**DOCUMENT DE TREBALL**

**XREAP2012-01**

# Evaluating antitrust leniency programs

Joan Ramón Borrell (GiM, XREAP)
Juan Luis Jiménez
Carmen García

# EVALUATING ANTITRUST LENIENCY PROGRAMS[1]

Joan Ramón Borrell[2] Juan Luis Jiménez[3] Carmen García[4]

January 2012

**Abstract**

This paper identifies and then quantifies econometrically the impact of leniency programs on the perception of the effectiveness of antitrust policies using country level panel data for a 10-year span. Leniency programs have been introduced gradually in antitrust legislation across the globe to fight more effectively against cartels. We use the dynamics of the diffusion of such policy innovation across countries and over time to evaluate the impact of the program. We find that leniency programs have had a significant impact on the perception among the business community of the effectiveness of each country's antitrust policy. Leniency programs have become weapons of mass dissuasion in the hands of antitrust enforcers against the more damaging forms of explicit collusion among rival firms in the market place.

**Keywords:** Antitrust; Policy effectiveness; Political economy

**JEL Codes:** D7; L4; O4.

---

[1] The authors thank the International Institute for Management Development (IMD), in particular Dr. Suzanne Rosselet, for supplying the data used in this study.

[2] Dep. de Política Económica - Institut d'Economia Aplicada (IREA) - Grup de Governs i Mercats (GiM), Universitat de Barcelona, Carrer Tinent Coronel Valenzuela 1-11, Spain; Public-Private Sector Research Center - IESE Business School, University of Navarra, Spain; Centre en Economia de la Salud (CRES) - Universitat Pompeu Fabra. Email: jrborrell@ub.edu; tlf: +34 934 039 722

[3] Contact author: Universidad de Las Palmas de Gran Canaria. Facultad de Economía, Empresa y Turismo. Despacho D. 2-12. 35017. Las Palmas de Gran Canaria. Tlf: +34928458191. jljimenez@daea.ulpgc.es

[4] Universidad de Las Palmas de Gran Canaria. carmen.garcia121@alu.ulpgc.es

## 1. Introduction

Leniency or amnesty programs have been gradually introduced over the last 18 years in the fight against cartels. These antitrust enforcement programs can secure lenient treatment for early confessors and conspirators who supply information that is helpful to the antitrust authorities. Under the terms governing a leniency program, a firm or individual that first confesses to involvement in a cartel (supplying details of meeting dates and the timing of the price agreements) may avoid criminal conviction, fines, or a custodial sentence. In some programs these exemptions might also be extended to other cartel members who provide additional information regarding collusion.

The first antitrust leniency program was created in the United States in 1973. However, it was largely ineffective until reformed in 1993. Its apparent success in obtaining evidence to prosecute cartel members, in destabilizing existing cartels, and in deterring cartel formation was quickly noted by antitrust authorities elsewhere and such programs were gradually adopted as part of antitrust enforcement reform across developed and developing economies. Italy was an early adopter of the program in 1990, followed by the European Commission in 1996 (a program that was overhauled in 2002), the UK in 1998, Belgium in 1999 and Germany and Ireland in 2000. Spain was a relative latecomer, not adopting a leniency program until 2007, as were Estonia and Lithuania (2008) and Slovenia (2010). By 2011, all the EU Member States had introduced leniency programs in their antitrust legislation.[5]

A leniency program was to be found on all five continents by 2007. The 1997 program in Korea was the first to be adopted in Asia. Israel introduced its program in 1999, Brazil, Canada and New Zealand adopted theirs in 2000, India in 2003 and Singapore and South Africa in 2004. This global diffusion of leniency programs ran parallel to the increase in the number of developing countries adopting antitrust laws (OECD 2002, 2003). Thus, in 2007, of the 151 developing countries 77 had enacted antitrust legislation and appointed antitrust authorities, while in 1990 this figure stood at just 10 (Waked, 2010).

Yet, Zhou (2011) claims that despite the evident popularity enjoyed by leniency programs the literature is ambiguous as to the deterrent effect of such programs. While Miller (2009) has shown that the aura of efficacy of the US program is matched by evidence, the efficacy of the EC leniency program is less clear (Brenner, 2009 and De, 2010). These mixed findings raise questions regarding the true impact of such programs in line with those raised by Waked (2010) in a more general examination of the drivers of antitrust laws in developing countries. This last study claims that legal provisions in such countries are often replicas of models employed by their developed counterparts and any evidence of the post-adoption efficacy of antitrust laws is scarce. But as these so-called copy-and-paste laws are not tailored to meet local needs, their enforcement is often quite ineffective.

[5] With the exception of Malta.

Waked (2010) argues that many developing countries adopted competition law not out of any great domestic conviction but rather because it comprised an obligation of regional trade deals. Indeed, an antitrust regime has often been a prerequisite for engagement in bilateral trade agreements, for securing admission into regional trade blocs, and for even participating in structural programs that open up developing economies (Marcos, 2006). For example, many Euro-Mediterranean Association Agreements between the EU and countries such as Egypt, Jordan, Turkey and Tunisia include provisions linking financial cooperation to the implementation of antitrust legislation (Waked, 2010).

This paper seeks to exploit this diffusion of leniency programs across the globe. Thus, it identifies and quantifies econometrically the impact of antitrust leniency programs on perceptions of the general effectiveness of antitrust policies with an unbalanced panel of countries for a ten-year span. We use the dynamics of the diffusion of this policy innovation across countries and over time to evaluate the impact of the program. We draw on program evaluation techniques to measure their impact on a broad measure of the country-level perception of antitrust effectiveness. Forced or exogenous variation in program adoption due to regional or bilateral agreements helps us in identifying econometrically a program's impact.

We find that leniency programs have had a significant positive impact on the perception of a country's antitrust policy among business people. Leniency programs have become weapons of mass dissuasion in the hands of antitrust enforcers against the more damaging forms of explicit collusion among rival firms in the market place. We also find that countries self-select and are more likely to adopt the program according to observables such as per capita income and regional policy commitments. However, at each level of observed likelihood of adoption, those that exhibit lower unobserved antitrust effectiveness are also more likely to adopt the program as they benefit most from it.

The paper is organized as follows: Section 2 offers a brief literature review; Section 3 provides details about the data and the methods used in the program evaluation; Section 4 presents the results; and finally, Section 5 concludes and discusses the paper's findings.

## 2. Literature review

The literature on antitrust effectiveness can be broken down into three specific fields of research the first includes papers on the measurement of antitrust effectiveness (see Nicholson, 2008 and Voigt, 2009); the second involves the analysis of its drivers (see Borrell and Jiménez, 2008 and Ma, 2010); and the third uses indicators of antitrust effectiveness to explain productivity and economic growth (see Borrell and Tolosa, 2008a and 2008b, Voigt, 2009 and Ma, 2011).

Nicholson (2008) undertakes a summary of existing antitrust measures. These include surveys, such as those undertaken by the International Institute for Management Development (IMD) and the World Economic Forum (WEF); discrete variables, provided in empirical studies that capture certain characteristics of competition law (see, for example, Evenett, 2003, Kee and Hoekman, 2007 and Borrell and Jiménez, 2008); input

and output measures of competition policy, such as agency budget and staffing levels, and the ratio between the two, etc.;[6] and finally, qualitative analyses. Nicholson also proposes an antitrust law index to indicate the presence and complexity of "laws on the book" and reports that strong laws do not necessarily represent effective antitrust policy.

Voigt (2009) introduces four new indicators of competition laws and agencies that reflect the basis and contents of competition legislation, the degree to which these laws are based on economic reasoning, the formal degree of independence of the antitrust authorities and their factual independence. He then relates these indicators with other policies, such as trade policy, and uses them to account for total factor productivity (TFP). He concludes that the quality of competition law and policy has a positive effect on TFP.

Studies of the drivers of antitrust effectiveness include Borrell and Jiménez (2008). Using broad indicators of competition policy (including WEF data and a cross-country database), the authors analyze its impact on antitrust effectiveness. They conclude that while effectiveness depends on per capita income and EU membership, there are other policies that present a more significant correlation, namely adopting an economic approach to judge abusive practices, disposing of a competition-oriented merger policy and introducing innovative policies such as leniency programs. Yet, they are unable to clarify whether it is having a leniency program that matters, or whether such programs are simply correlated with unobservable drivers of effectiveness at the country level. Likewise, Ma (2010) establishes a causal relationship between antitrust effectiveness and competition authority independence and confirms that it is *de facto* independence that is important for antitrust effectiveness.

Ma (2011a) reaches a similar outcome to that reported in his aforementioned study when using a simplified version of the Solow growth model to relate competition law enforcement and productivity growth. He concludes that the outcome driven by enforcement varies with a country's stage of development.

Ma (2011b) uses WEF data to estimate the channel through which legal origin can influence antitrust effectiveness. Using cross-country data, the author concludes that legal flexibility (i.e., the adaptability channel) has a greater influence on antitrust effectiveness than authority independence does (i.e., the political channel). Interestingly, he reports that countries in which a judicial decision is a source of law adapt more easily to changing economic circumstances and, therefore, have better enforcement of antitrust rules. Finally, Borrell and Tolosa (2008a and 2008b) identify and quantify the impact of an improvement in antitrust effectiveness on total factor productivity and labour productivity.

There is, however, a gap in the literature as cross-country comparisons of antitrust policy design has yet to tackle the question of whether there is anything to be learned in terms of the effectiveness of antitrust or competition policy efficiency from the dynamics of adoption of leniency programs. Here, it is our aim to fill this gap.

---

[6] Waked (2010) analyzes the factors that affect decisions regarding the budget and staffing levels of competition authorities in developing countries.

## 3. Data and Methods

### *3.1. Data*

The International Institute for Management Development (IMD) kindly provided us with information for one of the criteria reported at the country level in its World Competitiveness Yearbook. Specifically, IMD supplied us with criterion number 2.4.11: "Competition legislation" (Factor: Government Efficiency; Sub-factor: Competition and Regulations). Data are taken from its Executive Opinion Survey.

The IMD's World Competitiveness Center conducts an Executive Opinion Survey to complement hard statistical data drawn from international, national and regional sources. The aim of the survey is to measure competitiveness as it is perceived. The surveys are sent out to senior business leaders, representing a cross-section of the business community in each country. The questions are targeted to top and middle management, who are nationals or expatriates employed in local or foreign firms with an international dimension. The sample size and its distribution are proportional to the GDP breakdown of the economic sectors in each country's economy. Executives are asked to evaluate the present and expected competitiveness conditions for the country in which they have lived and worked for the past year. IMD alumni are also contacted. In the survey conducted in 2011, the IMD obtained 4,935 responses from 59 countries worldwide.

Many papers have used this information or similar data provided by the World Economic Forum as their perceived measure of antitrust effectiveness.[7] Here, under criterion 2.4.11: "Competition legislation", the survey asks executives to rank on a scale from 1 to 6 whether "Competition legislation is efficient in preventing unfair competition." The data are subsequently converted to a 0 to 10 scale. The IMD provided us with an unbalanced panel dataset containing information about the average country-level result for this item for the 46 countries included in its 1998 Yearbook and for the next 10 years. Each year the yearbook has increased the number of countries included so that in 2007 it provided information for 54. In our database, this variable ranges from 2.40 to 8.59. As Table 1 shows, the mean value for this variable is just 5.62, and its standard deviation is 1.23.

As the main purpose of our paper is to study the impact of leniency programs on antitrust efficiency, we gathered data concerning antitrust policy reforms in all the countries for which IMD antitrust effectiveness data were available. We were specifically concerned with identifying if and when leniency programs had been introduced. We obtained this information at the country level from various sources including the websites of individual

[7] Borrell and Jiménez (2008), Nicholson (2008), Waked (2011) and Ma (2011, forthcoming) use WEF data on antitrust effectiveness.

antitrust authorities and the International Competition Network (ICN). Table 1 also shows the descriptive statistics of these data.[8]

Our information includes antitrust effectiveness perceptions for three jurisdictions (Mainland China, Hong Kong and Malaysia), from a total of 53, that have yet to enact conventional antitrust legislation (at least before 2008), but whose governments forbid and prosecute certain restrictions on competition. The remaining countries all introduced competition legislation either before or after 1998. Here, we distinguish between those (a total of nine countries) that had enacted such legislation prior to this date, from the rest (41 countries), as our goal is to assess the impact of leniency programs during the ten years commencing 1998. This said, it is difficult to identify any impact when such programs were created at the same time, or at a date very close to, the enactment of the first law.

Our dataset is characterised by the wealth of cross-country information it provides on EU Member States (37% of observations), new EU Member States that have entered the Union during the last two enlargements (6% of sample), NAFTA countries (6% of sample), countries from the Asian-Pacific (6% of sample), and Mercosur countries (4% of observations), and the Andean Community (4% of observations). Overall, 58% of our observations are of country-year pairs in which regional agreements were binding. This is of relevance as some of these regional agreements contain binding commitments as regards competition law, and some even provide for the adoption of leniency programs (the case of the EU). Table 2 lists the countries making up the sample which during any one year were members of one of these regional agreements.

Table 1 shows that a leniency program is enforced for as many as 37% of the country-year pairs. Table 3 shows the adoption dynamics of leniency programs in the countries included in the IMD's Executive Survey between 1998 and 2007. So, while just 2% (i.e., the US) of the sample operated such a program in 1998, by 2007 over two-thirds (69%) had adopted one.

The "leniency" variable takes a value of 1 from the year a leniency program was implemented in any country. In addition to these two key variables, we collected a set of other covariates for which we wish to control in our econometric estimations. Thus, we record whether the country had been implementing a competition law prior to the onset of our study period. We also control for "first law" whenever the first antitrust legislation was enacted during the period 1998 to 2007. Additionally, the "law reform" variable records if a country reformed its competition legislation during the sample period. This being the case then the variable takes a value of 1 in any year following that policy reform.

A further factor related to competition policy is the "age of competition law" variable, which indicates how many years the law has been in force. It has a mean of approximately 25 years. We collected these data from a wide range of national legislative sources.

---

[8] We use data for 53 countries as the GDP per capita for Taiwan is unavailable. This country is, as a result, excluded from our analysis.

Other characteristics at the country level are captured by two variables. The first, gross domestic product per capita (hereinafter, GDP), measures the income of the country in current US dollars ($). Table 1 shows that the mean GDP per capita in our sample is about 15,788$. The "elections" variable takes a value of 1 in the year the country held general or presidential elections. Twenty-five per cent of country-year pairs in our sample held elections. This variable is deemed relevant as leniency programs typically result from broader competition legislation reforms, which in turn correlate with government changes following elections.

### *3.2. Method*

The dynamics of the adoption of antitrust leniency programs are ideally suited to the settings of a program evaluation exercise. Typically, the main problem in an empirical exercise of this type is assessing the impact of exposing a set of units to a treatment on a given outcome (Imbens and Wooldridge, 2009). Here, our units are the countries of the world, our treatment is the adoption of an antitrust leniency program, and the outcome is the perceived efficiency of competition legislation or antitrust effectiveness (see Section 4).

The key methodological concern in program evaluation is that each unit (in this instance, country) is exposed or otherwise to the treatment, and that only one case or the other is observed, i.e., the outcome can only be measured in the case of treatment or in that of non-treatment (the controls). Citing Holland (1986), Imbens and Wooldridge (2009) refer to this concern as "the fundamental problem of causal inference". Thus, to assess the impact of leniency programs, we need to compare countries at different points in time, some of which have adopted leniency programs (treated group) and others that have not (control group).

In the case of binary treatments, Imbens and Wooldridge (2009) remind us that the traditional focus in the econometrics literature is that of endogeneity or self-selection: countries that adopt leniency programs differ from those that choose not to do so. When these differences condition the response to the treatment, comparing the outcomes of the treated and the control groups does not offer causal inferences of the impact of the program under evaluation, even when we are able to control for observed covariates. For instance, OLS estimates of difference-in-difference (hereafter, dif-in-dif) estimators may be biased when there is selection based on unobservable as follows.

Let

$$Y_{it} = \mu_i + \rho_t + D_{it}\alpha + X_{it}^{'}\beta + w_{it} + \varepsilon_{it}$$

be the dif-in-dif equation to be estimated in order to identify the causal effect of the treatment (leniency program) on the outcome (antitrust effectiveness), $\alpha$. In this equation we assume that the error term has two components, an *iid* shock named $\varepsilon_{it}$ that cannot be anticipated at the beginning of period $t$, and an unobserved component of the outcome that can be anticipated at the beginning of period $t$.

Selection on unobservables is a problem when

$$D_{it} = 1\{Z_{it}\gamma + \nu_{it} \geq 0\},$$

and

$$E[w_{it}\nu_{it} \neq 0].$$

For instance, at the beginning of the period, the policy makers know $\omega_{it}$, and decide to self-select into the treatment whenever antitrust effectiveness is low or whenever it is high. In this case, the bias of the OLS estimate is as follows:

$$\alpha_{OLS} = \frac{Cov(YD)}{Var(D)} + \frac{Cov(\omega D)}{Var(D)} = \alpha_{IV} + Bias$$

$$\alpha_{OLS} = \frac{Cov(YD)}{Var(D)} + \frac{Cov(\omega \nu)}{Var(D)} = \alpha_{IV} + Bias$$

$$\alpha_{OLS} = \alpha_{IV} + Bias$$

$$Bias = \alpha_{OLS} - \alpha_{IV} = \frac{Cov(\omega \nu)}{Var(D)}$$

where $\alpha_{IV}$ is the estimate of the causal effect using instrumental variables that overcome the endogeneity or selection based on unobservables by seeking to identify exogenous drivers of the country groupings $(Z)$.

The endogeneity bias depends on the sign of $Cov(\omega\nu)$, the covariance between the unobserved part of the outcome and the unobserved component of the selection on the treatment. In our example, this is the correlation between what is anticipated by the policy makers but what goes unobserved in the econometrician component of antitrust effectiveness and the unobserved driver of adopting leniency.

On the other hand, the literature on randomised experiments provides a dominant approach to the analysis of the causal effects of programs or policies in observational studies. Imbens and Wooldridge (2009) refer extensively to Rubin's proposals for interpreting comparisons of potential outcomes as causal statements: pairs for outcomes defined for the same country both when it is and when it is not treated. Moreover, Imbens and Wooldridge (2009) highlight that the main attraction of this potential outcome set-up is that it allows for general heterogeneity in the effects of the treatment from the outset. In practice, the heterogeneity of the effect is important, often motivating economists' concerns about endogeneity.

In this case, selection on observables is a problem when $E[\varepsilon Z] \neq 0$. The unanticipated component of the antitrust effectiveness shock is correlated with the observable drivers of the self-selection on the treatment. The problem is still there when the anticipated part of the shock is zero, $\omega = 0$.

In the literature, what has been referred to as unconfoundedness, exogeneity, ignorability, or selection on observables removes any self-selection bias in comparisons made between the treated and the control groups. Adjusting treatments and control groups for differences in covariates, or pretreatment variables, is the key to obtain causal inference of effects.

Matching analysis was first proposed by Rubin (1974), in a paper in which he established the potential-outcome framework for causal inference. The seminal paper here is Rosenbaum and Rubin (1983). Let $Y_1$ represent the outcome (here, antitrust effectiveness) in the case of a unit (a country) exposed to treatment (implementation of a leniency program), which implies that $D$, the binary variable describing treatment status, is equal to one. By analogy, $Y_0$ is the outcome if the unit is not exposed to treatment ($D$=0). Our causal effect of interest is defined by the difference between $Y_1$ and $Y_0$, so it yields a problem of inference with missing data.

The average treatment effect of interest to us is that on the treated group (hereafter ATT) and it can be defined as:

$$E\left(Y_1 - Y_0 | D = 1\right)$$

We assume that both treatment status and potential outcomes are affected by a set of observable characteristics ($Z$). The potential outcome in case of no treatment is independent of treatment assignment, which states that:

$$Y_0 \perp D | Z$$

$$\Pr\left(D = 1 | Z\right) < 1$$

The first of these is the untestable conditional independence assumption (CIA); the second is a requirement for identification. Under these two conditions, the ATT can be identified as:

$$ATT = E\left(Y_1 - Y_0 | D = 1\right) = E\left(E\left(Y_1 - Y_0 | D = 1, Z\right)\right) =$$
$$E\left(E\left(Y_1 | D = 1, Z\right) - E\left(Y_0 | D = 0, Z\right) | D = 1\right)$$

Without selection on observables, or unconfoundedness, causal inference cannot be estimated by comparing the treated and the control groups using non-parametric techniques such as matching. Seen from this methodological perspective, the plausibility or otherwise of causal inference can only be verified by conducting a sensitivity analysis, i.e., evaluating the robustness of the inference to a set of 'what-if' assumptions regarding the process of selection on observables.

Here we use four inference techniques to identify and quantify the causal effect of antitrust leniency programs on the efficiency of competition legislation across countries: (1) tests of equality of means and equality of distributions; (2) simple difference-in-difference techniques; (3) instrumental variable techniques for estimating dif-in-dif equations; and (4) matching estimators.

First, we test the equalities of the means and of the distribution of the treatment group with respect to those of the control group. Second, we estimate difference-in-difference regressions to determine the mean causal effect, drawing on information before and after a comparison of the effect across countries. Third, using instrumental variables we check whether the estimates suffer from bias due to self-selection of adopters according to unobservables. Finally, we estimate non-parametrically using matching techniques to determine the lower bound of the causal effect, assuming that self-selection of the countries that adopt the program is conditioned only on observables.

## 4. Results

Table 4 and Figure 1 clearly show that the antitrust effectiveness outcomes of country-year pairs treated with the adoption of a leniency program and those of non-treated country-year pairs differ, the average difference being around 0.6 (i.e., 11%). Figure 1 shows that this difference is most marked for country-year pairs with an antitrust effectiveness below the mean. However, this is insufficient to indicate the unequivocal effect of the treatment since country-year pairs might self-select into the treatment.

Table 5 lists each country in our sample and its respective average antitrust effectiveness before and after treatment (including the dates on which the competition law was enacted and the leniency program adopted). The data suggest that countries at the top of the effectiveness ranking are more likely to adopt leniency programs, while countries some way off the top tend to have been early adopters. The data also show that adopters differ in terms of their observables, including the number of years since the enactment of their competition law, per capita GDP and NAFTA and EU membership.

We first estimate the causal effect of leniency programs on antitrust effectiveness using a simple difference-in-difference estimator. Table 6 reports the OLS estimates of regressing antitrust effectiveness on a set of country fixed effects, year fixed effects and the leniency program binary treatment. The table shows the estimates for the full sample, for the sub-sample of country-year pairs with competition law in force, and for the sub-sample of those with a competition law enacted before 1998.

The estimates seem to suffer a strong attenuation bias. All estimates of the impact of leniency are very close to zero and are not statistically significant. This suggests strong self-selection. However, we are unable to determine whether this self-selection is due to observables or unobservables, nor can we verify the direction of the bias.[8]

[8] Estimates taking logs of antitrust effectiveness are very similar to those in levels (original IMD data).

To rectify this, we next estimate the difference-in-difference regression using instrumental variable techniques and generalised method of moments (GMM) procedures that are robust to the presence of binary endogenous treatment.

Table 7 reports the instrumental variable (IV) estimates when regressing antitrust effectiveness on a set of country fixed effects, year fixed effects and the leniency program binary covariate. The key instruments for identifying the causal effect are observables, including GDP per capita and the integration of a country into a regional agreement. As the sample includes a large number of European countries, joining the EU during the sample period is considered a driver of the adoption of new antitrust rules in general, and of adopting leniency programs in particular. Additionally, we use the election covariate as an instrument on the grounds that countries seem much more likely to make legislative reforms in the "honeymoon" period following a general election.

The IV estimates clearly show that endogeneity, or selection on unobservables, is present. They also indicate that the bias is strong and negative. Although the IV estimates are not particularly precise, they all show that leniency has a positive and very strong impact on the perception of antitrust effectiveness.[9] As the bias is negative, the countries that adopt leniency programs are precisely the ones that have lower anticipated unobserved antitrust effectiveness ($\omega_{it}$ in the set up above) as the covariance between the unobserved drivers of program adoption ($\nu_{it}$) and the error term in the antitrust effectiveness dif-in-dif regression is negative: $Cov(\omega\nu) = 0$.

This would seem to be consistent with the pattern we described above. Thus, early adopters such as Italy and Belgium, who created programs in 1990 and 1999 respectively, rank relatively high in terms of their observables (e.g., GDP per capita), but they have an unobserved component that is lower than that of countries that occupy a similar ranking based on their observable covariates.

An additional concern, therefore, is that the impact of the introduction of a leniency program may not be homogeneous across countries, and here too there might be a strong selection on observables. According to Heckman et al. (1997), a difference-in-difference analysis might include two sources of bias: the first arises when changes have occurred in some countries, but there are no comparable countries in which changes did not occur and vice versa. The second bias arises from different distributions of the vector of observable variables that affect our endogenous variable within the two groups of countries.

The use of a matching estimator can eliminate these two potential biases by pairing treated countries (adopters of leniency programs) with control groups (the non-adopters) that present similar observable attributes.[10] In our case, this ATT is obtained by using the kernel

[9] Again, estimates taking log values offer very similar results.

[10] See Galiani et al. (2005) for an application of this method.

matching method.[11] Matching relies on the assumption that the selection is on observables rather than on unobservables, as outlined above. But given that selection on unobservables biases the estimates downwards, we estimate matching to determine the lower bound of the estimates based solely on selection on observables.

Table 8 summarizes the results of the matching estimator. In all the estimations we include the following as the exogenous variables driving the selection of the adopters on observables: "new country in EU", "age of competition law", "elections (t-1)", "GDP (t-1)" and "regional agreement", as described in Table 1. The estimations were conducted using bootstrap techniques.

Matching shows an average effect of adopting leniency from 0.23 to 0.31 points (maximum of 10) of antitrust efficiency. This represents a permanent increase of 4% to 5.4% over the sample average, and almost a third of one standard deviation. The effect is precisely estimated and is statistically significant at the 1% level. It is also around half of that obtained in the test of equality of means. Countries self-select on observables and this biases the mean comparison upwards. When correcting for self-selection on observables, the effect is halved.[12]

As discussed above, the main weakness of using the matching estimator is that it relies on an assumption of conditional independence of potential outcomes and treatment assignment given observables (Nannicini, 2008). This implies that selection into treatment is driven solely by factors observable by the researcher.[13] However, as we have seen, the IV estimations showed us that there may be some self-selection due to unobservables. Fortunately, in this instance the bias appears to be negative. Therefore, the causal effect we have estimated in the matching analysis is the lower bound of the true casual effect, which in this case we are not able to estimate precisely.

In any case, to verify the robustness of these results to the selection solely on observables, we conducted a sensitivity analysis (Table 9) in line with Ichino et al. (2008) and as implemented by Nannicini (2008). This analysis assesses whether (and to what extent) the estimated average treatment effect is robust to possible deviations from the conditional independence assumption.[14]

To perform this test, we simulate in the matching estimator a 'killer' *confounder* (in the authors' terminology, *U*), which is used as an additional covariate. This confounder uses a set of parameters $p_{ij}$ (where $i$ refers to being treated or otherwise and $j$ to a binary

[11] Four of the most widely used matching methods are nearest neighbor, radius, stratification and kernel. None of them is *a priori* superior to the others. See Becker and Ichino (2002) for a further explanation.

[12] Again, very similar results in logs as shown in Table 8.

[13] See Heckman et al. (1997) for an explanation of the bias associated with matching analyses.

[14] Note that this is not a 'test' of the conditional independence assumption, as this identifying assumption is intrinsically non-testable since the data are uninformative about the distribution of potential outcomes in the case of no treatment for treated units (Ichino et al., 2008).

outcome[15]), so that if *U* were observed, the estimated ATT would be driven to zero or far from the baseline estimate. Thus, we attributed some values to these four probabilities in accordance with the being treated (*i*) parameter and the outcome given (*j*) ($p_{11}$, $p_{10}$, $p_{01}$, $p_{00}$) and, if some of these configurations could be considered as being highly unlikely, then we had our support for the robustness of the matching estimations.

Nannicini (2008) denominates *d* as a measure of the effect of *U* on the untreated outcome ($d=p_{01}-p_{00}$); and *s* as a measure of the effect of *U* on the selection into treatment ($s= p_{1.}-p_{0.}$). Both measures have to be greater than zero since this implies a positive effect on the untreated outcome and on the selection into treatment, respectively. They are associated with the values of $\Gamma$ and $\Lambda$, which are the estimated odds ratios of *U* reported as the "outcome effect" and "selection effect" of the simulated confounder, respectively.[16]

We construct a table, in line with proposals in the two seminal papers (Nannicini, 2008 and Ichino et al., 2008), in which we simulate ATTs so that *d* and *s* increase by 0.1, varying from 0.1 to 0.6. What we are seeking are data that are quite similar to the baseline results when we increase both measures (*d* and *s*). The estimations in Table 9 show the robustness of our results because the ATT only tends to zero when *s* and *d* are greater than 0.4.

## 5. Conclusions

The dynamics of the creation of antitrust leniency programs across the globe provides a good description of policy innovation adoption. At the same time, the IMD survey data defining the perception of antitrust enforcement have enabled us to identify and quantify the impact of leniency program adoption on competition policy efficiency.

The main problem we have had to overcome in this paper is that countries tend to self-select into the treatment in a way that is unknown, although it would appear that program adoption does drive perceptions of antitrust effectiveness. We report here that countries self-select, being more likely to adopt the program according to observables that include per capita income and regional policy commitments. Nevertheless, at each level of observed likelihood of adoption, countries that exhibit lower unobserved antitrust effectiveness are also more likely to adopt the program as they benefit most from it. By correcting for one or other type of self-selection, we show that leniency programs have had a significant positive impact on the perception of a country's antitrust policy among the business community, especially in those countries whose antitrust enforcement is least credible.

---

[15] For continuous outcome (the antitrust effectiveness index in our case), we adapt the methodology on the basis of a binary transformation: Y=1 if the effectiveness index is higher than average effectiveness and Y=0 otherwise.

[16] The program *sensatt* in the STATA estimate, at every iteration, a logit model of $Pr(Y=1|T=0, U, W)$ reports the outcome effect. For the selection effect, the logit model estimated is $Pr(T=1|U, W)$. The other covariates are summarized at *W*.

Leniency programs have become weapons of mass dissuasion in the hands of antitrust enforcers against the more damaging forms of explicit collusion among rival firms in the market place. We find that this impact is equivalent to at least a 4% gain in antitrust effectiveness.

**References**


Borrell, J.R., Jiménez J.L. The drivers of antitrust effectiveness. Hacienda Pública Española – Revista de Economía Pública 2008; 185(2); 69-88.

Borrell, J.R., Tolosa M. Endogenous antitrust: Cross-country evidence on the impact of competition-enhancing policies on productivity. Applied Economics Letters 2008a; 15(2); 827-831.

Borrell, J.R., Tolosa M. Política de competencia y productividad: más allá de la calidad institucional y la apertura, Cuadernos Económicos de ICE 2008b; 76; 57-72.

Becker, S., Ichino, A. Estimation of average treatment effects based on propensity scores. The Stata Journal 2002; 2(4); 358-377.

Brenner, S. An Empirical Study of The European Corporate Leniency Program. International Journal of Industrial Organization 2009; 27(6); 639-45.

De, O. Analysis of Cartel Duration: Evidence from EC Prosecuted Cartels. International Journal of the Economics of Business 2010; 17; 33-65.

Dutz, M.A., Hayri A. Does more intense competition lead to higher growth? World Bank Policy Research Working Paper, 2320 and CEPR Discussion Paper No. 2249. 2000.

Evenett, S. Do all networks facilitate international commerce? US law firms and the international market for corporate control. Journal of Japanese and International Economics 2003; 17(4), 520-537.

Harrington Jr, J.E. Optimal corporate leniency programs. The Journal of Industrial Economics 2008; LVI (2); 215-246.

Chang, M.-H., Harrington, J. E. The Impact of a Corporate Leniency Program on Antitrust Enforcement and Cartelization. Mimeo 2010; http://www.econ.jhu.edu/pdf/papers/WP548.pdf.

Heckman, J.J., Ichimura, H., Todd, P. Matching as an econometric evaluation estimator: evience from evaluating a job training programme. The Review of Economic Studies 1997; 64; 605-654.

Hinloopen, J., Soetevent, A.R. Laboratory evidence on the effectiveness of corporate leniency programs. RAND Journal of Economics 2008; 39(2); 607-616.

Holland, P. Statistics and Causal Inference, (with discussion). Journal of the American Statistical Association 1986; 81; 945-970.

Imbens, G., Wooldridge, J.M. Recent developments in the econometrics of program evaluation. Journal of Economic Literature 2009; 47; 5-86.

Ichino, A., Mealli, F., Nannicini, T. From temporary help jobs to permanent employment: what can we learn from matching estimators and their sensitivity? Journal of Applied Econometrics 2008; 23(3); 305-327.

Kee, H.L., Hoekman, B. Competition Law as market discipline? European Economic Review 2007; 51(4); 831-858.

Kovacic, W.E. Achieving better practices in the design of competition policy institutions. Remarks before the Seoul Competition Forum, 2004. U.S. Federal Trade Commission.

Ma, T.-C. Competition authority independence, antitrust effectiveness, and institutions. International Review of Law Economics 2010; 30; 226-235.

Ma, T.-C. The effect of Competition Law enforcement on economic growth. Journal of Competition Law and Economics 2011a; 7; 301-334.

Ma, T.-C. Legal tradition and antitrust effectiveness. Empirical Economics 2011b; forthcoming.

Marcos, F. (2006) 'Do Developing Countries Need Competition Law and Policy?' Available at SSRN: http://ssrn.com/abstract=930562

Miller, N. H. Strategic Leniency and Cartel Enforcement. American Economic Review 2009; 99; 750-768.

Motta, M., Polo, M. Leniency programs and cartel prosecution. International Journal of Industrial Organization 2003; 21; 347-379.

Nannicini, T. A simulation-based sensitivity analysis for matching estimators. The Stata Journal 2008; 7(3); 334-350.

Nicholson, M. W. Quantifying Antitrust Regimes. FTC Working Paper 2004; Washington DC.

Nicholson, M.W. An antitrust law index for empirical analysis of international competition policy. Journal of Competition Law & Economics 2008; 4(4); 1009-1029.

OCDE. Fighting Hard Core Cartels: Harm, Effective Sanctions and Leniency Programs. Paris. 2002.

OCDE. Hard Core Cartels. Recent Progress and Challenges Ahead, Paris. 2003.

Ormosi, P.L. How big is a tip of the iceberg? A parsimonious way to estimate cartel detection rate, CCP Working Paper 11-6. 2011.

Rosenbaum, P., Rubin, D. The central role of the propensity score in observational studies for causal effects. Biometrika 1983; 70; 41-55.

Rubin, D. Estimating causal effects of treatments in randomised and non-randomised studies. Journal of Educational Psychology 1974; 66; 688-701.

Voigt S. The effect of competition policy on development: Cross-country evidence using four new indicators. Journal of Development Studies 2009; 45(8); 1225-1248.

Waked, D.I. Antitrust enforcement in developing countries: reasons for enforcement & non-enforcement using resource-based evidence. 5th Annual Conference on Empirical Legal Studies Paper 2010. Available at: http://ssrn.com/abstract=1638874

Zhou, J. New Evidence on the Efficacy of Leniency. 2011. Available at SSRN: http://ssrn.com/abstract=1932473

## Tables and Figures

**Table 1. Descriptive Statistics**

| Variables | Mean | s.d. | Min. | Max. | Source and observations |
|---|---|---|---|---|---|
| Antitrust effectiveness | 5.62 | 1.23 | 2.40 | 8.59 | IMD |
| Leniency | 0.37 | 0.49 | 0.00 | 1.00 | |
| Competition Law | 0.94 | 0.24 | 0.00 | 1.00 | |
| Age of Competition Law | 22.12 | 26.22 | 0.00 | 118.00 | |
| Per capita GDP | 15,787.93 | 12,740.40 | 419.40 | 56,389.21 | Nominal prices. World Bank |
| Elections | 0.25 | 0.44 | 0.00 | 1.00 | 1: General or presidential elections |
| Countries passing their first competition law between 1998-2007 | 0.16 | 0.37 | 0.00 | 1.00 | |
| European Union (EU) | 0.37 | 0.48 | 0.00 | 1.00 | 1: if the country is a EU member state |
| New country in EU | 0.06 | 0.23 | 0.00 | 1.00 | 1: new EU member state following 2004 enlargement |
| NAFTA | 0.06 | 0.24 | 0.00 | 1.00 | 1: if the country is a NAFTA member |
| Andean Community | 0.04 | 0.20 | 0.00 | 1.00 | 1: if the country is an Andean Community member |
| Asia-Pacific | 0.06 | 0.24 | 0.00 | 1.00 | 1: if the country is an ASEAN member |
| Mercosur | 0.04 | 0.20 | 0.00 | 1.00 | 1: if the country is a Mercosur member |
| Regional agreement | 0.58 | 0.49 | 0.00 | 1.00 | 1: Country included in any of the above regional agreements |

Source: Authors' own calculations unless stated otherwise. 479 observations. Unbalanced IMD sample of 54 countries over 10 years. Taiwan, for which GDP data are unavailable, is excluded.

## Table 2. Description of regional variables

| Variables | Description | Countries for which the variable takes a value of 1 for at least one year | # countries |
|---|---|---|---|
| European Union (EU) | 1=The country is an EU member that year | Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom | 24 |
| New country in EU | 1= New countries in EU since enlargement | Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Slovak Republic, Slovenia | 9 |
| Nafta | 1=The country is a Nafta member that year | Canada, Mexico, USA | 3 |
| Andean Community | 1=The country is an Andean Community member that year | Colombia, Venezuela. | 2 |
| Asia-Pacific | 1=The country is a member of the Asia-Pacific agreement that year | Mainland China, India, Korea | 3 |
| Mercosur | 1=The country is a Mercosur member that year | Argentina, Brazil | 2 |

Note: There were 19 countries for which all these variables take a value of 0: Australia, Chile, Croatia, Hong Kong, Iceland, Indonesia, Israel, Japan, Jordan, Malaysia, New Zealand, Norway, Russia, Singapore, South Africa, Switzerland, Thailand, Turkey, Ukraine.

## Table 3. Policy diffusion

| | Countries with leniency program | Countries in the IMD Survey | % adopters |
|---|---|---|---|
| 1998 | 1 | 45 | 2% |
| 1999 | 7 | 46 | 15% |
| 2000 | 11 | 46 | 24% |
| 2001 | 15 | 48 | 31% |
| 2002 | 17 | 48 | 35% |
| 2003 | 20 | 50 | 40% |
| 2004 | 28 | 50 | 56% |
| 2005 | 31 | 50 | 62% |
| 2006 | 36 | 52 | 69% |
| 2007 | 37 | 54 | 69% |

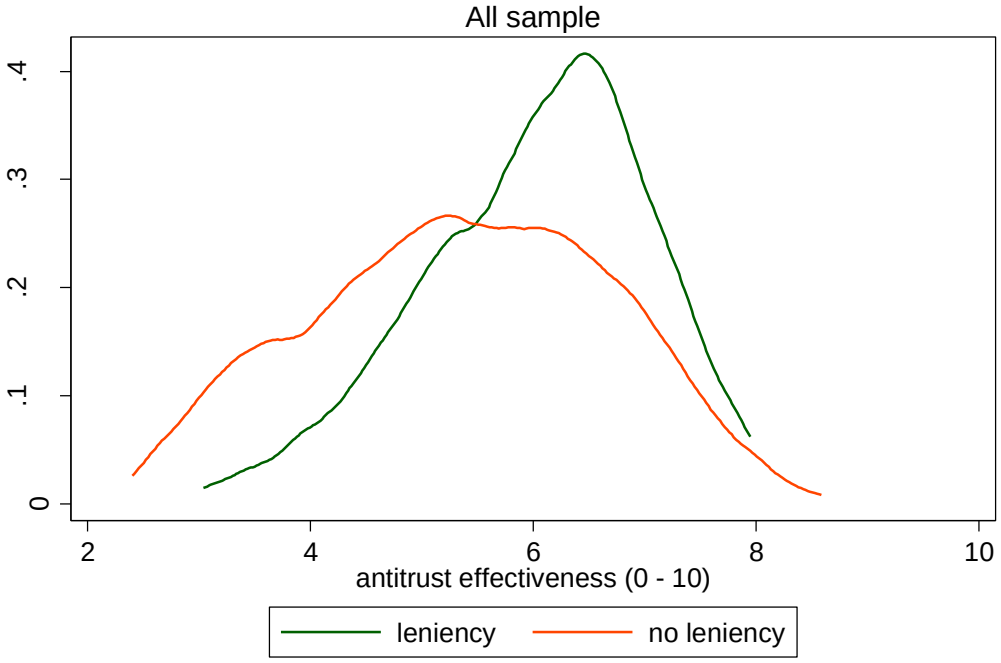
Source: Authors' own calculations based on information obtained from competition authorities' websites and the International Competition Network (ICN).

## Table 4. Mean antitrust effectiveness index

| No leniency | Leniency | Absolute difference t-test of mean equality | Relative difference | Two-sample Kolmogorov–Smirnov tests of the equality of distributions | Sample | # Obs |
|---|---|---|---|---|---|---|
| 5.36 (1.30) | 6.03 (0.99) | 0.66 (0.10)*** | 12.31% | 0.25*** | All | 489 |
| 5.38 (1.35) | 6.03 (0.99) | 0.64 (0.11)*** | 11.89% | 0.24*** | Only countries with competition law | 459 |
| 5.35 (1.32) | 5.99 (1.01) | 0.64 (0.12)*** | 11.96% | 0.24*** | Only countries with competition law predating 1998 | 383 |

Source: Authors' own calculations. Note: *** 1%, ** 5%, *10% significance test. Standard errors within brackets.

Figure 1.- Kernel Density Antitrust Effectiveness



## Table 5. Descriptive statistics by country (1998-2007)

| Country | Antitrust Effectiveness Before Leniency (average) | Antitrust Effectiveness After Leniency (average) | Absolute Change | Relative Change | Year of First Competition Law | Year of Competition Law Reform | Year of First Leniency Program |
|---|---|---|---|---|---|---|---|
| Finland | 7.78 | 7.59 | -0.19 | -2.4% | 1988 | 2004 | 2004 |
| Denmark | 7.35 | | | | 1998 | No change | 2007 |
| Australia | 7.27 | 7.42 | 0.16 | 2.2% | 1974 | No change | 2003 |
| Germany | 7.26 | 7.26 | 0.00 | 0.0% | 1958 | 2005 | 2000; 2006 |
| Austria | 7.10 | 7.77 | 0.67 | 9.4% | 1988 | 2006 | 2006 |
| Netherlands | 7.17 | 7.14 | -0.03 | -0.4% | 1998 | 2004; 2007 | 2002 |
| New Zealand | 6.92 | 6.93 | 0.01 | 0.1% | 1986 | No change | 2000 |
| Canada | 6.84 | 6.82 | -0.02 | -0.3% | 1889 | No change | 2000 |
| Norway | 6.87 | 6.59 | -0.28 | -4.0% | 1993 | 2004 | 2004 |
| Singapore | 6.40 | 6.78 | 0.38 | 6.0% | 2004 | 2004 | 2004 |
| USA | n.a. | 6.51 | | | 1890 | No change | 1978, 1993 |
| Chile | 6.42 | 6.53 | 0.11 | 1.7% | 1959 | 1999 | 2005 |
| Iceland | 6.49 | 6.29 | -0.20 | -3.2% | 1993 | 2005 | 2005 |
| Ireland | 6.57 | 6.37 | -0.20 | -3.0% | 1991 | 2002; 2006 | 2001 |
| Luxembourg | 6.44 | 6.41 | -0.04 | -0.5% | 1970 | 2004 | 2004 |
| Sweden | 6.49 | 6.36 | -0.13 | -2.0% | 1993 | No change | 2002 |
| France | 6.22 | 6.34 | 0.12 | 2.0% | 1953 | 2001 | 2001 |
| South Africa | 6.19 | 6.41 | 0.22 | 3.5% | 1999 | 2001 | 2004 |
| Belgium | 5.64 | 6.35 | 0.71 | 12.5% | 1993 | 2006 | 1999 |
| United Kingdom | 6.21 | 6.22 | 0.01 | 0.2% | 1948 | 2002 | 1998 |
| Switzerland | 6.21 | 6.05 | -0.16 | -2.6% | 1995 | No change | 2004 |
| Israel | 5.68 | 6.14 | 0.46 | 8.1% | 1950 | No change | 1988 |
| Taiwan | 6.01 | 5.59 | -0.42 | -7.0% | 1992 | 2002 | 2006 |
| Estonia (*) | 5.62 | | | | 1993 | 2001; 2006 | No Leniency |
| Spain | 5.63 | 5.22 | -0.41 | -7.3% | 1989 | 2007 | 2007 |
| Japan | 5.45 | 5.81 | 0.36 | 6.5% | 1947 | 2005 | 2005 |
| Hungary | 5.51 | 5.55 | 0.04 | 0.7% | 1996 | No change | 2003; 2006 |
| Malaysia | 5.47 | | | | No law | No change | No Leniency |
| Hong Kong | 5.37 | | | | No law | No change | No Leniency |

| Country | Antitrust Effectiveness Before Leniency (average) | Antitrust Effectiveness After Leniency (average) | Before and After Absolute Change | Before and After Relative Change | Year of First Competition Law | Year of Competition Law reform | Year of First Leniency Program |
|---|---|---|---|---|---|---|---|
| Portugal | 5.27 | 5.64 | 0.38 | 7.1% | 1993 | 2003 | 2006 |
| Jordan (*) | 5.33 | | | | 2004 | 2004 | No Leniency |
| Korea | 4.29 | 5.41 | 1.12 | 26.2% | 1980 | 1997 | 1997 |
| Brazil | 4.97 | 5.13 | 0.16 | 3.3% | 1988 | 2000 | 2000 |
| Greece | 4.98 | 5.05 | 0.07 | 1.3% | 1977 | No change | 2006 |
| Slovak Republic (*) | n.a. | 4.98 | | | 1994 | 2001 | 2001 |
| Czech Republic | 4.17 | 5.32 | 1.15 | 27.6% | 2001 | 2001 | 2001 |
| Colombia | 4.89 | | | | 1959 | No change | No Leniency |
| Italy | 4.65 | 4.83 | 0.18 | 4.0% | 1990 | No change | 1990 |
| China Mainland | 4.81 | | | | No law | No change | No Leniency |
| Mexico | 4.89 | 4.18 | -0.72 | -14.7% | 1992 | 2006 | 2006 |
| India | 4.87 | 4.60 | -0.26 | -5.4% | 1969 | 2003 | 2003 |
| Lithuania (**) | 4.73 | | | | 1999 | 1999; 2004 | No Leniency |
| Turkey | 4.73 | | | | 1997 | No change | No Leniency |
| Thailand | 4.53 | | | | 1999 | 1999 | No Leniency |
| Romania (*) | 3.73 | 4.07 | | | 1997 | 2003 | 2004 |
| Venezuela | 4.07 | | | | 1992 | 1997 | No Leniency |
| Slovenia (*) | 4.00 | | | | 1993 | 1999; 2004 | No Leniency |
| Poland | 3.55 | 3.92 | 0.37 | 10.4% | 1990 | 2004 | 2004 |
| Bulgaria (*) | n.a. | 3.50 | | | 1991 | 2003 | 2003 |
| Indonesia | 3.49 | | | | 1999 | 1999 | No Leniency |
| Croatia (*) | 3.46 | | | | 1995 | 2003 | No Leniency |
| Argentina | 3.37 | | | | 1923 | 1999 | No Leniency |
| Ukraine (*) | 3.23 | | | | 1993 | 2001 | No Leniency |
| Russia | 3.22 | | | | 1991 | 2006 | No Leniency |

Source: Authors' own (based on IMD World Competitiveness Yearbook).
Note: Countries marked with (*) did not have these data available for the whole period. Countries marked with (**) only had data available for the last year.

**Table 6. Dif-in-Dif Estimators. OLS. In levels, original data**

| | **Antitrust Effectiveness** | **Antitrust Effectiveness** | **Antitrust Effectiveness** |
|---|---|---|---|
| Leniency | -0.05 (0.07) | -0.002 (0.08) | -0.003 (0.08) |
| Country fixed effects | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes |
| Observations | 479 | 449 | 383 |
| Sample | All | Only countries with competition law | Only countries with competition law predating 1998 |

Note: *** 1%, ** 5%, *10% significance test. Robust standard errors within brackets. Taiwan excluded due to perfect multicollinearity).

**Table 7. Dif-in-Dif Estimators. In levels, original data**

| | **Antitrust Effectiveness (IV)** | **Antitrust Effectiveness (IV)** | **Antitrust Effectiveness (IV)** |
|---|---|---|---|
| Leniency | 2.54 (1.41)* | 4.99 (5.14) | 5.69 (6.24) |
| Impact/Mean | 45.04% | 88.48% | 100.89% |
| Country fixed effects | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes |
| Observations | 479 | 449 | 373 |
| Instruments | New country in EU, Regional Agreements, GDP(-1), Elections(-1) | New country in EU, Regional Agreements. GDP(-1), Elections(-1), Age competition law | New country in EU, Regional Agreements. GDP(-1) |
| Instruments Validity (Overidentification J Hansen Test) | 0.72 (p = 0.86) | 1.04 (p=0.90) | 2.9e-15 (p = 1.00) |
| F-test strong instruments | 15.55 (p = 0.00) | 8.96 (p = 0.00) | 10.49 (p = 0.00) |
| Sample | All | Only countries with competition law | Only countries with competition law predating 1998 |

Note: *** 1%, ** 5%, *10% significance test. Robust standard errors within brackets.

**Table 8. Summary of results of the matching estimator (IMD original data)**

| | Antitrust Effectiveness | Antitrust Effectiveness | Antitrust Effectiveness |
|---|---|---|---|
| | **in levels, original data** | | |
| Leniency | 0.225* | 0.230*** | 0.306*** |
| Impact/Mean | 3.99% | 4.07% | 5.43% |
| | **in logs** | | |
| Leniency | 0.055*** | 0.057*** | 0.069*** |
| Impact (%) | 5.65% | 5.87% | 7.14% |
| Sample | All | Only countries with competition law | Only countries with competition law predating 1998 |

Note: *** 1%, ** 5%, *10% significance test. Standard errors within brackets.

**Table 9. Sensitivity analysis of the matching estimator (in levels, original data, only countries with competition law passed before 1998). Leniency. 'Killer'confounders**

| | **s=0.1** | | **s=0.2** | | **s=0.3** | | **s=0.4** | | **s=0.5** | | **s=0.6** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Γ** | **Λ** | **Γ** | **Λ** | **Γ** | **Λ** | **Γ** | **Λ** | **Γ** | **Λ** | **Γ** | **Λ** |
| | **0.308** | | **0.307** | | **0.306** | | **0.267** | | **0.238** | | **0.194** | |
| **d=0.1** | 1.573 | 1.542 | 1.605 | 2.349 | 1.704 | 3.534 | 1.683 | 5.913 | 1.781 | 9.511 | 1.880 | 19.423 |
| | **0.300** | | **0.277** | | **0.256** | | **0.198** | | **0.149** | | **0.095** | |
| **d=0.2** | 2.415 | 1.506 | 2.433 | 2.240 | 2.547 | 3.680 | 2.668 | 6.031 | 2.613 | 11.073 | 3.008 | 24.188 |
| | **0.283** | | **0.251** | | **0.204** | | **0.117** | | **0.069** | | **0.007** | |
| **d=0.3** | 4.001 | 1.539 | 3.958 | 2.429 | 3.952 | 3.952 | 4.058 | 7.024 | 4.463 | 12.593 | 4.545 | 34.112 |
| | **0.273** | | **0.231** | | **0.168** | | **0.071** | | **-0.009** | | **-0.092** | |
| **d=0.4** | 5.972 | 1.563 | 5.757 | 2.461 | 5.976 | 3.929 | 6.336 | 6.956 | 7.395 | 16.850 | 8.205 | 106.117 |
| | **0.265** | | **0.201** | | **0.113** | | **0.008** | | **-0.073** | | **-0.246** | |
| **d=0.5** | 10.026 | 1.541 | 10.035 | 2.647 | 10.806 | 4.366 | 10.567 | 9.090 | 10.946 | 27.205 | 21.951 | 54.487 |
| | **0.247** | | **0.179** | | **0.067** | | **-0.045** | | **-0.174** | | **-0.457** | |
| **d=0.6** | 19.347 | 1.555 | 18.507 | 2.503 | 20.542 | 4.461 | 20.683 | 8.483 | 22.331 | 43.304 | 150.312 | 70.909 |

Note: Under the assumption that $Pr(U=1)$=0.4 and $p11-p10$=0, the differences $d= p01-p00$ (which capture the outcome effect of U in the absence of treatment) and $s= p1\cdot - p0\cdot$ (which captures the effect of U on the selection into treatment) uniquely define the parameters pij, with $i,j=\{0,1\}$. All ATTs are averaged over 100 iterations. Γ is the average estimated odds ratio of U in the logit model of $Pr(Y=1|T=0, U, W)$; Λ is the average estimated odds ratio of U in the logit model of $Pr(T=1|U,W)$. The baseline estimate without confounder is equal to 0.306.

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2006

**CREAP2006-01**
**Matas, A.** (GEAP)**; Raymond, J.Ll.** (GEAP)
"Economic development and changes in car ownership patterns"
(Juny 2006)

**CREAP2006-02**
**Trillas, F.** (IEB)**; Montolio, D.** (IEB)**; Duch, N.** (IEB)
"Productive efficiency and regulatory reform: The case of Vehicle Inspection Services"
(Setembre 2006)

**CREAP2006-03**
**Bel, G.** (PPRE-IREA)**; Fageda, X.** (PPRE-IREA)
"Factors explaining local privatization: A meta-regression analysis"
(Octubre 2006)

**CREAP2006-04**
**Fernàndez-Villadangos, L.** (PPRE-IREA)
"Are two-part tariffs efficient when consumers plan ahead?: An empirical study"
(Octubre 2006)

**CREAP2006-05**
**Artís, M.** (AQR-IREA)**; Ramos, R.** (AQR-IREA)**; Suriñach, J.** (AQR-IREA)
"Job losses, outsourcing and relocation: Empirical evidence using microdata"
(Octubre 2006)

**CREAP2006-06**
**Alcañiz, M.** (RISC-IREA)**; Costa, A.; Guillén, M.** (RISC-IREA)**; Luna, C.; Rovira, C.**
"Calculation of the variance in surveys of the economic climate"
(Novembre 2006)

**CREAP2006-07**
**Albalate, D.** (PPRE-IREA)
"Lowering blood alcohol content levels to save lives: The European Experience"
(Desembre 2006)

**CREAP2006-08**
**Garrido, A.** (IEB)**; Arqué, P.** (IEB)
"The choice of banking firm: Are the interest rate a significant criteria?"
(Desembre 2006)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**CREAP2006-09**
**Segarra, A.** (GRIT)**; Teruel-Carrizosa, M.** (GRIT)
"Productivity growth and competition in spanish manufacturing firms:
What has happened in recent years?"
(Desembre 2006)

**CREAP2006-10**
**Andonova, V.; Díaz-Serrano, Luis.** (CREB)
"Political institutions and the development of telecommunications"
(Desembre 2006)

**CREAP2006-11**
**Raymond, J.L.**(GEAP)**; Roig, J.L..** (GEAP)
"Capital humano: un análisis comparativo Catalunya-España"
(Desembre 2006)

**CREAP2006-12**
**Rodríguez, M.**(CREB)**; Stoyanova, A.** (CREB)
"Changes in the demand for private medical insurance following a shift in tax incentives"
(Desembre 2006)

**CREAP2006-13**
**Royuela, V.** (AQR-IREA)**; Lambiri, D.**; **Biagi**, **B.**
"Economía urbana y calidad de vida. Una revisión del estado del conocimiento en España"
(Desembre 2006)

**CREAP2006-14**
**Camarero, M.; Carrion-i-Silvestre, J.LL.** (AQR-IREA)**.**;**Tamarit**, **C.**
"New evidence of the real interest rate parity for OECD countries using panel unit root tests with breaks"
(Desembre 2006)

**CREAP2006-15**
**Karanassou, M.; Sala, H.** (GEAP)**.**;**Snower** , **D. J.**
"The macroeconomics of the labor market: Three fundamental views"
(Desembre 2006)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2007

**XREAP2007-01**
**Castany, L** (AQR-IREA)**; López-Bazo, E.** (AQR-IREA).;**Moreno** , **R.** (AQR-IREA)
"Decomposing differences in total factor productivity across firm size"
(Març 2007)

**XREAP2007-02**
**Raymond, J. Ll.** (GEAP)**; Roig, J. Ll.** (GEAP)
"Una propuesta de evaluación de las externalidades de capital humano en la empresa"
(Abril 2007)

**XREAP2007-03**
**Durán, J. M.** (IEB)**; Esteller, A.** (IEB)
"An empirical analysis of wealth taxation: Equity vs. Tax compliance"
(Juny 2007)

**XREAP2007-04**
**Matas, A.** (GEAP)**; Raymond, J.Ll.** (GEAP)
"Cross-section data, disequilibrium situations and estimated coefficients: evidence from car ownership demand"
(Juny 2007)

**XREAP2007-05**
**Jofre-Montseny, J.** (IEB)**; Solé-Ollé, A.** (IEB)
"Tax differentials and agglomeration economies in intraregional firm location"
(Juny 2007)

**XREAP2007-06**
**Álvarez-Albelo, C.** (CREB)**; Hernández-Martín, R.**
"Explaining high economic growth in small tourism countries with a dynamic general equilibrium model"
(Juliol 2007)

**XREAP2007-07**
**Duch, N.** (IEB)**; Montolio, D.** (IEB); **Mediavilla, M.**
"Evaluating the impact of public subsidies on a firm's performance: a quasi-experimental approach"
(Juliol 2007)

**XREAP2007-08**
**Segarra-Blasco, A.** (GRIT)
"Innovation sources and productivity: a quantile regression analysis"
(Octubre 2007)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**XREAP2007-09**
**Albalate, D.** (PPRE-IREA)
"Shifting death to their Alternatives: The case of Toll Motorways"
(Octubre 2007)

**XREAP2007-10**
**Segarra-Blasco, A.** (GRIT); **Garcia-Quevedo, J.** (IEB); **Teruel-Carrizosa, M.** (GRIT)
"Barriers to innovation and public policy in catalonia"
(Novembre 2007)

**XREAP2007-11**
**Bel, G.** (PPRE-IREA); **Foote, J.**
"Comparison of recent toll road concession transactions in the United States and France"
(Novembre 2007)

**XREAP2007-12**
**Segarra-Blasco, A.** (GRIT);
"Innovation, R&D spillovers and productivity: the role of knowledge-intensive services"
(Novembre 2007)

**XREAP2007-13**
**Bermúdez Morata, Ll.** (RFA-IREA); **Guillén Estany, M.** (RFA-IREA), **Solé Auró, A**. (RFA-IREA)
"Impacto de la inmigración sobre la esperanza de vida en salud y en discapacidad de la población española"
(Novembre 2007)

**XREAP2007-14**
**Calaeys, P.** (AQR-IREA); **Ramos, R.** (AQR-IREA), **Suriñach, J**. (AQR-IREA)
"Fiscal sustainability across government tiers"
(Desembre 2007)

**XREAP2007-15**
**Sánchez Hugalbe, A.** (IEB)
"Influencia de la inmigración en la elección escolar"
(Desembre 2007)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2008

**XREAP2008-01**
**Durán Weitkamp, C.** (GRIT)**; Martín Bofarull, M.** (GRIT) ; **Pablo Martí, F.**
"Economic effects of road accessibility in the Pyrenees: User perspective"
(Gener 2008)

**XREAP2008-02**
**Díaz-Serrano, L.; Stoyanova, A. P.** (CREB)
"The Causal Relationship between Individual's Choice Behavior and Self-Reported Satisfaction: the Case of Residential Mobility in the EU"
(Març 2008)

**XREAP2008-03**
**Matas, A.** (GEAP)**; Raymond, J. L.** (GEAP)**; Roig, J. L.** (GEAP)
"Car ownership and access to jobs in Spain"
(Abril 2008)

**XREAP2008-04**
**Bel, G.** (PPRE-IREA) **; Fageda, X.** (PPRE-IREA)
"Privatization and competition in the delivery of local services: An empirical examination of the dual market hypothesis"
(Abril 2008)

**XREAP2008-05**
**Matas, A.** (GEAP); **Raymond, J. L.** (GEAP); **Roig, J. L.** (GEAP)
"**Job accessibility and employment probability**"
(Maig 2008)

**XREAP2008-06**
**Basher, S. A.; Carrión, J. Ll.** (AQR-IREA)
Deconstructing Shocks and Persistence in OECD Real Exchange Rates
(Juny 2008)

**XREAP2008-07**
**Sanromá, E.** (IEB)**; Ramos, R.** (AQR-IREA); Simón, H.
Portabilidad del capital humano y asimilación de los inmigrantes. Evidencia para España
(Juliol 2008)

**XREAP2008-08**
**Basher, S. A.; Carrión, J. Ll.** (AQR-IREA)
Price level convergence, purchasing power parity and multiple structural breaks: An application to US cities
(Juliol 2008)

**XREAP2008-09**
**Bermúdez, Ll.** (RFA-IREA)
A priori ratemaking using bivariate poisson regression models
(Juliol 2008)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**XREAP2008-10**
**Solé-Ollé, A.** (IEB), **Hortas Rico, M.** (IEB)
Does urban sprawl increase the costs of providing local public services? Evidence from Spanish municipalities
(Novembre 2008)

**XREAP2008-11**
**Teruel-Carrizosa, M.** (GRIT), **Segarra-Blasco, A.** (GRIT)
Immigration and Firm Growth: Evidence from Spanish cities
(Novembre 2008)

**XREAP2008-12**
**Duch-Brown, N.** (IEB), **García-Quevedo, J.** (IEB), **Montolio, D.** (IEB)
Assessing the assignation of public subsidies: Do the experts choose the most efficient R&D projects?
(Novembre 2008)

**XREAP2008-13**
**Bilotkach, V.**, **Fageda, X.** (PPRE-IREA), **Flores-Fillol, R.**
Scheduled service versus personal transportation: the role of distance
(Desembre 2008)

**XREAP2008-14**
**Albalate, D.** (PPRE-IREA), **Gel, G.** (PPRE-IREA)
Tourism and urban transport: Holding demand pressure under supply constraints
(Desembre 2008)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2009

**XREAP2009-01**
**Calonge, S.** (CREB)**; Tejada, O.**
"A theoretical and practical study on linear reforms of dual taxes"
(Febrer 2009)

**XREAP2009-02**
**Albalate, D.** (PPRE-IREA)**; Fernández-Villadangos, L.** (PPRE-IREA)
"Exploring Determinants of Urban Motorcycle Accident Severity: The Case of Barcelona"
(Març 2009)

**XREAP2009-03**
**Borrell, J. R.** (PPRE-IREA)**; Fernández-Villadangos, L.** (PPRE-IREA)
"Assessing excess profits from different entry regulations"
(Abril 2009)

**XREAP2009-04**
**Sanromá, E.** (IEB)**; Ramos, R.** (AQR-IREA), **Simon, H.**
"Los salarios de los inmigrantes en el mercado de trabajo español. ¿Importa el origen del capital humano?"
(Abril 2009)

**XREAP2009-05**
**Jiménez, J. L.; Perdiguero, J.** (PPRE-IREA)
"(No)competition in the Spanish retailing gasoline market: a variance filter approach"
(Maig 2009)

**XREAP2009-06**
**Álvarez-Albelo,C. D.** (CREB)**, Manresa, A.** (CREB)**, Pigem-Vigo, M.** (CREB)
"International trade as the sole engine of growth for an economy"
(Juny 2009)

**XREAP2009-07**
**Callejón, M.** (PPRE-IREA)**, Ortún V, M.**
"The Black Box of Business Dynamics"
(Setembre 2009)

**XREAP2009-08**
**Lucena, A.** (CREB)
"The antecedents and innovation consequences of organizational search: empirical evidence for Spain"
(Octubre 2009)

**XREAP2009-09**
**Domènech Campmajó, L.** (PPRE-IREA)
"Competition between TV Platforms"
(Octubre 2009)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**XREAP2009-10**
**Solé-Auró, A.** (RFA-IREA)**,Guillén, M.** (RFA-IREA)**, Crimmins, E. M.**
"Health care utilization among immigrants and native-born populations in 11 European countries. Results from the Survey of Health, Ageing and Retirement in Europe"
(Octubre 2009)

**XREAP2009-11**
**Segarra, A.** (GRIT)**, Teruel, M.** (GRIT)
"Small firms, growth and financial constraints"
(Octubre 2009)

**XREAP2009-12**
**Matas, A.** (GEAP)**, Raymond, J.Ll.** (GEAP), **Ruiz, A.** (GEAP)
"Traffic forecasts under uncertainty and capacity constraints"
(Novembre 2009)

**XREAP2009-13**
**Sole-Ollé, A.** (IEB)
"Inter-regional redistribution through infrastructure investment: tactical or programmatic?"
(Novembre 2009)

**XREAP2009-14**
**Del Barrio-Castro, T.**, **García-Quevedo, J.** (IEB)
"The determinants of university patenting: Do incentives matter?"
(Novembre 2009)

**XREAP2009-15**
**Ramos, R.** (AQR-IREA), **Suriñach, J.** (AQR-IREA)**, Artís, M.** (AQR-IREA)
"Human capital spillovers, productivity and regional convergence in Spain"
(Novembre 2009)

**XREAP2009-16**
**Álvarez-Albelo, C. D.** (CREB), **Hernández-Martín, R.**
"The commons and anti-commons problems in the tourism economy"
(Desembre 2009)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2010

**XREAP2010-01**
**García-López, M. A.** (GEAP)
"The Accessibility City. When Transport Infrastructure Matters in Urban Spatial Structure"
(Febrer 2010)

**XREAP2010-02**
**García-Quevedo, J.** (IEB), **Mas-Verdú, F.** (IEB), **Polo-Otero, J.** (IEB)
"Which firms want PhDs? The effect of the university-industry relationship on the PhD labour market"
(Març 2010)

**XREAP2010-03**
**Pitt, D.**, **Guillén, M.** (RFA-IREA)
"An introduction to parametric and non-parametric models for bivariate positive insurance claim severity distributions"
(Març 2010)

**XREAP2010-04**
**Bermúdez, Ll.** (RFA-IREA), **Karlis, D.**
"Modelling dependence in a ratemaking procedure with multivariate Poisson regression models"
(Abril 2010)

**XREAP2010-05**
**Di Paolo, A.** (IEB)
"Parental education and family characteristics: educational opportunities across cohorts in Italy and Spain"
(Maig 2010)

**XREAP2010-06**
**Simón, H.** (IEB), **Ramos, R.** (AQR-IREA), **Sanromá, E.** (IEB)
"Movilidad ocupacional de los inmigrantes en una economía de bajas cualificaciones. El caso de España"
(Juny 2010)

**XREAP2010-07**
**Di Paolo, A.** (GEAP & IEB), **Raymond, J. Ll.** (GEAP & IEB)
"Language knowledge and earnings in Catalonia"
(Juliol 2010)

**XREAP2010-08**
**Bolancé, C.** (RFA-IREA), **Alemany, R.** (RFA-IREA), **Guillén, M.** (RFA-IREA)
"Prediction of the economic cost of individual long-term care in the Spanish population"
(Setembre 2010)

**XREAP2010-09**
**Di Paolo, A.** (GEAP & IEB)
"Knowledge of catalan, public/private sector choice and earnings: Evidence from a double sample selection model"
(Setembre 2010)

**XREAP2010-10**
**Coad, A.**, **Segarra, A.** (GRIT), **Teruel, M.** (GRIT)
"Like milk or wine: Does firm performance improve with age?"
(Setembre 2010)

**XREAP2010-11**
**Di Paolo, A.** (GEAP & IEB), **Raymond, J. Ll.** (GEAP & IEB), **Calero, J.** (IEB)
"Exploring educational mobility in Europe"
(Octubre 2010)

**XREAP2010-12**
**Borrell, A.** (GiM-IREA), **Fernández-Villadangos, L.** (GiM-IREA)
"Clustering or scattering: the underlying reason for regulating distance among retail outlets"
(Desembre 2010)

**XREAP2010-13**
**Di Paolo, A.** (GEAP & IEB)
"School composition effects in Spain"
(Desembre 2010)

**XREAP2010-14**
**Fageda, X.** (GiM-IREA), **Flores-Fillol, R.**
"Technology, Business Models and Network Structure in the Airline Industry"
(Desembre 2010)

**XREAP2010-15**
**Albalate, D.** (GiM-IREA), **Bel, G.** (GiM-IREA), **Fageda, X.** (GiM-IREA)
"Is it Redistribution or Centralization? On the Determinants of Government Investment in Infrastructure"
(Desembre 2010)

**XREAP2010-16**
**Oppedisano, V.**, **Turati, G.**
"What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"
(Desembre 2010)

**XREAP2010-17**
**Canova, L.**, **Vaglio, A.**
"Why do educated mothers matter? A model of parental help"
(Desembre 2010)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

## 2011

**XREAP2011-01**
**Fageda, X.** (GiM-IREA), **Perdiguero, J.** (GiM-IREA)
"An empirical analysis of a merger between a network and low-cost airlines"
(Maig 2011)

**XREAP2011-02**
**Moreno-Torres, I.** (ACCO, CRES & GiM-IREA)
"What if there was a stronger pharmaceutical price competition in Spain? When regulation has a similar effect to collusion"
(Maig 2011)

**XREAP2011-03**
**Miguélez, E.** (AQR-IREA); **Gómez-Miguélez, I.**
"Singling out individual inventors from patent data"
(Maig 2011)

**XREAP2011-04**
**Moreno-Torres, I.** (ACCO, CRES & GiM-IREA)
"Generic drugs in Spain: price competition vs. moral hazard"
(Maig 2011)

**XREAP2011-05**
**Nieto, S.** (AQR-IREA)**, Ramos, R.** (AQR-IREA)
"¿Afecta la sobreeducación de los padres al rendimiento académico de sus hijos?"
(Maig 2011)

**XREAP2011-06**
**Pitt, D.**, **Guillén, M.** (RFA-IREA), **Bolancé, C.** (RFA-IREA)
"Estimation of Parametric and Nonparametric Models for Univariate Claim Severity Distributions - an approach using R"
(Juny 2011)

**XREAP2011-07**
**Guillén, M.** (RFA-IREA), **Comas-Herrera, A.**
"How much risk is mitigated by LTC Insurance? A case study of the public system in Spain"
(Juny 2011)

**XREAP2011-08**
**Ayuso, M.** (RFA-IREA), **Guillén, M.** (RFA-IREA), **Bolancé, C.** (RFA-IREA)
"Loss risk through fraud in car insurance"
(Juny 2011)

**XREAP2011-09**
**Duch-Brown, N.** (IEB), **García-Quevedo, J.** (IEB), **Montolio, D.** (IEB)
"The link between public support and private R&D effort: What is the optimal subsidy?"
(Juny 2011)

**XREAP2011-10**
**Bermúdez, Ll.** (RFA-IREA), **Karlis, D.**
"Mixture of bivariate Poisson regression models with an application to insurance"
(Juliol 2011)

**XREAP2011-11**
**Varela-Irimia, X-L.** (GRIT)
"Age effects, unobserved characteristics and hedonic price indexes: The Spanish car market in the 1990s"
(Agost 2011)

**XREAP2011-12**
**Bermúdez, Ll.** (RFA-IREA), **Ferri, A.** (RFA-IREA), **Guillén, M.** (RFA-IREA)
"A correlation sensitivity analysis of non-life underwriting risk in solvency capital requirement estimation"
(Setembre 2011)

**XREAP2011-13**
**Guillén, M.** (RFA-IREA), **Pérez-Marín, A.** (RFA-IREA), **Alcañiz, M.** (RFA-IREA)
"A logistic regression approach to estimating customer profit loss due to lapses in insurance"
(Octubre 2011)

**XREAP2011-14**
**Jiménez, J. L.**, **Perdiguero, J.** (GiM-IREA), **García, C.**
"Evaluation of subsidies programs to sell green cars: Impact on prices, quantities and efficiency"
(Octubre 2011)

**XREAP2011-15**
**Arespa, M.** (CREB)
"A New Open Economy Macroeconomic Model with Endogenous Portfolio Diversification and Firms Entry"
(Octubre 2011)

**XREAP2011-16**
**Matas, A.** (GEAP), **Raymond, J. L.** (GEAP), **Roig, J.L.** (GEAP)
"The impact of agglomeration effects and accessibility on wages"
(Novembre 2011)

**XREAP2011-17**
**Segarra, A.** (GRIT)
"R&D cooperation between Spanish firms and scientific partners: what is the role of tertiary education?"
(Novembre 2011)

**XREAP2011-18**
**García-Pérez, J. I.**; **Hidalgo-Hidalgo, M.**; **Robles-Zurita, J. A.**
"Does grade retention affect achievement? Some evidence from PISA"
(Novembre 2011)

**XREAP2011-19**
**Arespa, M.** (CREB)
"Macroeconomics of extensive margins: a simple model"
(Novembre 2011)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**XREAP2011-20**
**García-Quevedo, J.** (IEB), **Pellegrino, G.** (IEB), **Vivarelli, M.**
"The determinants of YICs' R&D activity"
(Desembre 2011)

**XREAP2011-21**
**González-Val, R.** (IEB), **Olmo, J.**
"Growth in a Cross-Section of Cities: Location, Increasing Returns or Random Growth?"
(Desembre 2011)

**XREAP2011-22**
**Gombau, V.** (GRIT), **Segarra, A.** (GRIT)
"The Innovation and Imitation Dichotomy in Spanish firms: do absorptive capacity and the technological frontier matter?"
(Desembre 2011)

**SÈRIE DE DOCUMENTS DE TREBALL DE LA XREAP**

**2012**

**XREAP2012-01**
**Borrell, J. R.** (GiM), **Jiménez, J. L.**, **García, C.**
"Evaluating Antitrust Leniency Programs"
(Gener 2012)


**xreap@pcb.ub.es**