuse notation by writing $x \in \mathscr{F}$ whenever $f(s)=x, \forall s \in S$, with $x \in X$, namely a constant act. The choice behavior of the DM is described by a time-varying binary preference ordering $\succsim_t \subset \mathscr{F} \times \mathscr{F}$. As usual, $\succ_t$ and $\sim_t$ denote respectively the asymmetric and symmetric parts of $\succsim_t$ at time t. $\succsim_t$ is the primitive of the model and we require that it satisfies a number of behavioral axioms, some of them being compelling and convincing, others being more objectionable to some extent. In the following, I present a standard axiomatization with a discussion for each axiom:

3.2.1 Axiomatization

GS1, Weak Order: $\succsim_t$ is a complete and transitive binary relation over $\mathscr{F}$.

Transitivity comes (almost) for free[5]. Indeed, it simply requires that the DM behaves rationally, that is, consistently with her preference ordering. A truly irrational individual may not satisfies transitivity, but this is, however, an eventuality of little interest. With transitivity, we require that for any given triple of act $f,g,h \in \mathscr{F}$ such that $f \succsim_t g$ and $g \succsim_t h$, also $f \succsim_t h$ holds, *i.e.* (f,h) belongs to the binary relation $\succsim_t$.

Completeness, instead, requires that for any pair of acts $f,g \in \mathscr{F}$, either $f \succsim_t g$, $f \precsim_t g$ or both. Concretely, all the functions from states to outcomes should be considered, at least as conceivable acts if not actual ones. A choice has to be made and the DM looks at *all* possible acts without leaving none of them unexplored. In some cases, this is a strong requirement (see Section 4.5 for a discussion). Indeed, in complex problems, it is sometime impossible to express a defined preference without having already a probability ready to use. It is the case of reasoned choice *versus* raw preferences (Gilboa, 2009). In a sense, a conceptual loop arises since we require completeness to justify the existence of a subjective probability, but we need probability to justify the validity of completeness itself.

GS2, Archimedean: For every triple of acts $f,g,h \in \mathscr{F}$, if $f \succ g \succ h$, there are $\alpha, \beta \in (0,1)$ such that

$$\alpha f + (1-\alpha)h \succ g \succ \beta f + (1-\beta)h$$

The Archimedean axiom is a continuity requirement. It is not terribly compelling from a descriptive or from a normative point of view. In practice, it re-

[5] Transitivity of the symmetric part $\sim_t$ can sometime lead to a choice paradox. See GILBOA I. (2009).

quires that no act is infinitely preferred with respect to the others, that is, substitutability between different choices always works. However, in some environment, continuity it is just too strong and we may be obliged to weaken its implications. In particular, there is a full literature on non-Archimedean decisional models[6]. In the present work, we will weaken this axiom in Section 4.3 to give motivations for fear triggering and we refer to that section for further discussion on this topic.

GS3, Monotonicity: For every pair of acts $f,g \in \mathscr{F}$, such that $\forall s \in S, f(s) \succsim_t g(s)$, $f \succsim_t g$ is the case.

This is another rationality assumption, by which the DM weakly wants to prefer more to less, whatever the set of consequences X is.

• **GS4, Non Triviality:** There exists $f,g \in \mathscr{F}$ such that $f \succ_t g$.

• **GS5, Certainty Independence:** For every pair of acts $f,g \in \mathscr{F}$, every constant act $x \in \mathscr{F}$ and every $\alpha \in (0,1)$,

$$f \succsim_t g \quad \text{iff} \quad \alpha f + (1-\alpha)x \succsim_t \alpha g + (1-\alpha)x$$

That is, preferences ordering preserves under mixing with common constant acts. This is a weaker version of the Independence Axiom as stated in *Anscombe-Aumann,* which dictates that for every three acts $f,g,h \in \mathscr{F}$ and any $\alpha \in (0,1)$, $f \succsim_t g \Leftrightarrow \alpha f + (1-\alpha)h \succsim_t \alpha g + (1-\alpha)h$. For reference, we will call this stronger axiom GS5′.

GS6, Time Varying Uncertainty Aversion: For every time t, every pair $f,g \in \mathscr{F}$ and every $\alpha \in (0,1)$, $f \sim_t g$ implies

$$\alpha f + (1-\alpha)g \succsim_t f$$

Here is where fearful emotional state at time t affects DM's behavior. In non-fearful times, *GS*6 is satisfied with an equivalence. Namely, hedging between equivalent acts doesn't affect preferences. On the contrary, a fearful DM feels that *hedging is profitable to decrease the impact of her state of ignorance* on final out-

[6] See Schmidt A.J. (1998).

comes. Without having a control of the situation, she prefers to mix together equivalent acts. Notice that adding this axiom is to add some new structure. Indeed, without it, *GS*6 would trivially be satisfied with strict equivalence $\sim_t$, by means of the independence axiom *GS*5'. From a side the Gilboa and Schmeidler's axiomatization is weakened in *GS*5 compared with *GS*5', but reinforced in *GS*6.

The binary relation $\succsim_t$ is time-varying in a very intuitive sense. Individual preferences are subject to revision from time to time. We don't want to model a DM whose preferences are immutable over time. As a matter of fact, there are a lot of behavioral evidences going in the opposite direction[7]. This is not to say the DM is dynamically inconsistent, even if at the very end of the day the consequences are quite the same. Normally, we rule out time inconsistencies because, as we don't want our DM to behave inconsistently through space (transitivity), we wouldn't want her to behave inconsistently through time. In cases like these, dynamic consistency is another way to say DM is rational. However, if transitivity simply requires a rationality assumption, time consistency requires both rationality and time invariable preferences. Sometime we forget about the latter because we want to focus on specific topics over which such an assumption is more than plausible. This is not the case for fear modeling exactly because – as in section 1.1 – fear involves, among other things, a reordering of personal goals (Cosmides, Tooby, 2000), safety becoming the foremost. In this sense, fear responses are not "irrational", but simply are the result of modified preferences. Throughout, I will assume that at any time $t \in T$, the relation $\succsim_t$ satisfies each and every axiom. In particular, GS6 will be the only axiom which will be truly time-varying, sometimes being satisfied with equivalence $\sim_t$ over *any* pair of acts, some other times being satisfied with weak preference for hedging among acts[8].

In order to perform any analysis, however, we need to add a structural assumption to the Gilboa and Schmeidler's framework, which makes the time-varying preference relation $\succsim_t$ comparable over time to a certain extent. In particular, we need the following assumption:

Structural Assumtpion 1 (SA1), Stable Tastes: For any $t', t'' \in T$ and every pair of constant acts $x_1, x_2 \in X$,

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[7] We leave aside the question of uncertainty over future preferences (Cerreia-Voglio, in a seminar, made me aware of it). This is an issue which could be potentially relevant to our problem, but, in the present work, we simply disregard it, leaving it for future researches.

[8] That is for a certain t, there exists a pair $f,g \in \mathscr{F}$ such that $f \sim_t g$ and $\alpha f+(1-\alpha)g \succ_t f$ for any $\alpha \in (0,1)$.

(3.1) $$x_1 \succsim_{t'} x_2 \Longleftrightarrow x_1 \succsim_{t''} x_2$$

That is, the DM preferences over constant acts, which can possibly be mappings from the state space to the space of lotteries, are constant over time. If she prefers more to less at time t', she will do the same at any other time t''. This assumption is going to facilitate a lot the analysis throughout, as it lets us concentrate on the fear only rather than on the risk aversion too[9]. Implicitly, it says that, as time goes by, the risk aversion remains constant while the DM experiences fearful emotional states which are subject to – endogenous – variation. In other words, it allows us to filter out risk aversion from fear. At the same time, however, it is hardly objectionable. As a matter of fact, it is reasonable to assume that the same DM will stick to her own tastes over a period of time which spans our analysis. This appears to be similar to the assumption of utilities *ordinal equivalence* in Ghirardato *et* al. (2002), but it is intimately more appealing since it relies upon a unique DM. Precisely, it coincides with the assumption made by Siniscalchi (2009). Stable tastes make possible to give a comparative definition of fear, that is to give a mathematical meaning to statement "the DM is more (or less) fearful than before".

3.3 *Maxmin Expected Utility*

This axiomatization is sufficiently powerful to prove the existence and the uniqueness of the utility function and the subjective probability measure(s), which represent the preferences of the DM. Thanks to this well known result, whether or not these objects have a normative or a descriptive sense in themselves it is no more an issue of interest. Indeed, they directly stem from axioms which are normatively and descriptively justifiable, falsifiable[10] and, hence, empirically testable.

Before doing that, however, I introduce the standard mathematical framework which is normally use for this analysis. First of all let $B_0(\Sigma)$ be a convex subset of a vector space containing all *simple* Σ-measurable functions $\varphi : S \longrightarrow X$ whose *canonical form* can be written as

(3.2) $$\varphi = \sum_{i=1}^{n} \alpha_i \chi_{Ai}$$

[9] As discussed above risk aversion may sometimes be observational equivalent to fear.

[10] To be precise, *GS4* is not, since it contains an existential quantifier.

with $\{\alpha_i\}_{i=1}^n \subseteq \mathbb{R}$ and $\cup_{i=1}^n A_i = S$, $A_i \in \Sigma$, $A_i \cap A_j \neq \emptyset$, $\forall i,j \in I$. The closure of $B_0(\Sigma)$ with respect to the supnorm[11] is $B(\Sigma)$ and it contains $B_0(\Sigma)$ and all the functions φ at which sequences $\{\varphi_n\}_{n=1}^{\infty} \subseteq B_0(\Sigma)$ converge uniformly. Clearly, if Σ is a σ-algebra, $B(\Sigma)$ is the vector space of all bounded and measurable functions mapping S in X[12]. Finally, call $B_0(\Sigma,X)=\{\varphi \mid \varphi \in B_0(\Sigma), \varphi(S) \subseteq X$. From now on, we consider functionals of the form $V{:}B_0(\Sigma) \longrightarrow \mathbb{R}$ and we define the following,

Definition 1. *A* functional V_t: $B_0(\Sigma) \longrightarrow \mathbb{R}$ is a representation of $\succsim_t$ if for every φ, $\psi \in B_0(\Sigma)$,

$$f \succsim_t g \Longleftrightarrow V_t(\varphi) \geq V_t(\psi) \qquad (3.3)$$

The functional V_t is *affine* if for all $\alpha \in [0,1]$ and all $\varphi, \psi \in B_0(\Sigma)$,

$$V_t(\alpha\varphi + (1-\alpha\psi)) = \alpha\, V_t(\varphi) + (1-\alpha)\, V_t(\psi)$$

In convex vector spaces such as $B_0(\Sigma)$, only affine functional can be defined on it, not linear ones. They are both convex and concave, but not necessarily linear. More precisely, affine functionals are translation of linear ones, hence possibly having $V_t(\mathbf{0})=L(\mathbf{0}) + a \neq \mathbf{0}$.

The representation V_t is said to be *monotonic* if $\varphi(s) \succsim_t \psi(s)$, $\forall s \in S \Longrightarrow V_t(\varphi) \geq V_t(\psi)$; *non-trivial* if there exist φ, $\psi \in B_0(\Sigma)$ such that $V_t(\varphi) > V_t(\psi)$; *constant additive* if for all $\varphi \in B_0(\Sigma)$, $\alpha \in \mathbb{R}$, $V_t(\varphi + \alpha) = V_t(\varphi) + \alpha$; *positively homogeneous* if for all $\alpha \in \mathbb{R}_+$, $V_t(\alpha\varphi) = \alpha\, V_t(\varphi)$ and *c-linear* if it is both constant additive and positively homogeneous. Clearly, *c-linear* functionals are a subset of affine ones.

Finally, given a finitely additive measure $\mu : \Sigma \longrightarrow \mathbb{R}$, we denote as customary with $ba(\Sigma)$ the set of measures with bounded total variation norm, that is such that

$$\|\mu\| = sup_{\{A_i\} \in \mathscr{P}} \sum_{i=1}^{n} |\mu(A_i)| < \infty$$

[11] That is $d(\varphi_n - \varphi) = \sup_{s \in S} |\varphi_n(s) - \varphi(s)|$.

[12] The proposition underlying this result says that, given a measurable space (X,Σ), with Σ being a σ-algebra, $f \in B(\Sigma) = \{f | f{:}X \longrightarrow \mathbb{R}\}$ is bounded and measurable if there exists $\{\varphi_n\} \subseteq B_0(\Sigma)$ such that $\varphi_n \xrightarrow{unif} f$.

with $\mathscr{P}_S$ being the set of all possible Σ-partitions of *S*. Given this structure, every subset of $ba(\Sigma)$ has a weak*-topology. Clearly, the set of *probability* measures $\Delta(\Sigma)$ is just a convex subset of $ba(\Sigma)$.

More importantly, we have the following representation result.

Lemma 1. $\succsim_t \subseteq F \times F$ satisfies *GS1-GS4* and *GS5′* if there exists a monotonic positive affine functional $V_t : B_0(\Sigma, U(X)) \longrightarrow \mathbb{R}$ and a non-constant affine function $u_t : X \longrightarrow \mathbb{R}$ with $0 \in intX$ such that

$$f \succsim_t g \Longleftrightarrow V_t(u_t(f)) \geq V_t(u_t(g)) \tag{3.4}$$

Moreover, V_t is unique and u_t is cardinally unique.

Lemma 2. Let *C* be a convex subset of $\mathbb{R}$ with $0 \in intX$. A functional $L{:}\Phi(X) \longrightarrow \mathbb{R}$ with $L(0)=0$ is affine if there exists a $\mu \in ba(\Sigma)$ such that:

$$L(\phi) = \int_S \phi(s)\, d\mu(s) \qquad \forall \phi \in \Phi(C) \tag{3.5}$$

Moreover μ is unique and it is a probability measure if *L* is positive and normalized.

From to Ghirardato *et* al. (2002), such a $\succsim_t$ is said to be a biseparable preference. In particular,

Definition 2. Let $\succsim_t$ be a preference relation such that it satisfies *GS1-GS4*. Then the representation $V_t : B_0(\Sigma) \longrightarrow \mathbb{R}$ *of* $\succsim_t$ is biseparable if it is nontrivial monotonic and there exists a capacity[13] $\rho{:}\Sigma \longrightarrow \mathbb{R}$ such that letting $u(x)=V(x)$ for all $x,y \in X$ and all $A \in \Sigma$:

$$V_t(y_A^x) = u_t(x)\rho(A) + u_t(y)(1-\rho(A)) \tag{3.6}$$

By Lemma 1, uniqueness and cardinal uniqueness of *V* and *u* are satisfied. Moreover, ρ represents the DM's willingness to bet on events. As in Ghirardato *et* al. (2004) we present the following compact result which summarize all possible

[13] A capacity $\rho{:}\Sigma \longrightarrow \mathbb{R}$ is a set function such that *(i)* $\rho(\emptyset)=0, \rho(S)=1$ and *(ii)* for any $A,B \in \Sigma$ such that $A \subseteq B$, $\rho(B) \geq \rho(A)$.

representation of DM's preferences depending on how she behaves in front of ambiguity.

THEOREM 1. General Representation Theorem:

1. (Anscombe-Aumann, 1963). $\succsim_t$ satisfies *GS*1-*GS*4 and *G5′* if and only if there exist a probability measure $\mu : \Sigma \longrightarrow [0,1]$ and

$$V_t(\varphi) = \int_S \varphi(s) d\mu(s) \tag{3.7}$$

for all $\varphi \in B_0(\Sigma)$. Moreover $\mu \in ba(\Sigma)$ is unique.

2. (Schmeidler, 1986). $\succsim_t$ satisfies *GS*1-*GS*5 and it is such that for any pair of equivalent comonotonic acts[14] $\alpha f + (1-\alpha) g \sim_t f$, for all $\alpha \in [0,1]$ if and only if

$$V_t(\varphi) = C\int_S \varphi(s) d\rho(s) \tag{3.8}$$

for all $\varphi \in B_0(\Sigma)$, where $C\int_S \varphi(s) d\rho(s)$ is in the sense of Choquet, that is

$$C\int_S \varphi(s) d\rho(s) = \int_0^{\infty} \rho(\varphi(s) \geq t) dt + \int_{-\infty}^{0} 1\text{-}\rho(\varphi(s) \geq t)) dt \tag{3.9}$$

3. (Gilboa-Schmeilder, 1989). $\succsim_t$ satisfies *GS*1-*GS*6 if and only if there exists a unique, non empty, weak*-compact and convex set $C_t \subseteq \Delta(\Sigma)$ such that

$$V_t(\varphi) = min\, \mu \in C \int_S \varphi(s) d\mu(s) \tag{3.10}$$

PROOF: See references.

As it appears from this comprehensive result, as soon as the DM modifies her attitude towards ambiguity, that is, whether or not she is indifferent at hedging between equivalent acts, her decision rule changes accordingly. On the one extreme, we have a DM which is ambiguity neutral, meaning that she doesn't perceive any ambiguity on the choice problem over $\mathscr{F}$. Consistently, she behaves as an *Anscombe-Aumann* SEU maximizer and she is able to assess a unique probability distribution over the state space *S*.

[14] $f, g \in \mathscr{F}$ are comonotonic if there are no $s', s'' \in S$ such that $f(s') \succsim_t f(s'')$ and $g(s') \precsim_t g(s'')$.

A broader class of orderings is the CEU one, depicted in Theorem *1.b*. It is a generalization of the former case, because probabilities are finitely-additive capacities and because Choquet integrals with respect to a (probability) measure coincide with Riemann integrals. CEU was introduced by Schmeidler (1986) and it represents the attempt to account for non-additive beliefs over the states of the world, an eventuality which becomes frequent when ambiguity is concerned. However, this is not the wider generalization possibile. Indeed, we have posit that CEU results from a $\succsim_t$ which is indifferent among hedging between comonotonic acts only. Clearly, we don't want our DM hedges between constant acts $x,y \in X$, since these are inherently and objectively unambiguous. At the same time, under CEU, we assume the DM refuses to hedge among all comonotonic ones[15].

We therefore arrive to the last representation, introduced by Gilboa and Schmeilder (1989). In this case, the DM may possibly hedge among any two non-constant acts. The resulting decision rule has the form of a *maxmin* device which makes the DM primarily considering the minimal outcome achievable for each act *f* she looks at and, secondarily, choosing the one which leads to the maximum expected outcome. Therefore, the implied decision rule is such that given *GS*1-*GS*6:

$$(3.11)\quad f \succsim_t g \;\; iff \quad min\,\mu \in C_t \int_S u(f(s))\,d\mu(s) \geq min\,\mu \in C_t \int_S u(g(s))\,d\mu(s)$$

In particular, $f_t^* \in r(C_t) = \arg\max_{f\in\mathscr{F}} I(C_t, f) = \arg\max_{f\in\mathscr{F}} \min_{\mu\in C_t} \int_S u(f(s))d\mu(s)$, where $I : 2^{\Delta(\Sigma)} \times \mathscr{F} \longrightarrow \mathbb{R}$ and $r : 2^{\Delta(\Sigma)} \Longrightarrow \mathscr{F}$. The fundamental structure of MEU is the set of beliefs C_t considered by the DM. Obviously, it lends itself to a very intuitive interpretation, which is not so straightforward in the case of CEU. As a matter of fact, in MEU orderings, C_t encompasses the degree of ambiguity which is perceived by the DM. The bigger the set, the bigger the perception of ambiguity.

It is natural, at this point, to let C_t represent the extent at which the DM experiences fearful emotional states. As a matter of fact, *C_t is our conceptual representation of fear,* which is consistently extinguished only when C_t is a singleton, that is when the DM never hedges among equivalent acts if she has the opportu-

15 As these are just a subset of $\mathscr{F}$, we are implicitly defining a sort of "reduced"ambiguity aversion which can be more accurate for certain problems and less accurate for others. Constant act are trivially comonotonic, indeed.

nity to do so. Therefore, we would want to characterize this set of beliefs more in depth in order to understand what happen to C_t when *GS*6 modifies. The following corollaries and propositions serve for this scope. The first obvious result, which is already embedded in Theorem 1.*a*, tells us that when the DM experiences no fear, she succeeds in forming a unique belief describing her view over the state space, that is her set of beliefs C_t become a singleton, containing μ as the unique element.

COROLLARY 1. Let $\succsim_t$ be a preference relation such that *G*1-*G*6 hold and there is no pair $f,g \in \mathscr{F}$ with $f \sim_t g$ and no $\alpha \in (0,1)$ such that $\alpha f + (1-\alpha)g \succ_t f$. Then C_t is a singleton.

Alternatively, by Theorem 1 and Corollary 1, we can say that MEU is a generalization of SEU in which the former coincides with the latter only in those cases where the DM reveals no fearful attitudes, that is she doesn't perceive any ambiguity in the decision problem she is facing. Clearly, when $C_t=\{\mu\}$ the decision rule implied by *(3.11)* coincides with the standard expected utility maximization framework.

The following proposition serves to justify the discussion made in Section 3.1, in which *ad hoc* methods for modeling fear by means of time-varying utility functions were ruled out. As a matter of fact, with the structural assumption made in *(3.1)*, introducing Stable Tastes, we can avoid this path and instead we can consider a DM that, no matter the extent of perceived fear she is experiencing at a given time $t \in T$, behaves according to a (cardinally) unique utility function. As a result, fearful emotional states enter the DM's decision rule only by means of beliefs, and not by a time-varying utility function.

PROPOSITION 1. *Let* $\{\succsim_{t'}, \succsim_{t''}\} \subset \mathscr{F} \times \mathscr{F}$ *be two preference relations both satisfying GS*1-*GS*4. Stable Taste axiom *(3.1)* holds if *f* for any $t', t'' \in T$, $u_{t'} \approx u_{t''}$, that is the utility functions at different times are unique up to affine transformations.

Arrived at this point, however, we need to give a more thorough definition of fear. Consistently with the discussion above, we could say that $\succsim_t$ is a preference relation accounting for fear if it fails to satisfies independence for at least a pair of acts. Indeed, *GS*5′ inherently requires that for every $f,g,h \in \mathscr{F}$, and for all $\alpha \in (0,1)$,

$$(3.12) \qquad \alpha f + (1-\alpha)h \sim_t \alpha g + (1-\alpha)h$$

and by setting $h \equiv g$

$$(3.13) \qquad \alpha f + (1-\alpha)g \sim_t g$$

Therefore, by assuming $GS5'$, we are ruling out the possibility that the DM would rather strictly prefer to hedge between equivalent acts in order to increase her expected utility. However, at the same time, we are also ruling out the following,

$$(3.14) \qquad \alpha f + (1-\alpha)g \prec_t g$$

which would imply the DM being an ambiguity lover. Coupled with the parallel between fear and ambiguity aversion, we could also argue that *(3.14)*, being the opposite of *GS*6, could be use to model *euphoria* and *overconfidence* which, to a certain extent, are observationally equivalent to the antithesis of fear. Unfortunately, this is out of the scope of the present work, and I will leave further discussion on this topic for the future. For the time being, we are interested only in the *negative side of emotion,* as Shiv, Loewenstein, Damasio (2005) put it, that is in those cases in which independence fails to apply as in *GS*6.

Definition 3. (Fearful preferences). A preference relation $\succsim_t$ represents a fearful emotional state at time $t \in T$, if for at least a pair of equivalent acts, *GS*6 is satisfied with strict preference for hedging. Conversely, non-fearful emotional states are represented by $\succsim_t$ if independence holds for every $f,g,h \in \mathscr{F}$.

By Theorem 1.*c* and Definition 4, when the DM experiences fearful emotional states her set of beliefs is such that $|C_t|>1$. Clearly, as discussed above, the bigger her set of beliefs she considers in the decision problem, the greater the pessimism and the fear she experiences. In the following, in order to make this intuition operative, we try to formalize it by endowing the set C_t with some monotonicity property. In such a way, it will be possible to perform a comparative analysis of emotional states. In this respect, we want to understand what are the conditions by which some emotional states are more fearful than others. Before doing that, however, we need to introduce, as in Ghirardato *et* al. (2004), the following concept of unambiguous act.

DEFINITION 4. Let $\succsim_t$ be a preference relation satisfying *GS*1-*GS*6. We say that *f* is unambiguously preferred to g, written $f \succsim_{t^*} g$, if and only if,

$$\int_S u \circ f(s) d\mu'(s) \geq \int_s u \circ g(s) d\mu' \quad \forall \mu' \in C_t \tag{3.15}$$

Clearly, under fearful emotional states, $\succsim_{t^*}$ is not a complete order. The impossibility to unambiguously prefer one act over the other, coupled with ambiguity aversion, makes the DM behave as by *(3.11)*, that is by *maxminimizing* over her set of beliefs C_t. When $\succsim_t$ satisfies *GS*5', there are no pairs of acts such that *GS*6 holds with strict preference and, hence, $\succsim_t^* = \succsim_t$. Only in this case, $\succsim_t^*$ is complete. When instead *GS*5' is weakened as in *GS*5, we have that $\succsim_t^* \subset \succsim_t$, with $\succsim_t^*$ representing the maximal subset of $\mathscr{F} \times \mathscr{F}$ that satisfying independence.

CLAIM: (Ghirardato *et* al.*,* 2004). $\succsim_t^*$ is the maximal subset of $\succsim_t$ satisfying independence.

From the discussion above, the following corollary arises naturally:

COROLLARY 2. Let $\succsim_t$ be a preference relation satisfying *GS*1-*GS*6. The following are equivalent:
(i) $\succsim_t$ represents fearful emotional states;
(ii) $\succsim_t^* \subset \succsim_t$;
(iii) $|C_t| > 1$.

More importantly, the smaller the set $\succsim_t^* \subset \mathscr{F} \times \mathscr{F}$, the smaller the number of pairs of unambiguously preferred acts, hence, the bigger the pairs of ambiguous acts. In line with the definition of comparative risk aversion given by Yarii (1969)[16], it is then possible to give an equally shaped definition of comparative fear using the incomplete order $\succsim_t^*$.

DEFINITION 5. [Comparative fear].*Let* $\{\succsim_{t'}, \succsim_{t''}\} \subset \mathscr{F} \times \mathscr{F}$ be two preference relations satisfying *GS*1-*GS*6 and *SA*1 and let $\succsim_{t'}^*, \succsim_{t''}^*$ representing their respective unambiguous parts. The DM is more fearful at time $t'' \in T$ than at time $t' \in T$ if, for every $f \in \mathscr{F}$ and every $x \in X$,

[16] YAARI M.E., Some remarks on measures of risk aversion and on their uses, J. Econ. Theory "1" (1969), pages 315-329.

$$(3.16) \qquad x \succsim^*_{t''} f \Rightarrow x \succsim^*_{t'} f \quad \wedge \quad x \succsim^*_{t''} f \Rightarrow x \succsim^*_{t'} f$$

Moreover, $\succsim^*_{t''} \subset \succsim^*_{t'}$.

Finally, we arrive at the proposition bridging the variation of fearful emotional states with the dynamics of *Ct*.

Proposition 2 [Time-Varying Fearful states]. Let $\{\succsim_{t'}, \succsim_{t''}\} \subset \mathscr{F} \times \mathscr{F}$ be two preference relations both satisfying *GS*1-*GS*6 and Stable Taste axiom (*SA*1). Then the following are equivalent:
(i) $\succsim^*_{t''} \subset \succsim^*_{t'}$;
(ii) $C_{t'} \subseteq C_{t''}$.

3.4 *Fear and Pessimism: An Interpretation of MEU*

The decision rule implied by the *Maxmin* Expected Utility framework involves a maximization over a set of multiple probability measures, each of them representing a belief that the agent holds on the state space. To think that she necessarily has an opinion on *S* is both intuitive and reasonable. That's why the set C_t is non-empty[17] at each time $t \in T$. Indeed, if the underlying state of nature is sufficiently intelligible, we could even convince ourselves that her opinion are effectively translated in a probability measure $\mu_t \in \Delta(\Sigma)$, which is used in the maximization process. Less intuitively, however, we can think of a mental process by which the DM that actually behaves "as if"she is taking into account a multiplicity of beliefs. This is not very compelling because the one-to-one mapping between subjective opinions and subjective probabilities ceases to exist. Indeed, if someone has an opinion on something, it must necessarily be unique. When this is not the case, namely when the DM has several opinions on a certain topic, then she will probably have an opinion on her own opinions (and so forth), and therefore the uniqueness is guaranteed. So, how to interpret the coexistence of multiple priors in the set C_t? The only sound answer one can give is to say that C_t is just a *modeling tool to represent the difficulty or the impossibility to form an opinion.* Equivalently, C_t can be seen as the mathematical representation of oneself's opinion vagueness, lack of information, ignorance, etc.

[17] Technically, *GS*4 does the job. Non-triviality axiom is required exactly to find at least one subjective probability measure. Without *GS*4, Theorem 1 would still hold, but the vector μ_t would be the zero vector, and we won't be able to interpret it as a probability.

There is a second issue at stake which, since the very first days of MEU, has been a recurrent theme. Gilboa and Schmeilder's framework was – and still is – criticized for the high degree of pessimism it involves. Indeed, one could argue on what grounds the DM should be so pessimistic to consider uniquely the $\mu_t \in C_t \subseteq \Delta(\Sigma)$ which leads exactly to the worst expected outcome. Why not considering the second worst or an average of them or any other combination? Why does the DM care so much about apocalyptic descriptions of the world without taking into account the possibility that her ignorance could result in unexpected extreme and positive outcomes? The answer which is usually given concerns the fact that there are no reasons to assume $C_t = \Delta(\Sigma)$. On the contrary, the cardinality of C_t is a matter of subjective interpretation of the state of the world and it can well be the case that $C_t \subsetneq \Delta(\Sigma)$. For example, one could deem as ambiguous the following bet: "Win 10$ if you guess the weather on June 10 2015 and lose 5$ otherwise, confronted with some other certainty equivalent bet". The DM can be uncertain on what the probability of rain compared to those of sun and cloudy are and she could feel as to hedge among them. However, in this example, the ambiguity of the bet couldn't be as high as to account for those $\mu_t \in \Delta(\Sigma)$ which give positive probability to a snowing day. As a matter of fact, C_t doesn't always contain *all* possible probability measure, but only those which cannot be subjectively ruled out by hard evidence and common sense, if those things have a *meaning* within the problem.

However convincing from the point of view of modeling, this argument still doesn't fit very much with behavioral explanations. We still wonder what mental processes justify this state of deep pessimism, the degree of which depends on the cardinality of C_t. An interesting interpretation rests on the connection between fear and ambiguity depicted above. As a matter of fact, we would expect a fearful agent behaving like a MEU agent, since fear inherently implies a truly pessimistic view of the world. In this respect, we care no more about those criticisms saying that MEU is too "extreme'', because fear response – also from an evolutionary point of view – are meant to be exactly such that. Once again, the strength of the "as if"reasoning by which a fearful agent feels the world as becoming more and more ambiguous is reinforced. Indeed, the axiomatization in *GS*1-*GS*6, consistent with an increased ambiguity aversion, results in a behavioral rule which perfectly fits the way fearful individuals defend themselves from dreadful outcome, that is by getting increasingly pessimistic, conservative and safety-concerned (whatsoever safety is).

4. - Triggering Fear

The most controversial and complex problem to solve when modeling fearful emotional states is to detect what are the conditions that actually trigger fear. This problem doesn't lean for an easy solution for at least two reasons, the first one being that we need to find something which is endogenously embedded in the decision problem and, the second, being that we want to model fear as a rational response, that is a response that is justified by a switch in beliefs about the state of the world. Paraphrased in terms of MEU, the answer does not become clearer. Throughout, we highlighted how well the *maxmin* describes the behavior of an agent which is *already* experiencing a fearful emotional state, that is when $|C_t|>1$. However, we didn't spot a particular reason explaining why and how the agent rationally switch to a state of fear, that is why and how the DM enlarges his set of beliefs. Unfortunately, the literature on ambiguous choice does not come to help. Indeed, many works[18] have outlined how to handle problems in which ambiguity is entrenched upfront in the decision problem, but none of them gives behavioral reasons justifying a switch from a standard SEU framework to a MEU one or, equivalently, from a singleton set of beliefs to a non-singleton one.

4.1 *Savage-Null Events*

The problem is difficult to solve exactly because one has to find those conditions which make the DM enlarging her set of prior instead of simply updating the pre-existing one. That is, if a reason exists, it must be found at the boundaries of Bayesian decision theory[19]. In particular, the starting point must be the one in which Bayesian theory ceases to have predictive power, for example when null events are concerned.

The *rationale* could be the following. In order to arise, fear needs something to be happening – or to appear to be happening – which was totally unpredicted, something which was previously unconceivable in the DM's mind[20]. In Section 2.2, we have outlined that *surprise* is a fundamental ingredient for fear arousal. Furthermore, it can be argued that it is exactly this aspect which differentiate risk

[18] Ghirardato P. *et* al. (2002); Ghirardato P. *et* al. (2004); Maccheroni F. *et* al. (2006); Gilboa I. (2009); Siniscalchi M.(2009) and many others.

[19] Myerson R.B., (1986).

[20] For the time being, we make no distinction between an event that is unexpected and one which the DM is unaware of. However, the difference between the two is rather marked as it will become clearer in Sections 4.5.

aversion with a truly fearful experience. Therefore, we can say that fear is triggered by some previously unexpected event which oblige the DM to revise her beliefs. Being in a totally new environment and lacking a cognitive control of the underlying situation, the DM can't come up with a unique belief over the state of the world. Precisely, a set of beliefs could be a good approximation of her state of ignorance, inducing an high degree of pessimism and conservativeness, as depicted above. In the following, I treat formally these unexpected events by use of the, so-called, *Savage-null events.*

The treatment of such events is problematic because probabilities conditional on them are not well-defined and may lead to trivial choice problems in which all acts are indifferent (Blume, Branderburger, Dekel, 1991). Before stating the definition of $\succsim_t$-null event, let's introduce some ancillary notation. Consider again the framework introduced in Chapter 3.

Definition 6. For any $h,f \in \mathscr{F}$ and any $A \subseteq S$, define $h_A^f \in \mathscr{F}$ by:

$$h_A^f = \begin{cases} f(s) & \text{if} \quad s \in A \\ h(s) & \text{if} \quad s \in S - A \end{cases}$$

That is, h_A^f is a new act which coincides with h outside the event A, and is replaced with f in A. Most importantly, conditional preferences are defined as follows:

Definition 7. (Conditional Preferences) For $f,g,h \in \mathscr{F}$ and $A \subseteq S$,

$$f \succsim_{t|A} g \quad \Longleftrightarrow \quad h_A^f \succsim_t h_A^g$$

A $\succsim_t$-null event is a subset $A \subset S$ with zero probability. More precisely, without resorting to a probability assessment, Savage (1954) gives a definition of null events which makes use of these conditional preferences just introduced.

Definition 8. ($\succsim_t$-Null Events) The subset $A \subset S$ is $\succsim_t$-Null or Savage-null, if for any pair of act $f,g \in \mathscr{F}$, $f \sim_{t|A} g$.

More neatly, in order to be null, A must be such that given two constant acts $x, x' \in \mathscr{F}$ such that $x \succsim_t x'$, $f_A^x \sim_t f_A^{x'}$ is the case. Faced with a weakly dominant act on A, the DM must be nonetheless indifferent. In order to understand whether or not an individual really thinks an event – say meeting a talking dog – has a subjective zero probability, one may propose the following bet: she wins 100 dollars if such a dog really come to her and loses nothing otherwise. If she accepts the bet, by Definition 8, she is actually convinced that with no matter how small probability, such dogs exists. Conversely, if she is indifferent, it a Savage-null event. However, this elicitation scheme is not productive at all, since it has no predictive power. In the limit, we can propose at most weakly dominant bets to the DM. However, as analysts, we are not allow to say anything concerning the decision the DM will make over a weakly dominant act, since rationality only impose that, faced with *strictly* dominant acts, the DM *must* choose the dominant one. Nonetheless, even if Savage definition allows for Null Events to be within the framework, usually Bayesian decision theory rule them out by imposing an additional axiom to the standard axiomatization:

Definition 9. (Strict State-Independence)[21]. For all states $s,s' \in S$ and for any two constant acts $x,y \in \mathscr{F}$, $x \succsim_{t|s} y$ if and only if $x \succsim_{t|s''} y$

which is very similar to the Stable Taste Axiom, except for the fact that in the latter preferences are stable over time, while in this one they are stable over states. It is easy to prove that:

Proposition 3. Let $\succsim_t$ be a preference relation over $\mathscr{F}$. Axioms *GS*1-*GS*4, *GS*5′ and Strict State-Independence are necessary and sufficient conditions for the representation in *(3.7)*. Moreover, $\forall\ A \subseteq S$, $\mu(A)>0$.

This is the standard framework which is used in Decision Theory. Within it, null events are ruled out and Bayes" Formula always leads to well-defined conditional probabilities.

4.2 *Logical Omniscience, Unawareness and Null events*

At this point, a question arises naturally: should we feel free to rule out Null Event by assuming Strict State Independence as in Proposition 3? To me, a good answer to this question is, it depends. As a matter of fact, there are situations in which the analyst could and should safely assume that the DM behaves as if there

[21] This axiom is Axiom 5' in Blume L. *et* at. (1991) and Axiom 8 in Myerson R.B. (1986).

are no null events in the decision problem she is facing. Normatively, this is the way we approach every problem in which urns and balls are concerned. However, "*real life is not about urns and balls*"[22], that is, there are cases in which Strict State-Independence axiom is admittedly unrealistic. The philosophical discussion that could arise behind this apparently innocuous fact is huge. Unfortunately, it is totally out of the scope of this thesis and, therefore, I will limit to discuss some simple issues which closely concern fear.

The framework depicted in Proposition 3, namely a standard *Anscombe-Ausmann* decisional model with absent Savage-null events, doesn't seem a correct representation of reality at least in those case where the following two implications cannot be justified. As a matter of fact, no null-events would imply that either *(i)* DM has an impressive cognitive ability – allowing her to take into account *every conceivable* states of the world whenever she decides over something – or *(ii)* that she has a *myopic* view of the state space, *i.e.* the state space she actually contemplates is "incomplete"*in* and *to* some extent[23]. I now argue on these two points, since in both of them there is something which is not completely satisfactory, at least in the realm of standard theory.

In the first, the view that the DM is impressively rational in her probability assessment clashes both with common sense and the observable reality. In the logic literature, a DM which is able to account for every conceivable event is referred to as a *logical omniscient* individual, a notion which goes back to Hintikka (1962). In particular, in the framework of propositional logic – which we will loosely span throughout – this means that she is assumed to be so intelligent to know all valid *formulae*, with her knowledge being closed under implication. Namely, if she knows φ and if she knows that φ implies ψ, then she must also know ψ.

Unfortunately, it frequently happens to observe behaviors which appear to neglect the possibility of bad outcomes to arise. This tendency is natural and often driven by evolutionary argument. Without it, human being would be condemned to immobility and inaction. As an example, think of any human activity which may lead to death[24]. Consider this interpretation of the Raiffa's problem (1957):

[22] I steal this nice quotation of Schmleider from GILBOA I. (2009).

[23] The discussion in the following Sections will consider both the case in which the DM incompletely observes a subset of S or a projection of S, with S being the *true* state space.

[24] "Death"here is intended in a physical sense, but this is not meant to be a strict interpretation. One can figure out examples that involve non-physical "death". Formally, I'm am thinking about anything that leads to an infinite negative payoff.

you are standing on the sidewalk and you are willing to spend one dollar to buy a newspaper. Suddenly, you notice that on the other side of the road the same newspaper is selling for free. In every day life, you would certainly cross the street to pick a copy in order to keep the dollar in your pocket. However, this is not the case for an automaton which associate a small but still positive probability to every conceivable state of the world and also including the event "being ran over by a car". Does it mean that the DM choosing to cross the street evaluates the probability of being ran over as being zero? The common answer is negative and the argument is the following: the DM knows that set S of states of the world contains also the event in which she is hit by a car which invaded the sidewalk for its driver fell asleep. Unfortunately, this is way of reasoning is not convincing because it leads to trivial choice problems in which all acts are indifferent. Moreover, it clashes with observational evidences. Indeed, ruling out null events, while retaining logical omniscience, implicitly makes the DM behave excessively cautiously which is really not the case if we consider many human activities such as smoking, abusing drugs, fast driving, security markets investments, etc.

As a matter of fact, there are many obvious reasons to believe that agents are not logical omniscient. In the following, we present three of them.

(1) The most intuitive one is that people are time-bounded. Indeed, there are many – basically all – situations in which time is an issue and the DM just may have not enough time to consider *all* relevant events or, from a propositional logic point of view, she may have not enough time to deduce all the logical consequences of her own knowledge.

(2) Secondly, she may have a resource constraint with respect to her cognitive power. Paraphrased, she can be less intelligent than the archetypal iper-rational agent. For example, it can be that, no matter the amount of disposable time, she cannot derive the consequences of her own knowledge simply because she – consciously – ignores some of the rules. A student may not be able to deduce the consequences of a set of assumption she knows as true because she can't recall a theorem and its proof.

(3) Thirdly, the DM could unconsciously ignore some propositions. Assume φ is a proposition of which the DM is *unaware* of, that is she doesn't know φ and she doesn't know that she doesn't know φ, *ad infinitum.* Does it make sense to assume she has any form of positive knowledge on φ? Put in another way,

she may be unaware of the existence of some events which would be nonetheless relevant, if known, for her choice.

It is worth noticing that the three arguments above are strictly linked with the notion of Savage-null event. For the time being, we don't want to dig in the technical differences between the two. On the contrary, we just want to highlight that, as analysts, we face a trade off: if we want a decisional model with any predictive power, either we drop strict state-independence axiom and keep logical omniscience, or we keep strict state-independence but we allow for some degree of partial unawareness. In the former case, we will have a conditional probability system in which some conditional probability will be not defined (Section 4.3). In the latter, we will have to add some structure in order to model unawareness over the state space[25].

4.3 *A Non-Archimedean Representation*

Left aside the problem of logical omniscience, it is possible to handle null events using lexicographic ordering[26]. In this Section, as in the following one, we will try to develop a framework accounting at the same time for an ordering of beliefs, indeed a lexicographic one, and convex preferences such as in Chapter 3. Before doing that however, we give some motivations. In principle, we would like to model fear as a process which is triggered when something unexpected occurs. In particular, the unexpected event should cause the DM to enlarge her set of beliefs, making her decision rule pessimistic and her response conservative, as outlined in Section 4.1. Furthermore, we may want a degree of monotonicity to apply, implying that the more the event is unexpected, the stiffer the fear response and the wider the enlargement of the set of beliefs C_t, as predicted by Proposition 2 which now becomes operative. To this purpose, we need to weaken the Axiomatization 1, presented in Section 3.3, by working on the Archimedean axiom. Since from the very beginning of economic theory, basically since Edgeworth's work, substitutability has been a recurrent theme in any decisional model[27]. The underlying assumption is that any individual may be willing to trade off a certain amount a commodity she owns, if an appropriate amount of a second one it is offered to her in exchange. Made precisely within our decision theoretical setting,

[25] This second part was discussed in the thesis, but it is omitted here.

[26] See for a reference, BLUME L. *et* AL. (1991); BLUME L. *et* AL. (1986); CHIPMAN J. *et* AL. (1971).

[27] BLUME L. *et* AL. (1986) and MYERSON R.B. (1986 and 1991) stress this point.

no consequences are infinitely preferred with respect to others and, equivalently, there are not infinite odd ratios, *i.e.* probabilities of events are of the same infinitesimal order. However, this may be not the case in many real world situation. Indeed, there may be event which are indubitably non-null in the sense of Savage, but that are commonly neglected, because when compared with other events they appear as being *infinitely less likely.* More formally, let $F,E \in \Sigma$ be non $\succsim$-null events, if event F is infinitely less likely than event E, written $F \lll E$, then the following is always true,

$$f,g \in \mathscr{F}, \qquad f \succsim_E g \wedge f \precsim_F g \quad \Longrightarrow \quad f \precsim_{E \cup F} g$$

The classic example is the toss of a fair coin. For it, the probability of landing on the edge is infinitely less likely than landing on a side, but still non-null in the sense of Savage. Interestingly, this probability system has nothing at odds with Bayesian theory. In particular, lexicographic probabilities can be axiomatized by working on a system of preferences $\succsim_A$, $A \in \Sigma$, rather than working on a standalone preference over the whole state space (Myerson, 1986). If for any $A \neq \emptyset$, $\succsim_A$ over $\mathscr{F}_{|A} = \{f: A \longrightarrow X\}$ satisfies *GS1-GS5'*, than it can be represented by a utility function $u_A : X \longrightarrow \mathbb{R}$ and a probability measure $\mu : 2^{\Sigma} \times 2^{\Sigma} \setminus \{\emptyset\} \longrightarrow [0,1]$ such that,

(i) $\mu(\cdot|A) \in \Delta(\Sigma)$;
(i) $\mu(S|A) = \mu(A|A) = 1$;
(ii) for $E \subseteq F \subseteq G$, $F \neq \emptyset \Longrightarrow \mu(E|G) = \mu(E|\mathrm{F})\mu(F|G)$.

Furthermore, Myerson (1986) shows that given consistencies conditions on the system of conditional preferences $\succsim_A$, one can show that $\forall A \in \Sigma$, $u_A = u$, and that the set of probability distribution $\{\mu(\cdot|A) : \emptyset \neq A \subset S\}$ is a *conditional probability system* (CPS). In particular, if we consider the system of preferences constructed considering every possible pair of event E and F, it is possible to retrieve a lexicographic hierarchy:

Definition 10. Let $E,F \in \Sigma$ be any two non-empty events and $\succsim_{E \cup F}$ the conditional preference over $\mathscr{F}_{E \cup F}$. Then,
if $\mu(E|E \cup F) = 0$, then $E \lll F$;
if $\mu(E|E \cup F) \in (0,1)$, then E,F are of the same infinitesimal order;
if $\mu(E|E \cup F) = 1$, then $E \ggg F$.

Clearly, the number of infinitesimal orders will depends on the size of the state space S. In particular, it will never exceed the $|S|$-1 dimensions, when S is finite. On the contrary, if S is not, the route which is usually taken is to adopt an extra axiom which restricts the lexicographic hierarchy to finitely many levels[28].

An intuitive formalization with lexicographic probabilities arises naturally at this point: that of an order with non-overlapping supports. In the following analysis, we will try to avoid the use of such a structure, since, in principle, we would be better interested in orders of probabilities *with* overlapping supports. Nonetheless, the example is extremely clarifying on the use of lexicographic probabilities. As a matter of fact, given any CPS, $\{\mu(\cdot|A) : \emptyset \neq A \subset S\}$, we can define,

$$\begin{array}{lll} & \mu_1=\mu(\cdot|S) & \\ & \mu_2=\mu(\cdot|\Pi_1) & \text{with } \Pi_1=S - Supp\ \mu(\cdot|S) \\ (4.3) & \mu_3=\mu(\cdot|\Pi_2) & \text{with } \Pi_2=\Pi_1 - Supp\ \mu(\cdot|\Pi_1) \\ & \ldots & \ldots \\ & \mu_K= \mu(\cdot|\Pi_{K-1}) & \text{with } \Pi_{K-1} = \Pi_{K-2} - Supp\ \mu(\cdot|\Pi_{K-2}) \end{array}$$

In such a way, we have partitioned the state space in K subset, that is $S=\bigcup_{k=1}^{K}$ Supp μ_k. Moreover, $\mu=(\mu_1, \ldots, \mu_K)$ is called lexicographic conditional probability system (LCPS). This framework still accounts for null events in the sense of Savage (1954). In particular, in the LCPS just described, an event E is Savage-Null if and only if $E \subseteq \Pi_{K-1}$ and $\mu(E|\Pi_{K-1})=0$. In general, for any lexicographic hierarchy of beliefs with dimension K, $E \subset S$ is Savage Null if for all $k=1,\ldots,K$, $\mu_k(E)=0$. In light of this example, it is now easy to understand the notion Lexicographic Probability ordering. First, we give a general definition of what a lexicographic ordering is:

DEFINITION 11. [Lexicographic orderings]. Consider any two orders $\geq_L \subset X^K \times X^K$ and $\succsim \subset X$. $\geq_L$ is said to be a lexicographic order if, given $(a_k)_{k=1}^{K}, (b_k)_{k=1}^{K} \in X^K$ with $K \in \mathbb{N}$, $a \geq_L b$ if and only if whenever $b_k \succ a_k$, there exists $j<k$ such that $a_j \succ b_j$. In particular, if K=1 then $\geq_L = \succsim$ and, conventionally, if $X=\mathbb{R}$, then $\succsim = \geq$.

As with the order of words in a dictionary, a lexicographic order $\geq_L$ ranks vectors of dimension K. For example, $(10, 15, 9, 10) \geq_L (9, 20, 31, 16)$, and $(10, 15, 9, 10) \leq_L (10, 15, 9, 11)$ and so on. Consistently, a lexicographic probability system (LPS) is defined as follows:

[28] See FISHBURN P.C. (1971).

Definition 12. A Lexicographic Probability System, for short *LPS,* is a K-tuple $\mu=(\mu_1,\mu_2,\dots,\mu_K)$, for some $K\in\mathbb{N}$, of probability measures $\mu_k\in\Delta(\Sigma)$ for any $k\in K$.

Clearly, the inherent interest in these kind of lexicographic orderings $\geq_L\subset X^K\times X^K$ lies in the interpretation we can give, as analysts, to the different dimensions of the vector X^K. As discussed above, the lexicographic representation which I am going to introduce allows us to surpass the problems entrenched in a standard SEU when zero-probability events are considered (Blume *et* al. 1991). In particular, recalling that fear modeling is our main interest, we could think of a vector of probability distributions as in Definition 13 such that the first cell contains beliefs in standard emotional states, while subsequent cells contains beliefs at increasing levels of fearful emotional sates. Consistently with the discussion in Chapter 3, we would like to have LPS's made by sets of probability measures rather than singleton ones, with possibly overlapping supports.

To conclude, we come back to the concept of substitutability discussed at the beginning of this Section. So far, we explained what a lexicographic ordering is and how lexicographic probability system works. However, nothing has been said on the behavioral conditions which lead the DM to behave "as if" she accounts for an entire LPS rather than for an unidimensional belief[29]. Clearly, without modifying the standard axiomatization it is impossible to retrieve such a lexicographic representation. In particular, the Archimedean Axiom, presented in *GS*2, precludes the DM to prefer something infinitely more than something else[30]. An alternative axiomatization, accounting for lexicographic probabilities is provided in Blume *et* al. (1991), which weaken *GS*2 as follows:

Definition 13. [Non-Archimedean Axiom *GS*2'] For every $s\in S$, and every triplet of acts $f,g,h\in\mathcal{F}$ such that $f\succ_s g\succ_s h$, there are $\alpha,\beta\in(0,1)$ such that

$$\alpha f+(1-\alpha)h\succ_s |g|\succ_s \beta f+(1-\beta)h \qquad (4.4)$$

The difference with respect to GS2 is that, in GS', the continuity of preferences holds *only* conditionally on some events $s\in S$. On the contrary, it may be the case that, with unconditional preferences $\succsim$, continuity may not be satisfied anymore. In such a way, we are dicing an algebra of events Σ distinguishing among

[29] Hausner M. (1954) precisely calls his paper *Multidimensional Utilities* to compare them with standard unidimensional utilities.

[30] See Section 3.3.

events which are *infinitely more or less likely* than others. Finally, we present the representation of $\succsim$ derived when $GS2$ is substituted with $GS2'$.

THEOREM 2 [LEU Representation Theorem] Let $\succsim$ be a preference relation over $\mathscr{F}:=\{f|f:S\longrightarrow X$ with S finite. The followings are equivalent,

(i) $\succsim$ satisfies $GS1, GS2', GS3, GS4$ and $GS5'$.

(ii) There exists an affine function $U: X\longrightarrow\mathbb{R}$ and a lexicographic probability system $\mu=(\mu_1, \mu_2,...,\mu_K)$ on S such that,

$$f \succsim g \Leftrightarrow \Big(\sum_{s\in S} u(f(s))\,\mu_k(s)\Big)_{k=1}^{K} \geq_L \Big(\sum_{s\in S} u(g(s))\,\mu_k(s)\Big)_{k=1}^{K} \tag{4.5}$$

Moreover, U is unique up to affine transformations. Among the *LPS's* of minimal length K, each μ_k is unique up to linear convex combination of $(\mu_1,...,\mu_k)$ assigning strictly positive weight to μ_k.

PROOF: See Blume *et* al. (1991).

4.4 *Axiomatization of the Lexicographic Multiple Priors Model (LMP)*

In the following, we try to endow the *maxmin* framework discussed in Chapter 3, with a Lexicographic representation as in Section 4.3. In a sense, we provide an axiomatization connecting three different pieces of work, namely that of Hausner (1954), Blume *et* al. (1991), Gilboa-Schmleider (1989). Our purpose is to define a new decisional framework, that throughout we call *Lexicographic Multiple Priors* model (LMP), which is able to account for increasing levels of ambiguity as the DM proceed along his lexicographic probability system. In this sense, we will have to generalize the notion of LPS in order to account not only for singleton set of probability as it was in Definition 13 but also for set of beliefs as by Theorem 1.*c*. Therefore, we define:

DEFINITION 14. [GLPS]. A Generalized Lexicographic Probability System, for short *GLPS,* is a K-tuple $\mathscr{C}=(C_1,C_2,...,C_K)$, for some $K\in\mathbb{N}$, of sets of probability measures $C_k\subseteq\Delta(\Sigma)$ for any $k\in K$.

The story behind this idea is the following: an individual initially interpret the underlying state space using her *predominant* (possibly singleton) set of beliefs

C_1. If she subsequently receives signals confirming an event to which she is assigning zero-probability at order k=1, that is, if she become concerned about some *infinitely* less likely event, she is, therefore, unable to decide over a pair of acts, since, at order k=1 conditional probabilities are not well-defined. Hence, she moves along the lexicographic order, using a second-order (possibly larger) set of beliefs C_2 in which these conditional probabilities are eventually defined. If the event under consideration is not Savage-null, there will be a minimal kth-order in which the DM is able to express a preference.

We can now proceed for an axiomatization of such a lexicographic preferences. In particular, in order to obtain sets of beliefs and a MEU decision rule, we need to enlarge the axomatization of Blume *et* al. (1991) with C-independence (*L*.5.*b*) and Ambiguity Aversion (*L*.6). In order to have multidimensional probability systems we weaken GS2 as in Definition 14. In this sense, this framework is a non-Archimedean MEU. For sake of simplicity, we assume the state space S is now finite and we disregard the observations made on the time-varying preference system in Section 3.3.

Axiomatization 2:

L1, Weak Order: $\succsim$ is a complete and transitive binary relation over $\mathscr{F}$.

L2, Monotonicity: For every pair of acts $f,g \in \mathscr{F}$, such that $\forall s \in S, f(s) \succsim g(s)$, we have $f \succsim g$.

L3, Non Triviality: There exists $f,g \in \mathscr{F}$ such that $f \succ g$

L4, Conditional Archimedean: For every $s \in S$, and every triplet of acts $f,g,h \in \mathscr{F}$ such that $f \succ_s g \succ_s h$, there are $\alpha,\beta \in (0,1)$ such that

$$\alpha f + (1-\alpha)h \succ_s g \succ_s \beta f + (1-\beta)h$$

L5.a, State-Independence: For all states $s,s' \in S$ and for any two constant acts $x,y \in \mathscr{F}$, $x \succsim_s y$ if and only if $x \succsim_{s'} y$.

L5.b, Certainty Independence: For every pair of acts $f,g \in \mathscr{F}$, every constant act $x \in \mathscr{F}$ and every $\alpha \in (0,1)$,

$$f \succsim g \qquad \text{if } f \qquad \alpha f + (1-\alpha)x \succsim \alpha g + (1-\alpha)x$$

L6, Ambiguity Aversion: For every pair $f, g \in \mathscr{F}$ and every $\alpha \in (0,1)$, $f \sim g$ implies

$$\alpha f + (1-\alpha) g \succsim f$$

PROPOSITION 4 (*LMP* Representation Theorem). Let $\succsim$ be a preference relation over $\mathscr{F}$. The followings are equivalent,

(i) $\succsim$ satisfies $L1$-$L6$.

(ii) There exists an affine function $U : X \longrightarrow \mathbb{R}$ and a generalized lexicographic probability system *(GLPS)* $\mathscr{C} = (C_1, \ldots, C_K)$ on S such that,

$$f \succsim g \iff \left(min\, \mu' \in C_k \sum_{s \in S} u(f(s))\ \mu'(s) \right)_{k=1}^{K} \geq_L \left(min\, \mu' \in C_k \sum_{s \in S} u(g(s))\ \mu'(s) \right)_{k=1}^{K} \tag{4.6}$$

Moreover, U is unique up to affine transformations. There is a minimal K. Among the *GLPS's* of minimal length K, each C_k is unique up to linear convex combination of $(C_1, \ldots, C_k)$ assigning strictly positive weight to C_k. Finally, S is Savage-null if $f\, \mu'(S) = 0$ for any $\mu' \in C_k$ and any $k = 1, \ldots, K$.

Finally, the following Proposition is very important for the interpretation of the *Lexicographic Multiple Priors* model as a useful tool with which modeling fearful emotional states. Indeed, it shows that, given the axiomatization above, the way in which a Generalized Lexicographic Probability System is constructed implies that fear increases as we move along the dimensions $k \in \{1, \ldots, K\}$.

PROPOSITION 5. Let $\succsim$ satisfy $L1$-$L6$. Then, the resulting generalized lexicographic probability system $\mathscr{C}$ is such that, for any $C_k, C_{k'} \in \mathscr{C}$,

$$\text{for } k, k' \in \{1, \ldots, K\}, \quad k < k' \quad \Rightarrow \quad C_k \subseteq C_{k'} \tag{4.7}$$

5. - Future Developments: Interactive Fear

There are three main directions in which we would like to complete and extend this work. First, we aim to endow the framework discussed so far with true dynamics. In this sense, the present work has served to provide the tools needed to accomplish this task. In particular, a natural continuation of it would be the analysis of a dynamic Ellsbergian example with *ex ante* unawareness over the state space and absence of ambiguity in the mind of the decision maker.

The second step to be made is the implementation of this framework in a simple two-three players game. As a matter of fact, the idea to analyze fear in game theory sounds as natural as compelling. In such a game, each agent observes opponents behaviors and formulates second order beliefs, that is, beliefs on other players beliefs, based on these observations. In doing so, she tries to understand whether opponents behave in a certain way because of the fear or because they are better informed on the true state of the world. In this setting, payoff complementary should be a starting point. With the analysis of strategic interaction among agents, it will be possible to speak about *interactive fear,* trying to understand the way in which it spreads out and diffuse.

Finally, our third and final goal is to add a network structure in such games, in order to account for endogenous *fear contagion.* The principal interests, indeed, is to study whether or not, once fear enters in the network, the other players are subsequently "affected", by convincing themselves, one with the other, that their initial belief over the state space is no more the only one which should be taken into account. This *epidemic character* of fear has been discussed throughout and it is extensively treated in recent contributions in psychological literature[31]. Fear differs from other emotional states - such has regret, shame, hate - exactly for its intrinsic ability to diffuse and to be contagious. In this respect, it will be possible to show how the network structure can affect this process of fear contagion. As a matter of fact, if fear is learned through the observation of other player actions, the number of neighbors of a certain agent increases her degree of susceptibility. On the other side, however, the higher the number of neighbors, the less dependent the agent is on the emotional state of a single opponent, thus increasing the scope of the equilibrium analysis.

[30] See, for example, Olsson A. and Phelps E.A. (2004 and 2007) and Olsson A. *et al.* (2005).

APPENDIX

PROOF OF LEMMA 1: By von Neumann-Morgenstern representation theorem, weak order (*GS*1), continuity (*GS*2) and independence (*GS*5') holds if and only if there exists an affine and cardinally unique functional $V: B_0(\Sigma, U(X)) \longrightarrow \mathbb{R}$ which represents $\succsim_t$ as by Definition 2. Define a new functional $U: X \longrightarrow \mathbb{R}$ by $U(x) = V(x)$. Therefore, U inherits affinity from V. Moreover, by monotonicity (GS3), U is also a representation of $\succsim_t$, since $f \sim_t g$ if $f\, \forall s \in S$, $f(s) \sim_t g$, hence, $U(f)=U(g) \Longleftrightarrow f \sim_t g \Longleftrightarrow V(f)=V(g)$. Therefore, for each $f \in F$, the functional $I{:}B_0(\Sigma, U(X)) \longrightarrow \mathbb{R}$ is such that $U \circ f = V(f)$ and therefore I is a representation of $\succsim_t$. Suppose that $\varphi, \psi \in B_0(\Sigma, U(X))$ and that $U(f)=\varphi \geq \psi = U(g)$. Then $f \succsim_t g$ and $I(\varphi)=I(U(f))=V(f) \geq V(g)=I(U(g))=I(\psi)$. Therefore, I is monotone. Finally, for constant $k \in U(X)$ there exists $x \in X$ such that $k=U(x)$ and then $I(k)=I(U(x))=V(x)=U(x)=k$. For $k=0$, $I(0)=0$ and by monotonicity for all $\varphi \geq 0$, $I(\varphi) \geq 0$, hence I is a positive and normalized functional. By the affinity of V and U, we derive the affinity of I:

$$I(\alpha\varphi+(1-\alpha)\psi)=I(\alpha\, U(f)+(1-\alpha)U(g))=I(U(\alpha f+(1-\alpha)g))=V(\alpha f+(1-\alpha)g)=$$
$$=\alpha\, V(f)+(1-\alpha)V(g)=\alpha\, I(U(f))+(1-\alpha)I(U(g))=\alpha\, I(\varphi)+(1-\alpha)I(\psi)$$

We are left to show that $0 \in \text{int}\, U(X)$, which can be simply seen by choosing an appropriate V such that for any given $x_*, x^* \in X$, with $x_* \succ_t x^*$, we have $U(x_*)=V(x_*)<0<V(x^*)=U(x^*)$ and by convexity of X, there exists an $x \in X$, with $x_* \prec_t x \prec_t x^*$ such that $U(x)=0$. □

PROOF OF COROLLARY 1: If *G*1-*G*6 and ambiguity neutrality hold is also true that *G*5"holds. Therefore, Lemma 1 and Lemma 2 apply and the representation of $\succsim_t$ is given by *(3.7)*. Let's prove that in such a case the probability measure μ is unique. Suppose this is not the case. In particular, suppose that $V' \circ u(s) = \int_S u't(s)\, d\mu'(s)$ also represents $\succsim_t$. By Lemma 1, such an utility function is cardinally unique that there exists $\alpha \in \mathbb{R}_{++}$ and $\beta \in \mathbb{R}$ such that $u_t = \alpha\, u'_t + \beta$. Consider now an act $f \in \mathscr{F}$ and two constant acts x_*, x^* such that $x_* \succsim_t f \succsim_t x^*$. Hence, since u_t represents $\succsim_t$, $u_t(x_*) \leq u_t(f) \leq u_t(x^*)$. By the convexity of X, there exists an $\alpha \in [0,1]$ such that,

$$\alpha u_t(x_*)+(1-\alpha)\, u_t(x^*) = u(f)$$

By affinity of u_t and by setting $c=\alpha\, x_*+(1-\alpha)x^*$, we have the convex space X.

$$\alpha\, u_t(x_*)+(1\text{-}\alpha)\, u_t(x^*)=u_t(\alpha\, x_*+(1-\alpha)x^*)=u_t(c)=u(f) \iff c\sim_t f$$

That is, for any act $f\in\mathscr{F}$ there is a certainty equivalent act $c\in X$ such that $f\sim_t c$. Now, consider $x\succsim_t y$ and and the mixed act $x^y_A\in\mathscr{F}$ and let $c\sim_t x^y_A$. As by *(3.6)*,

$$u_t(c)=u_t(x^y_A)=u_t(x)(1-\mu(A))+u_t(y)\mu(A)=(u_t(y)-u_t(x))\mu(A)+u_t(y)$$

Since u'_t and μ' represent $\succsim_t$ as well, it is also true that

$$u'_t(c)=(u'_t(y)\text{-}u'_t(x))\mu'(A)+u_t(y)$$

and letting $u_t=\alpha\, u'_t+\beta$, we have that

$$\alpha\, u_t(c)+\beta=\alpha(u_t(y)\text{-}u_t(x))\mu'(A)+\alpha\, u_t(y) + \beta$$

$$u_t(c)=(u_t(y)\text{-}u_t(x))\mu'(A)+\alpha\, u_t(y) + \beta$$

Hence

$$(u_t(y)-u_t(x))\mu(A)+u_t(y)=u_t(c)=(u_t(y)-u_t(x))\mu'(A)+ u_t(y) \implies \mu=\mu' \qquad \square$$

Proof of Proposition 1: By Lemma 1, such $u_{t'}$ and $u_{t''}$ exist. *(If part)* If there exist $a\in\mathbb{R}_{++}$ and $b\in\mathbb{R}$ such that $u_{t'}=au_{t''}+b$, $x_1\succsim_{t'}x_2 \iff x_1\succsim_{t''}x_2$ clearly holds. *(Only if part)* Conversely, if *(3.1)* holds, for any $\alpha>0$, we can define two functionals $\hat{u}_{t'}$: $\alpha(x_1-x_2)\mapsto\alpha(u_{t'}(x_1)-u_{t'}(x_2))$ and $\hat{u}_{t''}$:$\alpha(x_1-x_2)\mapsto\alpha(u_{t'}(x_1)-u_{t''}(x_2))$. These are both linear because, if $x_1=x_2$, then $x_1\sim_t x_2 \implies u_t(x_1)=u_t(x_2)$ and then $\hat{u}_t(0)=0$ for any α. Moreover, they are non-zero since, by *GS*4, there are $x_1,x_2\in X$, such that $x_1\succ_t x_2$, hence $\hat{u}_{t'}(\alpha(x_1-x_2))>0$. In such a way, $\hat{u}_{t'}(\alpha(x_1-x_2))\geq 0 \iff u_{t'}(x_1)\geq u_{t'}(x_2)\iff u_{t''}(x_1)\geq u_{t''}(x_2) \iff\hat{u}_{t''}(\alpha(x_1-x_2))\geq 0$. By linearity of $\hat{u}_t$, *i.e.* $\hat{u}_t(0)=0$, and non triviality, there exists an $a>0$ such that $\hat{u}_{t'}=a\hat{u}_{t''}$ and for a given $x_0\in X$, letting $\alpha=1$, we have,

$$u_{t'}(x)-u_{t'}(x_0)=\hat{u}_{t'}(x-x_0)=a\hat{u}_{t''}(x-x_0)=au_{t''}(x)-au_{t''}(x_0)$$

$$u_{t'}(x)=au_{t''}(x)+(u_{t'}(x_0)-au_{t''}(x_0))=au_{t''}(x)+ b \qquad \square$$

PROOF OF THE CLAIM (Ghirardato *et* al., 2004). Let's prove first that $\succsim_t^*$ satisfies independence. That is for all $f,g,h \in \mathscr{F}$, and for all $\alpha \in (0,1)$,

$$(A.1) \qquad f \succsim_t^* g \Longleftrightarrow \alpha f + (1-\alpha) h \succsim_t^* \alpha g + (1-\alpha) h$$

$\Longleftarrow$). Let $\alpha f + (1-\alpha) h \succsim_t^* \alpha g + (1-\alpha) h$. By affinity of $u{:}X \longrightarrow \mathbb{R}$ we have,

$$\int_S u(\alpha f + (1-\alpha)h)d\mu \geq \int_S u(\alpha g + (1-\alpha)h)d\mu, \quad \forall \mu \in C_t$$

$$\int_S \alpha u(f) + (1-\alpha)u(h)d\mu \geq \int_S \alpha u(g) + (1-\alpha)u(h)d\mu, \quad \forall \mu \in C_t$$

$$\alpha \int_S u(f)d\mu + (1-\alpha)\int_S u(h)d\mu \geq \alpha \int_S u(g)d\mu + (1-\alpha)\int_S u(h)d\mu, \quad \forall \mu \in C_t$$

$$(A.2) \qquad \int_S u(f)d\mu \geq \int_S u(g)d\mu \quad \forall \mu \in C_t, \quad \Rightarrow \quad f \succsim_t^* g$$

$\Longrightarrow$). Let $f \succsim_t^* g$. That is for every $\mu \in C_t$, $\int_S u(f)d\mu \geq \int_S u(g)\, d\mu$. This implies that for every $h \in \mathscr{F}$ and any $\alpha \in (0,1)$,

$$\alpha \int_S u(f)d\mu + (1-\alpha)\int_S u(h)d\mu \geq \alpha \int_S u(g)d\mu + (1-\alpha)\int_S u(h)d\mu$$

Again, by affinity, this implies that $\alpha f + (1-\alpha) h \succsim_t^* \alpha g + (1-\alpha) h$.

Finally let's prove that $\succsim_t^*$ is maximal with respect to independence. Suppose that $\bar{\succsim}_t \subseteq \succsim_t$ it is such that $f \,\bar{\succsim}_t\, g \Longrightarrow f \succsim_t g$, for every $f,g \in \mathscr{F}$. Moreover assume it satisfies independence. That is, we require that for all $h \in \mathscr{F}$ and $\alpha \in (0,1)$,

$$f \,\bar{\succsim}_t\, g \Longrightarrow \alpha f + (1-\alpha) h \,\bar{\succsim}_t\, \alpha g + (1-\alpha) h.$$

Then,

$$\alpha f + (1-\alpha) h \,\bar{\succsim}_t\, \alpha g + (1-\alpha) h \quad \Longrightarrow \quad \alpha f + (1-\alpha) h \succsim_t \alpha g + (1-\alpha) h.$$

Therefore, (f,g) satisfies independence in $\succsim_t$ and then belongs to $\succsim_t^*$. We conclude that $\bar{\succsim}_t \subseteq \succsim_t^*$. □

Proof of Corollary 2. Clearly, *(i)*$\Longleftrightarrow$*(ii)* follows from Definition 4. Consider *(ii)*$\Longrightarrow$*(iii)*. Suppose $|C_t|$=1. Then, by completeness of $\succsim_t$, for every pair $f,g \in \mathscr{F}$, either $\int_S u(f)d\mu \geq \int_S u(g)d\mu$ or $\int_S u(f)d\mu \leq \int_S u(g)d\mu$ or both. But since $C_t=\{\mu\}$, every such a pair satisfies (3.15), hence $\succsim_t \subset \succsim_t^*$, contradicting *(i)*.

(iii)$\Longrightarrow$*(ii)*. If $|C_t|>1$, independence (*GS*5') is not satisfied for at least a pair of act $\{(f,g)\} \in \succsim_t$. Since $\succsim_t^*$ is the maximal subset of $\succsim_t$ satisfying independence, we have $\succsim_t^* \subseteq \succsim_t \{(f,g)\} \subset \succsim_t$. □

Proof of Proposition 2: First, let $\overline{co}^*(C_t)=\overline{co^*(C_t)}$ the closure of the convex hull of C_t in the weak* topology. That is $co^*(C_t)$ contains all the convex combination of the elements of C_t,

$$(A.3) \qquad co^*(C_t) = \left\{\mu' \in ba(\Sigma) \,|\, \exists \{\mu_i\}_{i=1}^N \subseteq C_t, \{\alpha_i\}_{i=1}^N \subset \mathbb{R}_+ : \sum_{i=1}^N \alpha_i = 1, \mu' = \sum_{i=1}^N \alpha_i \mu_i \right\}$$

Notice that, from the fact that C_t is a set of probability measures, also $co^*(C_t) \subset \Delta(\Sigma)$. Indeed, *(i)* $\mu'(\emptyset)=\Sigma_{i=1}^N \alpha_i \mu_i(\emptyset) = 0$, *(ii)* for $A \subset B$, $\mu'(A) = \Sigma_{i=1}^N \alpha_i \mu_i(A) < \Sigma_{i=1}^N \alpha_i \mu_i(B) = \mu'(B)$ and *(iii)* for a partition $\{A_j\}_{j=1}^\infty$ of A we have,

$$\mu'\Big(\bigcup_{j=1}^\infty A_j\Big) = \sum_{i=1}^N \alpha_i \mu_i \Big(\bigcup_{j=1}^\infty A_j\Big) = \sum_{i=1}^N \alpha_i \sum_{j=1}^\infty \mu_i(A_j) =$$
$$= \sum_{j=1}^\infty \sum_{i=1}^N \alpha_i \mu_i(A_j) = \sum_{j=1}^\infty \mu(A_k).$$

Finally, $\mu'(S)=\Sigma_{i=1}^N \alpha_i \mu_i(A)=\Sigma_{i=1}^N \alpha_i \mu_i=1$.

Moreover, notice that,

$$(A.4) \quad \int_S u(f(s))d\mu \geq \int_S u(g(s))d\mu \;\; \forall \mu \in C_t \text{ iff } \int_S u(f(s))d\mu \geq \int_S u(g(s))d\mu \;\; \forall \mu \in \overline{co}^*(C_t)$$

Necessity is proved simply by observing that $C_t \subseteq \overline{co}^*(C_t)$. We prove sufficiency, by use of a *contrapositive* argument. Let $f \succsim_t^* g$ and suppose there is a $\mu^* \in \overline{co}^*(C_t)$ such that

$$\int_S u(f(s))d\mu^* < \int_S u(g(s))d\mu^*$$
$$\int_S u(f(s))d\Big(\sum_{i=1}^{N}\alpha_i\mu_i\Big) < \int_S u(g(s))d\Big(\sum_{i=1}^{N}\alpha_i\mu_i\Big)$$
$$\sum_{i=1}^{N}\alpha_i\int_S u(f(s))d(\mu_i) < \sum_{i=1}^{N}\alpha_i\int_S u(g(s))d(\mu_i)$$

Then there must exist at least a measure $\mu i \in C_t$ such that $\int_S u(f(s)) d\mu_i < \int_S u(g(s))d\mu_i$, which contradicts $f \succsim^*_t g$.

(ii)⟹(i). Let $\overline{co}^*(C_{t''}) \subseteq \overline{co}^*(C_{t'})$ and consider $f,g \in \mathscr{F}$ such that $f \succsim^*_{t'} g$. Hence,

$$\int_S u(f(s))d\mu \geq \int_S u(g(s))d\mu \quad \forall \mu \in \overline{co}^*(C_{t'}) \tag{A.5}$$

Then it holds also for,

$$\int_S u(f(s))d\mu \geq \int_S u(g(s))d\mu \quad \forall \mu \in \overline{co}^*(C_{t''}) \subseteq \overline{co}^*(C_{t'}) \tag{A.6}$$

Whence, $f \succsim^*_{t''} g$.

(i)⟹(ii). Let $f \succsim^*_{t'} g$ imply $f \succsim^*_{t''} g$. Wlog we can consider $h \equiv f - g \in \mathscr{F}$ such that $f \succsim^*_{t'} g$ implies $\int_S u(h(s))d\mu \geq 0$ for all $\mu \in \overline{co}^*(C_t)$. Define the set,

$$\mathscr{F}_t^* = \{h \in \mathscr{F} \mid \int_S u(h(s))d\mu \geq 0, \forall \mu \in \overline{co}^*(C_t)\}$$

By *(i)*, we have that,

$$\begin{aligned}
\mathscr{F}_{t'}^* \subseteq \mathscr{F}_{t'}^* &\Leftrightarrow \bigcap_{\mu \in \overline{co}^*(C_{t'})} \Big\{h \in \mathscr{F} \mid \int_S u(h(s))d\mu \geq 0\Big\} \subseteq \bigcap_{\mu \in \overline{co}^*(C_{t''})} \Big\{h \in \mathscr{F} \mid \int_S u(h(s))d\mu \geq 0\Big\} \\
&\Leftrightarrow \bigcup_{\mu \in \overline{co}^*(C_{t'})} \Big\{h \in \mathscr{F} \mid \int_S u(h(s))d\mu \geq 0\Big\}^C \supseteq \bigcup_{\mu \in \overline{co}^*(C_{t''})} \Big\{h \in \mathscr{F} \mid \int_S u(h(s))d\mu \geq 0\Big\}^C \\
&\Leftrightarrow \overline{co}^*(C_{t''}) \subseteq \overline{co}^*(C_{t'})
\end{aligned} \tag{A.7}$$

By Theorem 1(*c*), C_t is unique, weak* compact and *convex,* then, being the convex hull the smallest convex set containing C_t, we have that $\overline{co}^*(C_t) = C_t$, whence, $C_{t'} \subseteq C_{t''}$.

Proof of Proposition 3: The representation theorem of *AA* applies in the first part. For the second, one implication is trivial. For the other, suppose $x \succsim_t y$ and let $A \subset S$ be null, *i.e.* $\mu(A)=0$. Then, by Definition 9, $f_A^x \sim_t f_A^y$ but, since $\mu(S)=1$, $f_{A^C}^x \succsim_t f_{A^C}^y$. Hence, Strict State-Independence is not satisfied. □

Proof of Proposition 4
We state three Lemmas before actually proving Proposition 4.

Lemma 3. If and only if $\succsim$ satisfies *L*1-*L*6, then there exists an affine utility function $u : X \longrightarrow \mathbb{R}$ which, conditionally on every event, represents $\succsim$. That is, for every $f,g \in \mathscr{F}$ and every $s \in S$:

$$f \succsim g \iff u(f(s)) \geq u(g(s))$$

Proof of Lemma 3: Conditional on each $s \in S$, the preference relation $\succsim$ is well behaved in the sense of von Neumann-Morgenstern. Therefore, Lemma 1 applies and it yields an affine utility function $u_s : X \longrightarrow \mathbb{R}$. Finally, under Strict State-Independence (*L*5.*a*), the conditional preferences $\succsim_s$ are independent of *s*, and therefore they can be represented by a cardinally unique affine function $u : X \longrightarrow \mathbb{R}$, also representing the unconditional preference $\succsim$ over $\mathscr{F}$. □

Lemma 4. The preference $\succsim$ over $\mathscr{F}$ induces an equivalent preference $\geq^*$ over $[0,1]^S$, such that $a \geq^* b$ if and only if there exist $f,g \in \mathscr{F}$, such that $u(f)=a$, $u(g)=b$ and $f \succsim g$.

Proof of Lemma 4: Notice that, given the von Neumann-Morgenstern Representation, the common utility function can be normalized in such way that u: $X \longrightarrow [0,1]$. Therefore any act f: $S \longrightarrow X$ can be rewritten as a vector $f=(f(s))_{s \in S} \subseteq X$, hence, by Lemma 3, $u(f)=a \in [0,1]^S$. Therefore, we can only construct a new preference relation $\geq^*$ in such a way that, if $a,b \in [0,1]^S$, there exist an $f,g \in \mathscr{F}$ such that $a=u(f)$ and $b = u(g)$ and we write

$$a \geq^* b \iff f \succsim g$$ □

Lemma 5. The preference relation $\geq^*$ satisfies the axioms *L*1-*L*6.

PROOF OF LEMMA 5: It is straightforward to see that each axiom on $\succsim$ is naturally inherited by $\geq^*$. □

PROOF OF PROPOSITION 4: Consider a preference relation $\geq^*$ over $[0,1]^S$, satisfying axiom $L1$-$L6$. As by Hausner (1954), there exist a multidimensional utility function made by K affine functionals $V_k: [0,1]^S \longrightarrow \mathbb{R}$, with $k=1,...,K$, such that,

$$(A.8) \qquad a \geq^* b \iff (V_k(a))_{k=1}^K \geq L \ (V_k(a))_{k=1}^K$$

where $\geq_L$ is lexicographic ordering. Moreover, $K \leq |S|-1$ since in a $(|S|-1)$-dimensional space, namely S, at most $|S|-1$ vectors can be linearly independent. Furthermore, at every $k \in \{1,...,K\}$, there exists a maximal $A \subset S$ such that $\succsim_A$ satisfies GS1-GS6, and so does $\geq^*_A$. Therefore, there exists a non-constant affine function $U_k: X \longrightarrow \mathbb{R}$ with $0 \in \text{Int}X$ and a normalized and monotone, quasi-concave functional $I_k: B_0(\Sigma, U_k(X)) \longrightarrow \mathbb{R}$, such that

$$(A.9) \qquad a \geq^*_A b \iff (I_k \circ U_k)(a) \geq (I_k \circ U_k)(b)$$

Then I_k admits a unique monotone superlinear and 1_S-additive extension and, hence, a unique convex and weak*-compact subset C_k of $\Delta(\Sigma)$ such that:

$$(A.10) \qquad I_k \circ U_k(a) = min_{\mu \in C_k} \sum_{s \in S} \left(U_k(a(s))\right) \mu(s)$$

Notice that, as in Lemma 3, Strict State-Independence implies that for all $U_k = u$. Finally, since by Lemma 4 $a \geq^* b \iff f \succsim g$ for a certain $f,g \in \mathscr{F}$ such that for every $s \in S$, $a(s)=u(f(s))$ and $b(s)=u(g(s))$, we have:

$$(A.11) \quad f \succsim g \Leftrightarrow a \geq^* b \Leftrightarrow \left(min_{\mu \in C_k} \sum_{s \in S} \left(u(f(s))\right) \mu(s)\right)_{k=1}^K \geq_L \left(min_{\mu \in C_k} \sum_{s \in S} \left(u(g(s))\right) \mu(s)\right)_{k=1}^K$$

The *if* direction follows easily from routine arguments. □

PROOF OF PROPOSITION 5: Let $k<k'$. First of all, define $\Pi_k := \cup_{\mu \in C_k} \text{Supp}\mu$ and $\Pi_{k'} := \cup_{\mu \in C_k} \text{Supp}\mu$ and notice that, by construction, for every k,

$$\Pi_k \subseteq \Pi_{k'}$$

Hence, $\succsim_{|\Pi k} \subseteq \succsim_{|\Pi k'}$. Now, let $\mathscr{F}^k := \{f | f : \Pi_k \longrightarrow X\}$ and equivalently for $\mathscr{F}^{k'}$. Therefore, $\mathscr{F}^k \subseteq \mathscr{F}^{k'}$ and $\mathscr{F}^{k'}_{|\Pi k} = \mathscr{F}^k$. Since the conditional preference preference relation $\succsim_{|\Pi k}$ over $\mathscr{F}^k$ is represented by the functional $J(\cdot) = \min_{\mu \in C_k} \Sigma_{s \in S} (u(\cdot))\mu(s)$ and the conditional preference relation $\succsim_{|\Pi k'}$ over $\mathscr{F}^{k'}$ is, in turn, represented by $J(\cdot) = \min_{\mu \in C k'} \Sigma_{s \in S} (u(\cdot))\mu(s)$, and since preferences over $\mathscr{F}^k$ must be consistent (*i.e. stable)* with those in $\mathscr{F}^{k'}_{|\Pi k}$, it follows that $C_{k'}$ must be at least as big as C_k. □

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Profile of the 2010-2011 Winners

FRANCESCA BRUSA (*fra.brusa@hotmail.it*) graduated *summa cum laude* in 2009 in Economics and Social Sciences at the "Luigi Bocconi" University of Milan. After graduating, she worked there as a teaching assistant in Financial Econometrics, which a postgraduate course in Finance. Being granted a Scholarship by Fondazione Luigi Einaudi (Torino), in October 2010 she started the MPhil programme in Economics at the University of Oxford. She is currently working on a final year project which tackles carry trade activities and volatility regimes under the supervision of Professor Janine Aron. The project was initially sponsored by the Bank of Italy.

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GIORGIO CHIOVELLI (*giorgio.chiovelli2@unibo.it*) graduated *summa cum laude* at the MA in Economics and Politics of European Integration at the faculty "Roberto Ruffilli", University of Bologna in March 2010. In July 2011 he obtained the M.Sc. in Economics at the Barcelona Graduate School of Economics "Universitat Pompeu Fabra". He is currently enrolled in the Ph.D. in Economics at the University of Bologna. His research interests are in political economy, democratization, ethnicity and civil wars, applied economic history.

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Professional Growth of «Angelo Costa» Previous Prize Winners

The Winners of the XIIIth Edition (2009)

Paolo Bonomolo (*paolizio@gmail.com*) obtained his Master of Science in Economics from "Luigi Bocconi" University of Milan in December 2007, under the supervision of prof. Sonia Petrone. He is currently enrolled in the 3rd year of the Ph.D. in Economics at the University of Pavia. His fields of research are Applied Macroeconomics and Monetary Economics, under the supervision of prof. Guido Ascari. He has been visiting research student at the University of Chicago Booth School of Business.

Federica Diamanti (*federica.diamanti@tesoro.it*) obtained in 2009 her M.S. in Economic and Social Sciences, in the field of International Economics and Development, summa cum laude and special mention from the "Tor Vergata" University of Rome. Since December 2010, she has been working as economic and financial officer at the DG International Financial Relations, Department of Treasury, Italian Ministry of Economy and Finance. In particular, her office contributes to the different work-streams of the informal groups G20 and G7/G8 concerning economic and financial issues. Her main areas of work and research are represented by: the G20 initiative "framework for strong, sustainable and balanced growth", the reform of the international monetary system, energy issues, the study of the macroeconomic and financial drivers of the commodities' prices volatility and its impact on global economy.

Silvia Duranti (*duranti.silvia@gmail.com*) graduated summa cum laude in 2009 in Political Science and decision-making Processes at the University of Florence. Her thesis won the "Mario Arcelli" prize assigned by Cespem (The Center for Economic and Monetary Policy Studies of the "Università Cattolica del S. Cuore" of Piacenza). In 2009 she was awarded a scholarship by the Ente Cassa di Risparmio di Firenze to continue her research activities on the topics developed in her thesis; in 2010 she won a scholarship from Confindustria Arezzo, to work on a research project on local development. She is currently doing research at IRPET (the Regional Institute for Economic Planning of Tuscany) thanks to a scholarship awarded to her for the study of "Local finance, public services and fiscal federalism". Her interests also include the effects of the use of flexible employment contracts on productivity.

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The Winners of the XIIth Edition (2008)

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LUCIA RIZZICA (*l.rizzica@ucl.ac.uk*) is Ph.D. student in Economics at University College of London. During her Ph.D. she has worked on migration from developing countries with a special focus on female migration. In 2010 Lucia worked at the research centre of the Bank of Italy where she studied the effects of the expansion of higher education provision in Italy. The paper produced is part of a wide research project on "gender equality" of the Bank of Italy. Her current research instead focuses on higher education and networks' formation. She is expected to finish her Ph.D. in spring 2013.

The Winners of the XIth Edition (2007)

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The Winners of the IXth Edition (2005)

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The Winners of the VIIIth Edition (2004)

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The Winners of the VIIth Edition (2003)

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The Winners of the VIth Edition (2002)

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Publications 2011:

«The Effects of Social Spending on Economic Activity: Empirical Evidence from Panel of OECD Countries», with Zdzienicka A., *Fiscal Studies*, vol. 32(4), 2011, pages 1-25; «Exchange Rate Volatility and Macroeconomic Performance in Central and Eastern European EU Member States», with Arratibel O., Martin R., Zdzienicka A., *Economic Systems*, vol. 35(2), 2011, pages 261-277; «Average Tax Rates Cyclicality in OECD Countries: A Test of Three Fiscal Policy Theories», with Karras G., *Southern Economic Journal*, vol. 19(1), 2011, pages 1-25; «Tax Design in the OECD Countries: A Test of the Hines-Summers Hypothesis», with Karras G., *Eastern Economic Journal*, vol. 37(2), 2011, pages 239-247; «Assessing Long-Term Fiscal Developments: A New Approach», with Afonso A., Agnello L., Sousa R., *Journal of International Money and Finance*, vol. 30 (1), 2011, pages 130-146; «The Real Effects of Financial Crises in the European Transition Economies»", with Zdzienicka A., *Economics of Transition*, 19 (1), 2011, pages 1-25; «The Impact of Government Spending on the Private

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The Winners of the V^th^ Edition (2001)

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Publications (2011):

BEE M., RICCABONI M. and SCHIAVO S., «Pareto versus Lognormal: A Maximum Entropy Test», *Physical Review E*, vol. 84, no. 026104, 2011, - doi: 10.1103/PhysRevE.84.026104; BELLONE F., NESTA L., MUSSO P. and SCHIAVO S., «L'impact des contraintes financières sur les performances à l'exportation des entreprises françaises», *Economie et Statistique*, no. 435-436, 2011, pp. 65-83.

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The Winners of the IVth Edition (2000)

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Publications:
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MATTEO PAGANINI (*mpaganini@libero.it*), after a nine-year financial experience in Group Banca Popolare di Milano, is currently responsible for Market Risk in Barclays Bank PLC Italy. His main study interests refers to market risk measurement, financial instruments pricing, asset liability management, liquidity risk and effective and robust market risk policies.

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The Winners of the IIIrd Edition (1999)

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The Winners of the II^nd^ Edition (1998)

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Publications:

«Un'analisi sulla gestione dei rifiuti urbani nei comuni capoluogo di provincia (Waste Management in Italy: An Analysis of City-Level Data)», *Economia delle Fonti d'Energia e dell'Ambiente*, vol. 52, no. 1/2009, pages 161-180.

The Winners of the I[st] Edition (1997)

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Publications 2010:

Baldassarre G., Mirolli M., «What Are the Key Open Challenges for Understanding the Autonomous Cumulative Learning of Skills?», *The Newsletters of the Autonomous Mental Development Technical Committee* (IEEE CIS AMD Newsletters), vol. 7 (1), 2010, page 11; Baldassarre G., Mirolli M., «Reply and Summary: On the Open Challenges for Understanding Cumulative Learning», *The Newsletters of the Autonomous Mental Development Technical Committee* (IEEE CIS AMD Newsletters), vol. 7 (2), 2010, pages 8-9; Caligiore D., Mirolli M., Parisi D., Baldassarre G., «A Bioinspired Hierarchical Reinforcement Learning Architecture for Modeling Learning of Multiple Skills with Continuous State and Actions», in Johansson B., Sahin E., Balkenius C. (eds.), *Proceedings of the Tenth International Conference on Epigenetic Robotics (EpiRob2010)*, Lund University Cognitive Studies, no. 149, 2010, pages 27-34; Caligiore D., Guglielmelli E., Parisi D., Baldassarre G., «A Reinforcement Learning Model of Reaching Integrating Kinematic and Dynamic Control in a Simulated Arm Robot», in Kuipers B., Shultz T., Stoytchen V.A., Yu C. (eds.), *IEEE International Conference on Development and Learning* (ICDL2010), Piscataway, NJ, IEEE, 2010, pages 211-218; Caligiore D., Borghi A., Parisi D., Baldassarre G., «TRoPICALS: A Computational Embodied Neuroscience Model of Compatibility Effects», *Psycological Review*, vol. 117, issue 4, 2010, pages 1188-1228; Chersi F., Mirolli M., Gurney K., Redgrave P., Baldassarre G., *Goal-Directed Motor Sequence Learning Based on Multiple Basal Ganglia-Cortical Loops*, Soc. Neurosci. Abs., 380, Abstract at the 40th Annual Meeting of the Society for Neuroscience (Neuroscience 2010), San Diego, US, 13-17 November 2010; Fiore V.G., Mannella F., Mirolli M., Cabib S., Puglisi-Allegra S., Baldassarre G., *A Computational Model of Dopamine and Norepinephrine Dynamics in Rats Exposed to Prolonged, Inescapable Stress*, Abstract at the 40th Annual Meeting of the Society for Neuroscience (Neuroscience 2010), San Diego, US, 13-17 November 2010; Mannella F., Mirolli M., Baldassarre G., «The Interplay of PPavlovian and Instrumental Processes in Devaluation Experiments: A Computational Embodied Neuroscience Model Tested with a Simulated Rat», in Tosh C., Ruxton G. (eds.), *Modelling Perception With Artificial Neural Net-*

works, Cambridge University Press, 2010, pages 93-113; MIROLLI M., MANNELLA F., BALDASSARRE G., «The Roles of the Amygdala in the Affective Regulation of Body, Brain and Behaviour», in ZIEMKE T., LOW R. (eds.), *Connection Science*, Special Issue, vol. 22(3), 2010, pages 215-245; OGNIBENE D., PEZZULLO G., BALDASSARRE G., «How Can Bottom-Up Information Shape Learning of Top-Down Attention-Control Skills?», in KUIPERS B., SHULTZ T., STOYTCHEV A., YU C. (eds.), *IEEE International Conference on Development and Learning* (ICDL2010), Piscataway, NJ, IEEE, 2010, pages 231-237; OGNIBENE D., PEZZULLO G., BALDASSARRE G., «Learning to Look in Different Enviroments: An Active-Vision Model which Learns and Readapts Visual Routines», in DONCIEUX S., GIRARD B., GUILLOT A., HALLAM J., MEYER J.-A., MOURET J.-B. (eds.), *From Animals to Animats 11* - Proceedings of the 11th International Conference on Simulation of Adaptive Behavior (SAB 2010), 2010; SANTUCCI V.G., BALDASSARRE G., MIROLLI M., «Biological Cumulative Learning Through Intrinsic Motivations: A Simulated Robotic Study on Development of Visually-Guided Reaching», in JOHANSSON B., SAHIN E., BALKENIUS C. (eds.), *Proceedings of the Tenth International Conference on Epigenetic Robotics (EpiRob2010)*, Lund University Cognitive Studies, 2010, pages 121-128.

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Anita Guelfi (*aguelfi@luiss.it*) starting from January 2009 Anita is also a Ph.D. student in History and Theory of Economic Development at the "LUISS Guido Carli" University in Rome.

Paola Rampone (*prampone@kpmg.it*) during 2011 has been continuing the experience in KPMG Advisory with the role of manager. In 2011 she contributed to a project devoted to the implementation of the information system for a major automotive corporation in North America.

Michele Trova (*michele.trova@venetobanca.it*), along the year 2011, consolidated his activity in the field of pricing of structured financial products and the parameterization of the front office systems currently in use by the Financial Department of Veneto Banca S.C.p.A., where he acted as Head of the Analysis & Financial Controlling unit. He has been appointed to study the implementation of the ALMO activity at the banking group level. He continued his research activity at the University of Venice where he has been confirmed instructor for the course of Investments at the IMEF Master and professor of Economics and Econometrics of the International Finance.

The Awarding Ceremony of the 2011 «Angelo Costa» Prize Winners

Prof. Carmen M. Reinhart congratulates Paolo Bonomolo.

Prof. Massimo Egidi, Rector of "LUISS Guido Carli" University of Rome, congratulates Federica Diamanti.

Dr. Luca Paolazzi, Head of Confindustria Research Department, congratulates Silvia Duranti.

Emma Marcegaglia, President of Confindustria, congratulates Matteo Falagiarda.

Dr. Giacomo Costa congratulates Marta Tarani.

Prof. Carmen M. Reinhart with President of Confindustria Emma Marcegaglia.

President of Confindustria Emma Marcegaglia with the winners of the 2009 edition of the «Angelo Costa» Theses Prize.

Prof. Carmen M. Reinhart with the winners of the 2009 edition of the «Angelo Costa» Theses Prize.

Our Referees for the Year 2009

The papers submitted for publication in the Rivista di Politica Economica are evaluated by two anonymous referees who do not know the identity of the authors. The role of these experts is fundamental to ensure the quality of the papers that will then be published in the journal.
Our particular thanks go to all the referees who – in a cooperative spirit – helped us selecting the works submitted to the editorial office of the Rivista di Politica Economica in the year 2009:

Alessandro Acquisti
Gian Luigi Albano
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Cristiano Antonelli
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RIVISTA DI POLITICA ECONOMICA

ANNOUNCEMENT OF THE 2012

Economics Undergraduate Theses Prize «Angelo Costa»

XV^th^ Edition

1 *Rivista di Politica Economica* (*RPE*) announces the XVth competition for the publication of the five most deserving papers taken from undergraduate theses in Economics (two-year M.Sc.) by students graduated in an Italian university. The Prize consists in the publication of the winning papers in the October-December 2012 issue of *RPE*, which will be published in English.

The initiative has two targets:

- to renew the commitment to make promising Italian graduates in Economics known, awarding them with the publication of their paper so as to encourage the continuation of their studies and their chances of admission to Master and/or Ph.D. programs;
- to promote the publication of excellent studies which too often remain as mimeos and cannot be appreciated by a larger audience.

2 The *RPE* editorial board will evaluate all papers taken from undergraduate theses in Economics defended by students graduated in an Italian university between May 1st, 2009 and October 30th, 2011 to be delivered to the editorial board within the deadline of November 2nd, 2011. The papers presented must be independent and self-sufficient with respect to the theses they are taken from and they shall in no way exceed a length of 30 pages (of 30 lines each) plus tables, graphs and appendix for a maximum of 10 additional pages. The papers submitted in the previous editions of the Prize will not be accepted.

3 The candidate shall send an e-mail with the following statements:

a) the candidate's surname, name, place and date of birth and contact details for notifications about the Prize, as well as the name of the advisor for the thesis;

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The candidate shall enclose the following documents:

(i) the candidate's degree certification (two-year M.Sc.) indicating final grade and title of the thesis;

(ii) two pdf copies of the paper in English of length as specified at point 2), of which:

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- one copy of the paper including the abstract but without any reference to the candidate's name or data.

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4 The Editorial Board of the Prize is composed by:

Dr. Giampaolo Galli
Director General of Confindustria and Editor of RPE;
Dr. Luca Paolazzi
Director of Confindustria Research Department;
Prof. Gustavo Piga
Managing Editor of RPE.

The Editorial Board of the Prize will evaluate the papers sent and the selected papers will then be submitted to an Italian referee expert in the subject dealt with in the paper. The 10/15 works rating the highest marks will be evaluated by the Members of the International Scientific Committee whose task is to choose the five final winners whose papers deserve publication.

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