

# Global & Local Economic Review

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Parametric Functional Analysis*

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Tonio Di Battista\* - Paola Cappola\*\*

**DISCOVERING DIVERSITY PROFILES USING  
PARAMETRIC FUNCTIONAL ANALYSIS**

**Abstract**

*A new approach to evaluating biodiversity is developed in this paper. It is our contention that biological diversity is seen as a function of the relative abundance of species in a community of animals or plants. In this setting, several researchers have suggested using parametric families of indices of diversity for obtaining more information from the data. Patil and Tailie (1982) introduced the concept of intrinsic diversity ordering which can be determined by using the diversity profile. It should be noted that the diversity profile is a non-negative and convex curve which consists of a sequence of measurements as a function of a given parameter. Thus, diversity profiles can be explained through a process that is described in a functional setting. Considering the data as a parametric family of functions, we obtain statistics that belong to functional diversity profiles. This approach can be useful as a means of considering biodiversity simultaneously, without losing any information with regard to the data.*

**JEL CLASSIFICATION:** C01; C40; C50.

**KEYWORDS:** BIODIVERSITY PROFILE, FUNCTIONAL DATA ANALYSIS, MONOTONIC DEPENDENCE  $L^p$  - space, FUNCTIONAL MEAN, FUNCTIONAL VARIABILITY.

**1. Introduction**

In statistics, the diversity concept relies on the variety of a phenomenon, which is generally related to the apportionment of some

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quantity into a number of categories. For example, in ecology, the researcher is interested in classifying a biological population composed of  $N$  units, into their species by counting the number of organisms belonging to each species. The objective is to determine the variety of living organisms in a delineated study area.

Environmental changes such as deforestation and pollution have strongly modified the ecosystem over time. Thus, an evaluation of the biodiversity distribution in a given area provides a correct interpretation of the pollution effects.

In this setting, the evaluation of biodiversity has become a crucial element of environmental monitoring programs (McCann 2002).

For this reason, statisticians have tried to introduce several indexes of diversity (Gove *et al.* 1994).

However they suffer shortcoming in that they are scalars, *i.e.* only one single value in terms of diversity, therefore the analysis depends on the measure of diversity that is adopted. We can assert that ecological diversity is a multidimensional concept including both the richness of the species (the number of different species) and the evenness of the species (the relative abundance of different species). The use of a single index greatly reduces the complexity of the ecological system. In fact, single measures of diversity could lead to a different ordering of communities in terms of their diversity. In fact, each index of diversity incorporates a particular degree of sensitivity to rare and common species.

In order to give a general solution to this problem, Patil and Taillie (1982), Tóthmérész (1995) and Liu *et al.* (2007), introduced a parametric family of indices of diversity, entitled diversity profiles, which consist of a sequence of measurements in respect to a parameter. In this way, different aspects of a community can be evaluated.

Therefore, the measure of biodiversity becomes a curve, unlike an index that is a scalar.

This new suggestion allows us to implement a suitable statistical approach (Gattone, Di Battista 2009).

The idea is to use functional data analysis (FDA) (Ramsay, Silverman 2005; Ferraty, Vieu 2006; Di Battista, Gattone, Valentini 2007).

Thus, the functional approach allows us to study the degree of

biodiversity by referring to the entire structure of the data.

The standard FDA approach is essentially to smooth the data on a prefixed domain, say  $R^m$  (in one-dimensional space  $m=1$ ), by means of some technique such as basis functions.

In fact functional data are often observed as a sequence of point data, then the function denoted by  $y = f(x)$  reduces to a record of discrete observations that can be labelled by the  $T$  pairs  $(x_j, y_j)$ , where  $x \in R$  and  $y_j$  are the values of the function computed at points  $x_j, j = 1, 2, \dots, T$ .

The use of basis functions converts the values  $y_{i1}, y_{i2}, \dots, y_{iT}$  for each unit  $i = 1, 2, \dots, n$  to a functional form that is computable at any desired point,  $x \in R$ . The aims of FDA are fundamentally the same as those of any area of statistics in a descriptive setting. One may want to investigate some essential aspects such as the mean and variability of the functional data. In inference however, assuming a suitable functional probability distribution, one may want to obtain a test of a hypothesis and obtain confidence intervals for one or more characteristics of the population.

However, in our framework, as explained in more detail later, the diversity profile is a function known in a fixed domain. In such a situation, we say that these functions belong to a parametric family of functional data.

Therefore, in this paper, we implement a suitable procedure that takes into account this specific issue (see Section 3).

## 2. Ecological diversity measures

Consider a biological population partitioned into  $s$  species. Then with  $N_l$  we denote the number of population units belonging to the  $l$ th species ( $l = 1, 2, \dots, s$ ). Hence  $\mathbf{N} = (N_1, N_2, \dots, N_s)^T$  denotes the abundance vector, whereas  $\mathbf{p} = (p_1, p_2, \dots, p_s)^T$  represents the relative abundance vector where  $p_l = N_l / \sum_{l=1}^s N_l$  represents the proportion of biological units belonging to the  $l$ th species, such that  $0 \leq p_l \leq 1$   $\sum_{l=1}^s p_l = 1$ .

The requirements of an index of diversity are:

1. it must be greater than or equal to 0 and equal to 0 only when  $p_l = 1$  for one species;

2. it takes its maximum when  $p_l = \frac{1}{s}$  for  $l = 1, 2, \dots, s$ ;
3. it must be an increasing function of  $s$ .

The simplest measure of diversity is species richness, *i.e.* the number  $s$  of species in a community. The entropy or Shannon index that was derived within the framework of information theory is widely applied in ecological studies (Shannon 1948). It is defined as

$$l_{sh} = - \sum_{l=1}^s p_l \log p_l \quad (1)$$

It is possible to show that the range of  $l_{sh}$  is  $0$  and  $\log p_l$ .

In the literature, several measures of diversity have been introduced. One of most famous is the Simpson index

$$l_s = 1 - \sum_{l=1}^s p_l^2 \quad (2)$$

in which the range is  $0$  and  $\frac{s-1}{s}$ .

Very useful for our purpose is the general expression for the measure of diversity introduced by Patil and Taillie (1982) as the average species rarity, *i.e.*

$$l(\mathbf{p}) = \sum_{l=1}^s p_l^R R(p_l) \quad (3)$$

where  $R(p_l)$  is a measure of rarity for species  $l$ . Some of the most frequently used indices of diversity are special cases of equation (3).

In the same work, Patil and Taillie (1982) also proposed a general measure of rarity given by

$$R(p_l) = \frac{1 - p_l^\beta}{\beta} \text{ for } \beta \geq -1 \quad (4)$$

Substituting the expansion (4) in (3), we obtain the  $\square$ -diversity profile as follows:

$$I(\beta) = \frac{1 - \sum_{l=1}^s p_l^{\beta+1}}{\beta} \quad (5)$$

We point out that the expression (5) is a function of  $\beta$ . Consequently, the

range of the measure of diversity becomes the domain of the function  $I(\beta)$ .

As it has been built, the  $\beta$ -diversity function varies for  $-1 \leq \beta \leq 1$ .

Following this approach and considering that the measure of diversity has become a curve in a prefixed domain; a suitable statistical method is functional data analysis (FDA). However the functions are well known. Hence, the standard FDA procedure must be suitably adopted in our case.

In the next section, some theoretical results of our approach are discussed (De Sanctis, Di Battista, 2012).

### 3. Parametric functional data analysis.

First of all let us introduce some mathematical tools:

Let  $X$  be an arbitrary measure space with a positive measure. We then denote with  $L^p(\mu)$   $0 < p < \infty$  the set of real or complex measurable functions on  $X$  for which we can verify the follows conditions:

$$\|f\|_p = \left\{ \int_X |f|^p d\mu \right\}^{1/p} < \infty \quad (6)$$

We call  $\|f\|_p$   $L^p$  - norm of  $f$  (Rudin, 2006).

In particular, when  $\mu$  is a Lebesgue measure on real space  $R^m$ , we write  $L^p(R^m)$  instead of  $L^p(\mu)$ .

If  $\mu$  is the counting measure on a set  $A$ , it is customary to denote the corresponding  $L^p$  — space by  $L^p(A)$ , or simply by  $c$ .

An element of  $L^p$  may be regarded as a sequence  $X = \{\varepsilon_\lambda\}$  and

$$\|X\| = \left\{ \sum_{i=1}^{\infty} |\varepsilon_i|^p \right\}^{1/p} \quad (7)$$

The following results are well known:

*Theorem 1.*

- i)  $L^p(\mu)$  is a (real or complex) vector space;
- ii) The relation  $f \sim g$  if and only if  $f(x) = g(x)$  for almost all  $x$  is an equivalence relation in  $L^p(\mu)$ . The set of equivalence classes (which we continue to denote  $L^p(\mu)$ ) is a metric space with respect to the distance  $d(f,g) = \|f\|_p$   $L^p$  - norm;

iii)  $L^p(\mu)$  is a complete metric space i.e. every Cauchy sequence in  $L^p(\mu)$  converge to an element of  $L^p(\mu)$ .

*Theorem 2*

If  $\{f_n\}$  has a limit  $f$  in  $L^p(\mu)$  then  $\{f_n\}$  has a subsequence which converges pointwise almost everywhere (a.e.) to  $f$ .

In general we do not have an orthogonality notion in  $L^p(\mu)$  because its norm is not induced by an inner product.

The only case where we have a *Hilbert space* (that is a vector space with an inner product whose induced metric space is complete) is  $L^2(\mu)$  with inner product

$$(f,g) = \int_x f g d\mu \tag{8}$$

In this paper we do not use the scalar product. We can then consider the *Banach-space* for every  $L^p$  space,  $p > 0$  as, for example,  $p = 1$ .

We assume that all the sets of functions are subsets of some  $L^p(\mu)$ . In particular a subset of functions  $S$  is a subspace if it is itself a vector space that is:

- 1) whenever  $f \in S$  and  $g \in S$  we have  $f + g \in S$
- 2) whenever  $f \in S$  and  $\alpha$  scalar we have  $\alpha f \in S$ .

Inspired by these mathematical tools, and assuming a monotonic dependence, we use the parameter spaces in order to transfer the statistics of the parameters to the functional space. In particular, we make the following assumptions:

- 1) Let the parameter space  $\theta$  be a convex subset of  $R^k$  that is  $(\theta_1, \theta_2, \dots, \theta_n)^t$ , where  $\theta_1 = (\theta_{11}, \theta_{12}, \dots, \theta_{1k})$ ; let  $\alpha_{ij}$  be a scalar with  $0 < \alpha_{ij} < 1$  and  $\sum_i \alpha_{ij} = 1$  for each  $j = 1, 2, \dots, k$  then

$$\sum_i \alpha_{ij} \theta_{ij} = \bar{\theta}_j \in \theta \tag{9}$$

for each  $j = 1, 2, \dots, k$ .

The extension to the general case in which  $\bar{\theta}_j = h(\theta_j)$  is a generic linear function of  $\theta_j = (\theta_{1j}, \theta_{2j}, \dots, \theta_{nj})^t$  is straightforward.

2) We suppose that there is a bi-univocal correspondence between a convex parameter space  $\theta$  and the family  $S$ , *i.e.* every functional datum  $f(\theta, x)$  of  $S$  is unequivocally defined by the parameter  $\theta$ .

Let us suppose the assumptions 1) and 2) to be true. Then for a matrix of parameters  $\theta$  where  $\theta_1 \leq \theta_2 \leq \dots \leq \theta_n$ , we have that

$$f(\theta_1, x) \leq f(\bar{\theta}, x) \leq f(\theta_n, x) \tag{10}$$

where  $\bar{\theta} = h(\theta)$  is a linear function of the parameters.

At this point we can give the following general definition:

Let the functional data be  $f(\theta_1, x), f(\theta_2, x), \dots, f(\theta_n, x)$  univocally defined by the set of parameters  $(\theta_1, \theta_2, \dots, \theta_k)$ , then a functional statistic for the set of the functional data can be obtained from a statistic of the parameters, say

$$\bar{\theta} = (h(\theta_1), h(\theta_2), \dots, h(\theta_k)) \tag{11}$$

The functional statistic will be an element of  $S$  which has as a parameter, the statistic  $\bar{\theta}$ .

This approach is advantageous because it is possible to require the same properties for the functional mean and variability in terms of the mean and variance of the parameters.

In order to study the functional variability, we first introduce the functional quantity represented by the  $r$ th-order algebraic deviation between the observed functional data  $f(\theta_i, x)$ , with  $i = 1, 2, \dots, n$  and the functional statistic  $f(\bar{\theta}, x)$ .

$$v_i^r(x) = |f(\theta_i, x) - f(\bar{\theta}, x)|^r \tag{12}$$

Then the  $r$ -order functional deviation can be measured pointwise by the  $r$ th order functional moment

$$v^r(x) = \frac{1}{s} \sum_{i=1}^r v_i^r(x) \quad (13)$$

For  $r = 2$  we obtain the functional variability.

It is possible to prove that the function  $v^r(x)$  has the following property:

if  $f(\theta_i, x) = f(\bar{\theta}, x)$  a.e., for  $i = 1, 2, \dots, n$  then  $v^r(x) = 0$  a.e.

#### 4. The simulation study

Suppose we want to study a population of living organisms in a delineated study area. Let us assume that the biological population under consideration is fixed, and has got a list frame of  $N$  known units. In the environmental scenery it is more frequently the that the study area is partitioned into a frame of  $N$  sub-areas such as plots or lines.

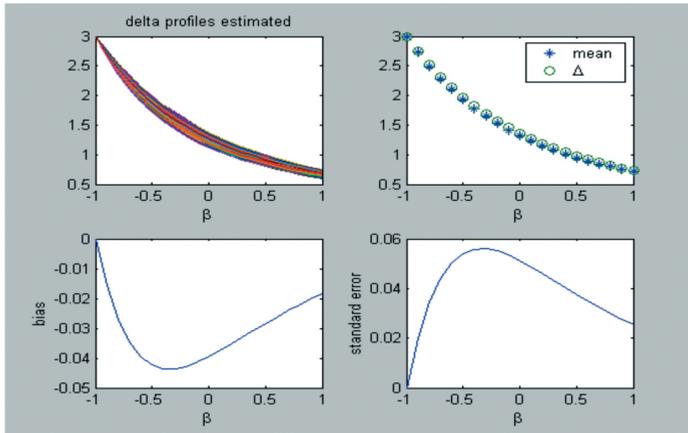
In the FDA context, it is convenient to consider the  $\beta$ -diversity profile as a parametric function of  $\beta = [-1; 1]$ .

Thus we can write  $y_i = I(\beta)$  for  $i = 1, 2, \dots, N$ , where  $I(\beta)$  has been expressed in (5).

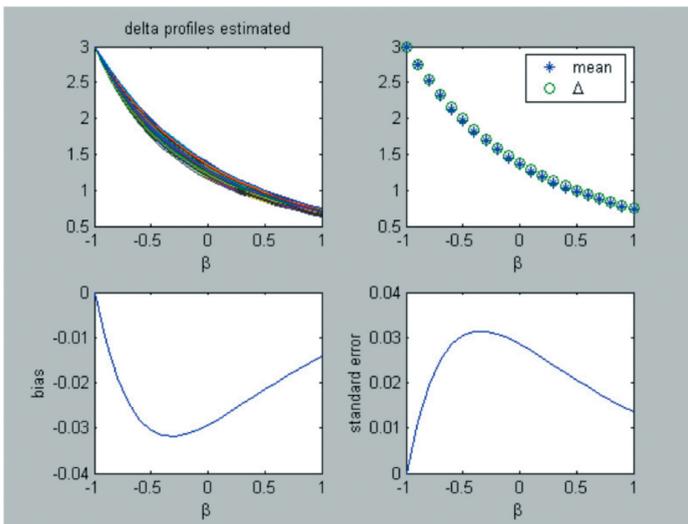
In this paper we simulate different biological populations by assigning to each component  $\theta$  different distributions, such as the Uniform, the Poisson and the Multinomial distribution. From each population we sample  $j = 5000$  samples with different sample sizes. In this case, the function  $y_i = I(\beta)$  is observed without error. For each sample of size  $n$ , we can evaluate the estimates  $\hat{\theta}$  from the observed  $\theta_1, \theta_2, \dots, \theta_n$ . The criterion explicated in (11) has been applied in order to obtain the profile of the functional diversity average.

**Figure 1.** Functional mean diversity profiles  $\widehat{I}(\beta) = \frac{1 - \sum_{i=1}^s p_i^{\beta+1}}{\beta}$  and standard error for a sample size  $n = 5$

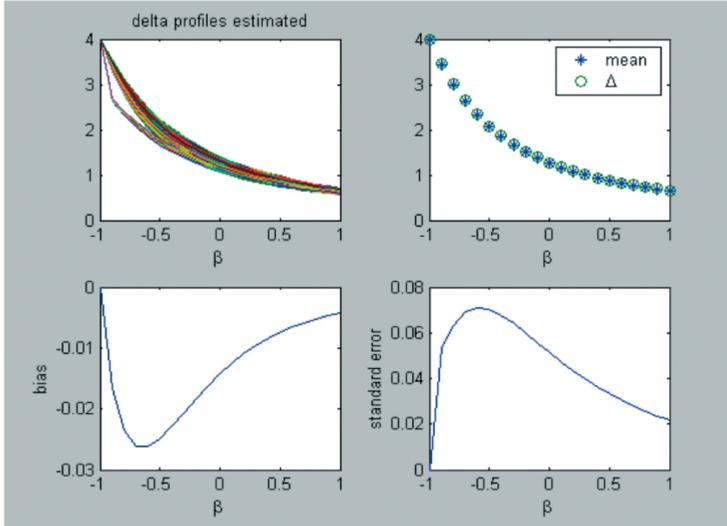
Uniform population  $N = 25$   $n = 5$   $s = 5$   $p = [0.4 \ 0.2 \ 0.2 \ 0.1 \ 0.1]$



poisson population  $N = 25$   $n = 5$   $s = 5$   $p = [0.4 \ 0.2 \ 0.2 \ 0.1 \ 0.1]$



multinomial population  $N = 25$   $n = 5$   $s = 5$   $p = [0.4 \ 0.2 \ 0.2 \ 0.1 \ 0.1]$



In Figure 1 we show the results for 3 populations with  $s = 5$  species, and with different levels of diversity. From each population we randomly choose samples of size  $n = 5$ . The functional mean, together the bias and the estimated standard error, are plotted in three different pictures. As desired, all the functional statistics belong to the family of diversity profiles explained in (5). Furthermore, the functional mean satisfies the internality property in all the simulation runs.

In particular, in the first line of each picture, we show the sampling distribution and a comparison between the functional profile estimate and the profile of the population. In the second line, on the other hand, we explain the behavior of the functional standard error and the functional bias. As we can see, the simulation gives good results.

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**Emiliano Colantonio<sup>1</sup> - Nicola Mattoscio<sup>2</sup>  
Iacopo Odoardi<sup>3</sup> - Antonella Perrucci<sup>4</sup>**  
**TRENDS IN CREDIT DURING THE “GREAT RECESSION”  
THE ITALIAN CASE**

**Abstract**

*The economic crisis of 2008 and the “Great Recession” have affected many aspects of economic development with consequences for the behaviour of economic agents. Due to years of deregulation in the United States (US), when banks were free to manage credit, the speculative bubble burst in 2007, which affected the financial markets in the following years leaving them insecure and with fewer resources. In many advanced economies, including Italy, a climate was established where such difficulties, combined with structural deficiencies, led to a period of persistent economic slowdown. Other causes of the prolonged recession are the so-called credit crunch, in particular the lack of credit available for businesses. In this paper, we use data from the Banca d’Italia, to analyse the Italian credit market with respect to consumers and businesses. We use multidimensional scaling analysis and compare different periods, selected for economic relevance, including the period from the introduction of the Euro to the burst of the real estate bubble (1999-2007), the period when the negative effects of the international economic crisis unfolded (2008-2009), the duration of the absence of economic recovery and the continuing recession in Italy (2010-2012).*

**JEL CLASSIFICATION:** E51; E52; E58.

**KEYWORDS:** CREDIT, MONETARY POLICY, MULTIDIMENSIONAL SCALING.

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## **1. Introduction**

The "Great Recession" has affected the banking sector in many Countries, which creates instability, and affects the availability of credit. The main force behind the speculative bubble, which burst in 2007, was the granting of credit. Shares in US financial markets and the dispersal of adverse effects to other advanced economies, shows that financial liberalisation and the widespread use of new ICTs in recent decades has connected international financial markets. The economic and financial crisis that ensued, led to stricter regulations that has changed the behaviour of financial institutions and intermediaries. The granting of credit may be connected to a particular phase in the economic cycle, and trends in the flow of credit, expansions, and contractions, and may be asymmetric with respect to changes in the economic cycle (Dell'Araccia, Garibaldi 2005). A distinctive characteristic of cyclical downturn is the greater volatility of credit contraction than credit growth, there being different explanations for the strengthening of credit compared to expansion, which happens in the case of cyclical upturns.

There are numerous socioeconomic variables involved in these relationships, and conditions of economic downturn trigger vicious circles, where the worsening of the economic environment leads to lower demand for loans due to investment uncertainty, deterioration in financial statements, and growing problems in maturing debt repayments. This increases the share of marginal borrowers, unable to restructure debt or get new loans, risking bankruptcy and the impossibility of repaying debts (Woo 2003). Banks' lack of liquidity, and a perception of the growing risk of default, lead to further restrictions, and necessitate strict controls on the outflow of resources, which must be covered by higher guarantees than in the past. It is not appropriate to increase banks' interest rates, associated with the risk of borrowers' default, as under normal conditions, the same banks establish a maximum limit of convenience of the rate at which they make loans.

The origins of the financial crisis of 2007 lie in changes to the flow of credit and represent a way to convey monetary policy, which increases the effects. Some small shocks are due to macroeconomic policy, which furthers the imperfections in the credit market. The credit represents

a nonlinear propagator of initial shocks, with stronger impact in a regime of tight-credit, where contractions in monetary variations have a greater effect on output than expansionary shocks (Balke 2000).

In this paper, we aim to consider all aspects related to the 2007 crisis in the credit markets, with particular reference to Italy. Firstly, we refer to changes that occur in the period prior to the international crisis and compare it to the subsequent period. Secondly, we examine the structural differences between Italian regions.

In the first paragraph, we look at the international situation, especially the banking sector, affected by the consequences of the 2007 financial crisis. In the following section, we consider all aspects that led to the so-called credit crunch in many advanced economies. In the third paragraph, we focus on real aspects and consequences of the restriction of credit, assuming a shift in the allocation of resources from businesses to households, in the European and Italian contexts. In the fourth section, we use multidimensional scaling analysis to examine several regionally specific variables in Italy, and consider three periods of economic significance. These are, the period from the introduction of the single European currency to the outbreak of the real estate bubble in the US (1999-2007), the years of the international economic crisis (2008-2009), and the lack of economic recovery and continuing recession in Italy (2010-2012). We conclude with some considerations of credit trends for different types of borrowers, taking into account the theoretical knowledge we develop in the first paragraphs and the results of our analysis of the three distinct periods.

### *1. The credit crunch following the financial crisis*

The credit crunch was the result of different and simultaneous actions by banks and control institutions. Loans were restricted due to a more stringent selection of potential borrowers and a mortgage crisis became a broad financial crisis. The main causes include the fall in the value of the banks' assets, fears regarding the future hoarding of capital, the need to hold additional funds, the effects of networks between banks, uncertainty, and the scarcity of private savings (Brunnermeier 2009).

This situation can be seen as market failure caused by the

supervening non-coincidence of the supply and demand of credit, or as a leftward shift of the bank loans supply curve, although both the safe real interest rate and the degree of creditworthiness of potential borrowers remains constant.

The expansion of private credit to households mainly for the purchase of real estate is a risk that can lead to banking crises, due to increased vulnerability. It is usually less risky to lend to businesses, due to expected and associated increases in income through investment (Büyükkarabacak, Valev 2010). Changes to the rules for the selection of borrowers triggered the 2007 crisis, in a general alteration in the conception of the credit cycle. Several US banks stopped waiting for credit to mature, and divided the debt, incorporating it into structured products with different risk levels, for financial investors. Prior to 2007, interest rates were low, due to the decisions of the *Federal Reserve*, and substantial injections of capital from abroad was used to control exchanges, allowing banks to approve large numbers of mortgages, after lowering the requirements for borrowers, especially for the purchase of real estate. These financial transactions caused growth in demand for real estate, with the consequent increase in its value, which in turn was used as a guarantee for mortgages. Removing this credit from the banks' balance sheets cut their risks (Brunnermeier 2009).

Since 2005, the damaging characteristics of the credit market increased, in particular, the unbalanced information on credit quality and the collapse in property value and overall profits. At the outbreak of the speculative bubble, the collapse in property value was a major reason for not repaying debt, as loans were often much higher than the property was worth. The absence of new investors willing to pay prices higher than actual values exacerbates the problem.

Restrictive measures on the activities of banks are often introduced during periods of recession to avoid failure. Banks at risk are those whose balance sheets show a poor relationship between capital and assets or whose securities could lose value. There are two possibilities to choose from, both would be to limit, a sharp restriction of credit or a strong risk of bank default (Bernauer, Koubi 2002). The risk is for both business relations between banks and for the effect of panic that would spread in the system due to any failures.

More stringent limits on the selection of the composition of capital and assets, requires banks to restrict credit, especially in relation to riskier assets, and implies the need to hold more capital.

These interventions have worsened the already serious economic situation by affecting the availability of credit for companies (Bernauer, Koubi 2002). Restrictions mean that small and medium enterprises (SME) now rely more on trade credit (Atanasova, Wilson 2003) that are payment terms agreements between suppliers and customers.

## **2. The effects of the crisis and the prolonged economic recession**

In previous sections, we consider the theoretical aspects of the financial crisis and the adverse consequences for credit. It is also necessary to observe the situation in contexts most affected by these events, including major international economies and more specifically in Italy.

Among the reasons given for the recession in many Countries, were issues related to the value of financial securities linked to subprime mortgages, which led to illiquidity in interbank markets.

Reduction in liquidity is typical of contexts with difficulties sharing risk, raising funds, or selling assets (Brunnermeier 2009). The consequences of intervention by the *European Central Bank* (ECB) and the *Federal Reserve* were lower rates and the provision of system liquidity. Monetary injections may generate a liquidity effect with positive results on the availability of credit to households and on real activities (Li 2000). The ECB may not issue new currency to comply with EU Treaties, which is different from the actions of the *Federal Reserve*.

There is a risk of triggering a financial bubble due to excessive injection of liquidity through the purchase of securities by central banks. The response to this is to increase interest rates, which are kept low during recessions.

In Europe, many banks have taken advantage of the low cost of debt, to acquire national government bonds, that are a safe and profitable investment, and useful as collateral for other loans. The break in the transmission of monetary policies, and the facilitation of loans to

households and businesses, is due in part to problems in bank balance sheets, and in Europe, many of the banks were obliged to rearrange their internal accounts.

Among the reasons for the slowdown in the transmission of monetary policy is the increase in uncollected accounts, the growing risk of insolvency, a general intensification of the so-called Country risk (e.g., Italy and Spain), and the necessity for several banks to repay those maturing bonds that are too expensive to refinance. In addition, customers have more problems repaying debts, are less willing to borrow, and more likely to postpone investments.

The strong interconnections between financial markets in many Countries and extensive deregulation in the financial sector has led to a succession of negative economic events, but, the source of the 2007 crisis originates from the finance and credit markets, making a quick economic recovery more difficult. These types of crises tend to prolong the economic slowdown (Claessens et al. 2012), and in several advanced economies the lack of economic upturn after 2009 has changed the opportunities for providing resources for consumption and investment. The prolonged effects have made it difficult to make the necessary structural changes that promote growth in the short term.

We consider various types of bank loans in our analysis, including those directly comparable and intended for government, businesses, and consumers.

Another alternative interpretation of the causes of the credit crunch is that resources were partially redirected from business investment to maintain households' consumption.

The difference between these two destinations for credit is that there is no effect on long-term income for households. We have already mentioned the statistical and economic significance of over-expansion for the banking crisis. Moreover, prior to the 1990s, the credit to households had a limited impact on the total amount of private credit (Büyükkarabacak, Valev 2010). We can relate the main problems for businesses, in the credit crunch of 2007-2009, to short-term financing channels, and not long-term loans (Akbar et al. 2013).

### 3. Analysis of the Italian regions: data, methodology and results

We consider bank loans as a variable affected by the international economic crisis and analyse distinct periods of economic significance to demonstrate the presence or absence of the so-called credit crunch, and which type of borrower it affects. We aim to compare the economic recession after 2008, with a suitably long period before the crisis broke out in the US in 2007, and with the first relevant effects in Italy in the subsequent year.

We have selected the first period from 1 January 1999, when the *Euro* became the single European currency until the speculative bubble burst in 2007, which we link to events in the US credit and real estate markets. We compare the first period with the most severe phase of the crisis, that spread worldwide (2008-2009), and later with the prolonged recession in Italy (2010-2012). We aim, in our analysis to highlight the structural characteristics between Italian regions, to find the differences between particular areas of the Country before and after the crisis, and consider the availability of credit.

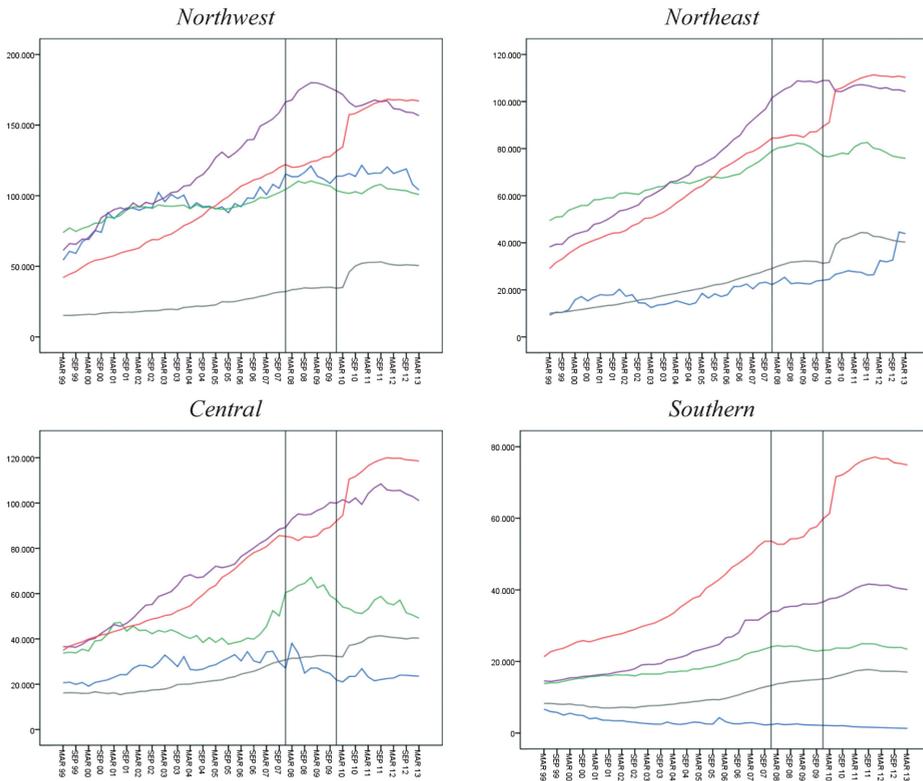
The data from the *Banca d'Italia* highlights that, after the spread of the economic crisis, loans to the productive sector were adversely affected, such as cash flow loans (for business investment), "productive" funding beyond the short-term and factoring (i.e. the management of credit and the ability to receive advance payments). This happened for several reasons, including the increased risk of default by customers, postponement of business investments, the first economic slowdown, difficulty repaying maturing debts, and initial signs of a shortage of liquidity in the interbank market. In contrast, the trend of loans to households, which continued positively after 2007, slows down and stabilises in value by 2010, due to the continuing economic recession. The prolongation of the economic recession makes it necessary to observe the period after 2010 separately from the immediate occurrence of the crisis.

Our analysis shows how the use of banks' funds and deposits (assets of banks resulting from investments through different destinations of loans) confirms the partial inversion of the flow of loans from producers to consumers. The reasons for this include turbulence in the capital

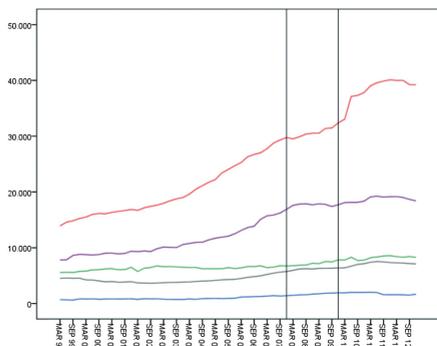
markets, the collapse of expenditure for consumption and investment, the weakness of the real estate industry, and the deterioration of the creditworthiness of bank customers.

The weak functioning of financing channels can have grave consequences for the real economy, since the lack of funding means companies may downsize investment programmes and may force a reduction in households’ consumption, which amplifies the negative effects on production and employment. The limitation of credit flows and the restriction on fiscal policy have profoundly affected national aggregate demand, putting a further brake on recovery.

**Figure 1. Different types of bank loans (millions of euros) based on the type of borrower in the three periods considered, in Italian macro-areas and in aggregate values (1999 - Quarter 1 of 2013)**

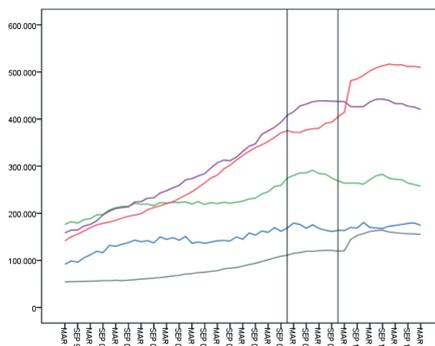


## Insular



- Financial companies
- Non-financial companies - industry
- Non-financial companies - construction

## Italy



- Non-financial companies - services
- Households and other

Source: Our elaborations on *Banca d'Italia* data

In the graphs, we show how for certain types of credit to firms (the time series show the loans by type in absolute value) the period of greatest impact of the crisis (between 2008 and 2009) shows a reversal in credit allocation. In some macro-areas from 2010, the flow of credit to construction companies increased, although the financial and non-financial companies related to industry were affected by the credit crunch. It is clear that in the period 2008-2009, there was a growing but attenuated trend for credit to households, with a strong recovery after 2010, to sustain consumption in a period of rising unemployment. At the beginning of the period, the credit to households in the wealthiest areas of the Country, the north and centre, was less in total than that intended for financial companies for productive purposes. This overtaking occurred in these areas from 2010, increasing over time. In southern regions, the greater importance of credit for consumption, compared to business investment, is evident from the beginning of the 2000s. During the crisis period however, this gap has widened, allocating a value to households of almost twice that for financial companies.

We use a Multidimensional scaling analysis (MDS) to analyse simultaneously the distances between the Italian regions and the changes in the granting of credit in the three periods. MDS is a useful tool that makes it possible to produce graphical representations of the 20 regions, based on the degree of similarity/dissimilarity between them. We aim to provide a representative map that best approximates the distances observed between the Italian regions, concerning the availability and granting of credit to households and businesses. Using this statistical method, we attempt to build a configuration of the various entities, merged in a small number of dimensions (two in our case). We do this by defining relations between regions in terms of proximity/distance with respect to the considered indicators. The resulting positioning map has the property to partition the regions into homogeneous groups, so that the degree of association between two regions is maximal if they belong to the same group and minimal otherwise.

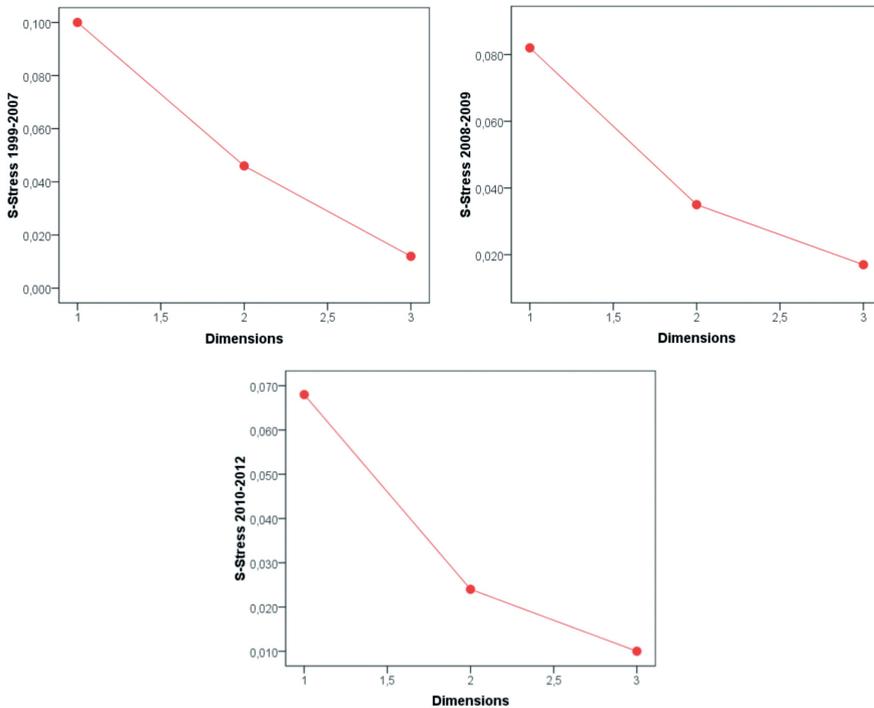
To be able to compare our variables directly, we selected the bank loans by type of borrower, that is, financial companies, non-financial companies (industries, construction, and services), producer households (businesses with up to five employees) and consumer households and others. We exclude bank loans to governments, in order to avoid outliers cases present in some regions. We use the quarterly data from *Banca d'Italia (Bollettino statistico, 1999-2013)* starting in the first quarter of 1999 and ending in the fourth quarter of 2012. We calculate the per capita values of each type of credit, and then consider the mean values for each region for the three distinct periods (1999-2007, 2008-2009, 2010-2012). To get the per capita values we use the resident population (*Istat* data) for households and the number of registered companies (*Unioncamere* data) for all types of credit for productive purposes.

We rescale the data between zero and one within each considered variable, in order to avoid possible distortions due to different ranges and magnitudes.

We assess the model's goodness of fit using the RSQ (for the three periods, in consecutive order, this indicator is equivalent to 0,988, 0,992 and 0,997), that indicates the proportion of variability explained by the corresponding dissimilarity distances, and the Stress Index (for the three periods, this indicator is equivalent to 0,060, 0,049 and 0,028). As a

rule, we find results to be robust when the size  $k$  achieves a Stress Index value lower than 0,15. We judge a two-dimensional model acceptable according to the values of the previous indices. Further investigation provides an additional basis for choosing the two-dimensional solution - the “elbow” rule - that suggests choosing the number of dimensions in correspondence to where the diagram yields an “elbow”, beyond which the broken line flattens (figure 2).

**Figure 2. S-Stress–dimensions diagrams for the considered periods, 1999-2007, 2008-2009 and 2010-2012**



Source: Our elaborations on *Banca d'Italia* data

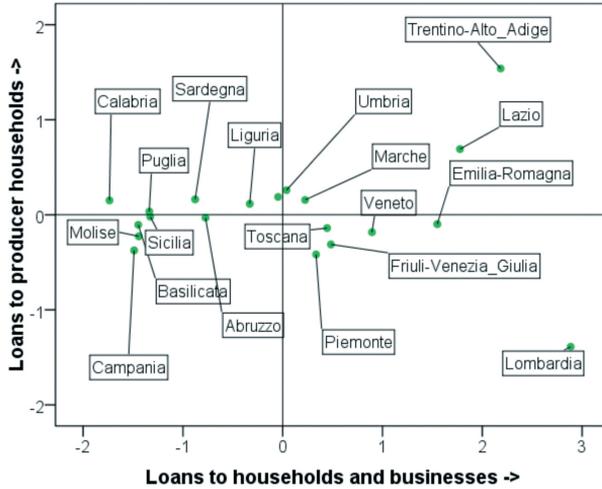
**Table 1. Correlations between variables and dimensions  
( $r > |0,6|$ )**

<i>Loans to</i>	<i>1999-2007</i>		<i>2008-2009</i>		<i>2010-2012</i>	
	<i>configuration</i>		<i>configuration</i>		<i>configuration</i>	
	<i>Dimens.</i>	<i>Dimens.</i>	<i>Dimens.</i>	<i>Dimens.</i>	<i>Dimens.</i>	<i>Dimens.</i>
	<i>1</i>	<i>2</i>	<i>1</i>	<i>2</i>	<i>1</i>	<i>2</i>
Financial companies	0,734		0,703	-0,633	0,745	
Non-financial companies - industries	0,842		0,928		0,937	
Non-financial companies - construction	0,889		0,905		0,950	
Non-financial companies - services	0,978		0,958		0,963	
Producer households			0,659	0,623	0,690	0,705
Households and other	0,959		0,964		0,944	

Source: Our elaborations on *Banca d'Italia* data

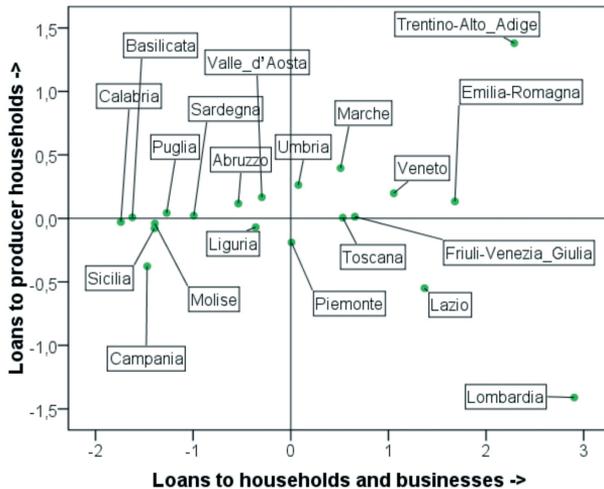
Using directions from the above table of correlations, we present the clusters of Italian regions in the three periods in the following graphs, which we compare for economic significance. Considering the relatively long period and important socio-economic changes, we expect a constant structural difference between the areas of the north and south of the country (for analysis of the credit in the Italian regions, see Mattoscio et al. 2013).

**Figure 3. Cluster of regions in a two-dimensional space (1999-2007)**



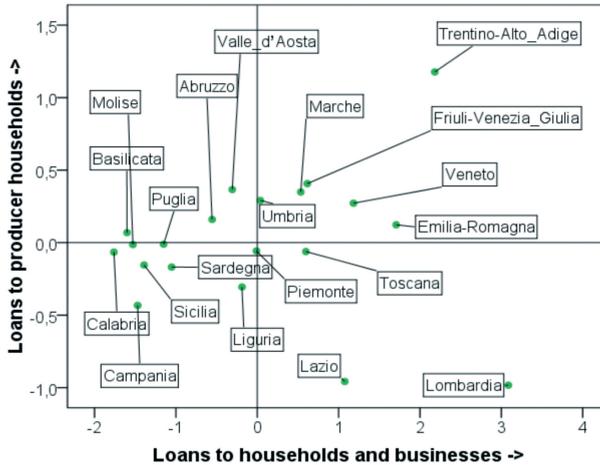
Source: Our elaborations on *Banca d'Italia* data

**Figure 4. Cluster of regions in a two-dimensional space (2008-2009)**



Source: Our elaborations on *Banca d'Italia* data

Figure 5. Cluster of regions in a two-dimensional space (2010-2012)



Source: Our elaborations on *Banca d'Italia* data

In the graphs (figures 3, 4, and 5), the Italian regions are positioned according to the similarity of per capita values of loans granted by banks to households and to different types of business. We can confirm the integrity of our analysis by the fact that in all periods the variables representing bank loans delineate the same axes. In particular, the most relevant is the horizontal axis, which represents loans to households and non-financial and financial companies. The vertical axis represents loans to firms of smaller size, with less than five employees. We note (table 1) that in the first period (1999-2007) there is no sufficiently high correlation ( $> |0,60|$ ) in the same table as an indicator of the vertical axis. In this period, as in the other two, the value for the producer households remains the highest among the variables with respect to that axis.

From the previous three graphs (figures 3, 4, and 5), we see, in the 13 years we consider (divided into the three periods previously described), that the Italian regions are displaced systematically on the horizontal axis, the most imported ordered where all the southern areas are positioned firmly to cover the negative part of the axis. By contrast, the richest regions of the north-central (except Liguria and Valle d'Aosta) are firmly positioned on the right side of the graphs,

to show high per capita values of loans, offered both to consumer households and various types of businesses by banks.

Some of the difficulties resented by national firms are due to the restrictive measures imposed at European level, which is in addition to the difficulty in granting new loans, due to low system liquidity and sudden changes and uncertainty. There have been greater repercussions in the more fragile economy in the southern areas due to scarce resources, and as we show in our analysis, where it is more difficult to obtain a loan. In the less wealthy areas, we expect a lower average level of consumption, as well as less entrepreneurial vitality. In addition, the southern regions have fewer international relations, which means more difficulty recovering from the crisis through international trade.

In our analysis of the vertical axis, we show a few outlier cases. The only two regions that strongly differ from the others are Lombardia, with low levels of lending to smaller businesses, and Trentino-Alto Adige, which always shows very high levels. This is due to the numbers of this type of business, and the importance to the local economy.

The result we found most interesting is how the economic crisis has not changed the domestic equilibrium. Although the average values in many categories have interrupted the positive trend, as it was previously, in some cases the flows have stopped or reduced growth, and have reduced them by different degrees in the various regions.

#### **4. Conclusions**

Granting credit to households and businesses in the Italian context after 2008 has been affected by two major events, the international economic crisis of 2007, triggered by the financial bubble, and the prolonged recession established because of the Country's structural weaknesses. The crisis originated in the US credit market, in the choice of debtors and the credit management in banks' balance sheets. In all the affected economies there is a climate of instability and mistrust, as well as difficulties in liquidity and resource supplies, which has led banks to curb lending activities. Our analysis shows that this course is related, and causes a general slowdown in economic activity for both consumption and investments.

From the original data and the results of our analysis we observe the changes in the granting of credit by Italian banks, which has been partially displaced from productive investment to household consumption, the latter weakened by rising unemployment. Besides this change of destination, it is evident that the chances of getting resources in different areas of the Country are strong, regardless of the phase of the economic cycle. In all the graphs, we show the unchanged distinction between the regions of the north and south, the latter already disadvantaged in terms of consumption demand and opportunities for productive investment, and slowed in obtaining new resources in both the short and long terms. Our graphs clearly show (figure 1) that since 2008, the effects of the international crisis are evident in the Italian banking sector with a general slowdown in the flow of credit granted. Since 2010, loans to households have increased, while loans to businesses remain stable, and in some cases, are decreasing.

We consider the bursting of the speculative bubble, with the consequences for credit, one of the reasons for the prolonged recession, which has affected areas of Italy in different ways. The three periods we consider in our MDS analysis are characterised by different socioeconomic factors, in periods of calm and crisis, and during the prolonged downturn. In the 13 years we analyse, there remains a clear distinction between the regions of the south and those of the centre and north of Italy, which remain positioned as arranged in ascending order according to the average values available to households and businesses (figures 3, 4, and 5). The mean values of loans are higher for the northern regions, for all categories considered, and the internal "distance" remains constant before and after the crisis, and before and after the credit crunch. The structurally weaker southern areas have less access to resources for consumption and investment.

In a context of increasing uncertainty, the imposed credit restrictions, changes imposed on fiscal policy at European level and the structural difficulties in some areas of Italy, result in a long period of reduced and postponed consumption and investment, which weakens domestic demand, and causes further difficulties for productivity and the national economy.

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Enrico Baffi<sup>1</sup>

COASE VERSUS PIGOU: STILL A DIFFICULT DEBATE  
AFTER FIFTY YEARS

**Abstract**

*This paper examines the positions of Coase and Pigou regarding the problem of the externalities. From the reading of their most two important works, it appears that Coase has a more relevant preference for an evaluation of efficiency at the total, while Pigou, with some exception, is convinced that is possible to reach marginal efficiency through taxes or liability. It is interesting to note that Coase, who developed the famous theorem, was convinced that it was not desirable to reach efficiency at the margin every time, and that a valuation at the total that indicated which solution was more welfare enhancing did not warrant the efficiency at the margin. It is possible that a certain confusion exists in the work of Coase, because, on one hand, he criticized Pigou for statements about the social desirability of moving some industries away from the towns, and on the other hand, he proposed a solution that gave subject. This forfeited the possibility of a solution that was in accordance with the idea the absolute right for an activity that was incompatible with the activity of another stressed by Coase, which is that any external effect is reciprocal. It would be appropriate to say that Pigou is more Coasian than Coase.*

*Beyond this criticism, Coase argued that Pigou's tools were not in accordance with the famous theorem, according to which a public intervention is not necessary in order to obtain efficiency when transaction costs are low. However, the theorem is not an idea that can be used to say that Pigou's methods are useless when transaction costs are high. Indeed, when transaction costs are high, efficiency cannot be reached through negotiations. Nonetheless, Coase refuted Pigou's tools in every situation. It is also very strange that he not apply his theorem when transaction costs were low, while Pigou imagined a transaction between parties. Through a deep examination of the article*

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*“The Problem of Social Cost,” it is understandable why Coase was against Pigou’s tools. First of all, he considered that the Pigou’s remedy was in the compensation of the victim, which to Pigou’s way of thinking was comparable to a strict liability rule. In this situation victim does not have sufficient incentives to take precautions to minimize social costs He understood that the compensation described by Pigou could bring about moral hazard and, therefore, bring about new social costs.*

*In subsequent years, the Coase Intuition was developed and has become a pillar of tort law and economics.*

*Pigou proposed also a tax as a remedy for the external effect, and the tax did not produce a behavior of moral hazard because the victim bore the expected costs. However, Coase was diffident with regard to the tax. He had an intuition unseen in other scholars in the following years. Coase understood that efficiency should also require a tax on the victim, so that the victim considers the increased costs of precaution. In other words, Coase understood that the tax did not produce the socially optimal activity level of the parties if the costs of precaution of the victims were not considered as a component of the tax on them. Coase believed that the tools of Pigou created so many problems that they were inefficient.*

**JEL CLASSIFICATION:** B31; D62; D86; H21; K0; K11; K12; K13.

**KEYWORDS:** EXTERNALITIES, COASE THEOREM, RECIPROCAL NATURE OF EXTERNALITIES, PIGOUVIAN TAXATION, PIGOUVIAN RULE OF STRICT LIABILITY, EFFICIENCY MEASURED AT THE TOTALITY, EFFICIENCY MEASURED AT THE MARGIN.

## **1. Introduction**

Ronald Coase and Arthur Pigou have made vast contributions to the field of economic science. Indeed, without their contributions, transaction cost economics, the economic analysis of law, and the new welfare economics might not have been developed. Pigou published his last edition of *The Economics of Welfare* in 1932 (Pigou 1932). Three decades later, in 1960, Coase sent his article on the problem of social cost to the press (Coase 1960)<sup>1</sup>. Although the two economists agreed

<sup>1</sup> All quotes from Coase are from this publication.

on many aspects, such as the problem of the maximization of welfare and the proper functioning of market competition (Coase 1960, p. 35), Coase's article comes across as a strong criticism of Pigou's stance and the tradition that has developed around his writings. In fact, Coase strived to highlight a number of deficiencies in Pigou's arguments. He directed many critical comments at Pigou, one of which has subsequently been termed "Coase's Theorem".

## 2. Reciprocal Nature of External Effects

In order to propose his general view of the problem of external effects, Coase strongly emphasized that the negative external effect is reciprocal in the sense that if the exercise of an activity is limited, a cost arises out of the non-exercise of this activity. Coase stated that Pigou and his followers were not aware of this aspect. In fact, such criticism did not actually concern Pigou, even though Coase placed great importance on this comment.

Pigou proposed taxes or compensations in case of external negative effects. It is clear that he believed that the activity undergone for a tax or a duty of compensation also produced benefits; otherwise he would have created a list of activities to be banned. Pigou imagined that one of his tools would have limited an activity, but only limited, because below a certain level of activity it would be convenient to pay the tax and continue the activity that would be socially beneficial.

In a number of cases it seems that Pigou went against his own philosophy. For example, he proposed constructing factories away from towns. In such circumstances, he seemingly attributed zero utility to the factories' activities, which he defined as "antisocial" (Pigou 1914)<sup>2</sup>. For Coase this was evidence that Pigou had not understood the concept of the reciprocal nature of the externalities. Nevertheless, Pigou's judgment may have been an attempt to evaluate the efficiency on the totality, which is similar to Coase's reasoning for other occasions, i.e., not looking at the conditions of marginal efficiency. In other words, it is possible that Pigou, similarly to Coase, understood that the condition of efficiency at the margins was not always the most efficient solution for

<sup>2</sup> Pigou uses the adjective "antisocial" a number of times. Also, in Pigou's *The Economics of Welfare* (1932), the adjective "antisocial" is used (e.g., pp. 185-186).

a problem of externality. This was because it was too difficult to apply measures in order to have social benefits equal to social costs. Surely, Coase moved beyond Pigou's ideas with regard to certain tendencies of how to work out the evaluation of the welfare on the whole and not on its margins—that were not characteristic of Pigou's work. Pigou's intention was to attenuate the exercise of a particular activity that caused damages without completely eliminating the exercise of the activity of the injurer. Instead, the activity of the injurer was controlled so that the social marginal benefits coincided with the social marginal costs. It is accurate to state that Pigou is more Coasian than Coase.

Of course, when Coase looked at the totality of welfare, he was also considering the conditions of efficiency at the margins, because in this way sometimes total welfare is maximized, but he did not believe in Pigou's tools for welfare maximization. He perceived that a Pigouvian tool could have the consequences of producing social costs, and he preferred an evaluation on the total.

Coase critiqued a way of reasoning that he used many times. Moreover, Coase did not accept Pigou's tools, which were the best methods for achieving efficiency if the reciprocal nature of the external effect is taken into account.

### **3. Coase's Argument Criticizing Pigou: The Equivocal Expressions**

As previously stated, Coase read Pigouvian thought in the sense that the English economist was not mindful of the reciprocal nature of externalities. Coase essentially focused on expressions used by Pigou, e.g., when he suggested that certain activities were "antisocial" and must be expelled from cities. The adjective "antisocial" undoubtedly is an unfortunate choice, but it points to the base of Pigou's reasoning, which contained a simple opinion that sometimes an activity produces more benefit than another. Therefore, by making an evaluation of the totality, as Coase also often does, the less useful activity must be excluded in order to prevent interfering with the more useful activity. At times, Pigou evaluated the totality without verifying the conditions of efficiency at the margin, which interestingly is the method used more frequently by Coase.

We can observe that Coase dropped the way of thinking that was derived from the idea of the reciprocal nature of external effect. In the following statement, Coase is still cautious,

George J. Stigler suggests the pollution of a stream. If one supposes that the negative effect is that of killing the fish, the problem to be discussed is as follows: Is the value of the lost fish higher or lower than the contamination of the stream? *There is hardly any need to say that one has to consider this problem both within its totality and within its margin* (Coase 1960, p. 96) [italics added].

From this statement, it is possible to see that Coase, quoting Stigler, believed that it was important to assure the conditions of efficiency of the margin, but his position changes in subsequent pages of *The Problem of Social Cost*.

In the significant case of *Bass v. Gregory*<sup>3</sup>, Coase was much more pointed. In this controversy, the defendant shut off a well from which beer fumes were emanating from a vent-hole for the plaintiff's small beer producing operation. The defendant chose this action because he was nauseated by this smell. The plaintiff succeeded in winning the case by asserting that he had right of prescription. An examination of Coase's assertions brings the following declaration to mind: "It is necessary to weigh harm against the good that can derive" (Coase 1960).

In Coase's thinking, what must be decided is whether the advantage derived from preventing the damage is greater than the loss caused by the damage. A world with no redistribution costs for rights established by the juridical system decisions can be actually based on the equity issue, and a determination of how resources are to be used in cases of nuisance are decided through negotiation (Parisi 2007)<sup>4</sup>. This is the consequence of the Coase theorem, but since transaction costs exist, judges must allocate in the right way to obtain the best solution<sup>5</sup>.

In his work Coase denotes a tendency to reason in the way Pigou sometimes reasoned and that Coase criticized. It is a way of reasoning

<sup>3</sup> *Bass v. Gregory*, Law Report-Queen's Bench Division (1890), Vol. 25, p. 481.

<sup>4</sup> Parisi offer a comprehensive explanation of the theorem and describe many criticisms that have been developed over the years.

<sup>5</sup> This idea was then developed after Coase article by Calabresi and Melamed (1972).

that wants to find the best solution and the totality and is not concerned with a result of efficiency at the margin.

In writing a comment about the decision, he states, “The economic problem is that of deciding which to choose a lower cost for beer and a worsened amenities in adjoining houses, or a higher cost of beer and improved amenities (Coase 1960, p. 114)”. The well from which the smell of beer was emanating was connected to an underground channel from a small beer producing center. The judge declared that the defendant possessed prescription rights and was thus permitted to allow the smell to emanate. Coase maintained that the problem in the case of *Bass v. Gregory*<sup>6</sup> was that the air from the well made the production of beer easier, but the sour air expelled by the well made life in the adjacent houses less pleasant. The economic problem consisted in the choice between a lower cost for the beer and less comfort in the neighboring houses or a higher cost for the beer and greater comfort. It is important to note that Coase reasoned in a way that had previously made him the subject of criticism when used by Pigou. He considered whether to stop all activity or to allow any level of activity (Cooter 1998, p. 457)<sup>7</sup>. He did not try to propose a solution that assured efficiency at the margins. He looked at two possible solutions: the activity must be completely stopped or the activity is totally legal. It is the same reasoning as when Pigou proposed to move certain industries out of the towns. In fact, it was a way to give an evaluation that looked at the total, because an evaluation based on the obtainment of efficiency at the margin could determine other costs so that the solution would not be the best one.

Simplified reasoning seemed to emerge in Coase’s arguments. In this case, the homeowner found himself faced with beer-tinged air, which compromised the quality of life for the surrounding households. The question of how the rights were to be divided was decided by judges. However, having been reminded of the institution of prescription, these judges recognized the right of the beer producer. Coase could have raised the following two criticisms that Pigou would possibly have made: 1) One should in fact be the decision whether it was possible

<sup>6</sup> *Bass v. Gregory*, Law Report-Queen’s Bench Division (1890), Vol. 25, p. 481.

<sup>7</sup> Cooter states that the article of Coase is similar to a judge’s opinion, “for every interpretation of his original paper there is a plausible alternative”.

to dictate certain hours during which the fumes could be let out, thereby creating lesser damage, and 2) One can establish the maximum quantity of air than can be released. Moreover, the costs could be minimized by introducing other fine regulations. In other words, in this case it would be possible to find prescriptions that guaranteed an equilibrium between marginal benefits and marginal costs, but Coase did not mention this problem. These are simple questions that can have a solution that equals marginal benefits with marginal costs.

Coase continues in the article to reason in the same way. He states,

The problem which we faced in dealing with actions which have harmful effects is not simply one of restraining the action of those responsible for them. What has to be decided is whether the gain from preventing the harm is greater than the loss which would be suffered elsewhere as a result of stopping the action which produced the harm (Coase 1960, p. 151).

Coase's declaration cannot be considered inexact in itself because alternative social organizations can provide major or minor social benefits. Nevertheless, it represents the refusal of Pigou's rigorous principle of seeking the conditions of efficiency at the margin using compensation for damages and Pigouvian taxes. Coase, writing these declarations of principles said the same thing the Pigou said when he proposed to move the industries out of the towns.

The last case considered by Coase concerns the rabbits that move from one piece of land to another.

Coase says that it would be undesirable if the legal system fixed the rule of liability at one pole. He says that from an economic point of view fixing the rule at one pole would be inefficient. He stated, "Given that transaction costs make arrangements of rights impossible unless we know the particular circumstances *we cannot say whether is desirable or not to make the man who harbors rabbits responsible for the damage committed by the rabbits on neighboring properties*" (Coase 1960, p. 147).

In this sentence Coase is very clear: the most efficient solution would be one which allowed the harboring of rabbits without any limitations. The victim's suffering should be overlooked, and efficiency could require a solution at one pole. The loyalty to the idea that since external

effects are reciprocal, an activity must be banned or totally allowed is abandoned. Coase looks at the efficient solution, and in this case, it would be not considering the efficiency at the margin.

Once the misunderstanding of Pigou's statement is solved, we can consider the arguments against Pigou. The first criticism is the famous theorem

#### **4. The Coase Theorem**

When an activity produces an external effect, Pigou thinks that a tax or a rule of liability must be introduced. Coase shows that in situations where transaction costs are low, the inefficiencies are resolved in a natural manner. For example, if a judgment does not recognize the right of A, which he values at 30, and recognizes the incompatible right of B, which he values at 50, the right remains the property of B.

Yet, if the court finds that the right belongs to A, who values it at 30, and does not recognize the right of B, who values it at 50, B acquires the right from A (Johnson, Shleifer 1999, p. 3)<sup>8</sup>. For judges it is not possible to push forward their own economic policy. This fundamental observation constitutes the so called "Coase's Theorem" and is tied to the reciprocal idea of external effects. The benefit of one entails a cost for the other. He shows that damage to A is a benefit to B and vice versa. Coase theorem says the in absence of transaction costs parties, through negotiation, reach the efficient result, and this result is the same independently from the initial allocation of rights (Parisi 2007).

In this situation, the criticism of Pigou is that through the negotiation the efficiency is reached, and Pigouvian methods are unnecessary. Pigou clearly stated that an activity should not be completely eliminated, but he proposed a tax or a compensation to obtain an efficient solution. Pigou did not discover that in situations where transaction costs are low his tools are unnecessary. Pigou had not discovered that an inefficiency could be eliminated through contracts between parties involved. Coase would later explain this in his article.

<sup>8</sup> The possibility of exchange through contracts can be difficult because "in many counties, courts are underfinanced, unmotivated, unclear as to how the law applies, unfamiliar with economic issues, or even corrupt".

The first criticism is that in low transaction cost efficiency is reached through negotiations. This partially explains Coase's diffidence regarding Pigou's ideas, and, as a consequence of this diffidence, the famous theorem teaches us that Pigou's methods are wrong when transaction costs are low. However, it does not say anything about the possibility of using Pigouvian methods when transaction costs are high.

So why did Coase refute Pigouvian tools in situations of high transaction costs? In other words, why did he refute the tools that assured efficiency at the margins when transaction costs were high?

## **5. The Moral Hazard Problem**

Coase presents cases in which the two Pigouvian systems generate poor results. More specifically Coase puts the victim in evidence. The legal system, according to Pigou, should state that the victim of an activity should be compensated. Coase explains that the externality is the production of the two activities of the two subjects and that the amount of the damage depends on both parties. With the system of Pigouvian compensation, the victim is completely insured against any damage the other party can cause, and for this reason the victim does not take precautions to avoid or mitigate damages. It is possible to say, synthetically, that the Pigouvian tool of compensation brings about a behavior of moral hazard on the part of the victim.

Coase asserts that the victim plays a role in the damages, and that role has a very important influence. Indeed, he showed the necessity of being clearly aware of the problem with regard to the case of rabbits that trespassed onto the neighbor's land. He believed that the possible solution was twofold. First, the activity must be completely forbidden, and second, the activity must be completely legal. Coase's reasoning depends on the comprehension that the moral hazard problem that can derived from the Pigouvian rule of compensation, in other terms, from the strict liability rule. Undoubtedly, Coase has an intuition about efficient tort rule that is not present in Pigou's arguments. Pigou imagined a rule of pure strict liability, and strict liability as the cause of much inefficiency.

Coase argued that if one were to require the owner of the rabbits to pay the full compensation for the damage, the victim would ignore the fact that he was also partially responsible for the damage. He further asserted that the negative external effect, in its totality, also depends on the action of the victim. Recent tort doctrine says that the victim must also take precautions in bilateral accidents. Coase had anticipated an important indication of law and tort law and economics. Years later scholars would discover that rule like simple negligence, strict liability with a defense of contributory negligence and other tort rules could cause the victim to take precautions, but at the time of Pigou the idea was strict liability. Victims did not have incentives to take precautions or to control their level of activity. A rule of strict liability pushes the victim to produce without considering the possibility of taking precautions against the negative effects that come from the fields of the neighbor. Efficiency, instead, requires that the victim take precautions. Efficiency requires also that the level of activity be controlled. Coase stated, "The reason does not lie in the man constructing tunnels for rabbits being solely responsible for the damage, but responsibility lies also on the man whose production has been eaten" (Coase 1960, p. 151).

Coase recognized that the problem of precautionary costs that the victim should bear is an important component of liability. However, he did not consider the fact that since the externalities are symmetrical, as he himself affirms, and since the owner of the rabbits pushed the production to the point where the net marginal private benefit was equal to zero, the solution is at one pole, and it is not compatible with the idea of the reciprocal nature of external effects.

Coase explained that externality affects are reciprocal. At one point he says that Pigou was wrong when he indicated that some industries should be taken out of the towns. At another point he suggested some methods to obtain efficiency that were similar to the ideas of Pigou about the industries. Indeed, Coase maintained the possibility that a rule that permits having as many rabbits as the owner wants could be efficient. This means that the owner could be allowed to increase the number of rabbits until the marginal benefit is zero. Since the neighbor suffered damage, accepting the idea that an activity that is incompatible with another one can be pushed until marginal cost is zero means that the

costs to the victim are not being considered. For Coase it was clear that the neighbor suffered a cost when the owner of the rabbits put a great number of rabbits on the land, but Coase loses coherency with his idea that external effects are reciprocal, because he is convinced that is necessary to look at the total rather than at the margin to obtain the most desirable result. Coase reasoned in the same way that Pigou had reasoned about “antisocial” industries and this made him the subject of criticism.

It can be said that Coase is more prone to make an evaluation of the total than Pigou, and that means that the reciprocal aspect of externality is not the first principle to take in mind. Instead Pigou is convinced that the efficiency at the margin is normally the best result for society. So Pigou is more loyal to the idea of the reciprocal nature of an external effect than Coase. As said previously, Pigou is more Coasian than Coase.

The Chicago economist is correct when he puts into evidence the risk of moral hazard. The consequences that he develops are many times more important when looking at the total welfare rather than the conditions of efficiency at the margins. This means that the reciprocal nature of externality is not an absolute obstacle to allow an activity without limits or to totally forbid others. Pigou had some good reasons, which reflect Coase’s thinking, to say the some industries should be moved out of town.

Moreover, this criticism is not sufficient cause to abandon Pigou’s ideas, even if we do not consider that Coase looks at the total rather than at the margin..Coase understands an aspect of Pigouvian way of thinking that has a great importance.

He states,

Since it has not been proposed that the proceeds from the tax should go to those who suffer the damage, the solution is not the same as that which obliges an undertaking to pay compensation for damage to the objects damaged by its actions, even if the two solutions were to be treated as identical (Coase 1960, p. 151).

Coase’s observation is correct, but something must his opinion must be clarified. First of all, Coase began his article by examining

the hypothesis of compensation of damages and then discussed the judgments that he considered socially desirable. These judgments assign a right to one party without indemnifying the other one. A similar situation is created by a Pigouvian tax, which does not provide the same solution as in the case in which injurers are obliged to pay compensation for damages to objects that are damaged as a result of their actions (Buchanan, Stubblebine 1962)<sup>9</sup>. The second aspect that emerges from this way of reasoning is that something very different exists between the two tools. With compensation, injured has no interest in taking efficient precautions because she will be totally compensated. So a problem of moral hazard emerges and social costs increase. However, in the case of the Pigouvian tax, the injured bears the expected cost (he is not compensated) and, therefore, it is in the victim's best interest to take efficient precautions. The criticism that Coase makes is of the compensation tool, but it is not a criticism of the Pigouvian tax. This tool does not create a problem of moral hazard, so it can be used to obtain efficiency. Coase also refutes the second tool of Pigouvian tradition. He seems to contest some Pigouvian ideas that he had discovered.

With reference to the problem of the rabbits that invade another's territory, Pigou affirmed (Pigou 1932, p. 185), "... [if] *the two occupants find themselves in the situation of lessee and lessor, ... a compensation can be realized through an adjustment of the rent...*" Here Pigou applies Coase's theorem; i.e., transaction costs are low in the case of the lessee and the lessor, and one can thus negotiate until efficient levels are reached. Yet, instead of admitting that Pigou's concept of costs of negotiation is correct, Coase puts forward a strong criticism of Pigou, proving that the problems of the rabbits arise generally between the lessee and the lessor. In this way, Coase affirmed either that the transaction costs were always high, even in a situation of bilateral monopoly, or he decided mysteriously not to apply his theorem.

The injurer and victim, that is, the lessee and lessor, can reach a mutually optimal solution for the problem of the rabbits through the contractual agreement, because transaction costs are normally low. This case resembles an application of Coase's theorem in which the costs of transactions are low, thereby making an efficient agreement

<sup>9</sup> Buchanan and Stubblebine, offer a good reason to say that a Pigouvian tax cannot work well.

between the parties possible. This is an application of Coase's theorem in as much as the costs of transaction are low and the parties can negotiate until they reach an efficient allocation of the resources. Nevertheless, Coase does not agree with this approach. Indeed, Coase's theorem shows great awareness and certainly provides one of the most important innovations of economic reflection. Yet, the real world is a world based on positive costs of transactions; therefore, negotiation is generally impossible, as Coase seems to admit (Pigou 1932, p. 354). But it also seems that Coase wants to contradict Pigou in every argument.

## **6. Coase Criticizes The Difficulty Of Applying Pigouvian Taxes**

A further criticism made by Coase regarding Pigou's thinking suggests that apart from the hardly comprehensible criticism in which Pigou would not consider the benefits of those activities that also cause damages, it becomes very difficult, if not impossible, to reconnect a tax or compensation to every activity that is incompatible with another one. In this case, Coase's criticism appears somewhat convincing although not completely. An enlightened legislator would use Pigou's instruments when possible, would evaluate the total, following Coase's thinking when this is the most efficient solution, and would let the market function on its own when the transaction costs are low. Consider an undertaking that generates the following four liquid waste items that should be discarded. These four sources of pollution could be controlled quite well with the methods of controlling externalities that have been considered: 1) a valuation of costs and benefits in the total; 2) free transaction between polluters and victims; 3) a Pigouvian tax; and 4) a system of compensation of damages. In many ways these ideas reflect the views of Pigou and Coase. It is important to also consider regulation, which can be seen as a fifth tool for the result of an efficient situation.

## **7. Coase's Personal And Unique Intuition**

Until now, Coase's thinking has been examined according to the instruments already known in the economic analysis of law. Coase is

afraid of the behavior of moral hazard and cannot rely on the tool of strict liability.

However, Coase has an exceptional insight that must be further considered by scholars. To take an example, he imagines a factory that has to pay 100 for the pollution it produces. But it can install a filter that costs 90. The choice of installing the filter appears to be the efficient solution. Nevertheless, it might not be. If the neighbors can move at the cost of 40, it would be more efficient for them to move rather than have the factory purchase and install the filter. Therefore, it would be efficient if these residents paid a tax equal to the cost of precautions at the factory; otherwise they would choose to stay in that place without considering the cost to the factory.

Coase's presented problem has wider implications. Should the victim pay the precaution costs of the factory? If the victim does not pay, it will not bear the total social costs. So its level of activity will be inefficient. In this way, the factory bears all the social costs and maintains an efficient level of activity, but the victim, who considers only his precautionary costs, maintains a level of excessive activity. It is a second-best solution, and it is important to determine which tool is more practical. However, when the opposite situation is examined, the factory is responsible only for its fault, and the victim must pay a tax equal to the increment of the cost arising from his/her presence. In this case, the victim bears his own costs of precaution and expected damage and takes into consideration the level of activity, and the factory bears only the costs of precaution but not the expected damage, because he will be diligent. The intuition of Coase is very important. Only when victims pay for the costs of precaution caused to the injurer they internalize all social costs. And injurers internalize all social costs if they pay a tax equal to the expected damage.

Finally, it can be stated that it is important to outline that Coase puts in evidence that party victims bears all social costs if they also bear the precautionary costs of the other party; otherwise, the private costs do not equal the social costs and the level of activity is excessive.

## 7. Conclusion

In his famous article Coase makes some criticisms of the Pigouvian tradition. Many ideas are convincing but his pessimism toward Pigouvian tools reaching efficiency seems excessive.

He considers some of Pigou's statements about "antisocial" industries and states that the external effect is reciprocal. For this reason an activity cannot be said to be antisocial. However, in the course of his reasoning the father of the idea of reciprocal nature of externality, which means that an activity cannot be allowed without limits and cannot be banned, becomes more prone to make valuations at the total than Pigou does. Making evaluations on the totality means that the condition of efficiency at the margin is not respected. So activities can be banned or totally disallowed. In other words the principle of the reciprocal nature of external effect is abandoned many times by Coase. Again, Pigou appears more Coasian than Coase.

We have underlined that Coase discovered two problems with Pigouvian methods.

As far as compensation methods, Coase understands that a problem of moral hazard emerges. With this possibility of social loss the compensation method does not bring efficiency. In regard to the tax, Coase find a different reason to oppose this method. Indeed, with the tax the victim is not victim is not compensated. But Coase has the awareness that the Pigouvian tax is an insufficient tool for the legal system wanting to promote efficiency. Indeed, with a single tax on the injurer, the victim does not consider the cost of precautions that the injurer must bear if the victim decides to "come to the nuisance". Coase understands that two taxes are necessary. More generally we can say that efficiency is obtained if victims also internalize the costs of precaution of injurers. So the single Pigouvian tax does not promote efficiency. A double taxation is necessary.

For further research, there are fields that could be the subject of important investigations. Particularly, it would be interesting to determine if, theoretically, a tax really should be asked to victims of an negative externality in order to control their level of activity and, practically, if this solution is possible. It's also important to understand

if the injurer must bear victims' cost of precaution. Coase considers only the case that victims must bear injurer cost of precaution, but if efficiency requires that both parties bear all social costs, injurer should bear also precaution costs of the victims.

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## THE AGEING PROCESS AND THE ITALIAN LABOUR MARKET

### Abstract

*The aim of this paper is to evaluate the role of the ageing process in the current age, where research activity is an expression of the characteristics of the human capital engaged in economic performance. The empirical evidence based on data about the Italian labour market, as a case study representative of the progressive ageing process in the last twenty years, shows an enlargement of the relative number of older workers at a high level of development and a higher supply of young labour when economic growth is fast. These results encourage the idea of evaluating the demographic dynamics on economic growth, with a Schumpeterian approach that captures the combined effect of experience and cognitive abilities linked to the age structure of employees and its influence on the capacity to generate new ideas.*

JEL CLASSIFICATION: J11, J40; O30; O40; O47;

KEYWORDS: DEMOGRAPHIC DYNAMICS, HEALTH, LABOUR MARKET, GROWTH, CREATIVITY

### 1. Introduction

The population ageing process, despite progressive health enhancements, is one of the main concerns debated in most developed countries.

By emphasizing the role of innovation, with reference to people's capacity to cope with a rapid change in technology and their ability to innovate, **this paper investigates the effects that the level of economic**

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development and its growth rate may produce on the occupational distribution among different age groups of employees.

The empirical evidence based on data about the Italian labour market, as a case study representative of the progressive ageing process in the last twenty years, inspired by an advanced economy, encourages the idea of evaluating the demographic dynamics on economic growth, with a Schumpeterian approach that captures the combined effect of experience and cognitive abilities linked to the age structure of employees and its influence on the capacity to generate new ideas.

The paper is structured as follows. The theoretical background fosters the idea that the ability to introduce new ideas is subject to age-related changes showing a decreasing trend throughout the lifespan. The second section shows two OLS (Ordinary Least Squares) regressions of the relative occupational distributions of three different age groups (young, adult and old age), compared two at a time and the level and rate of GDP per capita in Italy. The third part refers to a new perspective by which to analyze the relationship between the ageing process and economic growth. The fourth section concludes with policy implications.

## **2. Theoretical background**

Demographic dynamics, which is a consequence of changes in both fertility and mortality decline, is a health-related theme that can be considered one of the principal objectives of every government as it can affect the income level and economic growth rate of a country through a number of mechanisms.

One of the fundamental aspects of the link between health and economic growth is based on the fact that health, by influencing physical and mental capacities of an individual, is considered a determinant of human capital, which, in the context of Endogenous Growth Theory, results in a crucial driver of economic growth (Howitt, 2005). Macroeconomic studies of the effect of population health on economic growth and development are based on a production function approach that explains the GDP growth rate. Coherently with the theory, the empirical regression approach aimed at examining the impact of health on economic growth, based on cross-country or panel data, gives much evidence of the positive influence that

enhancements in the state of health, exemplified by life expectancy and adult survival rate, exercises on GDP growth rate (Anand and Ravallion, 1993; Becker *et al.*, 2005; Bhargava *et al.*, 2001; Bloom *et al.*, 2004; Weil, 2007). Nevertheless, the effect of better health seems to be larger for low and middle-income countries. This result can be attributed to the fact that high-income countries have already achieved high standards of living. It follows that health inequalities and the gap in living standards across countries can represent one of the causes of the disappointing economic performances in rich and poor nations.

Health enhancement has been one of the main determinants of the demographic change that has characterized all countries in the world, although at different rates and times. There is no doubt that better health conditions can affect mortality, fertility and life expectancy. These are the principal elements that determine demographic transition; the process characterized by a shift from a regime of high mortality and fertility rates to a regime of low mortality and fertility rates (Bloom *et al.*, 2003). There are several distinct phases in demographic transition that can foster economic growth, or hinder it, considering the variation of population growth rate that, over time, causes modifications in the dimensions of a population, its density and its age structure. It seems appropriate to underline that besides the impact of health on many behavioural aspects related to economic variables, which include saving patterns, labour force participation, investment and skill formation, these demographic aspects must be incorporated to better specify the analysis of economic growth and development.

Economic literature about the effect of demographic change on economic growth has been primarily based on a pessimistic view of the effect of population growth on economic growth, based on the negative effect on saving rate and allocation of resources (Coale and Hoover, 1958). A more optimistic view of the influence of population growth has spread since the last decades of the twentieth century with the emerging importance attributed to human capital in the economic growth process, which can promote technological progress. In fact, as populations increase so does the stock of human ingenuity (Kuznets, 1960, 1967). Considering technological change, the relationship between demography and economic growth can become positive (Simon, 1981).

Bloom *et al.* (2003) suggest that in order to properly evaluate whether population growth can foster or negatively affect economic growth, one cannot ignore the most important variable of population age structure: the manner in which a population is distributed across the different age groups and how it changes when the population grows. In fact, the age structure of a population and the age structure of a labour force can influence the productivity growth assuming that changes in the proportions of different age groups not only act through the saving rate and the investment in physical capital but also through the incidence on the aggregate human capital.

Lindh and Malmberg (1999) furnish a framework of an age structure augmented neoclassical model with gradual technological adjustment. Their framework is based on the transitional growth model developed by Mankiw *et al.* (1992), who assume that human capital is produced by educational investment alone. Giving evidence from microeconomics that experience plays a key role in human capital formation, Lindh and Malmberg claim that at the macroeconomic level, there is a high probability that an experienced workforce can augment the level of human capital of a country, all things being equal, with respect to the level of human capital available in a country with an inexperienced workforce. Thus, they insert in the model an experience effect on aggregate human capital through a composite measure of human capital by interacting the stock of educational capital with a Cobb-Douglas Index,  $N$ , of the age structure.

Further studies also suggest that the population age structure is a crucial factor in the explanation of the productivity growth as it can affect the creative capacity of a country and its absorptive capacity, assuming that the generation and the implementation of new ideas vary with age (Feyrer, 2004). It can lead to disparities in the ability to converge on the technological frontier, and also in the economic growth rate.

Demographic change focuses on if, how and to what extent innovative activity depends on the population age structure, principally of the labour force.

Considering the progressive ageing process of the population in most of the advanced economies that are in the last phase of demographic transition, attention has focused on the studies that analyse the variation

of cognitive capacities of individuals with age, assuming that it can have relevance in a deeper specification of human capital. A large consensus exists about age-related differences in cognitive functioning. Age-related studies describe a general downward development trend in cognitive capacities such as memory, reasoning, spatial visualization and speed of information through life with the increase of age among healthy and educated individuals (Hertzog *et al.*, 2009; Salthouse, 2009). This evidence is consistent with the view of Cattell (1963), who since the last century has identified two types of cognitive abilities: fluid intelligence (Gf) and crystallized intelligence (Gc). Fluid intelligence refers to cognitive functioning such as attention span, processing speed, reasoning, working memory capacity and spatial ability, which are relatively independent of education and acculturation. Crystallized intelligence is the main expression of influence of education, experience and acculturation. Fluid intelligence is expected to decline with age; on the other hand, crystallized intelligence tends to be higher at older age (Cattell, 1963). In this regard, an important aspect related to cognitive abilities and of crucial importance for the innovation rate of a country and its economic growth performance is creativity. Studies show that creativity, as the capacity of an individual to generate new ideas, also changes with age. In fact, the maximum level of creative activity is reached at some point in adulthood, generally in the twenties and thirties, although variability in creative achievement between disciplines is evident, and it is followed by a subsequent irreversible decline in succeeding years (Dennis, 1966; Lehman, 1953). It is evident that if creativity can be positively affected by a better state of health (Howitt, 2005), one cannot leave out of consideration the combined effects of age.

### **3. Different age groups and the Italian labor Market**

Italy is one of the countries where the demographic dynamics are causing a progressive ageing process in the population. This section analyzes how the level and rate of economic development influence the occupational distribution of three age groups in a period that runs from 1995 to 2012.

The age groups considered are named as follows: *young*, i.e. people

aged between 15-34; *adult*, i.e. people aged between 35-44; *aged*, i.e. people aged between 45-64.

To measure the relative occupational distributions of age groups, the ratio of the rate of employment of particular age groups will be used; that is what Cohon (1982) defines as the age-group concentration ratio ( $A_{ij}$ ):

$$A_{ij} = [(O_i/P_i)/(O_j/P_j)]$$

where  $O_i$  and  $O_j$  are the number of workers from age group  $i$  and  $j$ , respectively; and  $P_i$  and  $P_j$  are the population sizes of age groups  $i$  and  $j$ , respectively. The analysis may be more interesting if we investigate the effect of the level and the rate of GDP per capita on the ratio through its components (Cohon, 1982). That is, taking into account the logarithmic form of the age group concentration ratio:

$$\ln A_{ij} = \ln OC_{ij} + \ln EC_{ij}$$

$$\text{with } [A_{ij}] = [(O_i/P_i)/(O_j/P_j)] = [(O_i/E_i)/(O_j/E_j)][(E_i/P_i)/(E_j/P_j)] = [OC_{ij}][EC_{ij}]$$

where  $E_i$  and  $E_j$  are the number of workers of age  $i$  and age  $j$  who are economically active;  $OC_{ij}$  is the occupational component, the ratio of the proportions of economically active workers;  $EC_{ij}$  is the economic activity component, the ratio of the proportions of the age groups who are economically active. The following three equations will be estimated by an OLS regression:

$$\begin{aligned} \ln A_{ij} &= \alpha_0 + \beta_0 \text{GDP}_{\text{CAP}} + \gamma_0 \text{AGDP}_{\text{CAP}} \\ \ln OC_{ij} &= \alpha_1 + \beta_1 \text{GDP}_{\text{CAP}} + \gamma_1 \text{AGDP}_{\text{CAP}} \\ \ln EC_{ij} &= \alpha_2 + \beta_2 \text{GDP}_{\text{CAP}} + \gamma_2 \text{AGDP}_{\text{CAP}} \end{aligned}$$

where  $\alpha_0 = \alpha_1 + \alpha_2$ ,  $\beta_0 = \beta_1 + \beta_2$ , and  $\gamma_0 = \gamma_1 + \gamma_2$ .

Table 1 shows the results of the two OLS regressions performed on data from ISTAT database. The first one refers to the concentration ratio between *aged* and *young*, the second one between *aged* and *adult*.

There is a positive relationship between the level of GDP per capita and the proportional representation of the *aged* in occupational groups ( $0.18 \times 10^{-4}$ ). This representation of the *aged* is a result of a higher rate of economic activity among the aged with respect to the *young* age group

( $0.21 \times 10^{-4}$ ). This result could be related to the fact that, on the one hand, at a high level of economic growth, if young people spend more time in educational activity, such as attending academic classes or Master's programs, then their entry into the labour market may be late; on the other hand, the socio-economic condition shows a delay in going out to work. By comparing the 45-64 age group with the *adult* one, the data show an under representation of the former; the source of this effect lies in the negative relationship between occupational component (OC) and GDP per capita, which shows that at a high level of GDP per capita the most populous group of workers, relative to the amount of workforce in the same group, belongs to the *adult* age group.

**Table 1: OLS estimates**

$A_{ij}$	Aged/Young		Aged/Adult	
	Coefficient	S:E:	Coefficient	S:E:
Intercept	-0,33	0,25	-0,65	0,12
GDP per capita at current prices	1,77E-05	9,81E-06	-2,78E-06	4,84E-06
$\Delta$ GDP per capita at current prices	-1,91	1,15	-1,04	0,57

$OC_{ij}$	Aged/Young		Aged/Adult	
	Coefficient	S:E:	Coefficient	S:E:
Intercept	2,40E-01	6,48E-02	4,51E-02	0,031187671
GDP per capita at current prices	-3,24E-06	2,54E-06	-1,64E-05	1,22E-06
$\Delta$ GDP per capita at current prices	-0,52	0,30	-0,25	0,14

$EC_{ij}$	Aged/Young		Aged/Adult	
	Coefficient	S:E:	Coefficient	S:E:
Intercept	-0,57	0,19	-0,70	0,11
GDP per capita at current prices	2,09E-05	7,50E-06	1,36E-05	4,19E-06
$\Delta$ GDP per capita at current prices	-1,39	0,89	-0,79	0,49

Source: personal elaboration on ISTAT data

By analyzing the effect of the rate of development on the occupational distribution, there is a negative relationship between rate of growth of GDP per capita and the *aged* rate of occupation; this occurs both with respect to the *young* group (15-34 age group) and the *adult* group (35-44 age group) and three quarters of this is attributable to the rate of activity component. This result could be interpreted in the sense that at higher rates of economic growth those occupations requiring high capabilities to cope with innovations, i.e. young workers with high skills, register an increase. On the other hand, when economic growth is fast, a young labor market supplies higher growth.

Those results are of great interest in evaluating the role of the age structure of a population from a Schumpeterian perspective, evaluating the effect of the ageing process that characterizes most advanced economies on innovation capacity and, hence, productivity growth. This analysis gives life to the idea of testing the hypothesis that a variation in the age structure of the employees in skill intensive activities could affect the research efficiency of a country and then its age structure may be considered as an additional element that can affect the productivity growth, as, given all other conditions, it becomes an expression of the characteristics of the human capital engaged in economic performance. The next section introduces a Schumpeterian perspective of this process.

#### **4. Ageing process and growth: a new perspective**

The results as described above makes us think about the ageing process and the current age, where immaterial factors such as innovation, technology and knowledge play a crucial role. Human capital accounts for a major part of a country's economic growth (Castagna *et al.*, 2013; Castagna and Furia, 2010; Furia *et al.*, 2010). Creativity, as the ability to produce new ideas, becomes a crucial resource as a constitutive element of human capital. Age-related studies describe a general downward development trend in cognitive performance across a lifetime, starting in early adulthood, and an individual's creativity changes.

The relationship between health, age structure and research efficiency of employees in skill-intensive activities could be studied with a Schumpeterian approach. Better health conditions generally accompany

the demographic change and affect, in this manner, the age structure of a population. It is agreed that health and age can influence a qualitative aspect of human capital, i.e. creativity, related to cognitive capabilities, as there is no doubt that healthier individuals are more efficient in generating new ideas than sick or starving ones (Howitt, 2005). In those countries where there is a high life expectancy at birth, it is necessary to take into account the natural decline of cognitive capabilities during the lifespan of the individual despite a good level of health. It follows that population age structure and cognitive ability are interlinked with each other, and both influence the efficiency of skilled intensive activities and, therefore, economic growth.

Taking into account the cognitive decline over a lifetime as people age, it could be interesting to evaluate the effect of the population ageing process on economic growth by looking at the implications for the country's innovation technology.

Technological progress, which represents the driving force of long-term economic growth, takes place through innovations. Investment in R&D also plays an important role. In this context, great importance may be attributed to research efficiency, which expresses the productivity of R&D investment and can benefit from better employee health (Howitt, 2005).

To this effect, the possible link between research efficiency and population age structure, especially of the labour force, will be explained. In fact, even though an enhancement of health, generally associated with longer life expectancy, positively affects the research efficiency of a country as it increases the level of human capital and its efficiency, it is also essential to consider that with good health conditions, associated with low adult mortality rate and low fertility rate often under the replacement level, comes a variation in the age distribution of a population and a progressive ageing process that, in turn, can affect the aggregate research efficiency.

These considerations allow us to consider that there is a positive independent age effect on innovative activity by assuming that creativity or research efficiency increases with age because of the increase of experience during the working life. However, it could happen at a decreasing rate due to the decrease of cognitive abilities across the life span. During his life an individual can benefit from an increase in his

experience, but, at the same time, he has to face a decline in cognitive abilities as he grows older. At an aggregate level, this will mean that as the age structure of the labour force changes, there is a change in research efficiency. As the average age of the labour force increases, with a higher proportion in older age groups, the research efficiency of a country also increases, but to a lesser extent.

This hypothesis will be examined in depth in future papers.

## **5. Conclusions and policy implication**

The influence of demographic variables in the explanation of economic phenomena is often the subject of attention for researchers both to outline the opportunities for economic growth and to evaluate the sustainability of economic policy proposals.

Many industrialized countries, such as Italy, are now characterized by an intense ageing process, which is particularly important in view of its social and economic consequences. The ageing population process goes with the modernization of occidental societies. The two main causes identified are continual lower fertility and birth rates, often under the replacement level, that are a consequence of cultural and social changes, and a longer life expectancy associated with lower adult mortality, mainly due to better health conditions.

The European Union<sup>1</sup>, since the beginning of the twenty-first century, shows an historical overturning in the relative proportions of young and old people, due on the one hand to the improvement in general well-being, which has considerably increased life expectancy, and, on the other hand, to low fertility. This phenomenon is extremely prevalent in Italy.

By performing an OLS regression on an ISTAT (L' Istituto Nazionale di Statistica) database that covers a period from 1995 to 2012, this paper analyses the occupational distribution among different age groups. The principal result shows on one hand an ageing process that affects employees when the level GDP per capita is high and on the other hand, high rates of growth induce an increase in a younger labour supply. Both those results are consistent with the fact that fast technological

<sup>1</sup> This refers to EU-27

progress requires a high capability to cope with innovation, typically met through the young with recent and widespread education, but, with the most recent policy reforms in the labour market context directed at the deferment of retirement age, are also related to a longer and safer life. Such a policy may imply that the variation of relative productivity of a country can always be lower.

A country should establish labour market reforms that promote the occupation of a young workforce. This can lead to a bigger increase in relative productivity by deeply influencing the research efficiency of a country with respect to the other age groups and by making more efficient use of a larger R&D expenditure that is at the basis of the innovation rate of a country and its absorptive capacity. Obviously, this leads to the crucial importance of continually investing more in the fields of health and education, key elements of development.

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In the latest centuries, generally speaking, history records the alternation of some important seasons which lend themselves to represent economic models, which are the bases of modern economic thought.

First of all, there is the age of *colonial economy* centered on the role of imperial states, together with the birth of monopolistic companies, in the management of trades with dominion areas.

Then, the age of *international economy* was lived, culminating in the second post war trade relation system. It was mainly founded on the functions of the national states and their authorities to support both national expansionary fiscal policy and exchange clearings, in their trade ratios with the rest of the world.

At last, in the latest years, *interglobal economy* took vehemently the lead through the modern electronic infrastructures of telematic and telecommunications.

As the former models, the *interglobal economy* too does not automatically assure either stable equilibrium or the overcoming of traditional crises.

It gives benefits and disadvantages too.

From the normative and positive points of view, one of the disadvantages which most drew the attention of researchers is the weakening and disappearance of national and subnational economic and monetary policy instruments.

Instead one of the benefits which most attracted interest might be located on the nature itself of the technological revolution in progress, foreboding new opportunities in the integration process of local economic systems, which might qualify themselves as network growth links (or growth poles?).

The Review has the aim to represent and to inquire the normative and positive profiles of the fundamentals which might characterize the thin and difficult frontier between globalization and economic localism.



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