# MEASURING EXTERNALITIES IN AN INFORMATION COMMONS: THE CASE OF LIBRARIES

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**Resumo**

O presente artigo mede efeitos externos em um tipo específico de recurso comum, um information commons. Empregando uma nova base de dados relacionada a mais de 700.000 transações em distintas bibliotecas, durante um período de 10 anos (2006-2015), estimamos externalidades decorrentes de ações de usuários de bibliotecas sujeitos a sanções não-monetárias (professores e funcionários) sobre usuários sujeitos a uma sanção monetária (estudantes). Adicionalmente, estimamos efeitos de pares (?peer effects?) entre os usuários, considerando o número de itens que eles emprestam da biblioteca. Ao investigar externalidades, descobrimos um efeito "crowding-out": para cada unidade adicional na contagem de livros de professores e funcionários, ocorre uma redução aproximada de um para um nas contagens de alunos. No caso de efeitos de pares, encontramos uma influência positiva do comportamento de grupo sobre indivíduos: a cada 100 livros emprestados pelo grupo de pares de um usuário, há um aumento de três livros emprestados, em média. Os resultados relatados neste artigo têm importantes implicações para teorias baseadas no gerenciamento de recursos comuns, assim como na provisão de bens públicos.

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## THE CASE OF LIBRARIES

**ÁREA TEMÁTICA: Administração Pública, Governo e Terceiro Setor.**

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**Abstract**

The present paper measures external effects in a specific type of common-pool resource, an information commons. Employing a novel dataset related to more than 700,000 transactions in distinct libraries during a 10-year period (2006-2015), we estimate the external effects of actions of library users who were subject to a non-monetary sanction (professors and university employees) over users who were subject to a monetary sanction (students). Additionally, we estimate peer effects among users, considering the number of items they borrow from the library. When investigating externalities, we uncover a "crowding-out" effect: for an additional unity in professors and employees' counts, there is an approximate one-to-one decrease in students' counts. In the case of peer effects, we find a positive influence of group behavior over individuals: for every 100 books borrowed by a user's peer group, there is a rise of three books per user, on average. The results reported in this paper have important implications for theories based on common-pool resource management, as well as public goods provision.

**Keywords:** common-pool resources; externalities; public goods.

## 1. Introduction

Common-pool resources correspond to goods with unique characteristics: they are non-exclusive, but rival. The first property states that it is hard to exclude individuals from consuming the good, while the second property states that one individual's consumption may reduce other individuals' consumption. An important question related to this class of goods asks if their characteristics may lead to overexploitation. In a seminal contribution, Hardin (1968) predicted that such a situation would inevitably happen, given that individualistic attitudes may prevail in both the short and long run. For example, forest degradation would be a natural result in a setting where individuals and firms try to maximize their own private gains, the so-called "Tragedy of the Commons" (Hardin, 1968).

The present paper measures externalities in a specific type of common-pool resource, an information commons (Hess & Ostrom, 2007a, 2007b). Employing a novel dataset related to more than 700,000 transactions in distinct libraries during a 10-year period (2006-2015), we estimate the magnitude of external effects derived from the actions of library users who were subject to a non-monetary sanction over users who were subject to a monetary sanction. Additionally, we estimate the magnitude of peer effects among users, considering the number of items they borrow from the library. In both occasions, we exploit the fact that libraries are an example of a common-pool resource, with an emphasis on their basic properties. We also exploit differences among library users in terms of the incentives they face: while some users (professors and employees) are subject to non-monetary sanctions, in the form of daily suspensions, others (students) face monetary sanctions, in the form of fines.

Libraries constitute an ideal setting for studying externalities. The existence of a limited supply of books in a library may generate competition among users, as well as a congestion of library services. Given common-pool resources' rivalry property, one can imagine that, the higher the number of books that a user borrows, the lower would be the number of available books for remaining users. In a library setting, students from the same class, facing exam weeks, could compete for the same books. Following the same reasoning, professors from similar areas, preparing course materials before the semester begins, could face competition for library services from their colleagues. Moreover, the constant interaction among users with similar needs may generate peer effects in such a context. These features of the data allow us to study externalities in this setting by: (i) estimating the magnitude of external effects of users' actions, considering that they face distinct types of sanctions, and (ii) estimating peer effects among users with similar characteristics.

The main contributions of this paper include the following:

1. We evaluate a social dilemma situation in a field setting. When compared to previous work, we consider a novel example of a common-pool resource, an information commons (libraries).

2. The paper contributes to the literature on external effects measurement, by presenting estimates of externalities and peer effects among library users.

3. The paper also dialogues with the literature related to the importance of incentives in distinct settings, by evaluating the response of library users facing different types of sanctions.

4. The results of this research correspond to empirical evidence related to theories of public goods provision and common-pool resource management. They also represent a novel application involving big data.

In the next section, we describe each of these points in detail. For now, we anticipate two results. First, when investigating the externalities of professors and employees' actions over students, we uncover a "crowding-out" effect: for an additional unity in non-students' book counts, there is an approximate decrease of one-to-one in students' counts, *ceteris paribus*. These estimates correspond to an empirical measure of libraries' rivalry property. Second, when estimating peer effects among users with similar characteristics, we find a positive influence of group behavior over individuals: for every 100 books borrowed by a user's peer group, there is a rise of three books per user, on average. Taken together, these results suggest the importance of behavioral complementarities in a field setting, having important implications for theories based on common-pool resource management, as well as public goods provision.

The remainder of the paper proceeds as follows. Section 2 contains a selective description of the literature, as well as its relation to the contributions in this paper. Section 3 describes the data and research design employed in the analysis below. Section 4 contains the main empirical results, as well as a related discussion. Finally, section 5 concludes.

## 2. Related Work

This paper brings four contributions to distinct literatures. First, the results here presented dialogue with a well-established literature in social dilemmas, with an emphasis on common-pool resource management (Demsetz, 1967; Hardin, 1968; Olson, 1965; Ostrom, 1990, 1999, 2010; Perc et al., 2017; Perc & Szolnoki, 2010). Although there exists a large volume of evidence related to social dilemmas in artificial settings – such as laboratory experiments (Andreoni, 1988; Andreoni, Harbaugh, & Vesterlund, 2008; Dawes & Thaler, 1988; Perc et al., 2017) – this paper reports results related to social dilemmas in a field setting, along the lines of recent studies (Fehr & Leibbrandt, 2011; Gneezy, Leibbrandt, & List, 2016). Previous contributions in the literature emphasized examples related to themes such as forests, fisheries, and wildlife in general (Cárdenas, 2003; Dietz, Ostrom, & Stern, 2003; Fehr & Leibbrandt, 2011; Ostrom, 2007; Rustagi, Engel, & Kosfeld, 2010). Here, we present an example of application related to an information commons. On the other hand, it is worth noting that most contributions related to the inner workings of libraries have not explored collective action problems, such as those related to public goods provision and common-pool resource management (Getz, 1989; Koechlin, 2010; Paloheimo, Lettenmeier, & Waris, 2015). The present paper differs from previous contributions by expanding the scope of analysis and focusing on the internal dynamics of an information commons (Hess & Ostrom, 2007a, 2007b). To the best of our knowledge, this is probably one of the first attempts to measure externalities in an information commons.

Second, these results contribute to a growing literature related to the empirical measurement of externalities. While previous contributions focused on specific settings, such as traffic accidents (Edlin & Karaca-Mandic, 2006), crime (Ayres & Levitt, 1998), or natural resources (Fehr & Leibbrandt, 2011), we exploit the main properties of common-pool resources to estimate the magnitude of external effects in a novel setting. A related literature emphasizes the importance of peer effects in distinct settings (Breza, 2012; Marmaros & Sacerdote, 2006; Moretti, 2011), with a focus on the effects of group behavior over individuals. In the case of these contributions, although there were differences in terms of results obtained, most authors agree that peer effects measurement is fraught with difficulties. As mentioned above, the present paper adds to this literature by exploiting the fact that the existence of a limited supply of books in a library may generate competition among users, as well as a congestion of services. In particular, the constant interaction of library users with similar needs, such as students from the same class, allows us to estimate peer effects in this setting.

Third, by comparing the behavior of users subject to different kinds of sanctions (monetary and non-monetary), this paper adds to a transdisciplinary literature on the importance of distinct types of incentives. In fact, there is not a clear consensus among social scientists in terms of the superiority of monetary sanctions over other forms of punishment (Gneezy, Meier, & Rey-Biel, 2011; Kamenica, 2012). Although there exists some evidence from laboratory experiments suggesting that different types of sanctions can affect behavior through distinct channels (Fehr & Gächter, 2000; Masclet, Noussair, Tucker, & Villeval, 2003), the available evidence presents mixed results, either in terms of natural or field experiments (Bar-Ilan & Sacerdote, 2004; Funk, 2007; Gneezy & Rustichini, 2000a, 2000b; Haselhuhn, Pope, Schweitzer, & Fishman, 2012). In this sense, the present paper brings new results to an open debate, by evaluating the behavior of users responding to distinct types of incentives in a field setting[1].

Finally, the results reported in this paper relate to big data applications. While there is not a definitive consensus on the meaning of such a term (Stephens-Davidowitz,

[1] Ellingsen and Johannesson (2007), Gneezy, Meier, and Rey-Biel (2011), Kamenica (2012), and Perc et al. (2017) correspond to discussions related to the importance of incentives in distinct settings. Harrison and List (2007), Levitt and List (2008, 2009), Reiley and List (2010), and Rosenzweig and Wolpin (2000) present surveys related to field and natural experiments in economics. See Piehl and Williams (2011) and Polinsky and Shavell (2000) for discussions on the institutional requirements for the instauration of fines.

2017), it seems clear that it provides social scientists with an increasing set of tools to study distinct situations involving a massive volume of available data (Stephens-Davidowitz & Varian, 2014; Varian, 2014; Varian & Choi, 2009). By evaluating the behavior of library users involved in more than 700,000 transactions, the present paper contributes to a growing literature focused on the analysis of large amounts of data related to natural resource management (Song et al., 2015, 2017).

## 3. Material And Methods

### *3.1. Institutional Background And Data*

We study the behavior of library users covering more than 700,000 transactions during a 10-year period. We have access to confidential daily data related to library users of a private business school in São Paulo, Brazil, for the 2006-2015 period. The data contain detailed information on 16,232 individual users, covering 723,798 daily transactions. This corresponds to an unbalanced panel, since each library user may borrow different numbers of specific library items at distinct moments. For instance, one user may borrow two books on March 1st, and then borrow one more book on March 3rd, before returning previous items. The data is available in electronic format through a system named *Pergamum* (https://www.pergamum.pucpr.br), which provides technology services for several libraries in Brazil.

The data contain information on users' socioeconomic characteristics – such as gender, date of birth, and address – as well as library's confidential information, with each user's identification number, university category (high school, undergraduate, graduate, MBA, professor, and employee) and area of study (management, accounting, economics, international relations, advertising, and secretariat). For each user in the data, we are able to identify her department and category. The data also contain the dates when users borrow specific items from the library, as well as each item's code, and title. Based on each title, we build a measure of area of expertise for each book in the sample, such as management, accounting, economics, and law.

We also have access to the libraries' official yearly reports. These reports contain rich institutional information related to the internal workings of libraries for the 2005-2015 period. Based on this information, we are able to estimate the predicted devolution date for each user in the sample. In this specific case, the library's electronic system (*Pergamum*) imposes a rule of 15 days for non-students and graduate students, and seven days, for all other users. Each user can renew books after the predicted devolution date expires, conditional on a waiting list managed by library staff. Although we do not have access to the information available in such lists', we can observe when users renew library items by comparing the dates of borrowings of the same item over time. There are also differences in terms of the number of items that each user can borrow from the library: while professors and masters' students can borrow a maximum number of seven items, students can borrow a maximum of five, and university employees can borrow three items, only.

Table 3 presents descriptive statistics for the main variables used in the paper. The table's first and second columns display mean values for each variable, as well as standard deviation values, respectively. The third and fourth columns contain minimum and maximum values:

Table 3 - Main variables' descriptive statistics, 2006-2015

| VARIABLE | Mean | Std.Dev. | Minimum | Maximum |
|---|---|---|---|---|
| Age | 26.28 | 7.55 | 13 | 79 |
| Book Count | 2.65 | 1.42 | 1 | 7 |
| Female | 0.53 | 0.50 | 0 | 1 |
| First Year | 0.22 | 0.41 | 0 | 1 |
| Scholarship | 0.37 | 0.48 | 0 | 1 |
| 0 to 4 years in College | 0.89 | 0.31 | 0 | 1 |
| High School | 0.02 | 0.13 | 0 | 1 |
| Undergraduate | 0.66 | 0.48 | 0 | 1 |
| Graduate | 0.04 | 0.20 | 0 | 1 |
| MBA | 0.21 | 0.41 | 0 | 1 |
| Professor | 0.02 | 0.15 | 0 | 1 |
| University Employee | 0.01 | 0.08 | 0 | 1 |
| Management | 0.33 | 0.47 | 0 | 1 |
| Accounting | 0.37 | 0.48 | 0 | 1 |
| Economics | 0.14 | 0.35 | 0 | 1 |
| International Relations | 0.05 | 0.21 | 0 | 1 |
| Advertising | 0.04 | 0.20 | 0 | 1 |
| Secretariat | 0.02 | 0.14 | 0 | 1 |
| Management book | 0.32 | 0.47 | 0 | 1 |
| Accounting Book | 0.16 | 0.37 | 0 | 1 |
| Economics Book | 0.15 | 0.35 | 0 | 1 |
| Law Book | 0.08 | 0.26 | 0 | 1 |

Source: authors' calculations, based on library data.
Notes: (a) Observations correspond to the 2006-2015 period, covering 723,798 transactions by 16,232 library users.

For the main period of analysis in this paper (2006-2015), we observe 723,798 library transactions, made by 16,232 users. These users are, on average, 26 years old, with similar proportions in terms of gender. Among these users, 22% are in their first year in college, while 37% holds a scholarship. In terms of categories, most library users are either undergraduates (66%) or MBA students (21%). In terms of areas of study, the vast majority of users enroll in either accounting (37%), management (33%), or economics (14%). This is an intuitive result, since libraries are located in a business school. When looking at the library's books, a similar pattern reappears: one-third of these books correspond to management books, while accounting and economics books jointly respond for more than 30% of the total.

## *3.2. Empirical Strategy*

The present subsection describes the empirical strategy employed in the paper. In order to estimate externalities in the present setting, we proceed in two steps. First, we employ count models to correlate the number of items among users facing distinct types of sanctions (monetary and non-monetary). In doing so, we aggregate library users in two groups: one composed by students, only (named "Student"), and another composed by professors and university employees ("Non-student"). The first hypothesis we want to test is the following:

$H_A$ (Externalities): *Being subject to non-monetary sanctions, non-student users generate negative externalities over student users. Specifically, the higher the number of items borrowed by non-students, the lower should be the number of items borrowed by students*.

We test the latter hypothesis by running econometric specifications of the following form:

$$(1)\ \text{(Counts by Student)}_{it} = \alpha_i + \gamma\text{(Counts by Non-student)}_{it} + \mathbf{X}\beta_{it} + \Sigma_t(\psi_t) + \varepsilon_{it}$$

The dependent variable in the above specification corresponds to the number of item counts (number of books) that each user (denoted by the subscript *i*) facing a monetary sanction borrows every time (subscript *t*) that she goes to the library. We regress this variable on the number of item counts that users facing a non-monetary sanction borrows, and on a set of controls (**X**), which include users' age, gender, and area of study, as well as book characteristics. We also include time dummies in most specifications, to reflect days of the week, weeks of the year, and specific years, in some specifications ($\psi_t$). In the case of the term $\varepsilon_{it}$, it has a conditional mean of zero ($E(\varepsilon_{it} \mid t) = 0$). The parameter of interest, in this case, corresponds to γ, measuring the response of students' counts to variations in non-students' counts. By estimating correlations between item counts of different types of users, we try to capture external effects in this setting. Specifically, we measure the magnitude of an information commons' rivalry property.

When estimating the above specification, we employ two alternative methods: ordinary least squares (OLS), as well as count-based regressions (Poisson). We employ the latter methods, given the nature of the dependent variable, which is discrete and non-negative ($Y_i$ = 0, 1, 2, …). In the case of the Poisson distribution, the probability of occurrence of a count (*m*) for a given exposition is the following:

$$p(Y_i = m) = \frac{e^{-\lambda_i}.\lambda_i^m}{m!},$$

with E(Y) = Var(Y) = $\lambda$. In this context, $\lambda$ measures the expected number of occurrences of a rare event for a given exposition or, alternatively, the estimated average rate of incidence[2].

As a second step, when estimating peer effects among library users, we want to test the following hypothesis:

[22] For detailed expositions of count-based models, see Blevins, Tsang, and Spain (2015), Cameron and Trivedi (2009), and Trivedi (2010). Marmaros and Sacerdote (2006) corresponds to an application of count-based models involving peer effects. See also Fisman and Miguel (2007) for an example related to corruption practices among United Nations' diplomats.

$H_B$ (Peer Effects): *The library's rivalry property may generate competition among users with similar needs. Specifically, the higher the counts of books from a peer group, the lower should be an individual user's count.*

To test the above hypothesis, we run the following specification:

$$(2)\ (\text{Counts by User})_{it} = \alpha_i + \phi(\text{Counts by Peer Group})_{-it} + \mathbf{X}\beta_{it} + \Sigma_t(\psi_t) + \varepsilon_{it}$$

In the above specification, we regress an individual user's counts on the counts of a group that she belongs. Although we do not have official information related to class size and its composition for library users, we create peer groups based on user categories, area of knowledge and time at the university. For example, in the case of a first-year student majoring in management, we regress her number of book counts on the number of book counts of her classmates. Again, we employ OLS methods to estimate peer effects. However, given the possibility of endogeneity problems in this setting, we also employ instrumental variables estimations (Angrist & Krueger, 2001; Baum, 2007). We try to circumvent these potential problems by instrumenting peer groups' item counts with their own lagged values (one and two lags). In order to test these instruments' adequacy, we report the results of Sargan-Hansen tests (Baum, 2007) (more details below).

## 4. Results And Discussion

In this section, we present the results of the empirical analysis performed in the paper. We divide the section in two parts: a first part, reporting estimates of externalities derived from the actions of non-students over students; and a second part, reporting estimates of peer effects among users of similar groups. In the specific case of this section, we report the main message of each table in its respective heading[3].

*4.1.1. Externalities*

We present, in table 4, the results of OLS estimations for equation (1). In the table, the dependent variable corresponds to the average number of items that users in the student group borrow from the library (named "Counts by Student"). The table's first column reports the results of a simple bivariate regression relating item counts by students to item counts by non-students. We measure both variables in natural logarithmic scale. We do this to obtain an initial estimate of the sensitivity (elasticity) of the first variable to the second variable, as well as to evaluate the sign of the estimated correlation[4]. In the table's second to fourth columns, we progressively add

[3] We base the empirical analysis described in this paper on Angrist and Pischke (2009), Baum (2007, 2016), and Cameron and Trivedi (2009).

[4] We employ variables in logarithmic scale in OLS regressions. Specifically, we transform variables according to the following formula: $\log(X) = 1 + \ln(X)$, where *X* represents the variable in its original scale.

covariates to the specifications to control for fixed-effects that may contaminate the resulting estimates. We do this to evaluate the robustness of the main results in the table. In all cases, we cluster standard errors by the number of courses offered at the university in the sample period[5].

Table 4 – External Effects – OLS estimates, 2006-2015

Message: for a 10% increase in the counts by non-students, there is a -8% decrease in the counts by students

| VARIABLES | (1) Counts by Student | (2) Counts by Student | (3) Counts by Student | (4) Counts by Student |
|---|---|---|---|---|
| Counts by Non-student | -0.79*** | -0.79*** | -0.79*** | -0.80*** |
| | (0.032) | (0.034) | (0.034) | (0.048) |
| Acad. Year Fixed Effects | No | Yes | Yes | Yes |
| Book Fixed Effects | No | No | Yes | Yes |
| User Fixed Effects | No | No | No | Yes |
| Observations | 723,798 | 723,798 | 723,798 | 723,798 |
| Adj. R-squared | 0.204 | 0.214 | 0.215 | 0.234 |

Source: authors' calculations, based on library data.

Notes: (a) The dependent variable in the specifications corresponds to the number of items borrowed by students in the library. (b) Standard errors clustered by course (reported in parentheses). (c) The group "Student" corresponds to high school, undergraduate, graduate, and MBA students. The group "Non-student" corresponds to professors and university employees. (d) "Acad. Year Fixed Effects" correspond to a set of dummies for 6 days for each week, 51 weeks for each year, and the 2007-2015 years. (e) "Book Fixed Effects" correspond to a set of dummies for books' area of study (management, accounting, economics, and law). (f) "User Fixed Effects" correspond to a set of dummies for users' group ages (18-23, 24-30, 31-40, 41-50, 51-60, 60+), gender (female), area of study (management, accounting, and economics), and time at school (0 to 4 years). (g) Sample Period: 2006-2015. (h) Item counts expressed as natural logarithms. (i) Statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In all cases, there is a robust negative correlation between item counts among students and non-students, with an estimated coefficient of -0.80, on average. This result suggests that, for a 10% increase in the number of items borrowed by non-students, there is a -8% decrease in the number of items borrowed by students. At first, this evidence suggests that, on average, there is a negative correlation between items borrowed by users facing distinct types of sanctions, which confirms the library's rivalry property.

We investigate this result in detail in table 5, by presenting estimates of (1) based on a Poisson count model. Again, we regress the number of items borrowed by students on the number of items borrowed by non-students. We also progressively add covariates in the table's second to fourth columns, in order to control for distinct types of fixed effects.

[5] There are 193 courses in the university during the 2006-2015 period. These courses differ from the areas of study (management, accounting, economics, international relations, advertising, and secretariat) that a student may choose by the time she enrolls in the university. When clustering standard errors by the number of courses, we follow Moretti (2011).

Table 5 – External Effects – Poisson estimates, 2006-2015
Message: an additional count by a non-student generates a one-to-one displacement effect on students' counts.

| VARIABLES | (1) Counts by Student | (2) Counts by Student | (3) Counts by Student | (4) Counts by Student |
|---|---|---|---|---|
| Counts by Non-student | -22.70*** | -21.95*** | -21.44*** | -21.73*** |
| | (0.448) | (0.448) | (0.447) | (0.459) |
| Acad. Year Fixed Effects | No | Yes | Yes | Yes |
| Book Fixed Effects | No | No | Yes | Yes |
| User Fixed Effects | No | No | No | Yes |
| Observations | 723,798 | 723,798 | 723,798 | 723,798 |
| Log Pseudo-likelihood | -1.221e+06 | -1.217e+06 | -1.217e+06 | -1.209e+06 |

Source: authors' calculations, based on library data.
Notes: see Table 4 above.

The results in the table point to a negative estimate among students' and non-students' counts, with coefficients around -22.00. Given the non-linear nature of count-based models, it is worth discussing these estimates in detail. As stated above, the parameter of interest in this setting corresponds to γ, which measures the expected number of cases of a rare event, for a given exposition. Based on the estimates presented in the table, one can calculate the incidence rate ratio (IRR), which gives, as the name suggests, the average incidence rate of item counts for a given variation in the parameter of interest. For example, in the case of the estimate in the table's fourth column, $\hat{\lambda}$ = -21.73, it leads to an IRR value of 3.65e-10 (= $e^{-21.73}$). This result corresponds to the multiplication of the incidence rate of students' counts by a factor of 3.65e-10, *ceteris paribus*. Alternatively, this means that students' counts are -99.99% lower, on average. A similar result holds for the other estimates reported in the table. That is, an additional count by a non-student tends, on average, to generate a one-to-one displacement effect ("crowding-out") on students' counts[6].

### *4.1.2. Peer Effects*

In table 6, we report estimates of equation (2), based on two alternative methods: OLS and instrumental variables (IV) estimations. In the case of all columns in the table, we employ variables in natural logarithmic scale, which provides an interpretation of estimated coefficients as elasticities. We consider full specifications, controlling for academic year, book and user characteristics. We also report the results of Sargan-Hansen tests, in the case of instrumental variables' estimations (under the label "Hansen J Statistic", in the table). This statistic tests the validity of over-identifying restrictions, or alternatively, the validity of the instruments employed in the estimations (Baum, 2007).

[6] We obtain similar results in the case of negative binomial estimations. However, it is worth noting that, given the sample size (723,798 observations), overdispersion tests may present biased results (Cameron & Trivedi, 1990). This is the reason why we decided to report results related to Poisson estimations, only.

Table 6 – Peer Effects – OLS and IV estimates, 2006-2015
Message: for every 100 books borrowed by a user's peer group, there is a rise of three books per user.

| VARIABLES | (1)<br>Counts by User<br>OLS | (5)<br>Counts by User<br>IV |
|---|---|---|
| Counts by Peers | 0.03***<br>(0.008) | 0.04***<br>(0.010) |
| Acad. Year Fixed Effects | Yes | Yes |
| Book Fixed Effects | Yes | Yes |
| User Fixed Effects | Yes | Yes |
| Observations | 723,798 | 723,796 |
| Adj. R-squared | 0.052 | 0.052 |
| Hansen J Statistic | | 0.92<br>(0.34) |

Source: authors' calculations, based on library data.
Notes: (a) The dependent variable in the specifications corresponds to the number of items borrowed by library users. (b) Standard errors clustered by course (reported in parentheses). (c) In instrumental variables (IV) estimations, we instrument the regressor of interest ("Counts by Peers") with its own lagged values for t-1 and t-2. (d) we include academic year, book, and user fixed effects in all regressions. (e) Sample Period: 2006-2015. (f) Statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

One interesting result emerges from the table: in the case of estimations involving the entire sample period (2006-2015), there is evidence of positive peer effects, regardless of the estimation method employed. In particular, a 1% increase in peers' counts correlate to individual users' counts, by a value of +0.03%. That is, for every 100 books borrowed by a user's peer group, there is a rise of three books per user, on average. At first, these results suggest the existence of positive complementarities among users in the libraries investigated in this paper. It is also worth noting that they contradict one of the theoretical hypotheses tested here ($H_B$), which postulates a negative association between library users' book counts and their respective peers.

## 5. Conclusions

This paper presented estimates of externalities in a specific type of common-pool resource, an information commons. We estimated the magnitude of external effects of the actions of library users who were subject to a non-monetary sanction (daily suspension) over users who were subject to a monetary sanction (fine). We also estimated peer effects among users, considering the number of items they borrow from the library. Two main results emerge. First, we uncovered a "crowding-out" effect: for an additional unity in non-students' counts, there is an approximate decrease of one-to-one in students' counts, *ceteris paribus*. Second, when estimating peer effects among users, we found that, for every 100 books borrowed by a user's peer group, there is a rise of three books per user, on average. By providing results for the hypotheses tested above, we hope to stimulate more research on empirical topics related to an information commons.

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