CENTRO INTERDISCIPLINARIO DE INVESTIGACIÓN PARA
EL DESARROLLO INTEGRAL REGIONAL
UNIDAD OAXACA

INSTITUTO POLITÉCNICO NACIONAL

ECONOMÍA DE LA INFORMACIÓN Y EL CONOCIMIENTO PARA EL DESARROLLO RURAL: CASOS DE EVALUCACIÓN INSTITUCIONAL DE LAS TELECOMUNICACIONES, LA PROPIEDAD INTELECTUAL Y EL GOBIERNO ELECTRÓNICO DESDE LA PERSPECTIVA COMUNITARIA.

T E S I S

QUE PARA OBTENER EL GRADO DE:

DOCTOR EN CIENCIAS EN CONSERVACIÓN Y APROVECHAMIENTO DE LOS RECURSOS NATURALES

PRESENTA:
MANUEL GERARDO CHÁVEZ ÁNGELES

DIRIGIDA POR:
DR. PATRICIA SOLEDAD SÁNCHEZ MEDINA

SIP-14

INSTITUTO POLITECNICO NACIONAL

SECRETARIA DE INVESTIGACION Y POSGRADO

ACTA DE REVISION DE TESIS

En la Ciudad de Oaxaca de Juárez siendo las 13:00 horas del día 22 del mes de noviembre del 2013 se reunieron los miembros de la Comisión Revisora de Tesis designada por el Colegio de Profesores de Estudios de Posgrado e Investigación del **Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca (CIIDIR-OAXACA)** para examinar la tesis de grado titulada: "Economía de la Información y el Conocimiento para el Desarrollo Rural: Casos de Evaluación Institucional de las telecomunicaciones, la propiedad intelectual y el gobierno electrónico desde una perspectiva comunitaria".

Presentada por el alumno:

Chávez	**Ángeles**	**Manuel Gerardo**
Apellido paterno	materno	nombre(s)

Con registro: A 1 1 0 1 3 1

aspirante al grado de: DOCTOR **EN CIENCIAS EN CONSERVACIÓN Y APROVECHAMIENTO DE RECURSOS NATURALES**

Después de intercambiar opiniones los miembros de la Comisión manifestaron ***SU APROBACION DE LA TESIS***, en virtud de que satisface los requisitos señalados por las disposiciones reglamentarias vigentes.

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CARTA CESION DE DERECHOS

En la Ciudad de Oaxaca de Juárez el día 29 del mes abril del año 2014, el (la) que suscribe Chávez Ángeles Manuel Gerardo alumno (a) del Programa de **DOCTORADO EN CIENCIAS EN CONSERVACIÓN Y APROVECHAMIENTO DE RECURSOS NATURALES** con número de registro A110131, adscrito al Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, manifiesta que es autor (a) intelectual del presente trabajo de Tesis bajo la dirección de la Dra. Patricia Soledad Sánchez Medina y cede los derechos del trabajo titulado: "Economía de la Información y el Conocimiento para el Desarrollo Rural: Casos de Evaluación Institucional de las telecomunicaciones, la propiedad intelectual y el gobierno electrónico desde una perspectiva comunitaria". Al Instituto Politécnico Nacional para su difusión, con fines académicos y de investigación.

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A Marsa y Silvana

Information Economics for the Knowledge Economy & Rural Development: Institutional evaluation cases of common-pool resources in telecommunications, intellectual property and electronic government.

Manuel Gerardo Chávez-Angeles, MPA/ID

CONTENTS

RESUMEN

La presente tesis reúne tres ensayos sobre evaluación y desarrollo institucional. Constituyen una aplicación de la teoría y metodologías dedicadas al estudio de recursos comunes (*common-pool resources*) al análisis de las tecnologías de la información y comunicación (TIC) en zonas rurales del Estado de Oaxaca. La tesis es una propuesta metodológica para el estudio de TIC a través de tres casos de estudio: *(i)* Telecomunicaciones: Se analizan las decisiones municipales de inversión en infraestructura en telecomunicaciones. Se desarrolla un modelo de teoría de juegos de inversión municipal en TIC con un proveedor monopólico de servicios de Internet. Se definen líneas de pobreza digital y se presenta un modelo *probit* de sus posibles determinantes. *(ii)* Propiedad Intelectual: se analiza la comercialización de productos digitales piratas, principalmente audio y video. Se analiza el dilema entre la protección legal de los derechos de autor y el derecho de acceso a la cultura y el entretenimiento. Se presenta un modelo de teoría de juegos de "guerra de desgaste" entre las corporaciones poseedoras de los derechos de autor y los piratas. *(iii)* Gobierno Electrónico: se estudia el Sistema Nacional de Información Forestal de la Comisión Nacional Forestal y su importancia en la implementación de políticas de combate al cambio climático tales como REDD+. Se presenta un modelo de teoría de juegos sobre emisiones de CO2 y otros gases de efecto invernadero y se presentan varios escenarios prospectivos. Se concluye que hace falta un sistema descentralizado de comercio de carbono junto con la construcción de capacidades digitales.

ABSTRACT

This dissertation presents three essays on institutional evaluation and development. The thesis studies information and communication technologies (ICTs) as common-pool resources in the State of Oaxaca, Mexico. The cases presented are: *(i)* Telecommunications: this essay studies municipal strategic decisions on ICT investment. It presents a game theory model of municipal investment with a monopolistic provider, together with digital poverty lines and a *probit* model estimating possible drivers. *(ii)* Intellectual Property: This essay analyzes digital piracy. Particularly the tradeoff between the right to access cultural goods and protection of intellectual property rights. A war of attrition game theory model is presented to explain the interaction between the formal industry and pirates. *(iii)* Electronic Government: this essay analyzes Mexico's National Forestry Information System. The essay presents a game theory model of CO2 emissions and made some prospective scenarios. It discuss the importance of digital literacy for the implementation of climate change policies, particularly REDD+.

I. Introduction

The front page of the Financial Times announced the debate between two important economists on the Manhattan Island. While Jeffrey Sachs, Director of Columbia University's Earth Institute, wrote an editorial titled "*Pool resources and reinvent global aid*"; William Easterly, professor at New York University, published an op-ed with the title: "*Only trade-fuelled growth can help the world's poor*". Both articles hold contradictory views on the role of the government in development. The conflicting views of Sachs and Easterly aren't new. In his book *The End of Poverty* (2005), Jeffrey Sachs argues that the key to poverty alleviation and sustainable development is focusing on five central "development interventions": agriculture; basic health; education; power, transport and communications services; and safe drinking water and sanitation. William Easterly argues for more bottom-up approaches. In his book *The White Man's Burden* (2006), Easterly disparages the Sachs approach which he labels as a concentration on "Planners," and calls instead for more attention to "Searchers," that is, local people who are given the tools and resources to come up with their own entrepreneurial solutions to poverty. For David Bray, professor at the Florida International University, neither Sachs nor Easterly touches on the powerful incentive offered by common property. Recent studies by David Bray and colleagues suggested that around 10 percent of the communities in Mexico's 10 most important forests have sufficiently adapted their institutions and built their human and social capital to administer all the phases of forest extraction, including sawmill production. Another 25 percent have acquired other forms of value-added equipment including chainsaws, skidders, and logging trucks. Much of this has been done by communities where virtually no one had more than a primary school education. Today, a new generation of university-educated community members in leadership positions continues to develop and expand the model. *Zapotec* villagers of Mexico have developed an innovative model of "community capitalism" that employs one of the few resources easily available to the poor: the social capital provided by deep community ties. The communal trust, experience and knowledge nurtured over generations create a novel institution that UC-Berkeley economist Camille Antinori has called the "community as entrepreneurial firm." (Bray, 2010)

The aim of this thesis is to make and institutional assessment of knowledge and information commons for rural development in Oaxaca, Mexico. The thesis applies the theoretical framework develop by the Workshop in Political Theory and Policy Analysis at Indiana University for the study of CPR's management. The Institutional Analysis and Development (IAD) framework is intended to contain the most general set of variables that an institutional analysis may want to use to examine a diversity of institutional settings including human interactions within markets, private firms, families, community organizations, legislatures, and government agencies. It provides a meta-theoretical language to enable scholars from different disciplines to discuss any particular theory or to compare theories (Ostrom, 2010).

In 2009, Elinor Ostrom won the Economics Nobel Prize for her work in common-pool resource management. In *Governing the Commons*, Elinor Ostrom showed that individuals jointly using a CPR communicate with one another and establish agreed-upon rules and strategies that improve their joint outcomes. By devising their own rules-in-use, individuals using CPRs have overcome the overdevelopment of resources or Hardin's “tragedy of the commons”. CPRs are natural or human made facilities (or stocks) that generate flows of usable resources units over time. This kind of resources share two characteristics: 1) it is costly to develop institutions to exclude potential beneficiaries from them, and 2) the resource units harvested by one individual are not available to others. The first characteristic is held in common with those goods and services referred as public goods, while the second is held in common with those goods and services referred to as private goods in the economic literature (Ostrom, 1994). Most of her research focused on how rules affect the behavior and outcomes achieved by individuals using CPRs. To address these issues, Ostrom and colleagues at the Workshop in Political Theory and Policy Analysis at Indiana University challenged the indiscriminate use of three metaphors commonly applied to CPR situations to predict suboptimal use and/or destruction of resources: (1) Garret Hardin's tragedy of the commons (1968); (2) Olson's logic of collective action (1965); and (3) the Prisoner's Dilemma game. For doing so they develop the IAD framework. This was a general organizing tool that helps to develop a long term research program not only for research on CPRs but also on other problems where individuals find themselves in repetitive situation affected by a combination of factors derived

from a physical world, a cultural world, and a set of rules (Ostrom, et.al,1994). Self-organized commons require strong collective-action and self-governing mechanisms, as well as high degree of social capital on the part of the stakeholders. Collective action arises “when the efforts of two or more individuals are needed to accomplish an outcome” (Sandler, 1992). Another important aspect of collective action is that it is voluntary on the part of each individual (Meinzen-Dick, et.al. 2004). Self-governance require collective action combined with knowledge and will on the one hand, and supporting and consistent institutional arrangements on the other hand. Social capital refers to the aggregate value of social networks and the inclination that arises from these networks for people to do things for each other (Putnam, 2000).

In the IAD the focal units of analysis are “action arenas”, in which participants and an action situation interact as they are affected by exogenous variables and produce outcomes that in turn affect the participants and the action situation. Action arenas exist in the household; neighborhood or community; local, regional, national, and international councils; in firms and markets; and in the interaction among all of these arenas with others. In the simplest and most aggregated way to representing any of these arenas when they are the focal level of analysis exogenous variables affect the structure of an action arena, generating interactions that produce outcomes. Evaluative criteria are used to judge the performance of the system by examining the patterns of interactions and outcomes. Outcomes feedback onto the participants and the situation and may transform both over time (Ostrom, 2005).

Regarding the exploration of information and knowledge as commons or “new commons”, the field is still in its “early infancy”. The “information commons” movement emerged with striking suddenness. It was around 1995 that some scholars started to give a new usage to the concept of “commons”. Scholars started to study Internet users´ behavior and conditions on the web (e.g. congestion, free riding, conflict, overuse, and “pollution”) associated with other types of commons. The “knowledge as a common” thinking is in line with that of Davenport and Prusak (1998) who write that “knowledge derives from information as information derives from data”. (Hess and Ostrom, 2007)

Action arenas are linked across several levels of analysis. All rules are embedded in another set of rules that, if enforced, defines how the first set of rules can be changed. The embeddedness of rules within rules at several levels is similar to the embeddedness of computer languages at several levels. What can be done at a higher level will depend on the capabilities and limits of the rules (or the software) at that level and at a deeper level. Changes in the rules used to order action at one level occur within a currently “fixed” set of rules at a deeper level. Changes in deeper-level rules usually are more difficult and more costly to accomplish, thus increasing the stability of mutual expectations among individuals interacting according to a set of rules.

It is useful to distinguish three levels of rules that cumulatively affect the actions taken and outcomes obtained in any setting (Kiser and Ostrom, 1982).

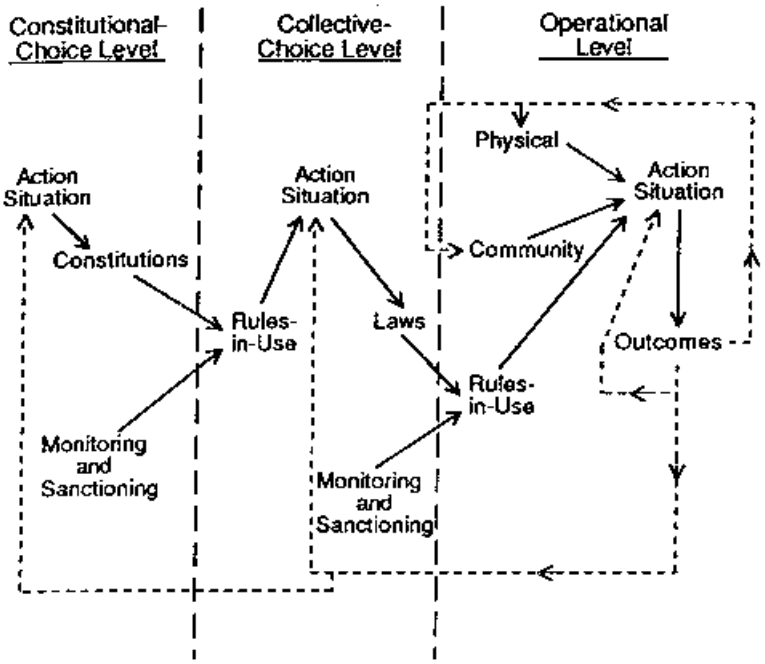
a) Operational rules directly affect day-to-day decisions made by the participants in any setting.

b) Collective-choice rules affect operational activities and results through their effects in determining who is eligible and the specific rules to be used in changing operational rules.

c) Constitutional-choice rules affect operational activities and their effect in determining who is eligible and the rules to be used in crafting the set of collective-choice rules that in turn affect the set of operational rules.

The thesis studies the development of digital capacities at the operational level. A central question posted by Douglas North (1990) is on the problem of human cooperation. North studies the evolution of institutions that create and hospitable environment for cooperative solutions to complex exchanges of goods, including knowledge. The fundamental problem underlying the question of cooperation is the manner by which individuals attain knowledge of each other preferences and likely behavior. This is a problem of common knowledge about individuals (or community members) likely behavior.

Linking levels of analysis



Fuente: Kiser y Ostrom (1982)

This thesis presents three essays on institutional evaluation. Each one applies the theory and methods use on common-pool resources research to information and communication technologies (ICTs) in rural areas. In general terms this thesis studies three cases of the “last mile”, that is the final leg of the telecommunications networks delivering communications connectivity to retail customers, the part that actually reaches the customer. Examples are the copper wire subscriber lines connecting telephones to the local telephone exchange, coaxial cable service drops carrying cable television signals from utility poles to subscribers' homes, and cell towers linking local cell phones to the cellular network. The last mile is typically the speed bottleneck in communication networks; its bandwidth limits the bandwidth of data that can be delivered to the customer. Costs in the last mile can become very expensive in rural settings where scale economies are absent. For a telecom company would be more cost effective to wire an intelligent building in the downtown of a big city with high connectivity than in the *Sierra Madre.* The high cost of setting the last mile of ICTs networks is one the principal

drivers of the digital divide.

The study of digital divide is of great importance since ICTs are an important determinant of salaries, knowledge acquisition and geographic dispersion of population *(Garicano y Rossi, 2006; Ioannides, Overman, Rossi y Schmidheiny, 2008). In that sense the big action arena studied in the thesis is the digital divide, while each case is a situation of that action arena. The thesis is a methodological proposal for studying ICTs for development:*

i. **Information commons and climate change: The gap between Mexico's National Forestry Information Systems and Community's Information Needs.** This article makes an assessment of the use of Mexico's National Forestry Information System for community forest management. Forest's information is studied as a common-pool resource and information economics is applied to the analysis of carbon trading. The article concludes that government performs as an information broker and matchmaker between firms shopping for carbon assets and community forest enterprises selling them. A more decentralize carbon market, better institutional arrangements and digital capacity building, are necessary for the implementation of carbon markets and policies aim to combat deforestation, forest degradation and climate change.

ii. **Information and Communication Technologies (ICTs) as a common-pool resource: Coordination, Competition and the Digital Divide in eight Municipalities of Oaxaca.** This article analyzes information and communication technologies (ICTs) as a common-pool resource. Using the Institutional Analysis and Development Framework (IAD) the article analyzes the case of telecommunication investment at the municipal level in Mexico. The article develops a game theory model showing the need for inter municipal coordination and cooperation. In a market with a monopolistic provider of telecommunications, municipalities need to coordinate in order to receive high payments from his investment in information technologies (IT). The article also defines digital poverty lines and presents a *probit* estimation of its determinants. It presents cases of ICT access in eight municipalities in Oaxaca, Mexico. The article makes policy proposals for a municipal telecommunication fund that would allow coordination and

cooperation in telecommunication investment. It also stresses the importance of open platforms and citizen participation.

iii. **Cultural Industries, Digital Divide and Rural Development: The case of digital piracy in Oaxaca, Mexico.** In rural Oaxaca the commerce of pirate cultural goods (e.g. music, cinema, books, software) is an entrepreneurial activity. Off-line piracy is very often the only media for accessing goods from cultural industries. Applying the Institutional Analysis and Development Framework we analyses copyright piracy in rural settings as an action arena. We used a war of attrition game theory model to explain why intellectual property rights are not enforced in rural communities, analyzing different levels of interaction and rules in use from the global to the very local. We propose new institutional arrangement to legalize the copy and transmission of cultural goods for education and rural development. Some interesting insights arrived regarding the cost of the "last mile" in the diffusion of cultural goods and ICT's infrastructure.

The papers develop game theory models to analyze these three different situations. In general, game theory highlights the problem of cooperation and explores specific strategies that alter the payoffs to the players. The prisoner´s dilemma that has been a mainstay of game theory is closely allied to Mancur Olson (1965) free-rider dilemma. Both suggest a discouraging perspective on the problem of human cooperation and coordination. However, Olson´s analysis and prisoner dilemma problems reflect the static nature of the analysis and the fact that it is a one-shot game. That is, when prisoner's dilemma game is played only once, it is a dominant strategy for players to defect and therefore not to achieve what would be an efficient outcome with respect to the aggregate well-being of the players. It is also well known that defection is not necessarily the dominant strategy if the situation is repeated over and over again, as many collective action problems are. In an iterated prisoner's dilemma game, one that is repeated, there is no dominant strategy. Robert Axelrod found that the winning strategy under these conditions of continuous repeated play is a strategy of tit-for-tat, one in which a player responds in kind to the action of the other player. In his book "The Evolution of Cooperation" (1984), Axelrod writes about the ability of human beings to devise cooperative solutions to problems without the intervention of a coercive state.

Russell Hardin (1982) focused on the n-person prisoner's dilemma and explores the problems faced by collective action. The difficulties of collective action depend not just on the size of the group, but also on the ratio of costs to benefits. Social conventions arise when there are asymmetries through which the participants may explore each other's motivations and capabilities in iterated games, leading to some social order. Michael Taylor (1982, 1987) explores the conditions under which social order can arise without state in anarchic situations. Taylor asserts that community is essential for anarchic social order and that the key features of community are shared common beliefs or norms, direct and complex relationship between members and reciprocity. The state destroys the very elements of community, its coercive action can minimized or destroy altruism.

The kind of knowledge and skills that will be acquired by the organization to further its objectives will play a major role in the way the stock of knowledge evolves and is used. In any situation modeled with game theory, a critical factor is the skill of the players and the knowledge they posses of the game. The difference between communicable knowledge and tacit knowledge is of great importance. Communicable knowledge is, as the name implies, knowledge that can be transmitted from one person to another. Tacit knowledge is acquired in part by practice and can be only partially communicated; different individuals have different innate abilities for acquiring tacit knowledge. Entrepreneurial skills for instance, are certain kind of skill that can't be easily transmitted. Learning by doing in organizations, as the term implies, means that an organization acquires coordination skills and develops routines that work as a consequence of repeated interaction. The kind of knowledge, skills, and learning that the members of an organization will acquire will reflect that payoff (or incentives) imbedded in the institutional constraints. For example, the skill and knowledge essential to the Merchant Adventurers in the XV Century were very different than those essential to the success of a modern textile-exporting firm. This has profound implications for institutional change. The demand for knowledge and skills will in turn create a demand for increases in the stock and distribution of knowledge, and the nature of that demand will reflect current perceptions about payoffs to acquiring different kind of knowledge. Thus, the demand for investment in knowledge is radically different across geography and history (North, 1990).
The incentives to acquire pure knowledge are affected not only by the structure of monetary

rewards and punishments, but also by social belief and prejudices. Galileo and Darwin are relevant examples in the history of science on this regards. Knowledge and ideology are mutually shaped. The way knowledge develops shapes our perceptions of the world around us and in turn those perceptions shape the search for knowledge (North, 1990).
Paul David (2002) makes a differentiation between knowledge and information. Knowledge refers to the capacity for intellectual or physical action; it is fundamentally a matter of cognitive capability. Information, on the other hand, is inert and passive data that has no meaning until used by those with the knowledge needed to interpret and process it. This is an important distinction for the conditions governing the reproduction of knowledge and information. While the cost of replicating information amounts to no more than the price of making copies (i.e. next to nothing thanks to modern technology), reproducing knowledge is far more expensive process because some, indeed many, cognitive capabilities are not easy to articulate explicitly or to transfer to others.

At the same time, knowledge can be articulated and clarified, expressed in a particular language and recorded on a particular medium. This is call codification. In some sense, codification involves the exteriorization of memory. When codified, knowledge is detached from the individual and the memory and communication capacity created is made independent of human beings as long as the medium upon which the knowledge is stored is safeguarded and the language in which it is expressed is remembered.

Nevertheless, it is important to distinguish that codification can be written or oral, this is the nature of language, and therefore the repository of codified knowledge can take very different forms. Texts, databases, oral tradition, are different examples of containers of codified knowledge. In the case of oral traditions, codification is not independent from human beings, it depend on guttural sounds. (David, 2002)

One important feature of written codification is that it enables intellectual life to solve the problem of memory, and allows a more free flow of knowledge and information, and greater capacity of accumulation. It is not the same to have millions of copies of a text (or a website) available to everybody, than depend on a *word of mouth* process for spreading knowledge

and information.

When written, learning programs are the produced that partially replace the person who holds and teaches knowledge, codification amount to the process of reducing human knowledge to information, and in the course of such transformation some things almost certainly something will be altered, and quite likely, other meanings will be lost. This is the reason why written knowledge has not always been well received. Aristotle was the first thinkers to alert about the damage that written communication would inflict on human memory. Ironically enough, we know Aristotle position against written accounts thanks to Plato texts. In the same way, written codification consists in translating knowledge into symbolic representation so that it can be stored on a particular medium. This creates new cognitive potentialities that remain inconceivable so long as the knowledge is attached to individual human beings and, hence, only heard (when spoken) or seen (when put into practice) through interaction with those carriers. Inscribing (through writing, graphics, modeling, virtuality) makes it possible to examine and arrange knowledge in different ways and to isolate, classify and combine different components. This lead to the creation of new knowledge objects such as lists, tables, formulae, etc. these are fundamentally important because they open up new cognitive possibilities (classification, taxonomy, tree networks, simulation) that can provide framework for the rapid production of new knowledge. Written codification thus plays a central role in society because it serves to further memorization, communication and learning, and form a sound basis for the creation of new knowledge. (David, 2002)

New information technologies affect knowledge creation in a number of different ways. For a start, the mere fact that one has the capacity to create such a wealth of information is truly revolutionary. Second, information technologies enhance creative interaction not only among scholars and scientist but, equally, among product designers, suppliers and the end customer. Third the new technologies enable the exploration and analysis of the content of gigantic database, which is in itself a potent means of knowledge enhancement (in natural, human and social science and management alike). Research stimulated by such possibilities has a strong influence in some areas of managerial work. Finally, the above three ways in which information technologies affect knowledge creation can be combined in the development of

large-scale decentralized systems for data gathering and calculation and the sharing of findings. (David and Foray, 2002)

Information and Communication Technologies (ICTs) as a common-pool resource: Coordination, Competition and the Digital Divide in eight Municipalities of Oaxaca.

Manuel Gerardo Chávez – Ángeles*
Patricia S. Sánchez – Medina**

Resumen

Con base en las investigaciones en recursos comunes (*coommon-pool resources*) se aborda el tema de los comunes de información y conocimiento para los municipios de Mexico. Por medio de la aplicación del Marco de Análisis y Desarrollo Institucional (IAD por sus siglas en inglés) se analiza el acceso a tecnologías de información y comunicación (TIC) como recurso común. Se desarrolla un modelo de teoría de juegos de inversión municipal en TIC con un proveedor monopólico de servicios de Internet y se analizan las decisiones municipales de inversión en infraestructura en telecomunicaciones como arena de acción. Se definen lineas de pobreza digital y se presenta un modelo *probit* de sus posibles determinantes. Se analizan ocho municipios de Oaxaca, Mexico, incluyendo el municipio urbano de Oaxaca de Juarez y siete municipios de alta ruralidad. Se analiza el grado de preparación para la interconección global a través de Internet. Se concluye la necesidad de impulsar la coordinación intermunicipal en la inversión en TIC a través de un fondo de inversión intermunicipal. Se resalta la importancia de las iniciativas ciudadanas en la construcción de los comunes de información y conocimiento. **Palabras Clave:** TIC, Municipios, Recursos Comunes, Comunes de información, Teoría de Juegos, Telecomunicaciones, Internet

Abstract

This article analyzes information and communication technologies (ICTs) as a common-pool resource. Using the Institutional Analysis and Development Framework (IAD) the article analyzes the case of telecommunication investment at the municipal level in Mexico. The article develops a game theory model showing the need for inter municipal coordination and cooperation. In a market with a monopolistic provider of telecommunications, municipalities need to coordinate in order to receive high payments from his investment in information technologies (IT). The article also defines digital poverty lines and presents a Probit estimation of its determinants. It presents cases of ICT access in eight municipalities in Oaxaca, Mexico. The article makes policy proposals for a municipal telecommunication fund that would allow coordination and cooperation in telecommunication investment. It also stresses the importance of open platforms and citizen participation. **Key Words:** ICTs, Municipalities, Common-pool resources, information commons, Game Theory, Telecommunications, Internet.

Introduction

The importance of digital technologies to human development has been on the table of international cooperation since the first phase of the World Summit on the Information Society in 2003 (Kummer, 2007). The Geneva Declaration of Principles states that:

> Our challenge is to harness the potential of information and communication technology to promote the development goals of the Millennium Declaration, namely the eradication of extreme poverty and hunger; achievement of universal primary education; promotion of gender equality and empowerment of women; reduction of child mortality; improvement of maternal health; to combat HIV/AIDS, malaria and other diseases; ensuring environmental sustainability; and development of global partnerships for development for the attainment of a more peaceful, just and prosperous world. We also reiterate our commitment to the achievement of sustainable development and agreed development goals, as contained in the Johannesburg Declaration and Plan of Implementation and the Monterrey Consensus, and other outcomes of relevant United Nations Summits.

In this regard, the Information Society has thrown up new challenges for the study of governance of telecommunications and cyberspace. The paradigm of common-pool resources has been of great use in the analysis of problems of handling information and knowledge. A wave of intellectual and legal exploration, known as the “new commons” or “information commons”, which study problems of overuse, parcelization, lack of cooperation and contamination of common-pool resources related to digital technologies (Hess and Ostrom, 2007, 3-21; Kranich, 2004).

Research into common-pool resources (CPRs), has shown how different social actors are capable of communicating among themselves and establishing agreements, rules and

strategies that improve their joint outcomes. Through setting up institutional arrangements, individuals in possession of common-pool resources have overcome significant social dilemmas of common action, such as the “tragedy of the commons” or situations like the prisoner’s dilemma (Ostrom, 2010).

This article undertakes a review of the most important literature on the information and knowledge commons from different perspectives. It discusses the concept of information commons used by social activists, legal experts and economic historians. Then, it introduces the concept used by research into CPRs before discussing the need to conduct research into the information commons in developing countries. Through a case study on rural telecommunications connectivity, the article discusses the use of IAD and game theory to analyze the digital divide. Lastly, it looks at field evidence for eight practical cases in the state of Oaxaca. The data obtained from the cases in Oaxaca are presented as an initial approximation to guide future research.

The information and knowledge commons

The discussion on the information and knowledge commons has been in the public and academic debate of the United States for more than a decade. In spite of these discussions, little attention has been paid to what happens in developing countries. In Mexico in particular, research into the commons has been limited to natural resources, with an emphasis on forest issues. Organizations such as the Civil Counsel on Sustainable Forestry in Mexico (*Consejo Civil Mexicano para la Silvicultura Sostenible*, CCMSS) has fostered the CPR paradigm for the community management of forests, while researchers like Leticia Merino and David Bray have done much the same but from an academic perspective. On the other hand, the federal government, through the National Forest Commission (*Comisión Nacional Forestal*, CONAFOR) has taken up some of the ideas of CPR management in its programs. However, very little has been done or written in the area of information commons (See: Bray, et. al., 2007).

In the United States, questions about Internet Governance intensified after the attack on the

Twin Towers of September 11, 2001. The phantasm of surveillance and control of electronic media by the United Stated circulated the halls of government and North American universities. In response, different groups of activists, such as the Center for Democracy and Technology, the Electronic Frontier Foundation and the American Civil Liberties Union issued press releases and statements, and set up actions to defend “freedom in cyberspace”. Nancy Kranich (2004), gives an extraordinary account of the best practices in the area of information commons and formulates the need to create a movement (similar to the environmental movement that arose during the last two decades of the twentieth century) to protect the public domain. Karnich analyzed the commons known as Open Democratic Information Resources, which includes the software commons, particularly Linux and the free software movement; General Public Licenses (GPLs) and Creative Commons; open access academic communications and electronic repositories for scientific research; institutional commons safeguarded mainly by universities and libraries; and some specific projects, such as the BBC Creative Archive and the Galiwinku Knowledge Centre.

Each of the examples of information commons analyzed by Kranich (2004, 30) have similar characteristics: they are collaborative; offer shared spaces (real and virtual) where persons with shared interests and concerns can meet; they use network technologies to build communities and benefit from positive external influences created by the network; they are interactive, which encourages exchange between participants; many are free or low cost; participants contribute content while at the same time benefiting from access; they strengthen social and human capital of participants; they govern through shared rules which are defined and accepted by their members; they incorporate democratic values where freedom of expression and intellectual freedom predominate.

In parallel to the actions of cyber-activists, we can identify works by legal experts who specialize in information law. Yochai Benkler (2006) proposed the idea of three different layers in which communication systems are immersed and make it possible to transmit messages: (1) the physical devices and networks needed to communicate; (2) the information and cultural resources from which new content can be created; and (3) the logistical resources, software and standards required to translate what human beings want to say into signals that

machines can process and transmit. Lessig (2001, 2006) also asks whether there should or should not be an architecture that is commonly governed and therefore available to any who wish to participate in social networks outside the markets. One of their proposals is the Creative Commons, a nonprofit organization whose main objective is to offer intellectual property licenses that make it easier to distribute and use content. The Creative Commons fills the space situated between the specter of absolute protection of authors' rights or "all rights reserved" and the public domain or "no rights reserved" (See: http://www.creativecommons.mx).

Lastly, from an economic and political science perspective, we find a third body of literature dedicated to the study of common-pool resources (CPRs). CPRs are defined as resources shared by a group of persons subject to social dilemmas. We can summarize these social dilemmas in three ways: (1) the well-known tragedy of the commons proposed by the biologist Garret Hardin; (2) the prisoner's dilemma; and (3) the problems of free-riding. CPRs are also defined as goods of high subtractability and difficult excludability (Ostrom, 2010).

Initially dedicated to natural resource problems, such as forests, fisheries, water, etc., with the advent of the so-called information society, this research has expanded to telecommunications and cyberspace. The problems of overexploitation, parcelization, lack of cooperation, contamination of common-pool resources linked to natural resources began to appear around 1995 in areas like the Internet, and the handling of information and knowledge. This has sparked a wave of intellectual and legal exploration known as the "new commons". Whether labeled the digital, electronic, information, virtual, communication, intellectual, internet and technological commons, all these concepts address the new territory of globally distributed information (Hess and Ostrom, 2007, 3-21). Particularly sciences, such as genomics, and industries that have been severely impacted by digital technology like the pharmaceutical, publishing and music industries, information management has encountered significant dilemmas on intellectual property, free exchange and commercialization.

TABLE 1. Types of goods

		Subtractability	
		Low	*High*
Exclusiveness	Difficult	*Public goods*	*Common-pool resources*
		Common knowledge	Libraries
		Sunsets	Irrigation systems
	Easy	*Club goods*	*Private goods*
		Magazine subscriptions	Computers
		Daycare	Sandwiches

Source: Authors' own elaboration.

Recently, some economists that are attempting to create knowledge using an evolutionist approach have joined the CPR study community. Paul David (2001) has defined concepts as open science which refers to the way knowledge was organized during the Renaissance and the Scientific Revolution of the sixteenth and seventh centuries. David proposes analyzing current institutions dedicated to scientific and technological innovation (particularly in Europe and the United States) by comparing them to the institutions that allowed the arts and sciences to flourish during the sixteenth and seventh centuries. Joel Mokyr (1998, 2000) on the other hand, has studied technological change from the evolutionist perspective placing emphasis on the free transmission of knowledge in what is characterized as a "market of ideas". To Mokyr, the standard neoclassical economic model gives a very poor explanation of technological development and proposes, in its place, the principles of evolutionary biology to account for scientific and technical innovation. In this regard, the economic history of technological change would be better understood in terms of the dynamics of Darwinian Evolutionary Theory.

Developing countries have conducted extensive CPR research into the management of irrigation systems in Nepal or the forests of India, Kenya, Mexico, Nepal, Tanzania, Thailand and Uganda, the latter through the International Forestry Resources and Institutions (Ostrom, 2010). Nevertheless, studies on the information and knowledge commons in developing

countries are somewhat scarce. Some research has proposed open and collaborative models for searching for medicines to tackle tropical illnesses, such as malaria, tuberculosis, leishmaniasis (Chávez, 2008; Bhardwaj, 2011), or have focused on analyzing topics related to intellectual property (Chávez, 2012; Lara and Osorio, 2012). The Open Source Drug Discovery Program (OSDD) is a program from the Council of Scientific and Industrial Research of the Indian government which seeks to provide an open platform for the search for medicines to tackle tropical illnesses (www.osdd.net). Apart from these efforts in India, it is still difficult to find the application of the paradigm of the commons to cases of information and knowledge in developing countries.

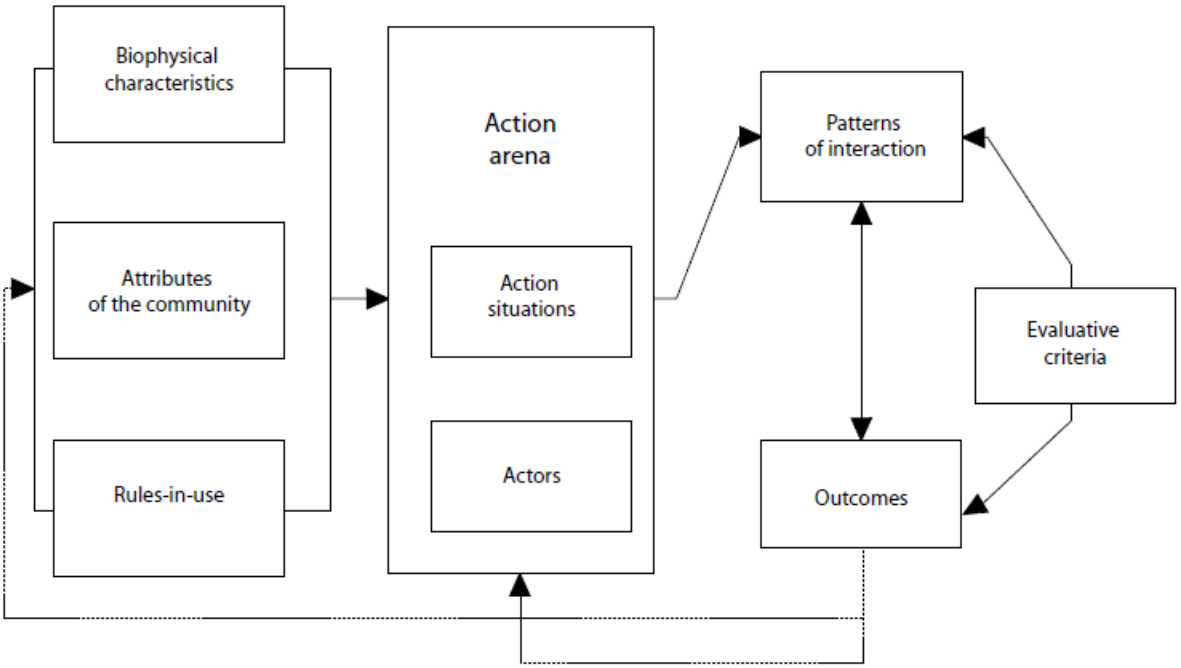
The Institutional Analysis and Development Framework (IAD) and the information commons

Elinor Ostrom (2010) and her colleagues at Indiana University have challenged the metaphors applied frequently to common-pool resources that project suboptimal outcomes to demonstrate that the predictions of the tragedy of the commons or prisoner's dilemma can be avoided. Over the last several years, the Institutional Analysis and Development Framework (IAD) was developed as a long-term organizational research tool. The IAD is a common framework congruent with game theory that allows a wide variety of empirical analyses to be conducted using experimental economics in the laboratory and quasi-experiments in the field. The complexity of local contexts faced by institutional development requires that the "one size fits all" theory be rejected. It is important to think of solutions that involve multiple levels of analysis and function which range from global to local and forms of polycentric governance (See: Ostrom, Walker and Gardner, 2006; Ostrom, 2010).

Polycentrism denotes the existence of multiple decision-making centers that are formally independent from one another. In practice, it is possible to build an interdependent network with competencies, contractual and cooperative relationships. It can also have centralized conflict resolution mechanisms. The political jurisdictions of a metropolitan area or irrigation district are able to function coherently with consistent and predictable interaction patterns. Therefore, polycentric governance could be said to operate as a system (Ostrom, Tiebout and

Warren, 1961).

FIGURE 1. Institutional analysis and development framework (IAD)



Source: Authors' own elaboration.

The IAD has been applied to a wide variety of cases. The scientific literature on common-pool resources has grown considerably over the last two decades. In particular, the "language of the commons" has been adopted by the environmental sciences and natural resource conservation with a great deal of enthusiasm (Bollier, 2007, 31), popularizing the idea that certain shared natural resources must be understood as a commons and therefore managed accordingly. The atmosphere, oceans, fisheries, freshwater (underground and surface), wildlife, the beaches, local open spaces, etc., are seen more and more as common-pool resources that must be managed to the benefit of all. Some environmental movements have even used the idea of the commons as part of their arguments in their fight against privatization and overexploitation of the lands and aquifers. The government of the commons is often involved in clashes between the State and the market on the fundamental rules of social governance. Many of these discussions involve the alignment of elements whose trade raises serious ethical questions, such as: seeds, genetic information, animal species, wildlife,

indigenous knowledge and cultural assets, many of which can be lumped together into the term biodiversity. Somewhere around the middle of the 1990s, the idea of common-pool resources started to be applied to scientific knowledge, information and academic communication (Ostrom, 2005, 2006, 2010).

When we think of the Internet as a common-pool resource, more often than not we think of it as belonging to the “new commons”. ICTs also share components subject to network effects, increasing returns to scale and positive externalities. In such cases, the tragedy of the commons is not as big a problem as parcelization and intellectual ownership of these resources. The infrastructure that enables access to the Internet, we find, still preserves important components that are more similar to a pasture than a neural network. We imagine an optical fiber cable or the number of orbital satellites. Nevertheless, icons of modern communication, an optical fiber cable or orbital satellite, have very limited capability. The cable can only transmit a maximum number of bits per minute before the connection becomes sluggish. In the case of orbital satellites, there will be a maximum number of satellites that are able to share orbit before they start crashing into one another. Telecommunications is, in this regard, a typical common-pool resource subject to decreasing returns to scale, and social dilemmas, such as tragedy of the commons and overexploitation. In the language of common-pool resources, Internet infrastructure (and that of telecommunications in general) is subject to high subtractability and difficult excludability.

Charlotte Hess (1995), analyzed the Internet as a global and local common-pool resource and found four types of resources:

- Technology and infrastructure commons which includes the physical network of cables, routers, switches, etc., that connect the Local Area Network to the global information highway (World Wide Web).
- Budgetary commons which consist of different types of financial resources related to the supply of information through the network and its technology.
- Social commons, which are created by the use of the Internet and include e-mail address lists, discussion forums, interactive games and social media.

- Information commons, which are comprised of flows and collections of digital data. These may include academic information, government documents, library catalogs, electronic books, online newspapers, videos, photographs, etc.

IAD and game theory: telecommunications in municipal governments.

Formal models are used to give logical and predictive rigor to the study of the commons. The IAD may be used in conjunction with methods, such as game theory, models based on agents (e.g. cellular automation) and experimental economics, for the study of the behavior, interactions and outcomes within an action arena.

Game theory explains the behavior of actors in CPRs situations in terms of maximization of benefits. Each actor has a strategy that mathematically expresses how the strategies of the other actors function. Actors make decisions taking into account those made by other actors until an equilibrium is reached that they cannot improved unilaterally, or the like, without moving simultaneously with other actors through concerted action. Such balances are called Nash Equilibriums. These types of equilibriums involve basic assumptions of rationality taken from neoclassical economics and public choice. Secondly, Nash equilibriums include the principle of rational expectations. If each player waits for a specific equilibrium to be played, then the maximization of benefits will lead this equilibrium to fulfill expectations. A third argument in favor of the use of game theory is meta-theoretical; in other words, it allows us to find socially optimal outcomes and observe why these equilibriums are not being played. This will allow us to build incentive schemes that prevent suboptimal outcomes and produce better ones (Ostrom, 2006).

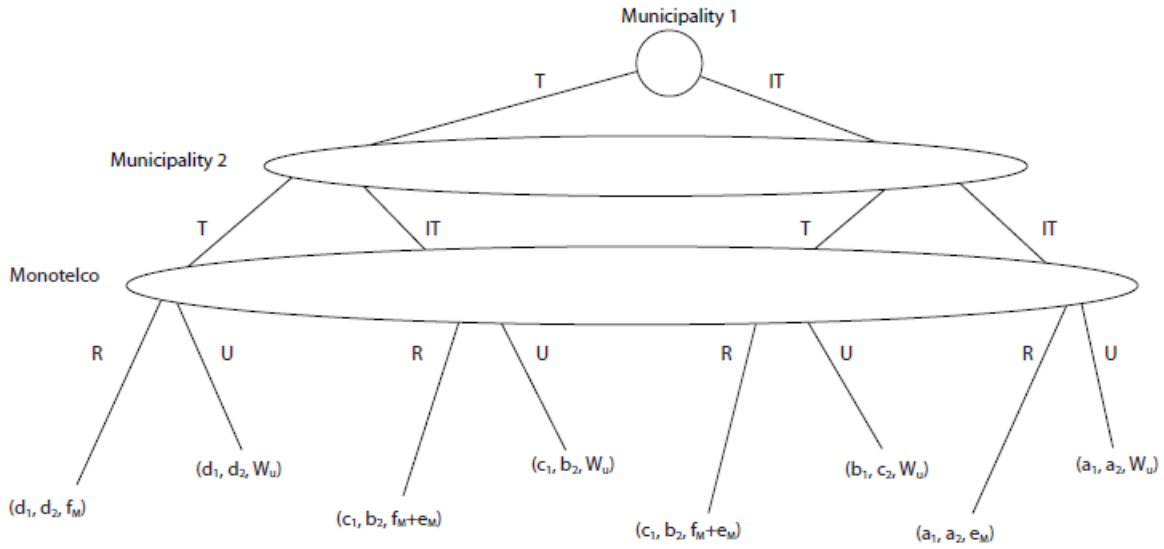
The units of analysis used in the IAD are action arenas, which are studied through the interactions that take place internally between actors and the outcomes they achieve. These interactions and outcomes must be studied and evaluated using theories relevant to each case. The components within an action arena are the action situations and actors. Despite the complexity of the situations analyzed by the IAD, it is possible to discover the structure of action situations through their components (Ostrom, 2005, 2006, 2010):

i. Characteristics of the actors involved (including behavior model and decision adopted theoretically).
ii. Position of the actors (who moves first? Who moves next?).
iii. Set of actions that actors can take at each decision node.
iv. Amount of information available at each decision node.
v. Outcomes of actions.
vi. Set of functions that map actors and actions to outcomes (strategies).
vii. Costs and benefits assigned to each action and the outcome obtained.

In this regard, the action situations can be characterized quite accurately through game theory. Consider for example the case of municipal telecommunications. One of the games seen regularly in the rural connectivity action arena is a strategic game that is played simultaneously between municipalities and the large telecommunications companies.

Imagine a situation where two rural municipalities decide simultaneously to invest in information technology (IT) or in some other non-digital technology (T). At the same time let us suppose that we find ourselves in an economy where there is only one provider of telecommunications (ISP) which we will call MONOTELCO. At the same time as both municipalities, this telecommunications provider decides whether it will invest in the rural or urban sector.

FIGURE 2. Rural connectivity game in a monopolistic market



Source: Authors' own elaboration.

The municipality may invest in IT in multiple ways: promoting connectivity in schools, increasing the bandwidth of the municipality, investing in IT for the municipal government, etc. The form of IT that the municipality selects implies a technological externality (which can be positive or negative) and network for the neighboring municipality.

We can express the normal form of the game as follows:

TABLE 2. Rural connectivity game in a monopolistic market

		Municipality 2	
		IT	*T*
Municipality 1	IT	a_1 a_2	b_1 c_2
	T	c_1 b_2	d_1 d_2

		Monotelco	
		Rural	*Urban*
Municipality 1	IT	e_1 e_M	e_1 w_U
	T	f_1 f_M	f_1 w_U

		Monotelco	
		Rural	*Urban*
Municipality 2	IT	e_2 e_M	e_2 w_U
	T	f_2 f_M	f_2 w_U

Source: Authors' own elaboration.

Any set of strategies whose outcome is for each player to maximize their payoff taking into account what the other players do is a Nash equilibrium. A Nash Equilibrium is a necessary condition for a set of strategies to constitute the solution to a game. In order to identify which strategies constitute Nash equilibriums and which ones do not, we have to identify the payoff vectors that the players are unable to improve on unilaterally. Such strategies are called pure strategies when chance is not involved. A special case of pure strategies are called dominant strategies, which means that a player has an incentive to play a specific strategy regardless of what the other players do. A mixed strategy involves chance. Mixed strategies require players to select their actions according to a probability distribution that determines payoffs.

Suppose that Municipality 1 will select IT with probability p and T with probability (1-p). Similarly, Municipality 2 will select IT with probability q and T with probability (1-q). The expected payoff for Municipality i will be:

$$pq\ (a_i) + p\ (1-q)\ (b_i) + (1-p)\ q\ (c_i) + (1-p)\ (1-q)\ (d_i)$$

In the case that there are dominant strategies p=1 and q=1, the expected payoff will be a_1, a_2 for municipalities 1 and 2, respectively. The dominant strategies of the municipalities toward investment in IT are because of $a_i > c_i$ and $b_i > c_i$.

At the same time, *MONOTELCO* must choose between investing in rural or urban areas; due to the lack of coordination, *MONOTELCO* must make the same decision for each municipality. *MONOTELCO* has a reserve income that we will call w_u, which constitutes the payoff obtained from investing in urban areas, and is independent from the investment in rural areas. Municipality *i* therefore will receive payoffs e_i, f_i corresponding to the expected payoffs for IT and T:

$$e_1 = q(a_1) + (1-q)(b_1) \quad \text{and} \quad f_1 = q(c_1) + (1-q)(d_1)$$
$$e_2 = p(a_2) + (1-p)(b_2) \quad \text{and} \quad f_2 = q(c_2) + (1-q)(d_2)$$

Once again, if there are dominant strategies p=1 and q=1, $a_i > c_i$ and $b_i > c_i$, the expected payoff will be (a_1 a_2) for municipalities 1 and 2, respectively. *MONOTELCO* will have a dominant strategy to invest in rural areas if $e_M > w_u$ and $f_M > w_u$.

The values of game payoffs determine their structure. We can classify the different outcomes into four different types of dilemmas faced by CPRs: (1) appropriation externalities; (2) assignment; (3) provision of resources; and (4) monitoring.

Appropriation externalities: A fundamental dilemma of CPRs is that players ignore the impact of their decisions on the benefits that the other players reap from CPRs. This appropriation externality leads to over- or under-exploitation of the CPR. In the case of rural telecommunications, it is possible to fall into a prisoner's dilemma where each municipality makes the decision to invest in T, ignoring the benefits of investing in IT simultaneously.

In telecommunications, the increase in the wellbeing of an economic agent in response to the decision of another agent to join and form part of the network is known as a network externality. A positive network externality arises when the good in question increases in value to a user as more and more users utilize the good and others like it. When an individual decides to form part of a telecommunications network, this decision has a positive effect on all other users of the same network (García, 2012).

TABLE 3. Prisoner's dilemma

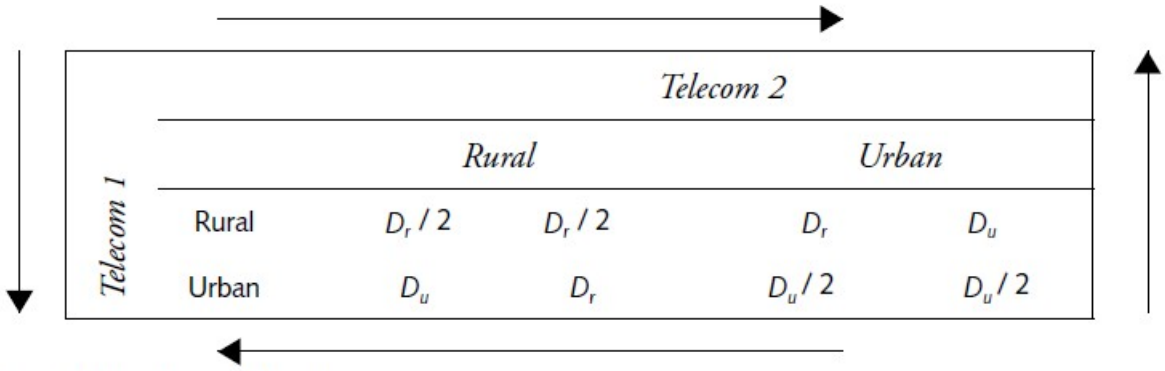
		Municipality 2			
		IT		*T*	
Municipality 1	IT	a_1	a_2	b_1	c_2
	T	c_1	b_2	d_1	d_2

Source: Authors' own elaboration.

Assignment problems: When players are confronted by a diversity of "appropriation niches" that differ in productive value, they face an assignment problem. In the case of rural telecommunications, the telecommunications company faces the dilemma of investing in rural or urban areas. In the case of MONOTELCO, the absence of competition means that it does not run the risk of having to share the demand of either of these two niches with a competitor. On the other hand, if we suppose the existence of a second telecommunications company, we may find chicken type situations where there are symmetrical equilibriums. An equilibrium of this type would result in one company investing in rural areas and the other in urban areas. The payoff structure and set of strategies of the game of chicken are such that they do not

allow the players to have a dominant strategy. The game of chicken has multiple equilibriums. In this game communication is of vital importance to achieving optimal outcomes. Each player must know the strategy of the other in order to avoid suboptimal outcomes.

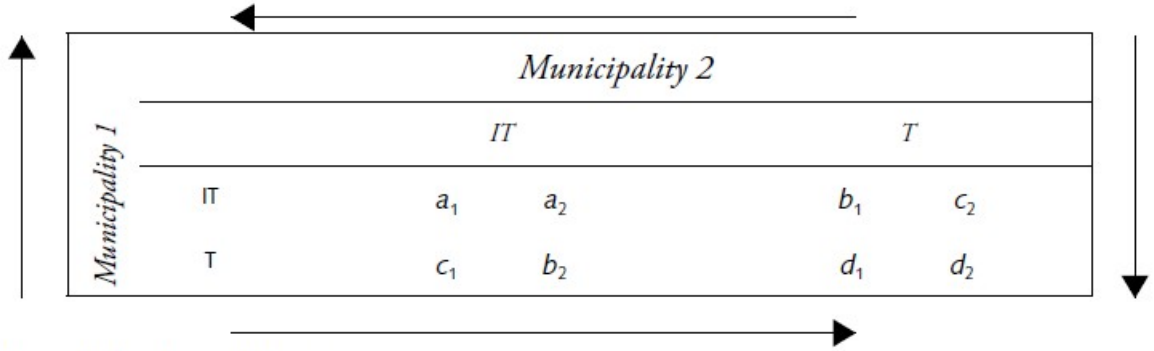
TABLE 4. Chicken



Source: Authors' own elaboration.

Supply of resources: Many users of CPRs face the problem or supply or maintenance of service. This decision can be modeled much in the same way as the procurement of a public good. In the case of rural telecommunications, investment in IT refers precisely to the supply of the necessary infrastructure for digital connectivity. In this case, there are two possible equilibriums: prisoner's dilemma or assurance. In the case of coordination between municipalities, assurance consists of both municipalities deciding to invest in IT. Assurance arises in several CPR situations where the contribution of a single player is insufficient to achieve collective benefits, whereas the contribution of both players will produce joint benefits.

TABLE 5. Assurance



Source: Authors' own elaboration.

Monitoring: There are two different positions in these types of games. They are inspired by irrigation systems where the players at the head of the system have access to the flow of water before the players at the tail of the system. The players at the tail have the opportunity to monitor what the players at the head are doing. In the case of rural telecommunications, we can think of the physical limitations of the bandwidth as a system that requires monitoring. Nevertheless, that the service is provided by a third party eliminates the need for monitoring. The regulator of the "flow of bits" in this case will be the company providing the service. Regulation will be applied through a system of prices.

Digital poverty and rural Mexico

In terms of the distribution of access to information and technology, we can assume that the digital divide and digital poverty are two different views of the same problem. The criteria for defining the digital divide vary from one community to another, from one country to another and from one society to another. Even so, the basic premise is the difference that exists between individuals and societies that have access to digital technologies and telecommunications. However, there are also other determining aspects, such as education, language, gender, income, age and geography. Therefore, the digital divide is not just a technological problem, but a social phenomenon that is part of a wider collection of social inequities (Rodríguez, 2006, 21-33). Digital poverty on the other hand is associated with the

demand for information and communication technologies. In this regard, the focus of study is the lack of goods and services based on ICTs (Barrantes, 2009, 47-49).

In Mexico, 21.1 percent of households do not have access to telecommunications. Of the households with telecommunications, 40.3 percent have a fixed telephone, 60.7 percent have a mobile telephone, 27.7 percent have cable TV and 18.1 percent have Internet. It is interesting to note the importance of connectivity via mobile telephone which is much higher than Internet connections, cable TV and even fixed telephone.

TABLE 6. Distribution of connectivity by household (%)

Telephone	*Mobile*	*Cable TV*	*Internet*	*Digital Poverty**
40.3	60.7	27.7	18.1	21.1

Source: Authors' own estimates using data from INEGI (2009), *None of the previous connections.

This information on household connectivity was taken from the 2009 National Survey on the Use of Time (*Encuesta Nacional de Uso del Tiempo*, ENUT) conducted by the National Institute of Statistics, Geography and Information Technology (*Instituto Nacional de Estadística, Geografía e Informática*, INEGI). Using this data we were able to define four lines of digital poverty and calculate a Probit model where Y=1 if the household is in a situation of digital poverty, and Y=0 if it is above the poverty line. The covariant vector X contains 18 variables grouped into five categories: socioeconomic variables, demand for mass media, social capital and social security.

TABLE 7. Lines of digital poverty

Name	*Definition*
Extreme digital poverty	Without telephone, mobile, cable TV or Internet connection
Medium digital poverty	With telephone, but without mobile, cable TV or Internet connection With telephone and cable TV, but without mobile or Internet connection
Moderate digital poverty	With fixed and mobile telephone and cable TV, but without Internet connection

Source: Authors' own elaboration.

The results of the Probit estimates are shown in Table 3. As you can see, extreme digital poverty has a negative correlation, which is statistically significant, with the possession of household assets (automobile, computer, refrigerator, stereo); you can also see a positive correlation, which is statistically significant, between digital poverty and whether the head of the family speaks an indigenous language, and if the household is situated in a rural area; regarding education variables, although schooling shows a negative correlation to extreme digital poverty, the literacy of the head of the family is not statistically significant, neither is it significant if the head of the family is a woman. In terms of media consumption, the number of hours spent watching television, and the number of hours spent reading and browsing the Internet, both share a negative correlation with extreme digital poverty. Social capital on the other hand is used as a proxy variable to address whether respondents attended parties, masses, gatherings, etc. during the past week; this variable shows no statistical relevance. Involvement in Federal Government programs for tackling poverty (*Procampo*, *Oportunidades*, 70 *y más*) shows a positive correlation and is statistically relevant to digital poverty. Lastly, access to health insurance, whether it is the IMSS, ISSSTE, Seguro Popular or private, shows a negative correlation to digital poverty.

TABLE 8. Probit estimations of digital poverty

Independent variables	*Dependent variables: Lines of poverty*			
	Medium digital poverty			
	Extreme digital poverty	*Digital poverty with analog telephone*	*Digital poverty with cable TV*	*Moderate digital poverty*
Computer	-2.86 (0.0984)**	-0.902 (0.0207)**	-1.006 (0.0199)**	-2.456 (0.0225)**
Automobile	-1.1 (0.0307)**	-0.332 (0.0138)**	-0.381 (0.0132)**	-0.328 (0.0223)**
Stereo	-0.518 (0.0253)**	-0.256 (0.0135)**	-0.390 (0.0134)**	-0.1294 (0.0270)**
Refrigerator	-1.025 (0.0286)**	-0.480 (0.0171)**	-0.216 (0.0170)*	-0.823 (0.0603)**
Indigenous language	0.153 (0.0424)**	0.1914 (0.0242)*	0.2086 (0.0240)**	0.2563 (0.0660)**
Rural	1.177 (0.0271)**	0.5146 (0.0148)**	0.3992 (0.0146)**	0.6126 (0.0378)**
Schooling	-0.0938 (0.0093)**	-0.0406 (0.0042)**	-0.0364 (0.0041)**	-0.0508 (0.0053)**
Literacy	0.0362 (0.0433)	0.0019 (0.0230)	-0.0477 (0.0227)*	0.1234 (0.0464)**
Gender	0.0229 (0.025)	-0.0094 (0.0127)	-0.0045 (0.0125)	0.0253 (0.0199)
Hours of TV	-0.0054 (0.0016)**	-0.00073 (0.00078)	-0.00010 (0.00077)	0.0049 (0.0012)**
Hours of reading	-0.0270 (0.0061)**	-0.00314 (0.00275)	-0.0205 (0.0028)*	-0.0168 (0.0033)**
Hours of Internet	-0.005133 (0.0049)	-0.0114 (0.0022)**	-0.0068 (0.0021)**	-0.0176 (0.0022)**
Social capital	-0.2369 (0.0293)	0.0153 (0.0117)*	-0.0121 (0.0150)	-0.0160 (0.0196)
Procampo benefits scheme	0.3703 (0.0919)**	0.2281 (0.0529)*	0.2359 (0.0533)**	0.2609 (0.1905)
Oportunidades benefits scheme	0.3317 (0.0387)**	0.1243 (0.0217)	0.1807 (0.0215)**	0.0922 (0.0601)
Adults aged 70 and older	0.1316 (0.0762)**	-0.0010 (0.0421)	-0.0029 (0.0415)	0.0235 (0.0880)
Health insurance	-0.1593 (0.0255)**	-0.1232 (0.0130)*	-0.0815 (0.0128)**	0.0109 (0.0211)

Investment in telecommunications in the municipalities of Oaxaca

Between 2010 and 2011, 8 studies were conducted in the state of Oaxaca. Using semi-structured interviews and qualitative surveys, the necessary information was collected for the study on telecommunications infrastructure in the municipalities of Magdalena Jaltepec, Miahuatlán de Porfirio Díaz, Monjas, Oaxaca de Juárez, San Ildefonso Amatlán, Santa Ana Miahuatlán, Santa Catarina Cuixtla and Santa Catarina Loxicha. The unit of analysis or action arena was "preparedness in an interconnected world", defined according to the guide drafted by the Center for International Development at Harvard University (2000). The guide proposes the assessment of the level of preparedness and strategic priorities of each community through the benchmarking of 5 groups of indicators, divided in turn into 19 categories, evaluating each one according to different levels of progress from stage one to stage four, while categories are ordered into 5 groups (See Annex 1 and 2).

TABLE 9. Poverty, marginalization and human development

	Poverty, 2010 (percentage of the population)*	*Degree of marginalization, 2010***	*Human development index, 2005****	*Annual income per capita, 2005*** (dollars PPC)*
Magdalena Jaltepec	84.6	high	0.74	3880
Miahuatlán de Porfirio Díaz	76.3	medium	0.76	6236
Monjas	86.4	very high	0.66	4262
Oaxaca de Juárez	30.9	very low	0.88	13018
San Ildefonso Amatlán	89.4	very high	0.70	3313
Santa Ana Miahuatlán	79.4	high	0.71	4498
Santa Catarina Cuixtla	73.3	high	0.74	4509
Santa Catarina Loxicha	93.5	very high	0.69	2473

Sources: *Coneval; **Conapo; ***PNUD.

In Oaxaca, 61.5 percent of the population lives in towns with less than de 5,000 inhabitants.

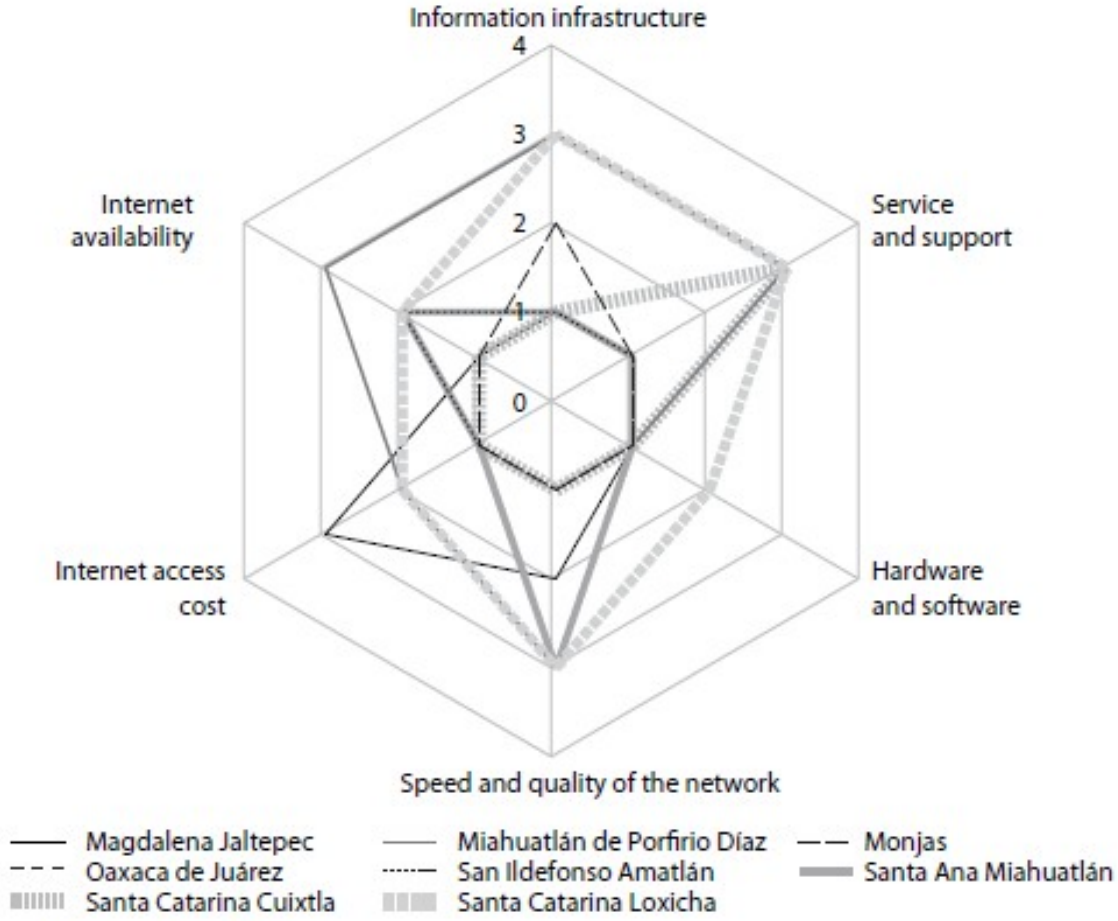
At the same time, 16.3 percent of the population over the age of 15 does not know how to read or write, occupying third place in terms of national illiteracy after Chiapas and Guerrero (CONAPO, 2010). According to the Mexican Institute for Competitiveness (*Instituto Mexicano de la Competitividad*, 2010), Oaxaca occupies last place in terms of competitiveness in the country. Its shortcomings are grouped under several indicators, such as: education quality, schooling, illiteracy, low penetration of information technology, and low percentage of individuals with advanced educations.

The connectivity of municipalities and communities in the state of Oaxaca is a complex map comprised of different potentials in each community. One community may be ready to use some ICT applications, but not others. At the municipal level, we can say that digital capabilities have a network component and a saturation component. The first, networks of individuals connected to the Internet, mobile telephones and telecommunications in general, show increasing returns to scale; in other words, they improve as more and more people are connected. On the other hand, the network infrastructure (basically bandwidth) deteriorates with every additional connection; in other words, it shows decreasing returns to scale. Without doubt, this is replicated at the national and global level, but it is the case of municipalities that concerns this paper.

Institutional arrangements refer to the institutions that govern connectivity and the development of digital capabilities. In Oaxaca, several of the communities studied have a regime of uses and customs; however, in the scope of telecommunications, there are often no clear rules and policies. In this regard, the community depends on state and federal government programs, and is also subject to legislation on such matters. It is fair to say that given the arena of competition in telecommunication at a national level, the municipalities of Oaxaca are very much dependent on the large companies, particularly Telmex. Municipalities often do not have many tools for promoting connectivity in their community other than “petitioning Telmex”. There are some innovative proposals from micro-entrepreneurs that provide telecommunications services (microtelcos), but ultimately they depend on connections to the large companies. In this regard, the options available to municipalities for developing their digital capabilities are often dependent on federal legislation and policies,

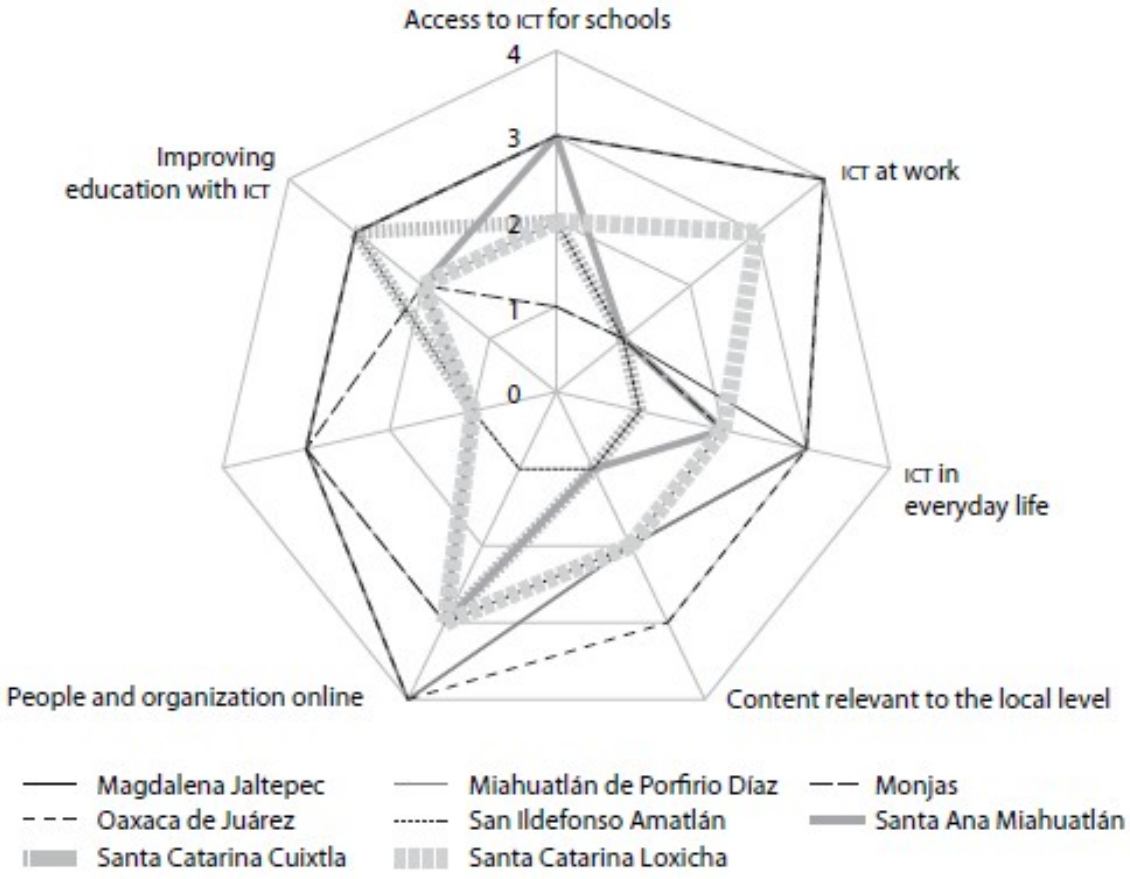
pointing the finger at the federal government as a possible cause of the lack of penetration of ICTs in the country.

FIGURE 3. Access to the Internet



Source: Authors' own elaboration.

FIGURE 4. Learning and society on the Internet



Source: Authors' own elaboration.

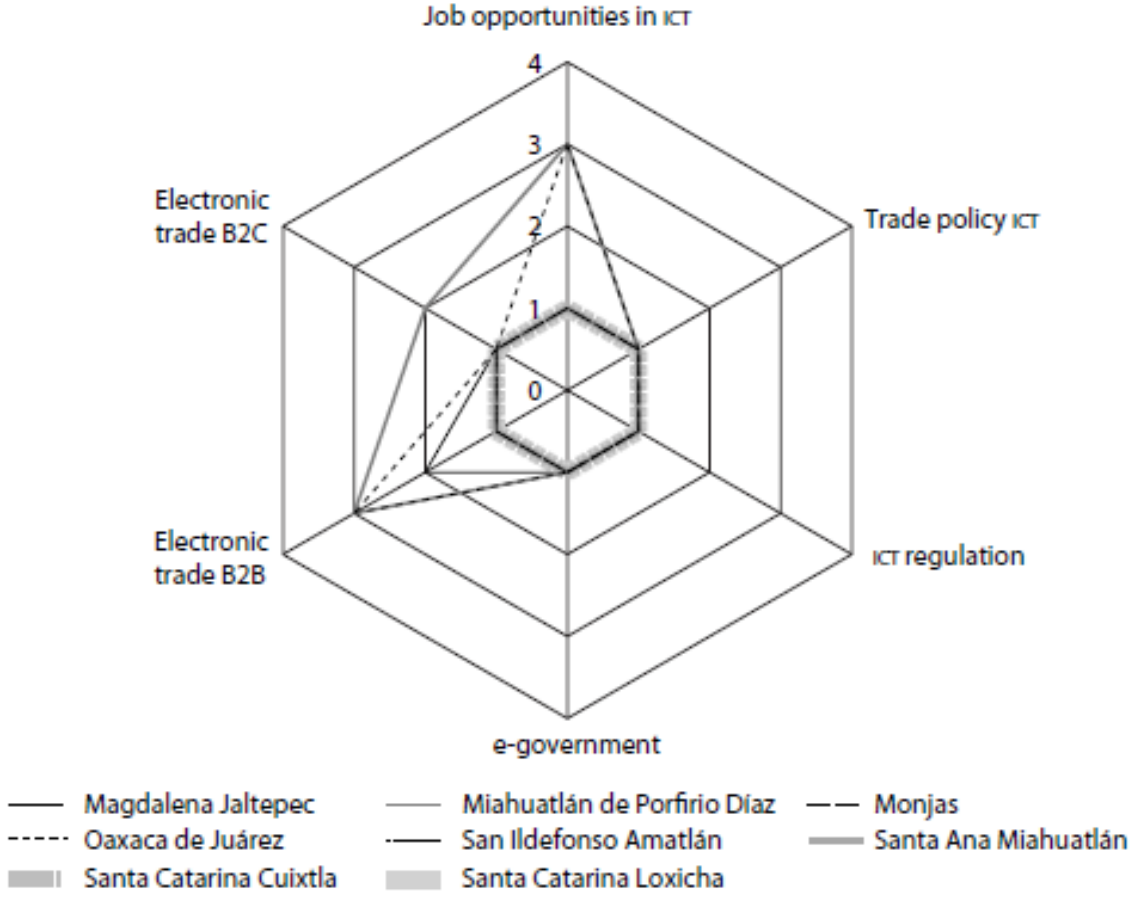
In terms of network interconnection, the municipalities analyzed, perhaps with the exception of Oaxaca de Juárez, do not have the infrastructure to allow telecommunications operators to interconnect with operators that transmit their information to local users. In other words, the network operator of the local loop, otherwise known as the "last mile", is underdeveloped or simply nonexistent.

Interconnection is defined as the technical and commercial agreements that allow operators to connect their equipment to other operators so that end users are able to access the end users of other operators. This allows one user from a single operator to connect to many more users provided their operator is able to interconnect to another operator. Interconnection

increases the potential for users from different networks to gain access to one another. In the absence of infrastructure of the operator of the local loop, an Internet service provider faces serious barriers to gain access the end user. In other words, Internet or long distance operators do not even have the option to buy access to the essential resources (that the operator of the local loop would normally have) to be able to access the end user (Castañeda, 2011).

In the state of Oaxaca, there are small private enterprises (SMEs) that substitute the low investment in the local loop of large companies. In the case of the city of Miahuatlán de Porfirio Díaz, there is at least one wireless Internet provider that exploits Telmex wireless signals using frequencies on the radio electric spectrum that fall within legislative grey areas. In this town, the offer of telephone lines by Telmex is very limited which makes it difficult to contract Internet service with the same company. These SMEs exploit Internet access and telephony over IP services through the Telmex infrastructure using dedicated links contracted to provide services to their clients. These companies provide radial links that border on piracy with a micro-regional range. Their spectrum covers at least fifteen communities radiating out from Miahuatlán de Porfirio Díaz (Coria, et. al. 2011).

FIGURE 5. Economics and public policies on the Internet



Source: Authors' own elaboration.

Conclusions

Rural municipalities in Mexico face a high degree of dependency on large telecommunications companies in the development of their connectivity policies. While on the one hand, demand in municipalities for telecommunication services is widely dispersed; on the other, the offer of such services is highly concentrated in the hands of a few internet service providers (ISPs). This means that large companies only invest in rural areas if demand is sufficient enough to be profitable which, in turn, represents a coordination problem

between municipalities.

Forms of inter-municipal coordination and its determinants vary from case to case. In a comparison between the United States and Germany, Wohlers (2009), found that some of the factors that determine the sophistication of local e-government proposals included the presence of professional administration and local socioeconomic characteristics, as well as geographical and regional demographic factors. In the case of Sweden, for example, it has been observed how innovation in e-government at the municipal level, and coordination between municipalities, can benefit from the interaction between government and citizens through open innovation models (Feller, et. al., 2011). In Pakistan, certain extra-technological variables have proven important in the relationship between government and citizens, such as trust in the Internet and trust in the government, as well as the quality of the information and the usability of government portals (Rehman, et. al., 2012). There is evidence in Mexico that local governments have started to use social networking tools known generically as Web 2.0. Although the application of tools such as Twitter or Facebook is still limited, their use tells us of a tendency toward greater interactions between government and citizens (Sandoval-Alamazan, et. al., 2011b).

Examples of this include the city of Mérida, Yucatán, which unilaterally improved connection quality as a means of addressing the digital divide (Sandoval-Almazan, et. al, 2011a). In the case of Oaxaca, it would seem that inter-municipal coordination mechanisms need to be created to allow joint investment in rural connectivity. In this regard, a rural connectivity fund (or trust) would need to be created where geographically neighboring municipalities can set aside financial resources that would enable them to attract the investment of large telecommunications companies in their regions.

The eight cases of Oaxaca give us some insight in the asymmetry of the level of preparedness for the interconnected world. In spite of the creation in 2011 of the Information Technology Development Institute (*Instituto de Desarrollo de Tecnologías de la Información*, IDTI) by the government of Oaxaca, there is still a complete lack of coordination in ICT investment at the municipal level. According to its creation decree, the attributes of the IDTI

are: (i) to establish policies and strategic programs to introduce improvements to processes and the use of information technologies in the agencies, entities and bodies of state Public Administration; (ii) design, program and execute technological projects to facilitate access by users to procedures and public services electronically; (iii) Coordinate the development of service and information programs for citizens in order to disclose content and public services of the State Government. (Coria, et. al. 2011).

While the cases analyzed do not constitute a representative sample, the results yielded sufficient information to develop this theoretical model which highlights the inadequacies of public policy and indicates the direction that future research must take. In this regard, taking into account the game theory model presented in this article. To achieve p=1 and q=1, in other words, to ensure that municipalities have dominant strategies for investment in information technologies and get telecommunications companies to invest in the rural sector, coordination mechanisms that go beyond a State Agency are required. Although the IDTI has the ability to design and operate these mechanisms, it still does not function as such. In this regard, a Rural Connectivity Fund like what happened in the United States would be essential to the development of rural telecommunications (See: FCC's 2011 Broadband Competition Report). Public initiatives to tackle the digital divide have also been observed in Europe. The European Union has launched e-inclusion initiatives for electronic government (Walterova and Tveit, 2012). Furthermore, it is vitally important that municipalities reach a consensus on the type of technology they wish to install if they are to strengthen technological and network externalities. The decision on the type of ICT (e.g. mobile vs. fixed) is just as important as the investment decision between IT or T. Given that the network generates collective benefits, a subsidy equivalent to the value of all externalities would be justified.

In terms of sources of research information, a representative telecommunications survey needs to be conducted at the municipal level. This is important not only in the case of Oaxaca, for which some preliminary results have already been presented, but also in every other municipality in the country.

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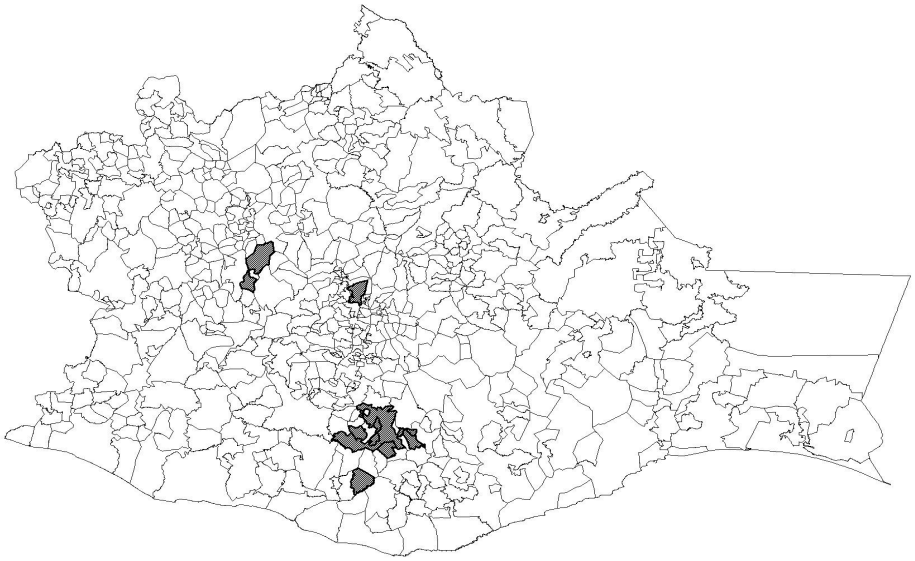
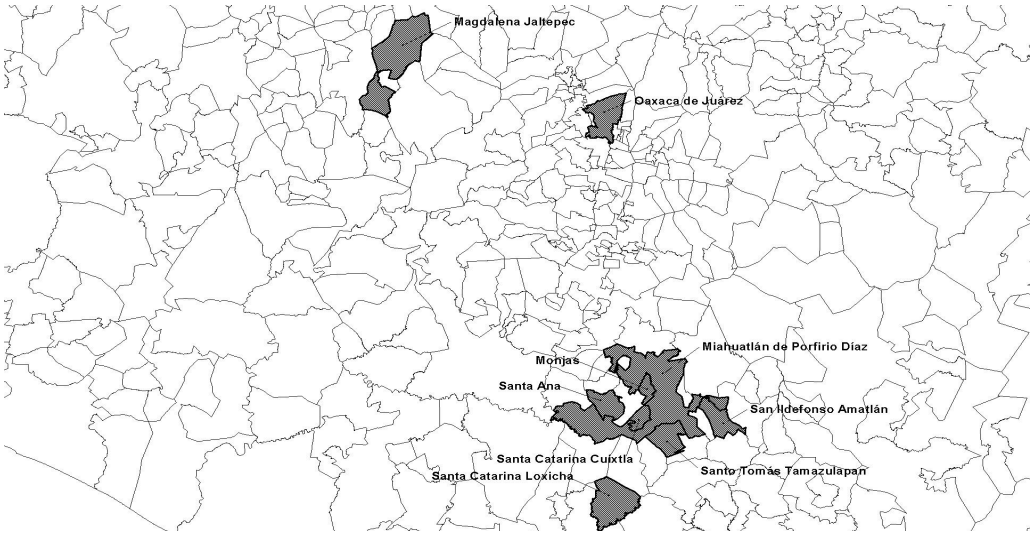
Annex 1. Municipalities of Oaxaca and the Study Area



Study Area



Annex 2 Indicators of Digital Capabilities*			
Group of indicators	**Question to answer**	**Categories/Subgroup of indicators**	**Type of performance and commonality**
1) Access to the Network	*What are the availability, cost and quality of the networks, services and necessary equipment in ICT?*	*Information infrastructure*	*Declining/ "Old" commons*
		Availability of the Internet	*Declining/ "Old" commons*
		Cost of Internet access	*Rules of Use*
		Speed and quality of the network	*Declining/ "Old" commons*
		Hardware and software	*Growing/ "New" commons*
		Technical service and support	*Growing/ "New" commons*
2) Interconnected Learning	*Does the education system integrate ICTs into its processes to improve learning? Are there technical training programs in the community that can train and educate the workforce in ICTs?*	*School access to ICTs*	*Declining/ "Old" commons*
		Using ICTs to improve education	*Growing/ "New" commons*
		Developing the technical strength of the workforce	*Growing/ "New" commons*
3) The Interconnected Society	*To what extent are individuals using information and communication technologies in the workplace and their personal lives? Are there significant available opportunities for those with ICT skills?*	*People and online organization*	*Growing/ "New" commons*
		Content relevant to local level	*Growing/ "New" commons*
		ICTs in day to day life	*Growing/ "New" commons*
		ICTs in the workplace	*Growing/ "New" commons*
4) The Interconnected Economy	*How are commerce and the government using information and communication technologies to relate to the public and between themselves?*	*Job opportunities in ICTs*	*Growing/ "New" commons*
		Electronic business to consumer trade (B2C)	*Growing/ "New" commons*
		Electronic business to business trade (B2B)	*Growing/ "New" commons*
		Electronic Government	*Growing/ "New" commons*
5) Network Policies	*To what extent do public policies promote or discourage growth of the adoption and use of ICTs?*	*Regulation of telecommunications*	*Rules of Use*
		Commercial ICT Policies	*Rules of Use*

***Source:** Harvard University (2000). Preparación para el Mundo Interconectado. Una Guía para los Países en Desarrollo. Center for International Development.*

Cultural Industries, Digital Divide and Rural Development: The case of digital piracy in Oaxaca, Mexico

Manuel G. Chávez-Angeles, MPA/ID, cSc.D.
Instituto Politécnico Nacional, CIIDIR-Oaxaca y Universidad de la Sierra Sur.
mchavez@unsis.edu.mx; mchaveza1001@ipn.mx

Patricia S. Sánchez-Medina, Sc.D.
Instituto Politécnico Nacional, CIIDIR-Oaxaca.
psanchez@ipn.mx

In rural Oaxaca the commerce of pirate cultural goods (e.g. music, cinema, books, software) is an entrepreneurial activity. Off-line piracy is very often the only media for accessing goods from cultural industries. Applying the Institutional Analysis and Development Framework we analyses copyright piracy in rural settings as an action arena. We used a war of attrition game theory model to explain why intellectual property rights are not enforced in rural communities, analyzing different levels of interaction and rules in use from the global to the very local. We propose new institutional arrangement to legalize the copy and transmission of cultural goods for education and rural development. Some interesting insights arrived regarding the cost of the "last mile" in the diffusion of cultural goods and ICT's infrastructure.

This paper was presented at the 1st Global Thematic IASC Conference on the Knowledge Commons at the *Université Catholique de Louvain,* September 2012. Submitted for its publication to the International Journal of the Commons.

Keywords: common-pool resources, cultural industries, digital divide, information commons, intellectual property, war of attrition.

INTRODUCTION

Digital technology has caused important disruptions in cultural and information industries. In music production and distribution, development of the MP3 file format dramatically changed business forever. MP3, created by engineers at the German company Fraunhofer Gesellshaft, is short-hand for Motion Picture Experts Group-Layer 3. An audio compression format that generates near compact disk quality sound at approximately 1/10 to 1/20 the size. Borrowing Peter Alexander (2002) example: Elvis Presley's "Hound Dog" on compact disk requires 24 megabytes of hard disk space, but when converted to MP3 the storage requirement falls to 2 megabytes. On a 28.8 kilobit per second Internet connection, the compact disk version of "Hound Dog" would take at least one and one-half hours to download from another computer. On the other hand, if the file were first converted to MP3, it would take approximately eight and one-half minutes.

Since 2000 when Metallica filed a lawsuit against Napster, the industry has responded to large-scale organized digital file sharing by taking legal action against the most prominent and sizable digital file distributors. For instance, MP3.com was found liable in U.S. District Court for infringing the copyrights of the Recording Industry Association of America (RIAA). Moreover, a federal judge rejected Napster's contention that it is protected by the digital copyright law and issued a preliminary injunction requiring Napster.com to stop distributing copyrighted materials. (Alexander 2002)

Seemingly, in May 2009 the U.S. Senate held a hearing on the future of newspapers. The Majority Statement signed by John D. Rockefeller, IV says:

> ". . During roughly the last six months, daily newspaper circulation has declined 7 percent. During roughly the past year, media companies have cut a heartbreaking 41,000 jobs. The inevitable result is less reporting, less news, and less coverage of our communities and interests at home and

abroad.

> From these facts we can infer that the newsgathering model that served us so well in the past is now in trouble. The future of journalism is digital. We are fast migrating from a world where news is cranked out daily over a regional printing press to one where news is distributed digitally over the infinite networks of the Internet. There is much to celebrate and explore in this change—access to an endless array of ideas and opinion and minute-by-minute updates on newsworthy events—but there is also is cause for concern.
>
> (. . .)
>
> Uneven access in to the Internet in some communities is a trouble that needs to be addressed. And then there are the unquantifiable losses. The daily promise of unfolding a newspaper, rustling its pages, and letting your eye dance across the page and survey its offerings is a pleasure, I fear, our next generation will not know."

In May 2012, the New Orlean's newspaper The Times-Picayune announced that it would drop back from daily publication to just three days a week. The same day the creation of NOLA Media Group was announced merging the paper edition of The Times-Picayune and its affiliated web site NOLA.com. The change left New Orleans as the largest city in the U.S. without a daily newspaper. A week later, readers rally and protested to "save the paper".

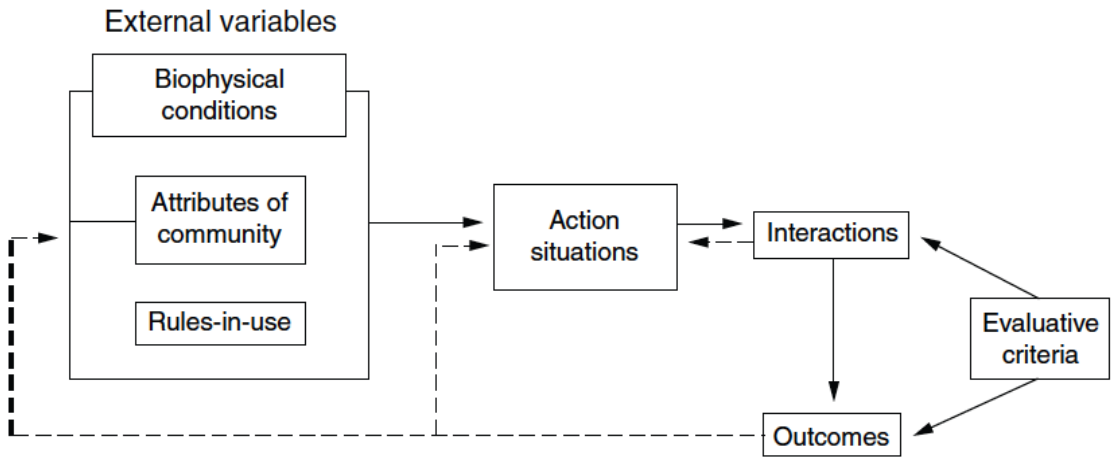
Yochai Benkler (2006) proposed the idea of three different layers embedded in communication systems that together make communication possible: (1) the physical devices and network channels necessary to communicate; (2) the existing information and cultural resources out of which new statements must be made; and (3) the logical resources the

software and standards necessary to translate what human beings want to say to each other into signals that machines can process and transmit. Benkler also made the question whether there will, or will not, be a core common infrastructure that is governed as a commons and therefore available to anyone who wishes to participate in the networked information environment outside of the market-based, proprietary framework.

This paper is about the commerce and exchange of goods from the second layer, and how conditions on the first and third layers affects commerce and exchange of information and cultural resources. We use the Institutional Analysis and Development (IAD) framework. In the IAD the focal units of analysis are “action arenas”, that exist in the household; neighborhood or community; local, regional, national, and international councils; in firms and markets; and in the interaction among all of these arenas with others. In the simplest and most aggregated way to representing any of these arenas when they are the focal level of analysis exogenous variables affect the structure of an action arena, generating interactions that produce outcomes. Evaluative criteria are used to judge the performance of the system by examining the patterns of interactions and outcomes. Outcomes feedback onto the participants and the situation and may transform both over time. The IAD framework provides a metat-heoretical language to enable scholars form different disciplines to discuss any particular theory or to compare theories. (Ostrom 2005, 2010) The action arena analyzed in this paper is intellectual property piracy.

Figure 1

Institutional Analysis and Development Framework



Source: Ostrom, 2010

2. MEDIA CONSUMPTION AND DIGITAL DIVIDE IN MEXICO.

Although digital technologies have global effects, its impacts are not evenly disruptive in different parts of the world. The degree of connectivity is an important feature in determining the degree of disruption for corporate and citizen strategies. The consumers habits related to the acquisition and distribution of cultural and information goods suffer fewer changes in places with low penetration of information and communication technologies. Using data from Mexico's 2009 National Survey on the Use of Time (ENUT), we estimate that while 60.7 percent of households own a mobile phone, making mobile technology the main driver in digital inclusion; 21.1 percent of households are still in a complete media blackout or extreme digital poverty, without access to wired or mobile telephones, the Internet or cable TV (Table1).

Table 1. Connectivity Diffusion per Households (%)				
Telephone	**Mobile**	**Cable TV**	**Internet**	**Extreme Digital Poverty***
40.3	60.7	27.7	18.1	21.1
Data: 2009 National Survey on the Use of Time (ENUT), INEGI * Any of the former connections are available in the household				

Although Mexico's digital poverty, 58.9 percent of hours devoted to leisure are spend on mass media provided activities like watching TV, surfing the Internet, reading magazines or books; 28.1 percent of hours devoted for leisure are spend on community and social gathering; 6.7 percent of hours are spend practicing some sport; 4.2 percent of hours are devoted to ludic activities, either playing and instrument or a video game; and only 2.1 percent of hours are devoted to cultural activities like visiting museums, concerts or exhibitions (Table 2).

Table 2. Demand for Leisure			
Time Devoted to Different Activities (%)	**Total Hours**	**Women**	**Men**
Community and social interaction (e.g. parties, church, civic events, phone calls, chat)	28.1	30.4	25.8
Culture (e.g. museums, parks, cinema, exhibitions, theater, concerts)	2.1	2	2.2
Playing non-sports (e.g. music instruments, dancing, painting, video games, board games)	4.2	3.2	5.1
Sports (e.g. soccer, basketball, swimming, boxing, karate, jogging, biking)	6.7	4.9	8.4
Mass media (e.g. books, magazines, newspapers, TV, radio, Internet)	58.9	59.5	58.5
Data: 2009 National Survey on the Use of Time (ENUT), INEGI			

Taking a closer look to mass media consumption, we estimate that 68.2 percent of hours are spend watching TV; 11.5 percent of hours are spend listening some kind of audio either listening the radio or music from a stream; 10.7 percent of hours are devoted to reading and only 9.6 percent of leisure time is spend in the Internet. Mexico in this regards is neither a

country of readers nor of cybernauts; it is a country of TV watchers. The low proportion of hour devoted to reading and surfing the web could be related to illiteracy and digital poverty. (Table 3).

Table 3.
Mass media demand per good

Total of hour		Reading hours		TV hours		Audio hours		Internet hours	
Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
483, 800.3	100	51940.7	10.7	329802.6	68.2	56030.15	11.5	46026.8	9.6
Data: 2009 National Survey on the Use of Time (ENUT), INEGI									

Regarding TV consumption, while 68.2 percent of hours (Table 3) devoted to mass media are spend watching TV only 27.7 percent (Table 1) of consumers have a connection to cable TV. According to the 2010 Census (INEGI, 2011) on this year 94.7 of households owned a TV. This evidence allow to infer that a high proportion of TV consumers are only watching channels broadcasted through VHF and UHF frequencies. This frequencies although legally own by the government are given on concession to the private duopoly TELEVISA-TVAZTECA. Both companies are famous for its soap opera productions, reality shows and reruns of old American TV series and cartoons. The biggest revenue for this networks come from advertising, including government and political marketing. Any major transnational company in Mexico selling consumer goods advertise through their channels. Recently the results of the 2012 presidential election were contested on tribunals arguing overspending, vote buying and TV network's bias. Social media movements like *#yosoy132* also blamed the duopoly for information bias during the presidential elections.

Using Mexico's 2010 National Survey of Income and Consumption (ENIGH) we estimated demand of products that are traditionally supplied by the publishing and recording industry by place of purchase. We found that paper support is still important and evidence of offline music piracy: 65.2 percent of books and 42.9 percent of magazines were bought on specialized stores (e.g. bookstores); while 64.9 of newspapers and 26.6 percent of magazines to street vendor (e.g. kiosks and *voceadores*). Regarding audio products, mainly music, 34.2 percent were bought to street vendors and 22.4 percent in street markets. Is very probable audio

bought in the street were pirate music CDs. For video games, 38.6 percent were bought in specialized stores. Is very important to notice the low percentage of transactions done through the Internet: 0.8 percent for books; 0.3 percent for magazines; and less than 0.1 percent for newspaper and music (Table 4).

Table 4.
Demand for Publishing and Recording (%)

	Goods				
Place of purchase	**Books**	**Newspapers**	**Magazines**	**Audio**	**Video games**
"Farmers" market	1.2	1.4	3.02	9.5	5.7
Street Market (*tianguis*)	3.6	0.3	1.6	**22.4**	10.2
Street Vendor	8.8	**64.9**	**26.6**	**34.2**	7.9
Convenience store	0.2	7.8	6.7	0.5	0
Specialized Stores	**65.2**	19.2	**42.9**	**19.1**	**38.6**
Supermarkets	3.8	0.7	14.1	6.9	12.5
Department stores	6.9	>0.1	2.1	2.4	13.6
Bought outside the country	0.4	>0.1	0.2	0.2	3.4
Club stores	0.8	>0.1	0.2	0.5	5.7
Person	8.02	5.3	1.9	3.9	2.3
Internet	0.8	>0.1	0.3	>0.1	0

Data: 2010 National Survey of Income and Consumption (ENIGH), INEGI

viii. WAR OF ATTRITION IN CULTURAL INDUSTRIES

Intuition about intellectual property markets can be gained form the war of attrition game. A simple static game, popular for study natural monopolies. The war of attrition was introduced

in theoretical biology by Maynard Smith (1974), to explain animals fight for prey. For instance, imagine a whale's carcass in an arctic beach. This is more meat than a single family of polar bears can eat. Nevertheless, the bear family that first arrive to (or found) the carcass will have to fight other families of polar bears that arrived to (or found) the carcass after them. If they allow for other family to approach and feed, the incumbents risk to be vanish from the carcass. Each time a new family arrive, the incumbents will have to fight in order to preserve its right to feed from the whale, or will have to leave if their contestants are strong enough to become the new incumbents. How many bears families would feed from a single whale carcass is hard to tell. *The survival of the fittest,* or as Smith (1982) puts it, *Darwinian fitness*, is the rule determining how many families of bears get the chance to feed from the carcass. In a simple fashion, Figure 2 exemplifies the game faced by both troops of bears. Q being the whale's carcass (could be put as pounds or calories in a whale carcass in order to have an unit), the dominant strategy for both troops is to fight as long as *Q* is positive. Both troops would get *Q/2.*

Figure 2
War of Attrition in the arctic beach

		Troop1	
		Fight	Leave
Troop 2	Fight	Q/2, Q/2	Q, 0
	Leave	0, Q	0,0
With any Q>0 the dominant strategy is to compete			

- War of attrition on cultural industries with blockade/deterrence costs.

Oligopolists are affected by many variables they cannot observe or estimate precisely: their own cost function, the cost function of their rivals, the state of demand or the potential of the market, and their rivals' strategic decisions. To the extent that some pieces of information are private we must envision market interaction as a game with asymmetric information. Riley (1980) and Kreps and Wilson (1982) introduced as asymmetric-information version to the realm of economics, focusing on predatory pricing behavior. In cultural industries, the war of

attrition is taken through legal means, as well as through price wars.

In industrial organization is possible to distinguish three kinds of behavior by incumbents in the face of an entry threat (Tirole 1995):

i. Blockade entry: The incumbents compete as if there were no threat of entry. Even so, the market is not attractive enough to entrants.
ii. Deterred entry: Entry cannot be blockade, but the incumbent modify their behavior to successfully thwart entry.
iii. Accommodate entry: The incumbent find it (individually) more profitable to let entrants enter than to erect costly barriers to entry.

Figure 3 shows this behavior in a simple way, where D_1 and D_2 are the blockade-deterrence cost for pirates and industry respectively. Dominant strategies would depend on the value of D_1 and D_2. Under asymmetric information, $D_1(D_2)$ and $D_2(D_1)$ are the blockade-deterrence strategies for pirates and industry respectively. *Darwinian fitness* would be replace by a combination of rationality and costs structure.

Figure 3
War of Attrition in cultural industries

		Industry	
		Blockade/Deterrence	Accommodate
Pirate	Blockade/Deterrence	Q/2-D_1, Q/2- D_2	Q, 0
	Accommodate	0, Q	0,0
Dominant strategies depends on D_1 and D_2.			

Now imagine an imagine an infinite population of individuals taking upon digital production (pirates and non-pirates) as an entrepreneurial activity. Let π be the profit for digital production:

(1) $\pi_i = p(Q/n) - c - D_i$; $\pi_m = pQ - c$

where π_i are profits for each firm on competitive equilibria and π_m is monopoly profit; *p* is the price of the pirate product and *Q* the total demand for that product; c is the cost of production and *n* is the total number of producers in the industry. Figure 4 shows the normal form for two firms

Figure 4
War of Attrition in cultural industries. Piracy as an entrepreneurial activity.

		Industry	
		Blockade/Deterrence	Accommodate
Pirate	Blockade/Deterrence	π_1 , π_2	π_m , 0
	Accommodate	0, π_m	0,0
Dominant strategies depends on D_1 and D_2.			

The total number n of producers (pirates and non-pirates) would be reach where $\pi = 0$:

(2) $n = pQ / D_i + c$

The higher the cost of blockade/deterrence the lower the number of producers. The cost of production is not an important variable given that it has been decreasing since the invention of the magnetic tape in the 1950s. In fact, there is not doubt that the current shift in cultural industries and the mushrooming of piracy is due to the plummeting of production costs after the invention of MP3 file format. Independent record labels can also be benefiting from the change in costs structure, mainly by lower production and distribution costs.

Tirole (1995) mentions four elements of market structure that affect the ability of established firms to prevent supranormal profits (rents) from being eroded by entry. Taking the case of digital music, Table 5 shows the change of market structure pre-MP3 vs post-MP3:

Table 5 Market structure elements		
	Pre-MP3	**Post-MP3**
Economies of scale: If the minimum efficient scale is a significant proportion of the industry demand, the market can sustain only a small number of firms that make supra-normal profits without inviting entry.	YES	NO
Absolute cost advantage: The established firms may own superior production techniques, learned through experience (learning by doing) or through research and development (patented or secret innovations). They may have accumulated capital that reduced their cost of production. They may also have foreclosed the entrants access to crucial inputs through contacts with suppliers.	YES	NO
Product-differentiation advantages: Incumbents may have patented product innovations or they may have cornered the right niches in the product space, or they may enjoy consumer loyalty.	YES	NO
Capital requirements: Entrant may have trouble finding financing fr their investments because of the risk of creditors.	YES	NO

1. **War of attrition in cultural industries with copyright**

Now assume the existence of copyright in a dynamic game with infinite periods of time where the profit for the pirates in the black market is given by:

$$(3)\quad \pi_P = \Sigma_0^T\, p(Q/n)$$

and for the industry is given by:

$$(4)\quad \pi_I = \pi_c + \pi_m = \Sigma_0^T\, p(Q/n) + \Sigma_T^\infty\, pQ$$

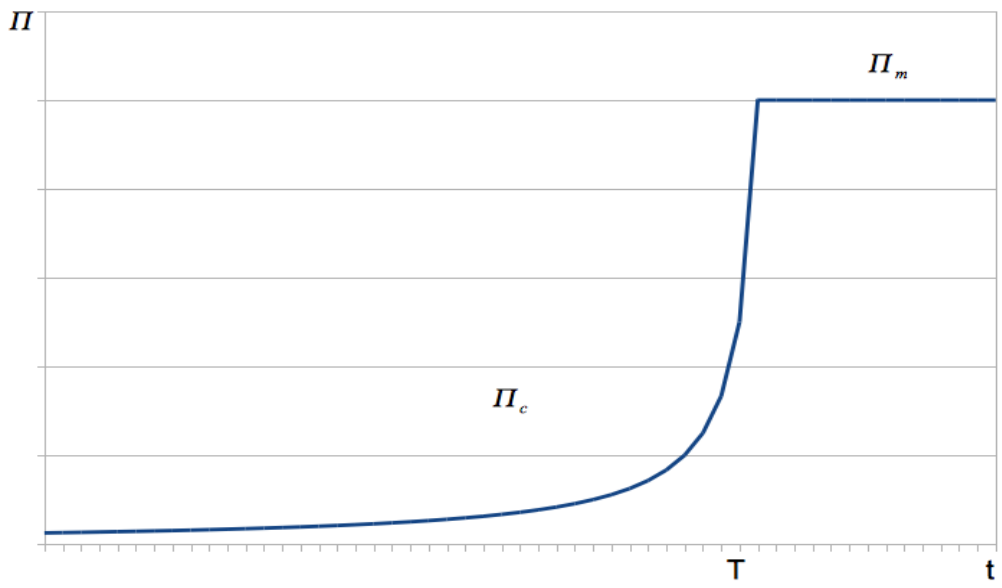
where π_c and π_m are profits on a competitive market and on a monopoly respectively; T is the period where competition leaves the market.

Figure 5 War of Attrition in cultural industries. Piracy as an entrepreneurial activity.			
		Industry	
		Blockade/Deterrence	Accommodate
Pirate	Blockade/Deterrence	π_P - D_P, π_I -D_I	π_P , 0
	Accommodate	0, π_I	0,0

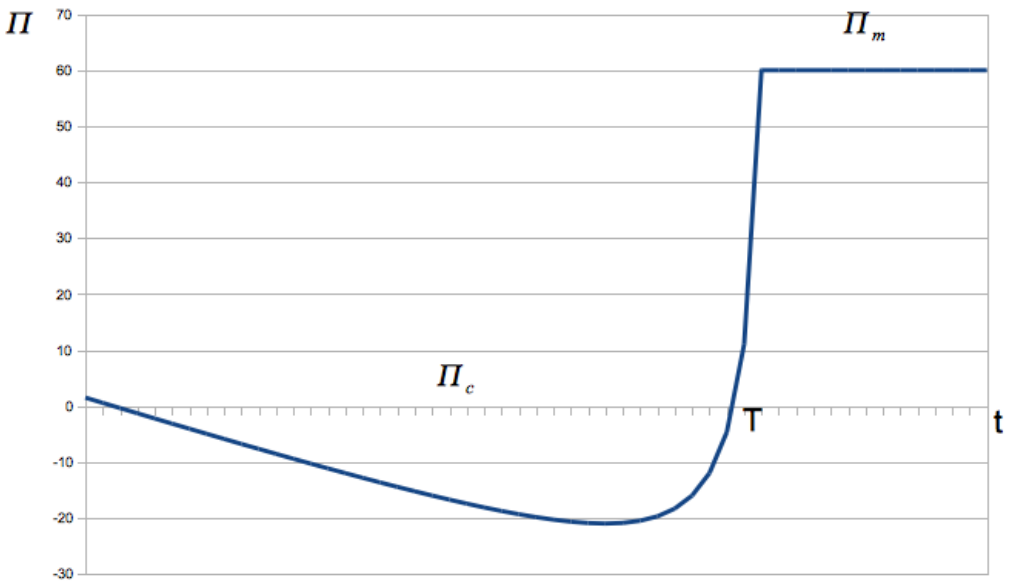
Clearly $\pi_I > \pi_P$. In this regards, how far is *T* does not matter as long as there are potential monopolistic gains ad infinitum after *T*. In the current state of affairs this potential monopolistic gains are given by copyright law. Once again only the costs D_P and D_I can change the dominant strategy for both (pirates and non-pirates) to enter the market.

Using equation 4 we performed a very simple lineal programming simulation. We assumed that *n* decreases constantly and that D_I increases also constantly. Our results (Figure 6) suggests that (at least under this assumptions), the industry would have to bear some economic loss before obtaining monopoly profits. This losses could be so deep that firms would prefer to accommodate before obtaining monopolistic power.

Figure 6
Profit for industry without deterrence (*Di=0*) cost and constant decrease of pirate's population (n)



Profit for industry with constant decrease of pirate's population and constant increase in the cost of blockade/deterrence (*Di>0; Di'>0*) .



1. DISCUSSION.

4.1. Police vs. Pirates. A love story.

In 2005, the OECD estimated that international trade in counterfeit/pirated products amounts to USD 200 billion, excluding digital products. The Anti-Counterfeiting Trade Agreement (ACTA) was signed on the 1st October 2011. ACTA is intended to combat Intellectual Property Rights (IPRs) infringements, namely counterfeiting and piracy, by enhancing international cooperation and enforcement. ACTA is intended to accelerate IPR enforcement, and make it more effective, so as to counter growth in counterfeiting and piracy. ACTA was negotiated between the EU and its Member States, the US, Australia, Canada, Japan, Mexico, Morocco, New Zealand, Singapore, South Korea and Switzerland. Once the agreement has entered in force, any member of the World Trade Organisation (WTO) may apply to join. The EU were joined on 26 January 2012 in Tokyo by representatives of 22 EU member states, however, the signatures need to be followed by ratification for ACTA to enter into force. (EU Parliament 2012)

The 4th of July 2012, 478 members of the European Parliament voted against the of Anti-Counterfeiting Trade Agreement (ACTA), 39 in favour, and 165 abstained, meaning the agreement will not enter into force in the European Union. ACTA aimed to more effectively enforce intellectual property rights on an international level. However, opponents were concerned that ACTA would have favoured large companies' interests at the expense of citizens' rights. The European Commission referred ACTA to the European Court of Justice in May for a ruling on the agreement and asked Parliament to wait for its conclusions. Simultaneously, Parliament decided to press ahead with its own scrutiny of the agreement. Five committees came out against the agreement while the petition committee received a petition against ACTA signed by nearly three million people. (EU Parliament 2012)

The 11th of July 2012, Mexico's ambassador to Japan signed on to ACTA. The reasons Mexico did not sign this agreement earlier, was that the legislature had also rejected ACTA,

and the executive branch had to get the Mexican Senate to ratify the agreement. Since Mexico joined the World Trade Organization on January 1st 1995, government's executive branch has traditionally support international initiatives aimed to more effectively enforce intellectual property rights. Media companies from developed countries worried that their business suffer great damage due to counterfeiting and piracy, have an important (although not always effective) ally in Mexico's law enforcement agencies. In support to intellectual property rights agreements Mexico's signed the Trade-Related Aspects of Intellectual Property Rights agreement (TRIPs) and Congress approved related legislation even before 1995.

The substantive legislation governing industrial property is contained in the Industrial Property Law (LPI), which has been in force since 1991. Its immediate precedent is the Law on the Promotion and Protection of Industrial Property, a body of law which was considered to be in accordance with the international standards of the time. The LPI regulates the legal concepts of patents, utility models and industrial designs, trade secrets, marks, advertising slogans and trade names, appellations of origin, and lay-out designs of integrated circuits. It also lays down the administrative procedures designed to protect and preserve industrial property rights and permitting the authorities to order the imposition of provisional measures aimed at the immediate suspension of allegedly violatory behaviour.

The area of copyright is currently governed by the Federal Law on Copyright, which came into force in 1996, abrogating the Federal Law on Copyright of 1956. This body of legislation contains provisions relating to copyright itself, to the moral and economic rights of authors, to the rules governing the transfer of such economic rights, to copyright protection, to neighbouring rights, and to limitations on copyright and neighbouring rights. It establishes guidelines with respect to copyright in national symbols and expressions of popular culture, registration of rights, reservation of rights of exclusive use, collective administration of rights, the National Copyright Institute, procedure before the judicial authorities, conciliation, arbitration, copyright infringement, trade-related infringement and administrative appeal.

On the 15th of June 2006 Mexico's General Prosecutors (PGR), together with other branches

of the executive branch and private corporations including TELEVISA, Business Software Association (BSA), the Motion Picture Export Association of America, Inc (MPEAA), signed the National Agreement Against Piracy. In the intellectual property area, Mexican law defines conduct that is subject to criminal action and punishable by monetary fines and imprisonment. In order to fulfill WTO agreements, Mexico decided to reform its legislation to ensure that conduct subject to criminal action in the intellectual property area was considered to constitute a serious offense, not only increasing the penalties, but also eliminating the privilege of release on bail. (PGR 2006).

Table 6
Felonies against intellectual property

	Year				January-June		
Action	**2007**	**2008**	**2009**	**2010**	**2010**	**2011**	**Change (%)**
Raids	1,692	1,990	1,897	1,666	782	677	-13.4
Arrested	296	456	827	929	391	1,065	172.4
Pirate products confiscated	140,063,138	68,820,254	39,221,420	105,328,083	12,714,931	9,168,085	-27.9
Piracy labs dismantled	206	217	200	91	61	78	27.9

Source: *5to Informe de Labores Procuraduría General de la República* (2011 General Prosecutor Annual Report)

In a digital divide environment where must of the piracy is done through hard copies (e.g. DVDs, CDs or USB memory sticks) the actions taken by PGR are old fashion raids. Between 2007 and 2010 PGR performed 7,242 raids; arrested 2,508 persons; confiscated 353, 432, 865 million copies of pirate items; and dismantled 714 laboratories (Table 6). Although this apparently spectacular numbers, there is no way to make proper evaluation of the effectiveness and impact of this measures. Total numbers for piracy activities remain unknown. At the same time, given the low cost of digital copying technology, is very probable that as soon a pirate lab is dismantled another one mushroomed filling its place. High-tech measures like Digital Rights Management (DRM) seems highly improbable to be effective. Corporations loose content control once products are cracked and off-line trade and exchange of hard copies come into place to be played in devices without an Internet

connection.

Table 7
Pirate products confiscated

Item	2007		2008		2009		2010	
	Number	%	Number	%	Number	%	Number	%
DVDs	692,435	29.4	2,283,632	14.6	1,783,122	37.4	2,025,024	34.5
Video games	28,554	0.8	270,120	1.7	77,399	1.6	239,192	4.1
CDs	2,328,807	62.2	1,850,406	11.8	1,329,790	27.9	1,399,820	23.8
Clothing	115,946	3.2	143,281	0.9	1,328,135	27.8	1,433,271	24.4
Shoes (pairs)	48,519	1.4	6,941	0.04	236,536	4.9	737,080	12.6
Medicines	356,447	10.0	1,102,550	19.49	7,555	0.1	31,466	0.5
TOTAL	3,570,708	100.0	5,656,930	100	4,762,537	100	5,865,853	100

Source: *5to Informe de Labores Procuraduría General de la República* (2011 General Prosecutor Annual Report)

Notwithstanding the difficulty of doing a proper evaluation of traditional PGR's police activities, its raids allow to infer the proportion of copyright infringement. The higher proportion of pirate goods confiscated by item are hard copies of music and cinema, CDs, and DVDs, followed by medicines, clothing, shoes and video games on that order (Tale 7). The highest proportion of CDs and DVDs, as well as the lowest proportion of video games confiscated is consistent with our estimates of demand from Table 4.

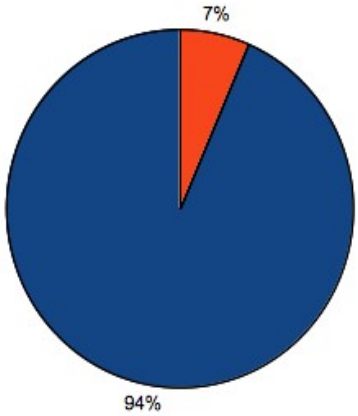
4.2. Oaxaca's Creative Economy.

Oaxaca is a Mexican state located in Southwestern Mexico. Is an important area for tourism, attracting people for its archeological sites, native culture and crafts. It has a significant coastline on the Pacific Ocean with important tourist area, which has the major resort of Huatulco. Oaxaca is also one of the most biologically diverse states in Mexico, ranking in the top three, along with Chiapas and Veracruz, for numbers of reptiles, amphibians, mammals and plants. Demographically, Oaxaca stands out due to the high percentage of indigenous peoples. It is estimated that at least a third are speakers of indigenous languages, accounting

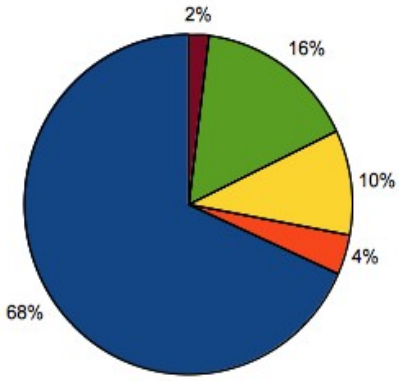
for 53% of Mexico's total indigenous language speaking population.

Figure 7
Contribution of culture to Oaxaca's GDP

A



B



A	
Other Economic Sectors	94.00%
Culture	7.00%

B	
Mass media	68.00%
Recreation	2.00%
Manufacturing	16.00%
Education	10.00%
Scientific and technical services	4.00%

Source: SECULTA, 2010

Since 2010, the State's Secretary for Culture and the Arts (SECULTA) embrace a paradigm of culture as an industry and tool for economic development. Following UNESCO's models the Secretary wrote a strategic plan based on trickle-down economics, or what could be terms a value chain of the cultural economy: monies collected by cultural enterprises, which produce and distribute culture, will make their way down to the cultural workforce, which originates cultural products.

Using statistics from Mexico's Central Bank the National Accounts System, SECULTA estimates that culture accounts for the 6.53 percent of State's GDP; 68.26 percent of this amount comes from mass media, mainly newspapers. SECULTA also makes the assumption that "manufacturing" in Oaxaca refers to art-crafts. Being a state without big industrial complexes, and having a tradition of pottery, wool weaving, wood craving, etc SECULTA estimates that 15.9 percent of culture's participation on GDP comes from art-crafts (Figure 7). Regrading employment, the Secretary estimates that 7.6 percent of employments comes from

cultural activities. (SECULTA 2010).

According to SECULTA, cultural sector produce a total of 24,070 jobs. Table 8 shows that the higher number of jobs are for musicians 2,863; bamboo artisans 9,007; and textile workers (d*eshiladores y bordadores*) 5,317. State's cultural policies do not account for informal (very often pirate) commerce of cultural goods. In terms of protection to intellectual property, Oaxaca's Secretary of Public Safety reports that the monthly income of pirates activities is around MX$290,000 (an approximate of US$21,500). Just in June 2012, the PGR performed raids in 7 (of 570) municipalities securing 8,200 pirate CDs and 26,228 pirate DVDs (SSPO 2011, 2012). In a qualitative research done in 1 of 570 municipalities of Oaxaca, we found there are approximately 25 cyber-coffees where illegal downloading takes place; and around 17 shops and 35 stands in the local *tianguis* (street market) selling pirate hard copies of music (CDs) and cinema (DVDs). Annex I shows photographs of music shops, street stands selling books, CDs and DVDs and a blanket at a political protest demanding a public library. Music shops are usually promotion agencies for local musicians and exchange centers of MP3 files. Local musicians usually give their MP3 recordings for free in exchange for promotion that lead to contracts for playing live (Chávez et.al. 2012).

Table 8 Employment in the cultural sector	
Occupation	**Number of jobs**
Directors of cinema and theatre	151
Museums managers	173
Cultural events coordinators	125
Cultural facilities coordinators	328
Archeologists and Historians	39
Researchers in the humanities	23
Librarians	149
Writers and literary critics	51
Painters	379
Illustrators	76
Sculptures	50
Scenographers	66
Musicians (composers)	16
Musicians (performers)	2,863
Singers	168
Dancers	120
Actors	6
Radio and TV anchors	316
Clown and circus	122
Audio and sound technicians	307
Bamboo artisans	9,007
Paper artisans	379
Textile artisans	1,778
Textile workers (d*eshiladores y bordadores*)	5,314
Pottery artisans	1,977
TOTAL	**24, 070**
Source: SECULTA, 2010	

a) CONCLUSION

Digital technologies offer unprecedented possibilities for human creativity, global communication, and access to information. Yet in the last decade, mass media companies have developed methods of control that undermine the public's traditional rights to use, share, and reproduce information and ideas. These technologies, combined with an oligopolistic structure in the media industry and new laws that increase its control over intellectual products, threaten to undermine creativity, privacy ad free speech.

In June 2000 Australia posed a question to the Permanent Mission of Mexico on the Council for TRIPs at WTO. The question was if there any specific exceptions to copyright under the law of Mexico to allow use of copyright material by third parties for permitted purposes (such as research, education, fair use or fair dealing?) Are there any significant judicial decisions with bearing on this issue? Are there any specific rules or findings concerning exceptions or limitations to copyright protection of computer software? (WTO 2001)

The mission answer that under the Federal Law on Copyright (LFDA), Title VI, merely establishes the limitations to copyright and neighbouring rights. **Until today this article haven't been applied**:

> Chapter I. Limitation in the Public Interest
>
> Article 147. The publication or translation of literary or artistic works shall be considered in the public interest where they are necessary for the advancement of science and national culture and education. Where it is not possible to obtain the consent of the owner of the corresponding economic rights, the Federal Executive may, through the Ministry of Public Education and either ex officio or at the request of a party, license the publication or translation in question against payment of compensatory remuneration. The foregoing shall be without prejudice to any international treaties on

copyright and neighbouring rights signed and ratified by Mexico.

In developed countries, libraries, civic organizations, and scholars have begun to turn the idea of information commons, with a wide variety of open democratic information resources now operating or in the planning stages. These include software commons, licensing commons, open access scholarly journals, digital repositories, institutional commons, and subject matter commons in areas like music, cinema and books. The basic characteristics in this commons is that they are collaborative and interactive, taking advantage of the networked environment to build information communities. Benefiting from network externalities, meaning that the greater the participation, the more valuable the resource. Many are free or low cost. Their governance is shared, with rules and norms that are defined and accepted by their constituents. they encourage and advance free expression. (Kranich, 2004)

In practice, information communities unite people around a common interest through increased access to a diffused set of information resources. The Internet is often the hub of these communities, facilitating connections and collaborations among participants, the exchange of ideas and links with others who have similar interests and needs. Scholars describe five characteristics that distinguish these Internet-based information communities: (Kranich 2004)

1. information-sharing with multiplier effects;
2. collaboration;
3. interaction based on needs of participants;
4. low barriers to entry
5. connectedness with the larger community.

In practice this is note very different to “Napsterizing” cultural products. The implementation of this sort of policy would have to analyze tradeoffs between innovation and consumer welfare (Hughes, et.al., 2002), at the same time that safeguard free-speech and the right for information. In any case government would have to intervene. So far its intervention has been enforcing the law through police activities. Mainly a “stick” strategy, that ignores the possible “carrots” offer by commons' policies that strength public access to culture, knowledge and information.

In Mexico low Internet connectivity hinder the opportunities offer by information commons and network externalities. A policy devoted to end digital divide would be a much better way to propel innovation than police's raids against pirates. SECULTA policies are a first step toward this goal. Nevertheless, it is necessary to implement clear policies for benefit sharing. Matt Sakakeeny, a professor at Tulane University, has study this kind of policies for the case of New Orleans. About this Sakakeeny says “Taken together, these case studies and theorizations point to a break between discourse and practice in cultural policy, a rhetorical gap that may be a universal feature of cultural policy. In New Orleans, there is no longer a need to demonstrate the expediency of local culture; no performer, administrator, or researcher would question the resourcefulness of creative labor in the local postindustrial economy. The more pertinent issue is then: For whom is expediency constituted? As culture is increasingly recognized as an asset for a productive economy, cultural policy has changed while economic patterns of marginalization have remained the same. This is the predicament of many black musicians in New Orleans.” (Sakakeeny 2008)

Although determine if the case of Oaxaca corresponds to that of New Orleans is out of the scope of this paper, we observe a clear contrast between a cultural policy that explicitly regards the role of culture as an economic asset and an ample low income population that produce must of these cultural goods and have low access to cultural goods from other parts of the world.

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Annex I. Demand for books and exchange of digital files in Oaxaca, Mexico

Information commons and climate change: The gap between Mexico's National Forestry Information Systems and Community's Information Needs

MANUEL G. CHAVEZ-ANGELES[1], PATRICIA S. SANCHEZ-MEDINA[2]
[1]*Instituto Politécnico Nacional, CIIDIR-Oaxaca and Universidad de la Sierra Sur.*
[2]*Instituto Politécnico Nacional, CIIDIR-Oaxaca.*

This article makes an assessment of the use of Mexico's National Forestry Information System for community forest management. Forest's information is studied as a common-pool resource and information economics is applied to the analysis of carbon trading. The article concludes that government perform as an information broker and matchmaker between firms shopping for carbon assets and community forest enterprises selling them. A more decentralize carbon market, better institutional arrangements and digital capacity building are necessary for the implementation of carbon markets and policies aim to combat deforestation, forest degradation and climate change.

Keywords: common-pool resources, information commons, information economics, climate change, carbon trading, REDD+.

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INTRODUCTION AND THEORETICAL FRAMEWORK

The United Nations Framework Convention on Climate Change (UNFCCC) recently launched its initiative for Reducing Emissions from Deforestation and Forest Degradation, plus conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+). The plus sign, added in 2009, indicates broad agreement that enhancing carbon stocks is to be included in REDD mechanisms (UNFCC, 2009).

REDD+ poses the question of how to build a sound and reliable method for measuring and monitoring the current state of carbon stocks and their changes over time. A reliable framework for measuring, reporting and verification is needed as a component of forest inventory that facilitates the quantification of possible CO2 reductions over time. This inventory is central to the implementation of REDD+ policies, seen as having the potential to generate enough incentives to end deforestation. REDD+ incentives are also seen as a threat to political decentralization and community management. Discussions concerning the implementation of REDD+ tend to consider either project-based or national-based implementation. Most proposals for REDD+ favor the latter approach, as it permits operations on a larger scale. Furthermore, it requires governments to implement national carbon accounting systems, to control leakage and to distribute the benefits of REDD+ to relevant stakeholders. At first glance, therefore, centralization could be considered a requisite for countries to receive REDD+ funds (Toni, 2011).

One of the greatest challenges for local communities today, is the adaptation of their

traditional, local and national institutions to the global demands for conservation and emission reduction. The aim of this research is to analyze Mexico's forest information, specially the National System of Forest Information as a common-pool resource (CPR). In *Governing the Commons*, Elinor Ostrom showed that individuals jointly using a CPR communicate with one another and establish agreed-upon rules and strategies that improve their joint outcomes. By devising their own rules-in-use, individuals using CPRs have overcome the over-development of resources or Hardin's "tragedy of the commons". An important lesson learned from CPR research is that any single, comprehensive set of formal laws intended to govern a large expanse of territory and diverse ecological niches is bound to fail if not matched to local institutions, landscape and biological and cultural environments in which they are located (Ostrom, 2010).

The information commons movement emerged with striking suddenness. It was around 1995 that some scholars started to give a new usage to the concept of commons. Scholars started to study Internet users behaviors and conditions on the web (e.g. congestion, free riding, conflict, overuse, and "pollution") associated with other types of commons. The knowledge as a common thinking is in line with the idea that knowledge derives from information as information derives from data (Hess and Ostrom, 2007).

INFORMATION COMMONS

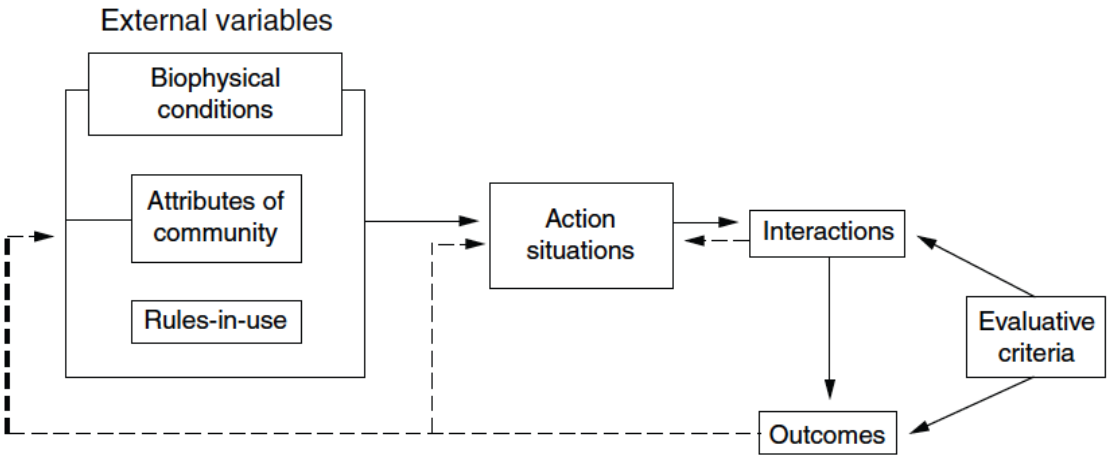
Ostrom (2010) and colleagues at the Workshop in Political Theory and Policy Analysis at Indiana University, have challenged the indiscriminated use of three metaphors commonly applied to CPR situations to predict suboptimal use and/or destruction of resources: (1)

Garret Hardin's tragedy of the commons; (2) Olson's logic of collective action; and (3) the Prisoner's Dilemma game. For doing so they develop the IAD framework. This is a general organizing tool that helps to develop a long term research program not only for research on CPRs but also on other problems where individuals find themselves in repetitive situation affected by a combination of factors derived from a physical world, a cultural world, and a set of rules. Self-organized commons require strong collective-action and self-governing mechanisms, as well as high degree of social capital on the part of the stakeholders. Collective action arises when the efforts of two or more individuals are needed to accomplish an outcome in a voluntary manner (Ostrom, 2010). Self-governance require collective action combined with knowledge and will on the one hand, and supporting and consistent institutional arrangements on the other hand. Social capital refers to the aggregate value of social networks and the inclination that arises from these networks for people to do things for each other (Putnam, 2000).

In the IAD the focal units of analysis are “action arenas”. Where participants and an action situation interact as they are affected by exogenous variables and produce outcomes that in turn affect the participants and the action situation. Action arenas exist in the household; neighborhood or community; local, regional, national, and international councils; in firms and markets; and in the interaction among all of these arenas with others. In the simplest and most aggregated way to representing any of these arenas when they are the focal level of analysis exogenous variables affect the structure of an action arena, generating interactions that produce outcomes. Evaluative criteria are used to judge the performance of the system by examining the patterns of interactions and outcomes. Figure 1 shows how outcomes feedback onto exogenous variables and the situation and may transform both over

time (Ostrom, 2005).

Figure 1. Institutional Analysis and Development Framework



Source: Ostrom, 2010

CPR's research has open an innovative field known as “New Commons”. This new field refers to the exploration of information and knowledge as commons. Potential problems in the use, governance and sustainability of a common can be used by some characteristic human behavior that lead to social dilemmas such as competition for use, free riding, and overharvesting. Typical threats to knowledge commons are commodification or enclosure, pollution and degradation, and nonsustainability. In this regards, there is a continual challenge to identify the similarities between knowledge commons and traditional commons, such as forest and fisheries, all the while exploring the ways knowledge as a resource is fundamentally different from natural resource commons (Hess and Ostrom, 2007).

FOREST INFORMATION AS A COMMON

Biophysical conditions

The SNIF is mainly an electronic database. As an information common, the SNIF is made up of the stored, sent and retrieved data on and via electronic formats. The focus is the content, the provision and retrieval of information, rather than the communication process and the communities created by use. The types of information could be endless: microdata, GIS, research papers, government documents, bibliographic databases, articles, journals, reviews, newspapers, opinions, letters, games, movies, maps, weather reports, digitzed images.

GIS information can be obtained by two means, remote sensing and personal interviews (e.g. household surveys, censuses, clinical information). Remote sensing can provide observations of land cover showing the print of agricultural intensification, urbanization, and road development; observations of vegetation density may be related to the effects of fertilization, irrigation, and other agricultural practices; and observations of deforestation may be linked to the effects of local policies on land use.

Attributes of community

According to the last National Agricultural Census (2007) data, Mexico's has approximately 1,023 municipalities (from a total of 2,440) with common property. These is equivalent to as much as 80% of forests under a common property regime. Mexico's has the largest sector of community-managed common property forests dedicated to commercial production of timber

in the developing world, both in number of communities and in the total number of hectares under commercial production. Besides timber production, most of forest communities use non-timber forest products and live under extreme poverty conditions. Table 1 shows correlations between common property land area (in hectares) and lumber production in these municipalities. Common property land area seems to have low (and even negative in some types of lumber) correlation with lumber production.

Table 1. Municipal correlation between the common property land area (*ha*) and lumber production by type (m^3)

	Common property	Total lumber production	Lumber logs	Lumber for primary sawmills	Lumber for posts	Fire wood	Pulp wood	Charcoal
Common property	1.0000							
Total lumber production	0.0180	1.0000						
Lumber logs	0.0242	0.9252	1.0000					
Lumber for primary sawmills	-0.0038	0.5059	0.1743	1.0000				
Lumber for posts	-0.0031	0.1274	-0.0024	-0.0026	1.0000			
Fire wood	-0.0228	0.0498	0.0021	0.0292	-0.0007	1.0000		
Pulp wood	-0.0055	0.0170	0.0428	0.0081	-0.0051	-0.0004	1.0000	
Charcoal	-0.0043	0.0671	-0.0028	-0.0042	0.0212	0.0886	0.0572	1.0000

Number of observations: 1023 municipalities
Source: Estimated using information of the Agricultural Census 2007 (*Censo Agropecuario y Ejidal 2007*)

Table 2 shows correlations between common property land area and the United

Nations Development Program's Human Development Index (UNDP, 2008). Correlation is low and positive for the composed IDH. Nevertheless when decomposing the index, while correlation of two of the three components (income and education) remain positive, the health component shows negative correlation. Consider that maternal mortality ratio in Mexico is 60 (per 100,000 births). This is a worrisome indicator considering that adjusted maternal mortality ratio for Canada in 2008 was 12 (per 100,000 births). According to the Millennium Development Goals Monitor, Mexico would not improve maternal health and achieve MDG goals unless some changes are made.

Table 2. Municipal correlation between common property land area (ha) and the Human Development Index (HDI by component)

	Common property	Human Development Index	Health Index	Income Index	Education Index
Common property	1.0000				
HDI	0.0375	1.0000			
Health Index	-0.0102	0.8846	1.0000		
Income Index	0.0592	0.8845	0.6708	1.0000	
Education Index	0.0509	0.8990	0.6917	0.6969	1.0000

Number of observations: 1023 municipalities
Source: Estimations made using information from UNDP (2005) and the Agricultural Census 2007 (*Censo Agropecuario y Ejidal 2007*)

Table 3 show correlation between the HDI by component and lumber production by type. We found that several types of lumber have negative correlations for the HDI. Nevertheless this grim numbers, recent studies by David Bray and colleagues suggested that around 10 percent of the communities in Mexico's 10 most important forests have sufficiently adapted their institutions and built their human and social capital to administer all the phases of forest extraction, including sawmill production. Another 25 percent have acquired other

forms of value-added equipment including chainsaws, skidders, and logging trucks. Much of this has been done by communities where virtually no one had more than a primary school education (Bray, 2010).

Tabla 3. Municipal correlation between the Human Development Index (by component) and lumber production by type (m^3)

	Human Development Index	Health Index	Income Index	Education Index
Total lumber	-0.0097	-0.4420	-0.0125	0.0283
Lumber logs	-0.0174	-0.0562	-0.0163	0.0234
Sawmill's lumber	-0.0004	-0.0070	-0.0060	0.0110
Lumber for posts	0.0484	0.0483	0.0313	0.0492
Fire wood	-0.0176	0.0031	-0.0170	-0.0321
Pulp wood	0.0100	-0.0015	0.0133	0.0148
Charcoal	0.0377	0.0256	0.0441	0.0316

Number of observations: 1023 municipalities
Source: Estimations made using information from UNDP (2005) and the Agricultural Census 2007 (*Censo Agropecuario y Ejidal 2007*)

Rules in Use

Despite four new forestry laws between 1986 and 2003, agrarian policy, government forest programs unrelated to forest legislation, and grassroots action have been more important in developing forestry sector than forest laws. Agrarian reform beginning around 1930's established communal governance institutions (in some cases blended with traditional forms of governance) and a common property resource on a nation-wide scale**.** Reforms to agrarian law in 1992 encouraged a transition from state-led to a community-led community forestry

sector. The reform to Article 27 of the Mexican constitution was a form of devolution or decentralization of control over natural resources (Bray, Antinori and Torres-Rojo , 2006).

Mexico's National Forestry Information System (SNIF) was created by the 2003 Sustainable Forestry Development Act (*Ley General de Desarrollo Forestal Sustentable*). The agency in charge of defining the rules and methodology for information gathering and interoperability is the Secretary for the Environment and Natural Resources through the National Forests Commission (CONAFOR in Spanish). According to the Act, the SNIF encompass:

ix. The National Forest and Soil Inventory.
x. Forests Zoning.
xi. National Forest Registrar.
xii. Evaluations of reforestation programs.
xiii. Traditional knowledge and information related to forests.
xiv. International treaties on forests.
xv. Economic information about forestry.
xvi. Information on research and development related with forest.
xvii. Information of NGO related with forestry sector.
xviii. All information important planning and evaluation of forestry policy.

Action Arenas

The focal unit of analysis is the role of information on carbon trading. The economics of information in carbon markets is analyzed through the game theory model shown in Figure 2. Imagine a game where two firms A,B have to decide between having high or low emissions of

CO2.

Figure 2. Carbon trading game

		A	
		low	high
B	low	a_1 a_2	a_1 b_2
	high	b_1 a_2	b_1 b_2

Scenario 1: Firms with low emissions make an investment I_i and receive transfers from the carbon bond market by TR_i, where $i=A,B$. Firms having high emissions pay an environmental tax t_i. $a_i=\Pi_i+TR_i-I_i$ and $b_i=\Pi_i-t_i$ where Π_i is the profit derived from firms $i's$ main commercial activity. In this simple model a firm would produce at low levels of emissions if $TR_i-I_i<t_i$. In this scenario, in order to achieve an equilibrium where at least one of the firms invest in low emissions, transfers would need to be $TR_i>t_i+I_i$. Several fiscal policies involving government transfers TR_i and t_i could be put in place in order to achieve an equilibrium with at least one firm has low emissions.

Scenario 2 (*Chicken*): Now assume the production of low or high emissions imply different technologies and therefore different costs. Also assume, firms having low emissions can sell carbon assets to those with high emissions. $\Pi_{low}=p(q_{low})q_{low}-c_{low}(q_{low})+TR(q_{high})$ if $q_{high}=0\rightarrow TR=0$ and $\Pi_{high}=p(q_{high})q_{high}-c_{high}(q_{high})-t(q_{low})$ symmetrically if $q_{low}=0\rightarrow t=0$ Regarding carbon market transfers, TR and t are functions of the production decisions of the competition: $TR(q_{high})$ and $t(q_{low})$. At equilibrium in the carbon bond market $TR=t$ and

equal to the market prices for carbon bonds. This redefine the payments in our game as shown in Figure 3.

Figure 3. Carbon trading game
(chicken equilibria)

		A	
		low	high
B	low	a_1 a_2	d_1 c_2
	high	c_1 d_2	b_1 b_2

where $a_1 < c_1$, $b_1 < d_1$ and $a_2 < c_2$, $b_2 < d_2$. This payoff parameters satisfy the inequalities that results in a *Chicken* game. *Chicken* has a payoff structure and set of strategies such that individual players do not have a dominant strategy. *Chicken* has multiple equilibria. In this sense, this problem become a signaling problem where each firm wants to deviate its competitor from doing the same thing she is doing. This also imply a matching problem where firms with low emissions are searching for firms with high emissions and vice versa.

Results: For money not for love.

Matching markets are markets with two sides, identifiable independent of market conditions, such that an agent on one side can benefit only by dealing with agents on the other side, and a feasible allocation is a reciprocal, all-or-nothing assignment, or matching, of agents on one side to agents on the other. The logic matching markets have been applied to labor markets, college admissions and 'marriage market'. The sides on those cases are firms and workers with heterogeneous skills; students and colleges; and sets of men and women. Gale and

Shapley (1962) proposed that a matching (of students and colleges, or men and women) could be regarded as stable only if it left no pair of agents on opposite sides of the market who were not matched to each other but would both prefer to be. They showed that a special property of two-sided (as opposed to one or three-sided) markets is that stable matchings always exist (at least when agents' preferences are uncomplicated). The idea is that, if we consider matching processes whose rules are that any two agents on opposite sides of the market can be matched to each other if they both agree, then, unless a matching is stable, there are players who wish to be matched to each other but who are not, even though the rules allow them to arrange such a match. So only stable matchings are likely to arise if the matching process is sufficiently "free" as to allow all potential matchings to be considered.

Carbon markets under REDD+ also face two sides looking for their match. On one set there are industrial firms in developed countries willing to differ their technological transformation by buying carbon assets. On the other set there are forest communities and small forestry firms in developing countries willing to conserve their forest and sell environmental services. In Mexico, CONAFOR works as a matchmaking intermediary between this firms. CONAFOR performs the role a parent, well-wisher or matchmaking intermediary would perform in an arrange marriage in some cultures.

Arranged marriages are predicated on the supposition that because of a variety of reasons such as imperfect and incomplete information and the tendency of young people to seek pleasure, young persons generally cannot be relied upon to find an appropriate spouse for themselves. In western style "love marriages" the individual wishing to get married typically looks for a spouse himself or herself. In contrast, in "arranged marriages" the

individual wishing to get married does not look for a spouse himself or herself. Instead, it is the matchmaking intermediary (e.g. family member, friends, relatives) who look for a spouse. Therefore, decision making processes in western love marriages are different from those used in arranged marriages (Batabyal, 2003).

This has important implications on the design of decision rules. For instance, is possible that if CONAFOR posses the monopoly of matchmaking a line of firms looking for a match will form at both ends. Therefore, firms will only wait for their turn if CONAFOR is fast enough, otherwise would not participate in REDD+. For firms in developed countries they could shop in other carbon markets different to Mexico's. For forest communities there option is to cut and sell the trees that otherwise would be conserve for carbon trading.

In this regards is of utmost importance to make data available and allow forest communities to "dress the bride". Make the proper signaling in order to find a suitable match. The engagement of the communities related to forest conservation must rely on local expertise and knowledge system. Communication between different communities (indigenous and non indigenous) is of great relevance in developing the best practices for the construction of carbon markets.

Evaluation

Ostrom and Hess (2009) identify seven major types of property rights that are most relevant to use in regard to digital commons. These are access, contribution, extraction, removal, management/participation, exclusion, and alienation. This rights are consider useful in rule

setting for an organization's digital repository. Few of them are observed by the SNIF.

- Access refers to the right to enter a defined physical area and enjoy non-substractive benefits. In the SNIF infrastructure is centralize. Only CONAFOR personal can access its servers and infrastructure.
- Contribution is the right to contribute to the content. SNIF is a closed system managed exclusively by CONAFOR.
- Extraction is the right to obtain resource units or products of a resource system. In the case of SNIF any data is available through the Internet o any other public media. There is no clear rules for having access to the SNIF. Normally it requires informal connections and red carpet access.
- Removal is the right to remove one's artifact from the resource. In SNIF No community can make correction o withdrawal its information.
- Management/participation refers to the right to regulate internal use patterns and transform the resource by making improvements. The process of data gathering and quality control is exclusive form CONAFOR.
- Exclusion is the right to determine who will have access, contribution, extraction and removal rights and how those rights may be transferred. The right to exclude users is exclusively from CONAFOR.
- Alienation is the right to sell or lease extraction, management/participation, and exclusion rights. SNIF has no mechanisms for secondary markets.

During the 17th session of the Conference of the Parties to the UNFCC (COP17) and

7th session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP7) held in Durban, South Africa, in 2011 some agreements were reach in terms of defining guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels. Information systems should: (UNFCCC, 2010, 2011)

iv. Be consistent with REDD+ Guidelines.
v. Provide transparent and consistent information that is accessible by all relevant stakeholders and updated on a regular basis.
vi. Be transparent and flexible to allow for improvement over time.
vii. Provide information on how all of the safeguards referred to REDD+ are being addressed and respected.
viii. Be country-driven and implemented at the national level.
ix. Build upon existing systems, as appropriate.

CONAFOR's SNIF may be a "country driven" and "existing system" for Mexico to build upon. Nevertheless so far SNIF is lacking transparency, flexibility, timely updating and provided access to all relevant stakeholders including forest communities.

CONCLUSIONS

REDD+ development initiatives should shift their approaches from top-down interventions to a grassroots participatory perspective where indigenous knowledge plays an important role. Initiatives to reduce the risks associated with the emission of greenhouse gases should

encourage polycentric approaches likely to achieve benefits at multiple scales and for disparate actors. Others are concerned with REDD+ impacts on indigenous peoples and communities, the ability of governments to adequately report emissions reductions or to control possible corruption. After all, REDD+ is more than just funding for developing countries and is likely to evolve into a market-based carbon trading system, an option that involves higher stakes and is far more controversial. Policy makers have also begun to realize just how much REDD+ success will depend on changes in forest governance at multiple levels (Ostrom, 2009).

Toni (2011) considers that REDD+ will change the structure of incentives for subnational policymakers, encouraging them to pursue further decentralization, control deforestation and restore degraded forests in order to keep receiving REDD+ funds. Decentralization referring to the transfer of powers and resources from central to democratically elected subnational governments; this has been commonly called either democratic decentralization or devolution. Reasons given in favor of decentralization include that it: (1) Increases local participation and local democracy; (2) improves efficiency and equity of service delivery; and (3) strengthens local government.

How this type of decentralization will affect municipal governments, however, remains an open question but an open information system seems to be a necessary condition for stopping deforestation and degradation. Community forest management (CFM) is one proven strategy for forest communities to move beyond deforestation or degradation and achieve sustainable management, under certain conditions. Where successful, CFM is often associated with both secure rights to forest resources and the development of multi-scaled

governance institutions (Cronkleton, Bray and Medina, 2011). Although Mexico is a success story in the development of CFM, the current architecture of the SNIF is a bottle-neck that has to be surpassed.

Community based monitoring and certification present an opportunity for the decentralization of SNIF. Nevertheless, important problems of bias and moral hazard should be address. One of the problems that more commonly hinder the efforts to find methods to reduce emissions is inadequate certification. For policies that provide diverse rewards for projects that reduce greenhouse gas emissions, there is a need for skilled personnel to certify that a project does indeed reduce ambient CO2 by some specified amount over a defined time period. An industry of consultants has emerged for filling this task. While many consultants are trained as scientist, the greatly increased need for certification has generated opportunities for at least some contractors lacking appropriate skills to make a living in the new “certification game” (Ostrom, 2009). Community based monitoring faces a similar problem. Few scientific expertise, low technical skills and digital divide are important obstacles for the implementation of carbon markets and fight deforestation and climate change. Is of utmost importance to invest in community capacity building in order to achieve REDD+ goals.

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General Conclusions.

This thesis is a collection of case studies. The main analytical tool used to assess these different situations is game theory. Case studies and game theory although very powerful and insightful, present limitations of external validity. The results of the thesis cannot be easily generalized to other situations and places.

For a long time the dominant form of modeling in social science is based upon the rational-choice paradigm. Game theory, in particular, is typically based upon the assumption of rational choice. An alternative to the assumption of rational choice is some form of adaptive behavior. The adaptation may be at the individual level trough learning, or it may be at the population level trough differential survival and reproduction of the more successful individuals.

Behavioral economics applies models of systematic imperfections in human rationality, to the study and engineering of organizations, markets and policy. These imperfections include limits on rationality, willpower and self-interest and any other behavior resulting from an evolved brain with limited attention. The study of individual differences in rationality, and learning, is also important for understanding whether social interaction and economic aggregation minimizes effects of rationality limits. The intersection between behavioral economics and game theory is called behavioral game theory. One of the central contributions of behavioral game theory is the study of limits on strategic thinking. One type of theory studies how finite automata that implement strategies with limited calculation and memory will behave. Empirically-driven theories posit some distribution of steps of thinking. The other important contribution is precise theories of how monetary payoffs to one player and others map onto the focal player's utility. Behavioral game theory has largely been shaped by experimental observation of educated people playing games in experiments for money. Here, equilibrium predictions do not always fare well compared to other approaches, but equilibrium theory might apply at other levels of analysis, especially low and high levels, such as animal behavior sculpted by evolution (e.g., optimal foraging), and decisions of firms and nation-states which are widely-deliberated and analyzed carefully (Camerer, 2013).

An important problem of the models presented in this thesis is first that they used the assumption of rationality and second that they assume that information and transaction costs

do not exist. To assume that complete information is freely available and that transactions costs can be ignored does not generate theoretical explanations that can be used in a setting where information is scant, potentially biased, and expensive to obtain and where most transactions are costly. Ostrom (2010) identified three problems with the current theories of collective action that reduced their usefulness that shamefully are present in this thesis:

- The need to reflect the incremental self-transforming nature of institutional change.
- The importance of the characteristics of external political regimes in an analysis of how internal variables affect levels of collective provision of rules.
- The need to include information and transaction costs.

The question is how to bridge the gap between current theories of collective action and empirical instances of collective action in CPR situations and develop more relevant theories of institutional change.

Applying evolutionary psychology to economics can help to bridge that gap. Rationality and biases, decisions between selfishness or cooperation, individuality versus heterogeneity are examples of how evolutionary psychology can explain anomalous behavior including violations to rational choice. Evolutionary mechanisms can also explain the curious persistence of altruistic behavior in one-shot anonymous interactions, and the observed heterogeneity of agent types.

Behavioral economics (or the application of evolutionary psychology to economics) has a close relationship with evolutionary economics. As a field, evolutionary economics had been around since Joseph Schumpeter applied evolutionary thinking to economic problems. For Schumpeter the word “evolution” meant no more than “change”. After 1982 when Richard Nelson and Sidney G. Winter published *An Evolutionary Theory of Economic Change*, the field experienced continues grow. Nevertheless, evolutionary thinking may not displace much of economic theory a strong case should be made for the economics of knowledge and technology in the long run and for institutional change. There are serious doubts about the usefulness of neoclassical tools that view long-run technological growth exclusively as another outcome of rational behavior in a well-defined environment (Mokyr, 2000).

In game theory, evolutionary models have been applied with success to the economics of

knowledge and technology in the long run. Mokyr (2000) makes a strong case for games played against nature. Technology is considered to contain an irreducible component of utilizing nature's regularities for human material well-being which is at the heart of it. Mokyr therefore suggest that a possibly useful alternative for the economic history of science and technology is to look at models that we could be characterized as Darwinian. Robert Axelrod (1997), applied evolutionary approaches to coalition formation and standard setting alliances in the IT industry. Axelrod and colleagues use game theory to estimate the choices of nine computer companies to join one of two alliances sponsoring competing UNIX operating system standards in 1988.

This thesis use game theory to analyze cooperation, competition and coordination in the use of knowledge and information commons.

- The thesis concludes that rural municipalities in Mexico face a high degree of dependency on large telecommunications companies in the development of connectivity policies. While demand in municipalities for telecommunication services is widely dispersed; supply of such services is highly concentrated in the hands of a few internet service providers (ISPs). This means that large companies only invest in rural areas if demand is sufficient enough to be profitable which, in turn, represents a coordination problem between municipalities.

- Also the thesis concludes that in the current circumstances government as matchmaking institution in carbon trading mechanism like REDD+ posses the monopoly over the information of firms looking for a match. Therefore, if government is not efficient enough (as it often is) firms would not participate in REDD+. Firms in developed countries could shop in other carbon markets different to Mexico's, while forest communities would take the alternative to cut and sell the trees that otherwise would be conserve for carbon trading. In this regards is of utmost importance to make data available and allow forest communities to self report their results. Communities would have the incentives to make the proper signaling in order to find a suitable match. Engagement of communities related to forest conservation must rely on local expertise and knowledge

system. Communication between different communities (indigenous and non indigenous) is of great relevance in developing the best practices for the construction of carbon markets. REDD+ development initiatives should shift their approaches from top-down interventions to a grassroots participatory perspective where indigenous knowledge plays an important role. Initiatives to reduce the risks associated with the emission of greenhouse gases should encourage polycentric approaches likely to achieve benefits at multiple scales and for disparate actors.

- Using **a** war of attrition game theory model, the thesis studies intellectual property piracy and defense in cultural industries. The higher the cost of blockade/deterrence the lower the number of producers. In cultural industries, the cost of production is not an important variable given that it has been decreasing since the invention of the magnetic tape in the 1950s. In fact, there is no doubt that the current shift in cultural industries and the mushrooming of piracy is due to the plummeting of production costs after the invention of MP3 file format. Independent record labels can also be benefiting from the change in costs structure, mainly by lower production and distribution costs. Yet in the last decade, mass media companies have developed methods of control that undermine the public's traditional rights to use, share, and reproduce information and ideas. These technologies, combined with an oligopolistic structure in the media industry and new laws that increase control over intellectual products, threaten to undermine creativity, privacy and free speech. **I**n Mexico low Internet connectivity hinder the opportunities offer by information commons and network externalities. Piracy then is related with public interests and fairness in access.