The Complementarity between Community and Government in Enforcing Norms and Contracts, and Their Interaction with Religion and Corruption*

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Abstract

We investigate the complementarity between informal communities and formal government enforcement of norms of reciprocation and exchange. We observe that, in a cross-country analysis, GDP is positively correlated with a measure of confidence in reliance on others within a community, and with the interaction of the that measure and a measure of Rule of Law - suggesting that informal community and formal enforcement can be complements. We introduce a model in which people exchange informally within their community as well as externally on a market. We show that informal community and formal enforcement are complements: the news that someone was convicted of cheating on the market leads that person to be ostracized by their community, bolstering incentives. Although transactions within a community can be less directly beneficial than those on a wider market, doing some transactions within a community and others on a formal market lowers overall costs of enforcement and is still welfare-enhancing compared to either extreme for a wide range of costs of formal enforcement. We also show that religion can enhance the complementarity between community and formal enforcement, while corruption undermines it.

Keywords: Community, Government, Contracts, Reputation, Enforcement, Laws, Courts, Trust, Religion, Corruption, Norms

JEL Classification Numbers: C72, C73, D23, D73, H11, K12, O17, P48, P51, Z12

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"The key to successful economic exchanges here is not necessarily an impartial and efficient third-party enforcing agency, but the existence of a level of trust or other self-enforcing institutions within relevant networks of commerce, credit, wage-labor, and other contractual relations that support free market activities. In other words, the state is neither necessary nor sufficient. The simple model in which it is only the state and threat of its justice and police systems that makes people behave cooperatively seems a poor description of any known situation."

Joel Mokyr (2008), page 71

1 Introduction

The quote from Joel Mokyr above makes clear the importance of incentives beyond the fear of punishment by the state in supporting economic exchange. Despite the mountains of evidence that reputations matter, we still know little about how informal social relationships *interact with* formal institutions in the enforcement of norms and contracts. Does the presence of one form of enforcement enhance the effectiveness of the other?

In this paper, we provide both empirical observations and theoretical modeling concerning how informal communities *complement* formal institutions to enforce basic exchanges in a society. We consider the simplest form of production, where people have tasks to complete in order to survive: producing food, shelter, clothing, caring for children, etc. They can either perform all tasks themselves, or informally share and exchange them with other members of their community, or perform some and exchange for others via markets in which contracts are enforced by a government. We consider mixtures in which some tasks are informally exchanged within a community and others are conducted via a market.

We treat government and its legal system as providing a "formal enforcement" of exchanges that occur through markets; and the pressures (e.g., threats of ostracism or other punishments) that come from communities as providing "informal enforcement" of exchanges that occur outside of the market. We also explore the impact of the supernatural beliefs that accompany some religions (e.g., any anticipated punishments and/or guilt that result from committing a sin) in terms of providing enforcement in both regimes: providing incentives to be honest in both market and non-market interactions. We explore the following questions. Under what circumstances are various forms of enforcement complements in providing effective incentives? Why and when do we see co-existence of various forms of enforcement? How does corruption affect the functioning of both the formal enforcement as well as informal community enforcement, and the complementarity between the two?

We begin the paper with some background observations of cross-country correlations of overall production (log GDP) with the strength of community, religion, and the formal enforcement of laws. Although such correlations cannot be taken to be causal, they provide a backdrop and some basic guidance of facts with which a reasonable model should be consistent. As one should expect, the basic correlations are consistent with findings in some of the previous literature: GDP is negatively correlated with the amount of religious activity in a country,

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positively correlated the formal enforcement of laws, and positively correlated with a measure of how much one believes they can count on other members of one's community for help.[1] The more novel relationship that we document is an interaction effect: GDP is positively correlated with the product of community and rule of law. Thus, GDP is significantly more positively correlated with rule of law the greater the perceived strength of community. In other words, community and formal legal enforcement are complements in predicting productive outcomes. This interaction is then also amplified by beliefs in punishment in the afterlife: the interaction gets stronger the larger the percentage of people who "believe in hell".

Our main contribution is a new theory. We introduce a simple model that allows us to investigate the relationship between community and formal legal enforcement. In the model, the various tasks that a household has to undertake can be done by themselves, by others in their community, or by others in the general economy (through trade in markets). The benefit of exchanging with others in the community or general economy comes from specialization: an individual specializes in tasks in which s/he has a comparative advantage and then there is trade. The driving assumption is that the larger the pool over which there is exchange, the greater the benefits from trade and lower the overall costs of providing tasks. That is, production by autarky is more time-consuming than production within the community, which is more time-consuming than production by the most efficient means in the whole economy.

An equilibrium in this setting is then a specification of which tasks are exchanged in the community and which are exchanged in the overall economy. Community enforcement is informal and comes from the threat of ostracizing someone who has not delivered on the tasks that they were supposed to perform for others in the community. The future loss of interaction with others in the community thus forces the individual into autarky on those tasks that are normally done within the community. Enforcement of exchanges in the overall economy is done by a government. People who do not perform are caught with some probability, which depends on the amount spent on the legal system. People who break formal contracts face legal costs and other potential formal punishments (e.g., fines for damages, jail time for fraud, etc.), and their names are made public.

On a basic level, in our model there is substitution between exchanging tasks within one's own community and exchanging them more widely on the open market: tasks that are done in the general economy are no longer done within the community, and vice versa. However, we show that there is also an important *incentive complementarity* between the two forms of exchange when some tasks are done on one and other tasks are done on the other. When people are caught for breaking contracts on the formal market and their names becomes public, people within their communities may notice and can also choose to ostracize them. For instance, someone caught embezzling and cheating on a contract can lose his or her reputation and risks being ostracized by his neighbors. As a result, the punishment from getting caught

[1]Scheve and Stasavage (2006) finds evidence for religion as substitute for state in terms of providing social insurance. Campante and Yanagizawa-Drott (2015) estimates a negative effect of the strictness of a religious practice (Ramadan) on economic growth. For more general background on the economics of religion, see Iannaccone (1998); McCleary and Barro (2006); Iyer (2016) and the papers cited therein.

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by the police is more than the fine itself, and also includes the loss of the (future) value of community interaction. Government enforcement becomes more effective and less costly as the use of community increases. Thus, even as the market substitutes for community in terms of performance of tasks, their use together makes the market more effective and cheaper to operate - so they are substitutes in terms of *task* provision and at the same time complements in terms of *incentive* provision.

Instances of making criminals known to their communities have been prevalent throughout history and are still pervasive today, even in well-developed societies. During the inquisition in Spain and Portugal, the auto-da-fé was a public parading and shaming of accused people (fewer than five percent were executed, e.g., see Henningsen (1993)). In ancient China, among "the five punishments", mo, also known as qing, was the punishment where the offender would be tattooed on the face or forehead with indelible ink. The quote from Mokyr (2008) above refers to the importance of sustaining economic exchanges via reputations. As Mokyr states (pages 79-80): "In Britain during the Industrial Revolution, the social norms of what was perceived to be a gentlemanly culture with an emphasis on honesty and meeting one's obligations, supported cooperative equilibria that allowed commercial and credit transactions to be consummated and partnerships to survive without overly concern about possible defections and other forms of opportunistic behavior. Gentlemen (or those who aspired to become gentlemen) moved in similar circles and faced one another in a variety of linked contexts. [...] The prevalence of a social convention that defined "gentlemanly" or "polite" behavior and penalized serious deviations from it through irreparable damage to one's reputation, supplemented formal (legal) relations with a moral code that enabled an effective mode of transacting without relying on the State except in extremis." In modern settings, there are public databases on malpractice suits in medicine and law, public listings of court cases as well as lists of ex-convicts for various crimes, required registration of sex-offenders, and publication of police logs of crimes by local newspapers and web sites.[2] There are also many web sites that provide opportunities for people to report on transactions - for instance, rating providers of various goods and services.

Although only some instances of publicizing crimes and court cases are deliberately for public shaming, while others may be for government transparency, public safety (e.g., in the registration of sex offenders or malpractice suits) or other reasons, they still have the same consequence of making someone's transgressions known to their community. This not only leads to difficulties in future employment (e.g., see the discussion and references in Ahmed and Lång (2017)), but also leads to other more direct ostracism by members of a community (e.g., Winnick and Bodkin (2008)). These social sanctions have been found to have a significant deterrent effect on crime (e.g., Buonanno, Pasini, and Vanin (2012)). Thus, the complementarity that we analyze here is not simply a theoretical construct: the difficulties faced by ex-convicts or people accused of malpractice, etc., are substantial and costly to them. In some cases, the loss of reputation and ostracism by an offender's community can be as costly or even more costly

[2]Our model will concentrate on economic transactions rather than violent crime and other norms, but it should be clear that the value of community reputation as a complement to incentives in other arenas applies more generally than to the economic transactions that we formally analyze.

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than any fine or nominal punishment, and have been found to have a significant deterrent effect on first-offenders (and more on repeat offenders below).

With this basic model in hand, we explore how the overall welfare of the society depends on the combination of community and government enforcement. Although exchange within a small community is more costly in terms of having less efficient production; when combined with a formal market and legal enforcement provides greater incentives at a lower cost of enforcement than a system that involves only government or only community. As we show in detail, a split of doing some tasks within community and others on an open market can be optimal for a (wide) range of costs of formal enforcement. Although some societies may not have much discretion in which tasks are done within a community simply because markets are not yet well developed, our analysis still sheds light on how that affects the welfare. It also shows that even in some well-developed societies, having some community-provided tasks can still be welfare enhancing.

The model provides several novel comparative statics - most notably in terms of the cost of government enforcement. When governments are very effective and legal enforcement is cheap, then no community exchange is needed and doing everything on the market is the efficient equilibrium. However, once government enforcement becomes moderately expensive, then efficiency requires reliance on a combination of government together with community interaction and enforcement. *There is an important discontinuity here*: the amount of community that must appear in any equilibrium is either zero or bounded away from zero. Having a small amount of community does not satisfy its internal incentive constraint, and so the number of exchanges within the community must pass a threshold before community reciprocation can be sustained. Communities need some critical level of interaction in order to function, given their self-enforcement, and so they either exist above that critical level or not at all. As government enforcement becomes more expensive, community exchange is increasingly used, until a second point of discontinuity: eventually one shifts completely away from exchange on a market and entirely to doing tasks within one's own limited community. This comes from the fact that formal enforcement must happen at some minimum level in order to make the market function, and thus there is minimal effective scale of markets as well.

It is important to emphasize that both of these discontinuities come in a completely smooth system without any fixed costs. The minimal scale at which both community and the market must operate come from incentive constraints that require a minimal level of perceived punishment - either in terms reciprocation or by the size of the government.

This sheds important light on the relationship between formal and informal institutions: community and markets both require a minimum scale, and once one pushes either above a certain level, they must jump upwards and displace the other altogether. There are strong complementarities in some range, but eventually there are also sharp substitution effects.

With the analysis of the base model in place, we then provide three further investigations.

First, we examine the supernatural punishment and moral reasoning inherent in many religions. We model religion as operating at two levels. One is that it is like a community within which people know and trust each other via repeated interactions and exchanges. In this regard it is simply a special case of the communities discussed above. The second, "supernatural pun-

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ishment", is that people believe that there are gods who will punish them if they fail to obey certain norms of behavior. This might also or instead involve an indoctrinated moral code and "guilt" so that a person feels badly when undertaking certain behaviors. Such beliefs can be useful in enforcing behavior, but can also be costly to instill in a population (Levy and Razin, 2012; Campante and Yanagizawa-Drott, 2015; Power, 2017; Schaumberg and Flynn, 2017).

The supernatural punishment or guilt comes regardless of whether one is punished by a community or law enforcement, and thus it is not complementary to the other forms of enforcement. Effectively, it substitutes for them, as the greater the belief in supernatural punishment for cheating on a contract, the less other enforcement is needed. However, since it changes the incentive constraints – it alters the complementarity between community and formal enforcement. In particular, as we show, for low costs of formal enforcement it removes the complementarity, but then for a medium range of costs it enhances and extends the complementarity between the other two since it reduces the scales needed to have either the community or the market function.

In addition, we show that there are two conditions for supernatural punishment to make large improvements on welfare: the cost of formal enforcement is in an intermediate range, and the religious effect amplifies the complementarity; and the supernatural belief applies to all transactions, even with strangers on the market. These conditions echo a pattern documented in Norenzayan et al. (2016); Roes and Raymond (2003); Henrich et al. (2010), that beliefs in "Gods" and other moralizing exist in relatively larger societies; whereas small societies/religious groups can govern themselves with other forces and without any supernatural beliefs or other moralizing (just as "community" in our context). As maintaining religious beliefs in a society can be costly, it is important to have both scale and scope of the incentive effects.

Our second further investigation is to explore how corruption affects equilibrium and welfare. Most obviously, corruption increases the cost of government enforcement: one has to pay more to get the same effective enforcement. The other effect is that there are 'false-accusations' so that people are "caught" and fined even if they did not really breach a contract commit a crime. This more subtle effect changes the interaction between formal and community enforcement by lowering the informativeness of someone being found guilty by the government as evidence of a crime or breach of contract. This randomness decreases the value of a reputation and the future value of being in a community since one faces a chance of being ostracized even when behaving well. More generally, if one has a high expectation of being (falsely) accused by the government and losing one's reputation, then there is lower probability of future interaction within community and so the community loses value. According to Pettit and Western (2004), nearly sixty percent of African American males who did not earn a high school degree spent time in prison by the time they were 35. (See also Loury et al. (2008).) Not only does the time in prison lower interaction with their original communities, but also the subsequent ostracism and difficulties faced by ex convicts leads to diminished expectations of future community interactions from an early age. These decreased incentives outside the community and within, and disrupts their complementarity. As we show, together with the cost of ostracism, this lowers the complementarity between community and policing and reduces the range in which

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they are used together.

Eventually, if corruption becomes so high that the community loses trust in law enforcement, then it no longer ostracizes its members who are "caught", which then completely destroys the complementarity between government and community. This means that small changes in corruption can lead to discontinuous drops in the effectiveness of policing and welfare. There are numerous historical and current examples in which loss of faith in policing has led to changes in ostracism of ex-convicts by communities - undermining the complementarity between community and formal enforcment, and rendering formal enforcement less effective.

Finally, our third further investigation involves the growth of formal government. If investments are needed to grow a government and legal enforcement, then we then the effectiveness of a community can enhance the progression to grow a government, while potential corruption can undermine it.

Related Literature Ours is not the first study of the co-existence of formal and informal exchange. For example, there are models in which people can choose between formal markets and informal exchange, such as Kranton (1996) and Gagnon and Goyal (2017), as well as discussion of how people's membership in clubs has changed over time and how that correlates with lower trust (e.g. Putnam (2000)). There is even evidence that the introduction of a formal credit market can erode social relationships (Banerjee, Chandrasekhar, Duflo, and Jackson, 2018; Heß, Jaimovich, and Schündeln, 2018). There are studies of how community enforcement can substitute for other forms of enforcement or exist in different balances across cultures (Greif and Tabellini, 2010, 2017),[3] and how willing a community is to participate in legal enforcement (whistle-blowing, reporting breach of contract,...) enables enforcement (Acemoglu and Jackson, 2017). There is also ample evidence that market and/or state can function well on a large scale in the right circumstances (Acemoglu, Johnson, and Robinson, 2001; Persson, 2002; Tabellini, 2010; Besley and Persson, 2011; Acemoglu and Robinson, 2012; Bednar and Page, 2017; Acemoglu and Wolitzky, 2018), and those institutions can be either enhanced or hampered by culture (beliefs and values) (Bisin and Verdier, 2017; Alesina and Giuliano, 2015).

Perhaps the most closely related of the previous literature, are studies of how the size of a community matters in terms of how effective it is at enforcing behavior, and when it is better to rely instead on a government for legal enforcement. In particular, Dixit (2003a,b) shows how community enforcement can do worse than an effective government, and how the size of the community matters - with medium sized communities doing worse than both smaller communities or larger government-based communities.

The key way in which our work differs from the previous literature is that we are focused on the *complementarity* between community and formal government, and the importance of using them together, rather than the circumstances under which either or both thrive. We do not examine the size of the community in terms of how many people it encompasses, but instead on

[3]For more general background on formal versus informal arrangements, see North (1990, 1991); Aoki and Hayami (2001), for instance.

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the relative fraction of exchanges that it handles. We examine the interaction between informal and formal enforcement, rather than the substitution of one for the other.

Our modeling builds upon a vast literature that shows that communities can be effective, locally, in overcoming obstacles to collective action and cooperation, and facilitating the provision of local public goods and sharing of resources and the settling of disputes (Ostrom, 1990; Bernstein, 1992; Tsai, 2007; Ellickson, 2009; Xu and Yao, 2015). This is bolstered by a set of models and theories of community enforcement (Ardener, 1964; Coleman, 1988; Raub and Weesie, 1990; Besley, Coate, and Loury, 1993; Fearon and Laitin, 1996; Anderson, Baland, and Moene, 2009; Lippert and Spagnolo, 2011; Kandori, 1992; Mihm, Toth, and Lang, 2009; Jackson, Rodriguez-Barraquer, and Tan, 2012; Ali and Miller, 2016), reputation Spagnolo (1999); Mailath and Samuelson (2006), and even of religious enforcement (Levy and Razin, 2012). We put such a model of community enforcement to work in conjunction with formal legal enforcement.

Other authors have made the point that contracts are necessarily incomplete, and so some things have to be handled outside of formal contracting: thus there are situations in which both formal and informal enforcement are needed. This is a major foundation for theory of the firm that fostered a huge literature (e.g., see (Holmstrom and Tirole, 1989; Hart, 1995; Shleifer and Vishny, 1997; Holmström and Roberts, 1998; Dixit, 2011) for surveys). This can lead to complementarities as informal relationships can reduce uncertainty about what will happen and thus enable formal contracts that might not work otherwise; and vice versa some formal enforcement can reduce the incentives to cheat on informal arrangements (e.g., MacLeod and Malcomson (1989); Bohnet, Frey, and Huck (2001); Poppo and Zenger (2002); Lazzarini, Miller, and Zenger (2004); Cook, Hardin, and Levi (2005)). Also building on asymmetric information, but on selection rather than moral hazard, Bodoh-Creed (2017) shows that as public institutions attract more untrustworthy people, that can leave a more trustworthy pool of people for the private-order institutions. These analyses are all completely different from our analysis. Instead of building on any uncertainty, our approach is built directly on complementarities in enforcement in one type of interaction due to consequences in another. Thus, our analysis is complementary to the previous literature on uncertainty and provides a new reasoning behind why we should expect both to be in use.[4]

Our extension regarding supernatural punishment, guilt, moral codes, and religion, relates to a literature on religious beliefs. Empirical studies show that supernatural beliefs facilitate cooperation in human groups (Atkinson and Bourrat (2011)) and serve as a costly signaling device that helps to strengthen communities (Power (2017)), that church attendance reduces crime (Moreno (2018)), and can be positively correlated with economic growth (Barro and McCleary

[4]Both reasonings are largely consistent with the data. Clearly, contracts tend to be incomplete and there is much reason to believe that part of that incompleteness is dealt with by informal enforcement and interaction (e.g., see Uzzi (1996)). In terms of our theory, there are also many instances in which formal finding of guilt by a court or tribunal damages a person's reputation and leads to consequences in other interactions, including those mentioned above and below. So ours is not a "competing" theory to that of incomplete contracting: both reasonings apply to different extents depending on the context.

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(2003)) and growth-promoting economics attitudes(Guiso, Sapienza, and Zingales (2003)). Religious beliefs have also been found to be negatively correlated with innovation (Bénabou, Ticchi, and Vindigni (2015)).Our analysis of religion is highly stylized, but still provides new insights into how religion can enhance other forms enforcement and their complementarity in some circumstances and not others.

2 Empirical Background

Before introducing our model, we present a few observations of correlations from cross-sectional data. Although these are clearly simply high-level correlations, they are still useful in providing some guidance as to the covariation that exists in the formal and informal institutions across countries, and in giving a sense of what tendencies a model should be able to explain.

2.1 Description of the Data

There are 106 countries included in our data, and our data focuses on 2016. We examine how the log of GDP (per capita) of a country correlates with a few variables that relate to formal and informal enforcement of transactions.

The measure of formal enforcement of contracts that we use is an index called "rule of law" that is constructed by the World Bank as part of their World Governance Indicators. As they state, "Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." The variable is compiled from a long list of variables that measure enforcement and perceptions of enforcement and compliance.[5]

Informal community interaction and enforcement is captured via a variable from the Gallup World Poll (2016). The variable is "count on to help". This is the fraction of people in a country who answered "yes" when asked "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?" We use this variable as a proxy for whether community enforcement is present and people feel that a favor would be granted if needed.

Another variable that we track from the same poll is "religion". It is the fraction of people in that country who answered "yes" when asked "Is religion an important part of your daily life?" This variable captures two things. One is religion is often a measure of informal community in many societies. Secondly, in some cases it also measures beliefs in supernatural rewards and punishments for good or bad behavior.

Table 1 provides descriptive statistics for the key variables of interest, and Table 2 provides their direct correlations with each other.

[5]For more details, see www.govindicators.org.

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Table 1: Descriptive Statics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
ln GDP per capita	106	8.163	1.347	5.705	7.025	8.237	9.074	10.962
Rule of Law	106	−0.272	0.886	−2.371	−0.798	−0.391	0.059	1.927
Count on to Help	106	0.783	0.124	0.290	0.720	0.805	0.880	0.950
Religion	106	0.762	0.235	0.190	0.612	0.870	0.950	0.990

Notes: Data reported in the table are from 2016. The natural log of GDP per capita data are from World Bank. "Rule of Law" is from Worldwide Governance Indicators by the World Bank, and it is a continuous variable that mainly captures perceptions of the extent to which people have confidence in and abide by the rules of society. The variables "Count on to Help" and "Religion" are from Gallup World Poll 2016, which are the fraction of people in a country who answered "yes" when asked "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?" and "Is religion an important part of your daily life?", respectively.

For easy interpretation of the variables other than log of GDP per capita, the other variables are normalized by subtracting their means and dividing by their standard deviations.

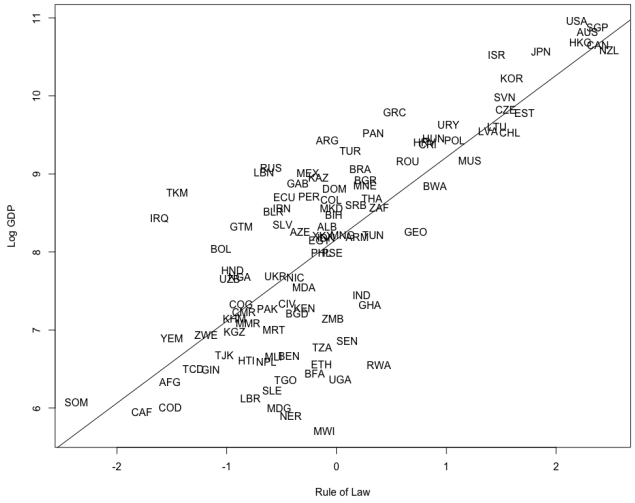
Table 2: Correlation Matrix

	ln GDP per capita	Rule of Law	Count on to Help	Religion
ln GDP per capita	1	0.780	0.631	-0.679
Rule of Law	0.780	1	0.451	-0.584
Count on to Help	0.631	0.451	1	-0.543
Religion	-0.679	-0.584	-0.543	1

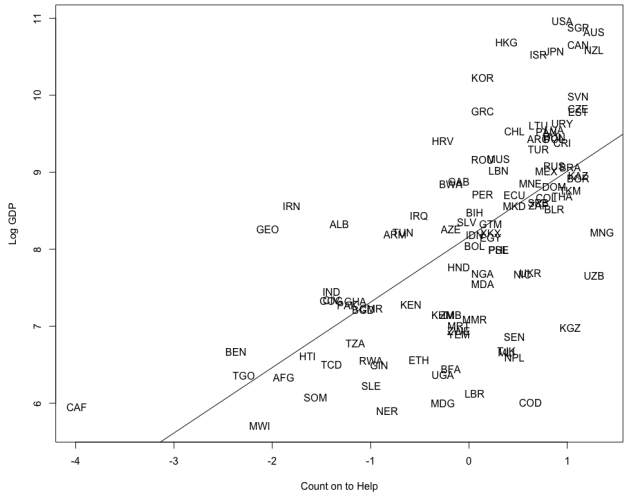
Notes: Data are from World Bank and Gallup World Poll 2016. Variables are defined in Table 1. The pairwise correlation coefficients are reported in the Table.

Figures 1a-1c show the raw relationships between log of GDP per capita and Rule of Law, Count on to Help, and Religion, respectively.

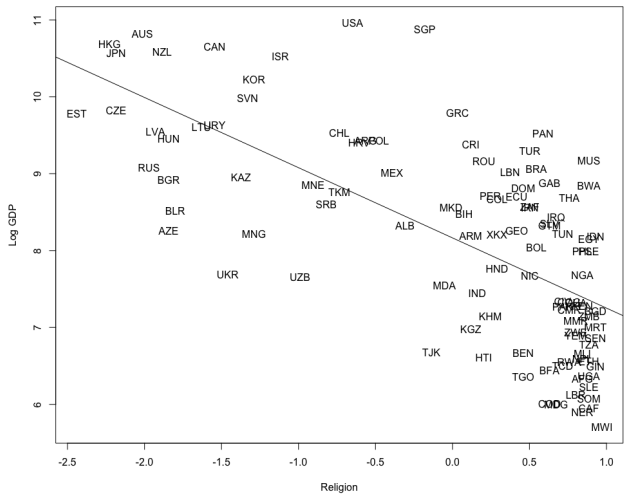
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(a) Log of GDP per capita plotted against Rule of Law.



(b) Log of GDP per capita plotted against Count on to Help.



(c) Log of GDP per capita plotted against Religion.

Figure 1: Data are from World Bank and Gallup World Poll 2016. The y-axis is the natural logarithm of GDP (per capita). The x-axis are the Z-scores of "Rule of Law" and "Count on to Help", and "Religion", respectively, which are defined in Table 1.

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2.2 The Relationship Between Production, Community, Rule of Law, and Religion

We first examine how GDP (logged, per capita) varies with 'Rule of Law' and 'Count on to Help', as reported in Table 3.

First, in all specifications, separately and together, 'Rule of Law' and 'Count on to Help' are both significantly, and positively related to log of GDP per capita. Moreover, the magnitudes of the relationships are strong.

Most importantly, when combined, 'Rule of Law' and 'Count on to Help' have a positive interaction term – suggesting a complementarity: the effect of enforcement is higher when there is more community. Thus at least one measure of community acts as a complement to formal government enforcement in predicting output.

Table 3: Log GDP regressed on Rule of Law and Count on to Help

	Dependent variable:		
	ln GDP per capita		
	(1)	(2)	(3)
Rule of Law	1.050***		0.770***
	(0.083)		(0.086)
Count on to Help		0.850***	0.544***
		(0.102)	(0.087)
Rule of Law × Count on To Help			0.146**
			(0.071)
Constant	8.163***	8.163***	8.098***
	(0.082)	(0.102)	(0.077)
Observations	106	106	106
R^2	0.608	0.398	0.718

Notes: Data are from World Bank and Gallup World Poll 2016. The dependent variable in each column is natural log of GDP per capita. The independent variables are the Z-scores of variables "Rule of Law" and "Count on to Help", which are defined in Table 1. Robust standard errors are reported in parentheses.
*p<0.1; **p<0.05; ***p<0.01

Next, we briefly discuss the relationship between religion and log of GDP per capita, which is captured in Table 4.

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Table 4: Log GDP regressed on Religion, Rule of Law and Count on to Help

	Dependent variable:			
	ln GDP per capita			
	(1)	(2)	(3)	(4)
Rule of Law		0.827***	0.669***	0.758***
		(0.096)	(0.088)	(0.113)
Count on to Help			0.290***	0.330***
			(0.099)	(0.104)
Religion	−0.914***	−0.499***	−0.582***	−0.557***
	(0.097)	(0.096)	(0.123)	(0.124)
Rule of Law × Religion		0.113	0.126	0.021
		(0.075)	(0.083)	(0.119)
Rule of Law × Count on to Help			0.304***	0.222*
			(0.090)	(0.112)
Count on to Help × Religion			0.450***	0.414***
			(0.136)	(0.138)
Rule of Law × Count on to Help × Religion				0.131
				(0.106)
Constant	8.163***	8.228***	8.342***	8.323***
	(0.097)	(0.086)	(0.092)	(0.093)
Observations	106	106	106	106
R^2	0.460	0.691	0.772	0.775

Notes: Data are from World Bank and Gallup World Poll 2016. The dependent variable in each column is natural log of GDP per capita. The independent variables are the Z-scores of variables "Rule of Law", "Count on to Help" and "Religion", which are defined in Table 1. Robust standard errors are reported in parentheses.
*p<0.1; **p<0.05; ***p<0.01

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'Religion' is negatively related with GDP per capita in its direct effect. There is a positive interaction between 'Religion' and 'Count on to Help'. It has positive but insignificant interactions with 'Rule of Law' and the combination of 'Rule of Law' and 'Count on to Help'.

One limitation of the above measure of "religion" is that it is very broad, while our analysis builds on one specific aspect of religions (see Section 5): that they invoke supernatural gods who punish bad behaviors.

To get a direct measure of that aspect of religion, we adopt an alternative variable "Belief in Hell", from World Values Survey (WVS). The variable is the fraction of people in that country who answered "yes" when asked "Do you believe in hell?" [6]

Results are presented in Table 5. As shown in column (4), 'Rule of Law', 'Count on to Help' and 'Belief in Hell', when all combined together, have a positive (and significant and substantial) interaction term. This pattern is consistent with a theoretical result we will present in Section 5: an increase in religious (supernatural) belief *enhances the complementarity* between community and the government.

[6]We use data from WVS waves 3, 4 and 6 which are the three most recent waves that include a corresponding question. We use three waves instead of one to obtain a larger sample size (57 observations in merged our data, compared to less than 40 if only wave 6 were used). The most recent available wave is used when data from more than one wave is available for the same country. To be more specific, the corresponding variables in survey are: V187 "Do you believe in hell" in Wave 3 (1995-1999), V194 "Believe in hell" in Wave 4 (2000-2004) and V149 "Believe in: hell" in Wave 6 (2010-2014). No relevant question was asked in Wave 5.

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Table 5: Log GDP regressed on Belief in Hell, Rule of Law and Count on to Help

	Dependent variable:			
	lngdp			
	(1)	(2)	(3)	(4)
Rule of Law		0.878***	0.724***	0.780***
		(0.114)	(0.115)	(0.114)
Belief in Hell	−0.465***	−0.029	0.045	−0.067
	(0.141)	(0.114)	(0.101)	(0.109)
Count on to Help			0.447***	0.482***
			(0.099)	(0.097)
Rule of Law × Belief in Hell		−0.077	0.038	−0.094
		(0.115)	(0.117)	(0.127)
Count on to Help × Belief in Hell			−0.101	0.013
			(0.103)	(0.111)
Rule of Law × Count on to Help			0.090	0.067
			(0.124)	(0.119)
Rule of Law × Count on to Help × Belief in Hell				0.269**
				(0.120)
Constant	8.708***	8.670***	8.662***	8.656***
	(0.140)	(0.112)	(0.100)	(0.096)
Observations	57	57	57	57
R^2	0.165	0.615	0.728	0.753

Notes: Data are from World Bank (2016), Gallup World Poll (2016), and World Values Survey (Waves 3, 4 and 6). The dependent variable in each column is natural log of GDP per capita. The independent variables are the Z-scores of variables "Rule of Law", "Count on to Help" and "Belief in Hell". The former two variables are defined in Table 1, and "Belief in Hell" is the fraction of people in that country who answered "yes" when asked "Do you believe in hell?" There are fewer observations than in other tables due to missing values in the variable "Believe in Hell". Robust standard errors are reported in parentheses.
*p<0.1; **p<0.05; ***p<0.01

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3 A Model of Community and Government Enforcement

We now turn to our main results: a model and investigation of the interaction of formal and informal enforcement of behavior. As we will see below, community and government enforcement are complements for a wide range of parameter values, and religion will be a complement to formal and informal enforcement for some parameter values, and other times will not interact. Also, (costly) religion will be absent in societies with the most efficient governments and only present in societies that involve some combination of formal and community enforcement - and so have a negative correlation with overall productivity. So the results below are consistent with the observed correlations above.

We begin with a description of the base model.

3.1 Tasks and Time

A set of agents is divided into a set of communities. As will become clear, the specification of who is in what community is not vital to the model, but to fix thoughts think of a finite set of equal sized communities.

Generally we think of the number of agents per community to be relatively small and the number of agents overall to be large, so that agents can easily know and keep track of everyone within their community, but do not track or recognize people outside of their community. We do not examine issues regarding the size of the population in a community as those have been explored elsewhere (e.g., Dixit (2003a,b)), and just presume that communities are small enough so that people are quickly aware of any deviations from social norms within their community. It could be interesting to endogenous the size of a community and relate it to various parameters in the model, but that is beyond the scope of the present paper.

Time proceeds in discrete periods $t \in \{1, 2, \ldots\}$. Agents discount time according to a common discount factor $\delta \in (0, 1)$.

Every agent has to complete a task in each period t – cooking, doing laundry, taking care of kids, fixing their house, getting medical help, producing some good, moving, getting advice, borrowing money, etc. – and has a capacity to do one task during the period.

In any given period, an agent can either complete their own task, some other agent's task, or consume an outside option (leisure or some exogenous wage). The opportunity cost of effort (leisure, self-employment, outside wage, etc.) is normalized to be 1 per unit of time.

The cost if the agent's task is completed by the agent directly, by someone in the same community, or by a outsider on a market, is t_s, t_c, and t_m, respectively. We let

$$t_s > t_c > t_m > 0.$$

This ordering represents the gains from trade in a simple stylized way. Efficiency (ignoring incentives and enforcement costs) requires that all the tasks be exchanged on the market in the full society, as the widest scope and scale allow for the greatest matching of tasks to

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specializations and the greatest cost advantages. It is also better to have a task done by other community members than a person him or herself, if we restrict attention to just a community.

Within a community of a given fixed size, the savings from someone else in the community doing the task is $t_c < t_s$. Thus, agents can specialize activities within a community and trade tasks. More generally, there are larger economies of scale and scope in doing tasks when we expand the possibility of trading tasks throughout the full society, as well as gains from specialization and comparative advantage. This results in the lowest cost when tasks are exchanged across the full society, and so $t_m < t_c$.

3.1.1 Remarks on the Allocation of Tasks

Of course, there may be some tasks where the given person him or herself is the best qualified; so think of the tasks that we model as the marginal tasks that agents must complete and someone else could do at a lower cost, and in which the best fit might be on the open market. Even then, there are some tasks, such as building a house, that are done on the open market in richer countries/locations and within a community in poorer locations.

What determines which tasks are done where is beyond the scope of this paper and not really essential to the insights developed here. Here we explore the complementarity and evaluate how welfare depends on the split, but we are agnostic as to what determines that split. More generally, one could build a theory that takes into account comparative advantage of tasks and heterogeneity in costs to decide which ones would be done in on the market versus informally. We are mainly interested in the impact of relative fraction done on one versus the other, and so do not theorize as to which ones are done where.

Nonetheless, it is important that there is some convention for which tasks are marketed and which ones are done informally within the community. The convention that there are some types of tasks that are only done within a community helps in ostracizing an agent, as an ostracized agent cannot substitute for the community tasks by instead going to the market. For instance, that agent might lose advice, help in emergencies, and so forth, which are all community-based tasks. More generally, one could also lose social interaction, sources of news, contacts, and other support which are also valuable. How big an impact this has will depend on the relative split of tasks. For instance, in a poor country where one relies on neighbors to help watch children, to lend money and food, etc., the impact of ostracism will be more drastic than in a country where those things can all be done on a market.

3.2 Equilibrium and Incentive Constraints

For tasks done inside the community, things work by reciprocation and there is no formal enforcement. You may help a colleague by teaching their class, or watch a neighbor's pets while they are away, or watch their kids, etc., and the incentives are based on future reciprocation. If one fails to perform a task, the community can punish the agent by ostracizing the person (i.e., no longer trusting and exchanging with the person). This is a key aspect of community:

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it is small enough so that people can track who has not behaved well in the past and thus can collectively punish that person.

For tasks done outside of the community, things work by legal enforcement and "fines" (which encompass any sort legal costs, damages, loss of license, monetary fines, jail time, etc., depending on the circumstances). You may contract with someone to rent an apartment, provide credit, repair your car, manage your investments, etc.

The amount of legal enforcement also includes things like the enforcement of property rights and contracts by courts. For instance, if one sues a person or company for breach of contract will that suit be heard in a reasonable time, or are there huge backlogs of pending cases. How easy is it to evict someone? Can a landlord falsely evict someone and get away with it? How easy is it to fire a worker who fails to do their job? Can a manager be punished for harassing workers? The answers to these questions differ dramatically around the world and even within different jurisdictions in the same country.

We distill this into a single parameter ϕ that we refer to as a probability of being "caught" by the government, but it should be interpreted as embodying the full justice system including the delineation of property rights and rules, the monitoring and reporting of behavior, the ease of bringing lawsuits, and the judicial enforcement of rules and property rights.

Most importantly for the complementarity, if someone is caught and incurs any fines or legal costs, loss of license, etc., for cheating for not delivering on a task they are exchanging on the market, then one's own community may learn about this and then ostracize the agent. For instance, if an agent is caught stealing money that he or she is managing, then that arrest may heard about by the rest of his or her community, who may then react by no longer trusting or interacting with the agent.

We do not explicitly model the barter or pricing of tasks on the market, which cancel out given the symmetry of the model. We instead directly model the incentives to deliver on an agent's side of performing a task.

It is easy to see that to understand the efficient frontier of equilibria all tasks are shared/traded - or else there is simply autarky. Completing just some fraction of tasks by one's self will never be part of an efficient equilibrium, since doing more things one's self just makes the incentives constraints harder to satisfy since the value of future interaction is lower, which decreases incentives to do others' tasks when asked. Thus, to characterize efficient equilibria, we examine incentive constraints when all tasks are exchanged either within community or outside, and none are done by the person him or herself.

To define equilibrium, we start with the incentive constraints that must be satisfied.

Let q denote the fraction of one's tasks done within community and $1-q$ the fraction done outside of the community. An easy and important way to think about this, is that there is a convention of which tasks are marketed and which ones are done within a community.

If an agent is doing a task for someone within their community then the penalty for not doing the favor will be that the agent's future tasks that were supposed to be done within the community must be done by him or herself instead. If an agent fails to do a task for an outsider, then a formal enforcement applies as if a contract has been broken, with a random possibility of

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being caught and fined. In addition, the agent's own community might learn about the "crime" and also ostracize the agent.[7]

Incentives for Reciprocation within a Community

Let

$$V = \frac{\delta(t_s - t_c)}{1-\delta}$$

denote the future discounted change (per community task) in costs that an agent would face for having to do tasks him or herself that were supposed to done by the community. In autarky a person faces costs of $\frac{t_s}{1-\delta}$, while by cooperating those costs are $\frac{t_c}{1-\delta}$.

An agent can fail to complete his or her task in a given period, but then faces a loss of reciprocation in the future. The maximum penalty is going to autarky.[8]

The incentive constraint for doing a task within one's community is thus:

$$t_c \leq qV = \frac{\delta q(t_s - t_c)}{1-\delta}. \qquad (IC^{com})$$

This applies to the q fraction of community tasks.

This constraint simplifies to

$$q \geq \frac{t_c}{V}.$$

In what follows, we focus on the case in which $V \geq t_c$ so that there is some possibility of having a community-enforced equilibrium, otherwise the model becomes degenerate and the only option is either autarky or entirely outside enforcement.

Incentives to Abide by an Agreement under Outside Exchange

If an agent fails to perform a task for an outsider, the agent is caught with a probability ϕ, and then pays a fine f.

While we do not model it here, ϕ itself could depend on whistle-blowing and reporting of infractions by individuals (e.g., see Acemoglu and Jackson (2017)). For instance, if a consumer is cheated then that person may bring a civil suit (or criminal suit in the case of fraud or criminal negligence) against the other party.

In addition, ψ denotes the probability that the fact that an agent is caught cheating on the market is then learned about by his or her own community. In many contexts, ψ will be quite high - as in the contexts that we noted in the introduction: such as the auto-da-fé, tattooing, etc. This drives the complementarity between community and formal enforcement. If $\psi = 0$,

[7]Our model is extreme in that cheaters are always caught within the community, and that people know everyone's community past but not necessarily their outside past. In reality there will be noise in all directions. The model is rich enough as a first-order approximation, and it does not appear that adding noise on any of these dimensions does anything but complicate expressions without adding much new insight. We comment in the concluding remarks on where the most promising directions for adding noise appear to be.

[8]Less drastic punishments can be part of an equilibrium. Examining the strongest incentives provides a characterization of the equilibrium frontier, and so we focus on the most drastic punishment.

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then there is no complementarity. A community can ostracize its members who are caught cheating on the market.[9] This provides extra incentives.

The incentive constraint for an agent to complete a task for someone outside of the community is then:

$$t_m \leq \phi f + \phi\psi qV, \qquad (IC^{mark})$$

which becomes

$$\phi \geq \frac{t_m}{f + \psi qV}.$$

Note that the value of community in providing incentives, qV, is proportional to q. A larger fraction of community tasks, q, results in a more valuable reputation within one's community, and will enhance the complementarity between community and formal enforcement.

Built into the statement of the incentive constraint is that someone who has cheated and been caught once, will not benefit from doing so again. This can be justified in two ways. One is that the government keeps a list of agents who have been found guilty of a breach of contract: once an agent is caught the agent is on parole and monitored forever after - so ϕ increases. Alternatively, the fine or consequences for a repeat offender is higher than for a first-time offender. It could also be that a person can be barred from a market, for instance losing a license to practice medicine, law, dentistry, carpentry, architecture, etc. All of these are seen routinely in law enforcement. Without this, once arrested and ostracized by their community an agent will prefer to cheat on the market forever. This leads to a different outside incentive constraint that is more complex but it still has all of the same comparative statics as this simpler one. [10]

We assume the costs of being caught cheating on the market, f, is exogenously fixed, and finite (more on this below). In addition, we assume $f > t_m$ in what follows. This condition together with the assumption that individuals being arrested will be monitored for sure provide enough incentives for those individuals not to deviate in future outside interactions, and hence IC^{mark} is the correct constraint.

To fix ideas, think of someone who fails to report taxes from some transaction. If they are caught once, then they are audited for sure rather than just being audited with probability ϕ in

[9] Again, there can be many equilibria and some might not involve ostracism. However, ostracism provides the maximum incentives and can be part of an equilibrium, and so we study this strongest incentive constraint to characterize the equilibrium frontier.

[10] The other incentive constraint is $t_m \leq \phi f + \phi\psi \left(qV - \frac{\delta}{1-\delta}(1-q)(t_m - \phi f)\right)$. The added term on the right hand side accounts for the added the value from cheating on the market forever after if an agent is ostracized from her community (as then the agent anticipates that the outside constraint will no longer be satisfied if it was binding with ostracism). A transformation of the equation gives

$$t_m \leq \phi f + \frac{1-\delta}{1-\delta q}\phi\psi qV,$$

whose right hand side is still increasing in both q and ϕ and generally has the same properties as the simpler incentive constraint. Which incentive constraint is more relevant would depend on context and whether past "criminals" are monitored more closely than the rest of the population, or fine repeat criminals more drastically. For the sake of exposition, we assume that they do.

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all future interactions. Whether their friends and neighbors learn about this transgression and ostracize the person may be random and is captured by the parameter ψ. Thus, ψ could depend on how well lawsuits and criminal cases are publicized, and the extent to which community members pay attention to such publicized lists. More generally, "ex-convicts" are monitored in a variety of ways, and whether their past record is known to a community differs by region and crime.

Equilibrium When we refer to *equilibrium* we mean a convention of which fraction of tasks are done within community, q, with the remaining $1-q$ done on the open market, such that the incentive constraints are satisfied: if $q > 0$ then IC^{com} is satisfied and if $q < 1$ then IC^{mark} is satisfied.

This is a shortcut for defining equilibrium, as opposed to formally defining the extensive form game and the subgame perfect equilibria of that game. The notation for defining matchings and histories here would become cumbersome, with the end equilibrium outcome possibility set remaining the same. Given the complexity of the analysis below, we adopt the simple route of working with a definition directly in terms of incentive constraints (much as the principal-agent and contracting literatures have done).

Effectively, our community constraints operate as if an ostracized agent is never dealt with again. We use this to provide the most extreme incentives, while other equilibria could be constructed with forgiveness and more relaxed constraints in some situations. Again, our intent is to characterize the most efficient equilibria in terms of on-path utility possibilities, which will already be complicated enough, and so we leave the fuller characterization of all equilibria aside; especially as that can be done with standard arguments.[11]

Which q's can be equilibria depend on the level of formal enforcement ϕ (and all the other exogenous parameters that define the setting). By the assumption that $V \geq t_c$, $q = 1$ is always an equilibrium. With the assumption that $f > t_0$, then when $\phi = 1$ is it also possible to have $q = 0$ (all market) be an equilibrium.

We can think of ϕ as being a choice variable of a government or planner, and thus can see how welfare works as a function of ϕ, q combinations for which q is an equilibrium.

The combination of ϕ, q for which the incentive constraints are satisfied are pictured in Figure 2.

[11] One could also examine renegotiation-proof equilibria, which might change the specific level of equilibrium cooperation, but would not change the basic interaction effects and complementarities.

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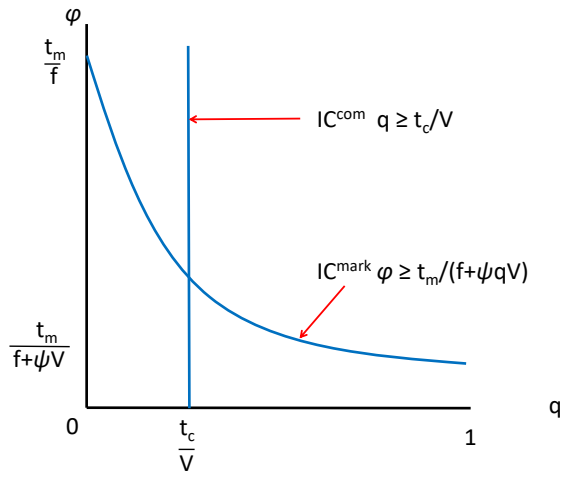


Figure 2: The community and outside incentive constraints. Higher levels of legal enforcement and tasks done within community pass both incentive constraints.

The potential welfare-maximizing points are pictured in Figure 3.

It makes no sense to use more ϕ than is necessary to satisfy the incentive constraints, as legal enforcement is costly (more on this below). This leads to three potential regions for welfare-maximization: either just one but not both of community and legal enforcement is used (so q is either 0 or 1 and then the corresponding incentive constraint must hold), or both are used and then both constraints must hold.

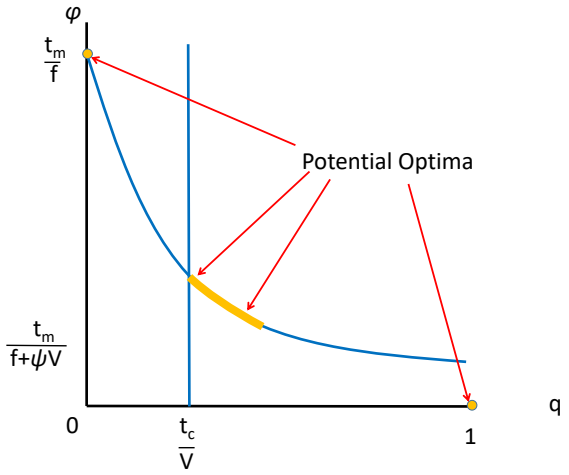


Figure 3: The potential optima involve satisfying both constraints (in which case it makes sense to choose the lowest ϕ), or else going to a corner in which either all community is used $q = 1$, or all market is used $q = 0$ and then the outside constraint binds.

A Remark on Fines

One can always make sure that the incentive constraint IC^{mark} holds with very little formal enforcement by setting f to be huge.

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There are (at least) four reasons that this is not done.

First, breach of contract is generally pursued by civil courts and the payments that are in question are often limited to the provable damages incurred. In some egregious cases this might involve punitive damages or a criminal case (e.g., fraud). Thus, in many cases the fine level will only involve reparations and some legal costs. In more serious cases it may involve more serious punitive payments, jail time, or loss of license, but in most standard breach of contract cases will be fairly limited. In that sense, loss of reputation can be extremely important in enforcing behavior, as the quotes by Mokyr alluded to.

Second, there is a moral concept of 'cruel and unusual punishment' or that a 'punishment should fit the crime.' For instance, the Eighth amendment to the US constitution states that "Excessive bail shall not be required, nor excessive fines imposed, nor cruel and unusual punishment inflicted," and such policies date back to English Law in 1689. The UN's Universal Declaration of Human Rights states that "No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment." This has a long history, for instance Hamarabi's code states: "If a man destroy the eye of another man, they shall destroy his eye. If one break a man's bone, they shall break his bone. If one destroy the eye of a freeman or break the bone of a freeman he shall pay one gold mina. If one destroy the eye of a man's slave or break a bone of a man's slave he shall pay one-half his price."

A third justification for this is that there may be errors made and with a positive probability of errors, then huge fines for small offenses are not welfare maximizing.

A fourth reason is that it can be costly for a government to punish - especially when this involves imprisonment.

We do not model these reasons, but simply take it as given that f is a finite exogenous number - generally a fine "commensurate" with the offense - and so then a positive ϕ, as well as ψ in some cases, are necessary for incentives.

We also emphasize that although we refer to government and legal enforcement for simplicity, another application of our analysis is to various platforms and markets that are monitored by a private company and the users of that system.

3.3 The Optimal Mixture of Community and Legal Enforcement

We now characterize the welfare-maximizing level of ϕ and equilibrium q, as a function of the setting.

Even though q may not be a choice variable of a society, analyzing how welfare depends on q is still useful.

The societal welfare includes the costs of legal enforcement as well as the total costs of doing tasks.

Let $C(\phi, q)$ be the (per-capita) cost of legal enforcement needed to support a probability ϕ of being 'punished' by the government (e.g., sued and found guilty) when someone breaches a contract on the market, when $1 - q$ is the fraction of tasks done on the market.

We assume that C is increasing in ϕ, so a larger legal apparatus is needed to punish people

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who breach a contract with higher probability, and C is non-increasing in q - so that it is weakly more costly to enforce more transactions. We assume that C is differentiable in both arguments, but only when $\phi > 0$, so that we allow for a discontinuity when $\phi = 0$, so that there can be a fixed cost that kicks in for positive enforcement.

Two canonical examples are:

(i) $C(\phi, q) = \phi(1 - q)$ for some $c > 0$, so that the amount of enforcement is per probability of catching people per outside transaction, and

(ii) $C(\phi, q) = \phi$ for some $c > 0$, so that the amount of enforcement is per probability of detection per capita.

One can imagine many cases in between. For simplicity, we draw most of our figures for case (ii), but our results apply to more general cost functions.

We take C to be quasi-convex in (ϕ, q). This allows for costs to adjust with q and for having cost savings with scale of $1 - q$ - having less than per capita costs, just as in (i) above. This is exactly the condition that ensures that the lower contour sets of the minimization program are convex - and so are precisely what is needed to ensure a well-behaved optimal equilibrium problem.

Maximizing the welfare of the society is equivalent to minimizing the total costs of doing tasks plus the cost of legal enforcement:

$$qt_c + (1 - q)t_m + C(\phi, q),$$

where this presumes that the incentive compatibility constraints are met. Fines could be consumed by other agents (and do not appear in equilibrium in any case), and so they are not included in the welfare function.

The characterization of the best combination of legal enforcement ϕ and equilibrium q is therefore given by the program:

$$\min_{\phi, q \in [0,1]^2} q(t_c - t_m) + C(\phi, q)$$

$$s.t. \quad q\left(\frac{\delta q(t_s - t_c)}{1 - \delta} - t_c\right) \geq 0, and$$

$$(1 - q)\left(\phi f + \phi\psi\frac{\delta q(t_s - t_c)}{1 - \delta} - t_m\right) \geq 0$$

where q in the first constraint captures that IC^{com} is only needed if $q > 0$, and similarly $1 - q$ in the second constraint captures that IC^{mark} is only needed if $q < 1$.

The various potential solutions to this program are pictured in Figures 4 and 5. Again, we draw things for the case of $C(\phi, q) = c\phi$, but most of our results (unless otherwise stated) apply more generally.

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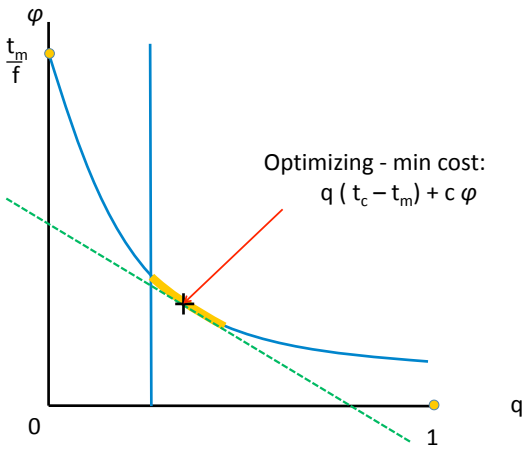
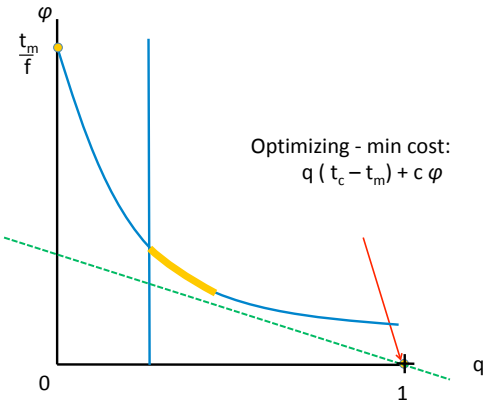
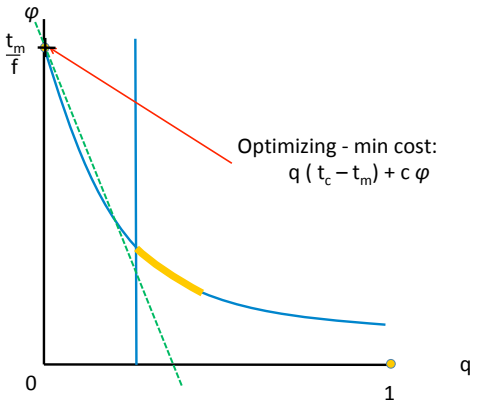


Figure 4: The optimum - minimizing $q(t_c - t_m) + c\phi$ when c is in a middle range.



(a) For high costs of legal enforcement, c, the solution is all community .



(b) For low costs of legal enforcement, c, the solution is all market based.

Figure 5: There are corner solutions where only community (for high costs, panel a) or only market/outsiders (for low costs, panel b) are used. Note that in (b) the line is not tangent to the outside IC curve, since the tangent point would not be feasible as it would involve an internal q but the community IC constraint would be violated.

The market incentive constraint IC^{mark} binds unless it is so expensive that only community is used, as in panel (a) of Figure 5. We emphasize that in (b) the line is not tangent to the outside IC curve, since the tangent point would not be feasible as it would involve an internal q but the community IC constraint would be violated. Thus, in that case it is the outside IC constraint with $q = 0$ that must hold.

In contrast, the community constraint only binds when there is a particular corner case: using the minimal amount of community (that satisfies its incentive constraint) to help enhance the deterrence of legal enforcement, as in Figure 6. Again, in this case the line is not tangent to the outside IC curve, but instead hits at the corner where both IC constraints hold.

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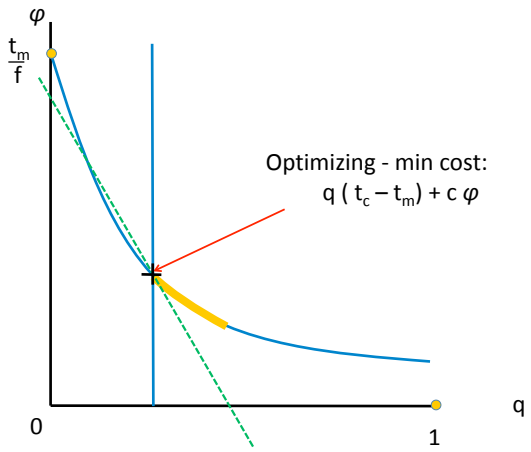


Figure 6: The community IC constraint only binds (generically) at a corner when it is better to have the minimum amount of community to (that satisfies its incentive constraint) to help enhance the deterrence of legal enforcement.

3.4 Comparative Statics in the Cost of Legal Enforcement, c

We now provide more detailed comparative statics in costs of legal enforcement. In order to do this, we break C into two parts:

$$C(\phi, q) = cP(\phi, q),$$

where we can interpret $P(\phi, q)$ to be the size of the legal apparatus needed to get a probability of enforcement ϕ on a market of size $1 - q$, and where c is a unit cost of enforcement. Assume $P(\phi, q) > 0$ whenever $\phi > 0$ and $q < 1$ so that formal enforcement does not come for free. This parametrization allows us to do comparative statics in c while considering both scenarios (i) and (ii) from above, as well as many other forms of the cost function.

A larger c can correspond a more costly or relatively labor-intensive technology, e.g., in more rural, poorer, or less developed societies. For instance, c would be higher in a legal system that relies heavily on labor, compared to a system that relies on less costly technology. Thus, richer and more developed countries may have lower c's than poorer developing states. In addition, c captures the *effective* cost in the sense that in a corrupt system it is more costly to deliver the same probability of enforcement due to moral hazard on the part of the judges and others involved in enforcement, and hence corruption can be partly captured by larger c. Section 6 provides a more extensive look at corruption, but an inflation of c captures a basic impact of corruption. In addition, a higher c can be due to an ineffective or overloaded court system. For example, in some cities it can be very difficult and time-consuming to evict a tenant who fails to pay rent. This leads to less renting on the open market.

We hold other parameters fixed (such as t_c, t_m, t_s, f, ψ and δ) and provide the comparative statics in those other parameters in Appendix B.

The figures above suggest how the welfare-maximizing equilibrium mixes of community and

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enforcement work as we vary the unit cost of legal enforcement, c, and here we state that this holds quite generally.

PROPOSITION **1 (Optimal Community and Legal Enforcement, and Comparative Statics in c)**

There exists $\overline{\psi} \geq 0$ such that:

1. *If $\psi < \overline{\psi}$ then the optimal level of community is bang-bang: all-community is optimal if $c > c^* \equiv \frac{t_c - t_m}{P(0,t_m/f) - P(1,0)}$, and formal enforcement is optimal if $c < c^*$.*

2. *If $\psi > \overline{\psi}$, then there are three thresholds, $c^{mark} < c^{mix} \leq c^{com}$, such that*

   - *all community is optimal if $c > c^{com}$*
   - *a high community level, $q \in \left(\frac{t_c}{V}, 1\right)$, is optimal if $c^{mix} < c < c^{com}$,*
   - *the minimal community level, $q = \frac{t_c}{V}$, is optimal if $c^{mark} < c < c^{mix}$, and*
   - *all legal enforcement is optimal if $c < c^{mark}$.*

   Moreover, c^{mark} is increasing and c^{com} is increasing in ψ.

The precise term for $\overline{\psi}$ depends on the law enforcement cost function $C(\phi, q)$. In the case in which $C(\phi, q) = c\phi$ it is easy to check that $\overline{\psi} = \frac{f/V}{1 - t_c/V}$. The general analysis appears in the appendix.

Without a large enough ψ, the complementarity between formal and community enforcement is so low that just using one or the other is always better than working with both.[12] Once complementarities are large enough, then the optimizing choice behaves as in Figures 4 - 6, which is what the proposition states.

The range of costs for which there is a complementarity and both community and formal enforcement are used – i.e., that c^{com} is strictly decreasing and c^{mark} is strictly increasing in ψ – is pictured in Figure 7. As ψ increases, the outside incentive constraint becomes easier to satisfy, as there is more implicit punishment from law enforcement. In terms of which objective functions hit an optimum on the yellow part of the curve, the lower that curve is, the wider the range of c for which that curve contains the optimal point. A larger ψ enhances the complementarity and effectiveness of mixtures in which both community and policing are active - lowering that curve and hence the comparative statics in the cutoff thresholds, while it does not affect the payoff under the all-market or all-community regimes. Therefore such an increase in ψ expands the region of parameters in which a mixture regime is optimal.

[12] For instance, in Figure 6, if the IC^{mark} curve was much flatter due to a low ψ, its intersection with IC^{in} would be very high on that curve, and the minimal cost line would always be below it and intersect one of the two extreme points instead.

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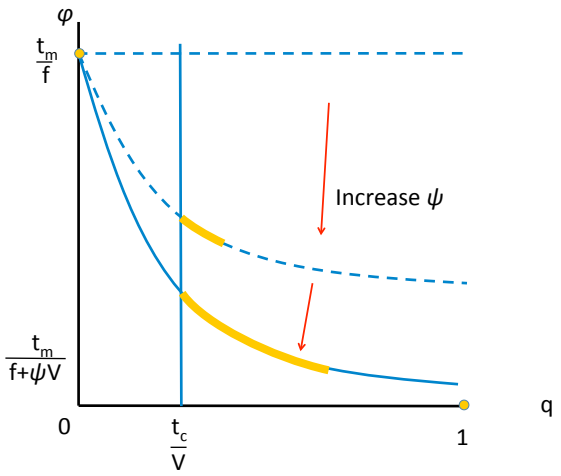
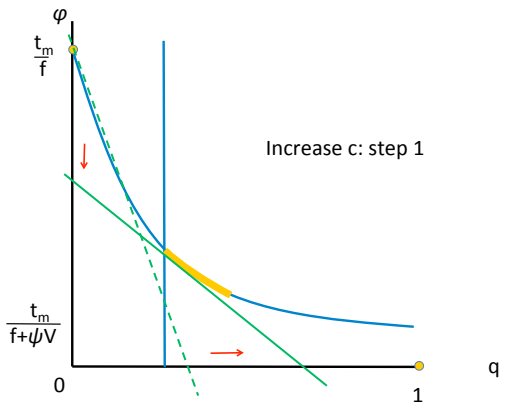


Figure 7: As ψ increases, the outside incentive constraint gets easier to satisfy. More of the potentially optimal region gets used as the constraint is lowered and it hits the optimal objective function for a wider range of c.

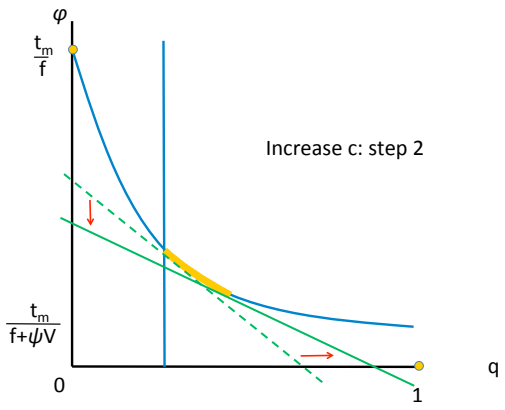
The benefits from increasing ψ make it clear why there are so many instances in which authorities publicize convictions, such as those referred to in the introduction. It can be a relatively cheap way of improving enforcement. In fact, even if the fine is 0, a high ψ can make formal enforcement very effective: an authority does not formally punish the person but does publicize their misbehavior. This is, in part, how enforcement on many online platforms works, as well as the way that the enforcement of the 'Gentleman's' rules worked as described by Mokyr (2008) - news of misbehavior and the subsequent loss of reputation and standing in one's clubs and society were strong punishments and worked well even in the face of relatively ineffective fines and courts.

As stated in Proposition 1, there are multiple regimes, depending on which one, or both, of the community and the market are active. The evolution of that optimal regime, as well as comparative statics within the mixed regime in which both community and market are used, are depicted in Figure 8.

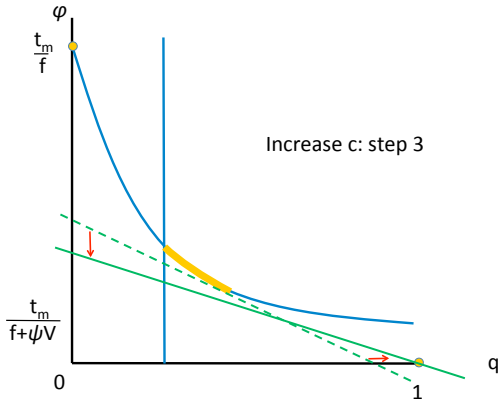
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(a) Starting from a low cost, moving to a medium cost: change from all market to using a mixture of market and community



(b) Starting from a medium cost, moving to a slightly higher medium cost: increase the amount of community used



(c) Starting from a medium cost, moving to a high cost: change to all community

Figure 8: Comparative statics as c increases.

The following result holds for both within-regime and across-regime changes.

PROPOSITION **2 (Comparative Statics in the Cost of Law Enforcement c, Part II)** *As c increases, welfare weakly decreases and strictly decreases whenever markets are being used. Moreover, the use of community weakly increases and the probability of enforcement ϕ weakly decreases (strictly whenever q increases).*

3.4.1 An Example of the Change in Equilibrium and Welfare with Changes in Law Enforcement Costs

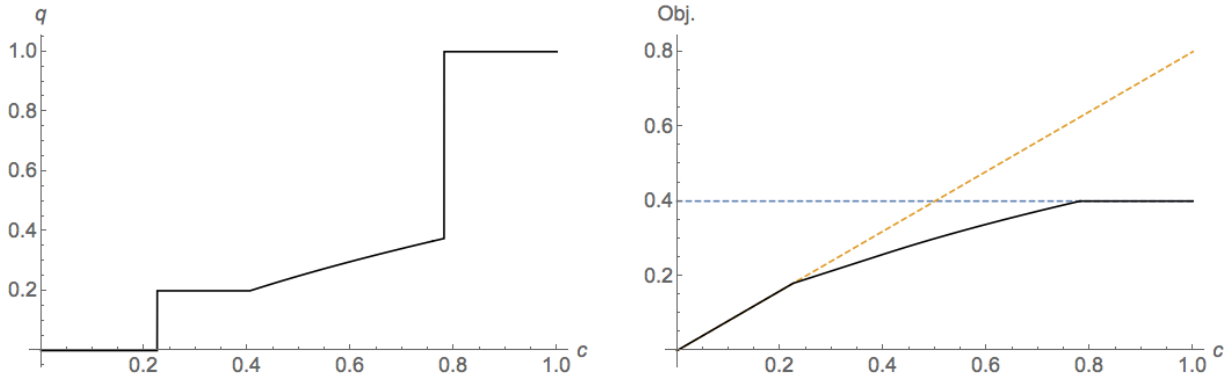
We illustrate the comparative statics in the model by detailing how welfare and optimal equilibrium structure vary as we change the cost of law enforcement.

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For the purposes of this example, we set $t_s = 1, t_c = .8, t_m = .4$, $f = 0.5$, $\delta = 20/21$, $\psi = 1/2$, and cost of policing $C(\phi, q) = c\phi$.

With these parameters, (IC^{com}) requires $q \geq 1/3$. Therefore, the society either does everything on the market, or else at least a fraction of at least $1/3$ within community.

This example belongs to case 2 of Proposition 1, and the thresholds work out to be $c^{com} = 0.225$, $c^{mix} = 0.405$, and $c^{mark} = 0.78125$, which characterize the four optimal regimes.



(a) The Fraction of Community Task Provision

(b) Overall Costs (Opposite of Welfare: $q(t_c - t_m) + c\phi$)

Figure 9: Comparative statics in the cost of law enforcement: an example. The horizontal axis is the cost of law enforcement c, and in the left hand panel is the quantity of community used, while in the right hand panel the overall cost to society (in law enforcement and/or opportunity costs of doing things within community) are pictured.

The comparative statics and discontinuities are pictured in Figure 9.

In panel (a) of Figure 9 we see the four regimes and two associated discontinuities. When costs of law enforcement are very low, only the market is used, which corresponds to Figure 5, panel (b). Once we cross the threshold of $c^{com} = 0.225$, then we switch to a regime in which some community tasks are provided, which corresponds to Figure 6. Now community is being used as a complement to law enforcement. This involves a discontinuous rise in the level of community, since community cannot be used without satisfying its incentive constraint, which requires a $q \geq .2$ in this example. Until we get to a cost of law enforcement of $c^{mix} = 0.405$, there is no change in the mixture of community and market that is used, as it is still most efficient to use the minimal amount of community needed to satisfy the incentive constraint. Once costs are greater than $c^{mix} = 0.405$ (and less than $c^{mark} = 0.78125$) the level of community used increases, as using more of it further reduces the amount of law enforcement needed. This corresponds to the optima in Figure 4. Once costs exceed $c^{mark} = 0.78125$, then the law enforcement becomes too expensive and it is best to switch to all community, which corresponds to Figure 5, panel (a). Here we see another discontinuity: law enforcement is now more expensive than working entirely within a community, and there is an abrupt change.

It is worth emphasizing that law enforcement and the market drops away discontinuously

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and is not used for a wide range of c, *even though we have not assumed any fixed cost*.[13] The first discontinuous jump up in community use comes from the fact that community enforcement requires a minimal threshold in order for future reciprocation to outweigh current temptation. The second discontinuous jump also does not involve any fixed cost, but it comes since market incentives require a minimal probability of being caught and thus a minimal expenditure on law enforcement. Thus, there are no optimal equilibria with tiny amounts of community or tiny amounts of market - each must be used in an amount above some threshold or not at all.

In panel (b) of Figure 9 we see the associated rate at which overall costs go up as the cost of law enforcement rises. Things begin in a region in which the rise is one-for-one, as at very low costs all enforcement is by the government. Once we get to the middle range, then there is a mixture of formal legal and community enforcement, and so the slope decreases. This is the range of complementarity: the overall cost is increasing by less than the cost of law enforcement, since it is complemented by community ostracism and less law enforcement is needed to achieve the same incentives. Throughout this range, the slope at which costs rise is decreasing, since more substitution is used, which lowers the amount of law enforcement that is needed. Eventually, things switch to entirely community enforcement and overall costs no longer rise with the cost of law enforcement.

There are many parameters of the model for which we develop comparative statics (discounting, fines, task costs, ψ). As they affect incentives differently, there are interesting contrasts in their comparative statics. For the sake of length, we present them in Appendix B.

One interesting set of comparative statics concerns changes in $t_m - t_c$. As a country industrializes and urbanizes, the relative gains from trade on an open market compared to doing everything within community increase. This tilts the objective function and benefits to society towards the market. At the same time, a decrease in t_m also makes the formal incentive constraint easier to satisfy. These combined forces tend to lower the optimal amount of community, which is consistent with what is seen in many settings as an economy grows. It does not always cut that amount to zero, as the complementarity from community can still be very large and useful (see Section B.3).

4 The Complementarity Between Community and Law Enforcement

As tasks are either provided by the community or by outsiders, there is a sense in which community and market are substitutes: an increase in q necessarily decreases $1 - q$ on a one-for-one basis. However, when it comes to enforcement and incentive constraints, there is a complementarity, which is why we see both community and law enforcement for a wide range of parameter values. This holds for a range of costs for which using community enhances incentive

[13]This is in contrast to the argument in, for instance Casari (2007), in which fixed costs play an important role in the adoption of a formal institution (charters).

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constraints sufficiently to lower overall costs of policing enough to overcome the added cost of community provision of tasks.

Although we have been discussing this complementarity between community and law enforcement, we have not formally proven that there exists a true complementarity in terms of the usual definition of supermodularity. Here we are explicit about that complementarity.

4.1 Incentive Complements

Rather than a strategic complementarity in the usual game theory sense, this is an "incentive complementarity" – it is an interaction between different types of enforcement in that the increased used of one actually increases the incentives associated with the other. Thus, we use this terminology.

Let $\Pi(\phi, q)$ be the expected welfare associated with the best equilibrium at given levels of (ϕ, q). Thus, $\Pi(\phi, q)$ captures the payoffs from an equilibrium q can associated cost of law enforcement at level ϕ if q is an equilibrium, and otherwise it presumes autarky in community and/or market if the corresponding incentive constraint is not met at (ϕ, q).

We normalize by subtracting the value of autarky and we omit notation for all the primitive parameters of the setting, which are held fixed in the analysis below.

In particular,

$$\Pi(\phi, q) = \begin{cases} -C(\phi, q) & \text{if neither } IC^{com} \text{ nor } IC^{out*} \text{ is satisfied,} \\ q(t_s - t_c) - C(\phi, q) & \text{if } IC^{com} \text{ but not } IC^{mark} \text{ is satisfied,} \\ (1-q)(t_s - t_m) - C(\phi, q) & \text{if only } IC^{out*} \text{ is satisfied (as if } \psi = 0), \\ q(t_s - t_c) + (1-q)(t_s - t_m) - C(\phi, q) & \text{if both } IC^{com} \text{ and } IC^{mark} \text{ are satisfied.} \end{cases}$$

If the community incentive constraint is not met, but the outside constraint is met, then it must be that the outside incentive constraint is met ignoring any community ostracism - which is indicated by the * on IC^{out*} which is the constraint that $t_m \leq \phi f$.

In order to define complementarity, we first define the standard increasing differences condition. There are *weak increasing differences* relative to some $\{(q, \phi), (q', \phi')\}$ such that $q' < q, \phi' < \phi$ if

$$\Pi(\phi, q) - \Pi(\phi', q) \geq \Pi(\phi, q') - \Pi(\phi', q'); \tag{WID}$$

and there are *strict increasing differences* if

$$\Pi(\phi, q) - \Pi(\phi', q) > \Pi(\phi, q') - \Pi(\phi', q'). \tag{SID}$$

We say that community and law enforcement are *incentive complements* at (q_0, ϕ_0) if:

- weak increasing differences holds for every $\{(q_0, \phi_0), (q', \phi')\}$ such that $q' < q_0, \phi' < \phi_0$, and $\{(q, \phi), (q_0, \phi_0)\}$ such that $q > q_0, \phi > \phi_0$, and

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- for every neighborhood of (q_0, ϕ_0), strict increasing differences holds for some $\{(q_0, \phi_0), (q', \phi')\}$ such that $q' < q_0, \phi' < \phi_0$, or some $\{(q, \phi), (q_0, \phi_0)\}$ such that $q > q_0, \phi > \phi_0$, within that neighborhood.

Thus, incentive complementarity requires weak inequalities for all monotone comparisons around the point (q_0, ϕ_0), and strict inequalities for some monotone comparisons around the point (q_0, ϕ_0) (including arbitrarily close comparisons).

Thus, the definition of incentive complements requires that using more policing becomes weakly more effective at higher rates of q, and strictly for some points within each neighborhood of q.

Whether community and law enforcement are incentive complements or not depends on the actual values of (q, ϕ)'s. In particular, consider two points (q, ϕ) and (q', ϕ'): if incentive constraints are already met in either case, or not met at all in either case, then increasing law enforcement is just a waste of cost and so we won't expect a strict difference unless a complementarity is built into the cost function. Instead, the incentive complementarity here comes because of a change in incentive constraints due to the interaction between community and law enforcement.

To make this point most clearly, consider a case in which the cost function can be written as

$$C(\phi, q) = c_0 + c_1\phi + c_2 q,$$

so that there is no inherent complementarity between ϕ and q in the cost function. The strict complementarity thus has to come from the interaction of the incentive constraints. We state the following proposition for this form of cost function, and prove it for a more general class of cost functions (including, for instance $C(\phi, q) = c\phi(1 - q)$) in the appendix.

PROPOSITION **3 (The Complementarity in Incentives)**

Community and law enforcement are incentive complements whenever they are used together in an optimal equilibrium: if (q^*, ϕ^*) is optimal and $0 < q^* < 1$, then community and law enforcement are incentive complements at (q^*, ϕ^*).

Moreover, community and law enforcement are incentive complements at (q^*, ϕ^*) and $0 < q^* < 1$ if and only if *$\psi > 0$ and IC^{out*} is binding and IC^{com} holds at (q^*, ϕ^*).*

Proposition 3 states that community and law enforcement are incentive complements whenever the they are both active at an optimum. Recall from Proposition 1, a necessary and sufficient condition for some interior $q^*, \phi^* \in (0, 1)$ to be optimal is that ψ is above some minimal level, so that when an agent is caught for not doing a task for an outsider, that agent's own community learns that fact with a high enough probability to induce some nontrivial cost of ostracism on the agent. This is seen in Figure 10. The intuition is that having more community interaction makes law enforcement more effective as the cost of being caught is higher due to the community reaction of ostracizing people who cheat on the market. In this case, law enforcement gains an extra impact since it results not only in a fine but also in a loss of

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community interaction. Thus, the impact of law enforcement on profits increases with more community interaction.

This is consistent with the observations we saw in the data in which there was a positive interaction between formal and informal exchange: whenever they are both used in combination, then they should lead to increased effectiveness in enforcement.

We remark that this suggests that the most effective law enforcement is combined with active advertising of arrests. By informing the public of all cheating on the market in a highly visible forum increases incentives.

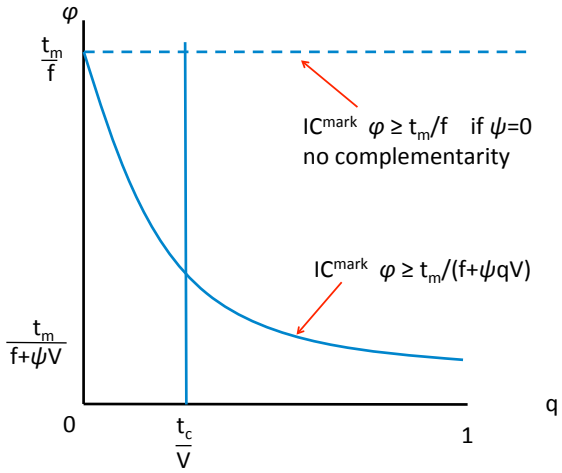


Figure 10: The incentive complementarity comes from ψ: the chance that people in the community learn of an arrest and then ostracize. Without that effect, there is no incentive complementarity and both incentive constraints are constants - and then the optimal equilibrium is either all market or all community.

Note that the incentive complementarity does *not* mean that more law enforcement is used as community interaction increases - in fact the opposite will typically be true as when law enforcement becomes more effective then less of it is needed to enforce contracts. The incentive complementarity is in the effectiveness of law enforcement (the increasing differences), and does not imply a higher optimal level. The incentive constraint for work outside the community will always be binding whenever it is being used at an optimum - as without any law enforcement there would not be any incentive to abide by a contract, and law enforcement does not affect internal community incentives.

4.2 Cost Savings from the Complementarity

For a variety of reasons, including technological ones, it may be that a society has little choice with respect to which tasks are done within a community as opposed to on the market, and so it does not have discretion over its q, or may not have the means to influence that choice. Thus, we should be agnostic on the extent to which q is chosen or influenced.

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Nonetheless, one can calculate the value of having the complementarity for any fixed level of q, since one can see the minimal amount of law enforcement that is necessary to enforce the rules with the complementarity, compared to how much law enforcement would be necessary to sustain the same q without any complementarity. This is pictured in Figure 11

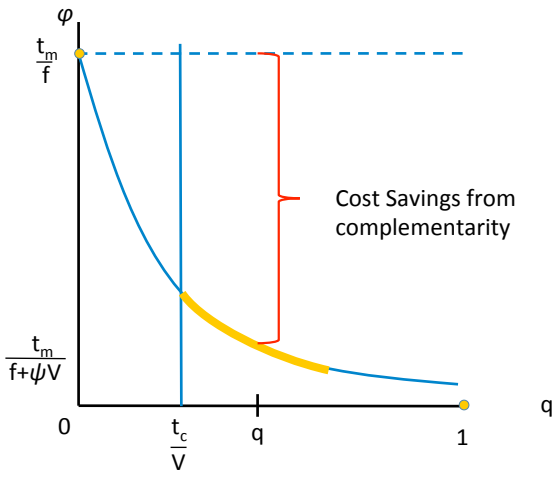


Figure 11: The difference between the law enforcement costs necessary to enforce incentives with complements compared to without, represents the costs savings for a society due to the complementarity, even if the society is not at an "optimal" q or cannot choose its q.

4.3 Simultaneously Substitutes and Complements

We re-emphasize that although the market and community substitute for each other in a very basic way, this does not preclude them being complements at the same time. In particular, they are substitutes in the obvious sense that a task done on the market no longer has to be done by the community: q and $1-q$ sum to 1. This is also reflected in the observation that more developed societies (which have a smaller cost of law enforcement c) rely more on the market and less on the communities. This overall trend is consistent with many empirical and anecdotal findings (McCleary and Barro, 2006; Lowes, Nunn, Robinson, and Weigel, 2017; Banerjee, Chandrasekhar, Duflo, and Jackson, 2018), and is the subject of much of the previous literature (e.g., Kranton (1996); Gagnon and Goyal (2017); Dixit (2003a). This mechanical substitution does not at all preclude their simultaneous use being more powerful than their uses alone – this is the sense of the incentive complementarity. Increased use of one makes the other cheaper and more effective. So, they are substitutes in terms of *task* provision, but at the same time complements in terms of *incentive* provision.

The complementarity in incentives means that when one develops formal institutions (market and legal enforcement), nurturing and maintaining some community interactions can be vital to a successful growth of the formal institutions. The importance of this insight is illustrated as follows.

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4.4 Community-Poverty Traps

Building the institutions for law enforcement tend to involve an up-front investment that could be large. This is exacerbated by the fact that, as we have seen, law enforcement is used discontinuously and so to be welfare-enhancing it should be used above a minimum scale. This makes it difficult for a society to transition from local community enforcement to having a market economy. This is especially true if the society must pay for investments out of its current consumption.

We remark that our analysis provides some insight into this sort of Community-Poverty trap. Growth and future prosperity may depend on having some market interactions, and the costs of transition can be prohibitive to a given society. Our remarks come from our three comparative statics above. Let us take them in order.

The first is that a stronger community value (high V) and a large ψ – a valuable community closely attuned to law enforcement - both make law enforcement more effective and cheaper. Thus, a strong community can increase the range of settings where a transition can be made. Thus rather than a strong community delaying transition, it can actually help a transition given the complementarity.

The second is that religion - or strong norms of guilt or moral code - also enhance the effectiveness of law enforcement and community (Section 5). In particular, they can extend the range of law enforcement costs at which there are greater gains from transitioning - again making the transition more attractive.

The third is that (anticipated) corruption not only makes law enforcement less attractive, but it can also erode the complementarity resulting in a further reason not to transition (Section 6).

We visit these points next.

5 Religion and Supernatural Punishment

An important aspect of some religions that reach beyond community comes in two forms. One is that they invoke supernatural gods who punish bad behaviors. Another is that a person can be conditioned to feel guilt for bad behaviors.

Supernatural punishment and/or feeling guilty for bad behaviors can be found in most major religions in various forms. For instance, Christianity, Islam, and Judaism are relatively explicit regarding punishments for sins. Hinduism and several branches of Buddhism emphasize rewards and/or punishments through reincarnation and rebirth. Chinese traditional religion emphasizes moral reciprocity ("bao ying") and also the veneration of ancestors in not having them feel shamed because of the offsprings' misbehaviors. Such beliefs in ancestors and ancestral gods are shared by many local religions that exist throughout the developing world.

Of course, guilt can also be conditioned in ways other than via "religion". For our purposes, it does not matter exactly where this extra cost of cheating comes from, and we refer to it as

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"religion" for convenience, but it can be any conditioned response. Regardless of the mechanism, this results in an extra cost of not reciprocating or abiding by an agreed transaction.

We model this as an extra guilt cost or anticipated supernatural punishment, $S \geq 0$, that a person faces when they do not complete a task. The case of $S = 0$ is the model up to now.

Getting people to fear this punishment involves some indoctrination - people must be taught what is wrong and come to believe that they should feel guilt and/or will be punished with a bad future in life or the afterlife. This comes at a cost $K > 0$ that is an amount of time that it takes to be indoctrinated, etc., and is reflected in society's welfare calculation.

The new versions of the incentive constraints are:

$$t_c \leq S + \frac{\delta q(t_s - t_c)}{1 - \delta}, \tag{IC^{comS}}$$

$$t_m \leq S + \phi f + \phi\psi \frac{\delta q(t_s - t_c)}{1 - \delta} \tag{IC^{outS}}$$

Including the cost of "religion", the welfare optimization problem becomes:

$$\min_{\phi, q \in [0,1]^2, sign(S)} q(t_c - t_m) + c\phi + K sign(S)$$

$$s.t. \;\; q\left(S + \frac{\delta q(t_s - t_c)}{1 - \delta} - t_c\right) \geq 0,$$

$$(1 - q)\left(S + \phi f + \phi\psi \frac{\delta q(t_s - t_c)}{1 - \delta} - t_m\right) \geq 0.$$

Here, just as with fines, we take the level of the anticipated punishment S as exogenous (e.g., "eye-for-an-eye"), and only examine the choice of whether society is better or worse off by having a religion.

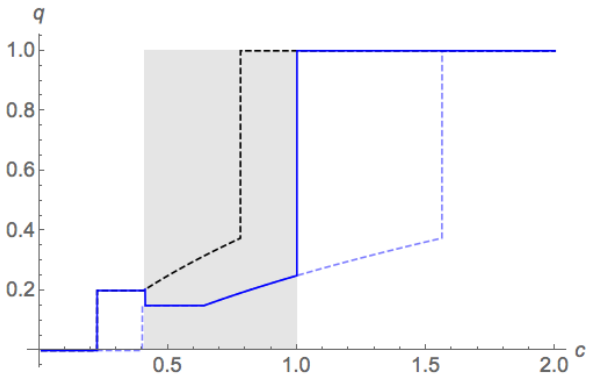
5.1 Religion, Supernatural Punishment, and Shifting Incentive Complementarities

To illustrate how the optimal mix of government and community changes once we add supernatural punishment, we begin by revisiting the example from Section 3.4.1. We keep the base parameters the same as in Example 3.4.1, but we add in various levels of supernatural punishment.

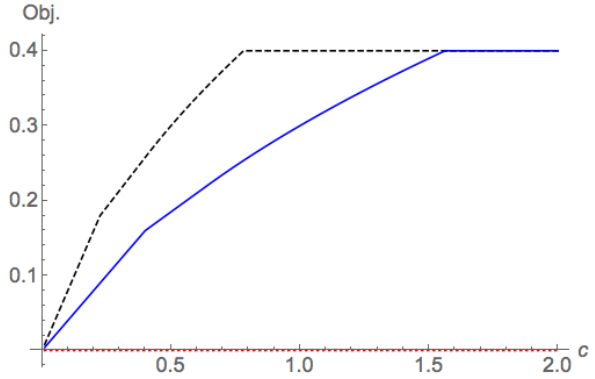
We start with the case in which $K = 0$, to see how that changes the incentive structure, and later we add in a positive cost of indoctrination.

The new structure of the optimal equilibrium as a function of the cost of law enforcement is pictured in Figure 12.

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(a) The fraction of Community Task Provision (q)



(b) Overall Costs (Opposite of Welfare: $c\phi + q(t_c - t_m) + sign(S)K$)

Figure 12: Notes: Dashed: S = 0 (no supernatural punishment, i.e. Example 3.4.1), Blue: S = 0.2, Red dotted: S = 0.4. $K = 0$, other parameters are the same as in Example 3.4.1.

The extreme at which $S = 0.4 = t_m$ (the red dotted line) is the benchmark for which (IC^{mark}) never binds. In this case, the supernatural punishment is so effective that every task can be completed outside without any law enforcement, and so all tasks are done outside with full compliance and no enforcement costs.

The less trivial cases are for $S < 0.4$. We picture the case of $S = 0.2$ as a representative situation.

The effects are clear (and a full analysis and proposition appear in the appendix). First, a supernatural punishment makes the outside incentive constraint easier to satisfy, as law enforcement is bolstered by a cost of guilt or afterlife-punishment. This leads to a larger region of enforcement costs for which there is no community but only a market. Community is only used after a higher threshold of costs. Second, the more interesting change is that once community is used there is a larger range of costs for which there is an incentive complementarity between community and law enforcement. Religion makes both incentive constraints easier to satisfy, and in particular, and then makes community a more effective complement to law enforcement - so that it is used for a larger range of parameters. Here, supernatural punishment makes both community and outside enforcement more effective, and shifts and enlarges the range of costs of law enforcement for which community is a useful complement.

Next we consider how things change when 'religion' comes with a cost.

5.2 Religion, Costly Supernatural Punishment, and Shifting Incentive Complementarities

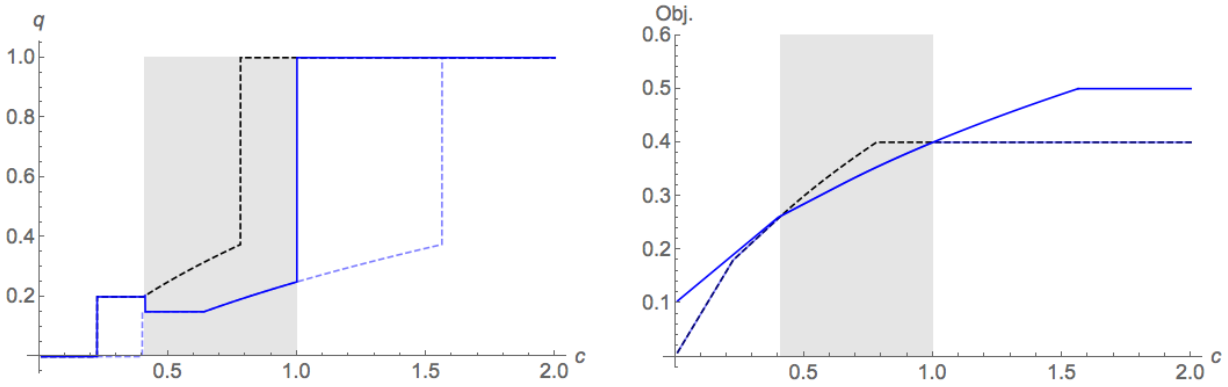
We now extend the example from Section 5.1 to include positive costs of maintaining a religion $K = 0.1$. So, there is a cost associated with any positive level of supernatural punishment $S > 0$. This involves whatever indoctrination and reinforcement that is required to have the population believe in the punishment.

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We examine when having a religion with a supernatural punishment is a part of an optimal, when it is costly. For example, if a society is such that it works entirely by community, then the supernatural punishment is redundant and does not help. In that case, it is more cost effective to have a religion that does not involve costs associated with indoctrinating people to believe in supernatural punishment. [14]

Therefore, for each set of parameters we first find the optimal system with (S, K), then compare it to the optimal system with zero supernatural punishment $(S, K) = (0, 0)$. When the former results in higher welfare, the supernatural punishment must be active in the welfare-maximizing system and must be affecting a binding incentive constraint or else it would not be worth the cost of maintaining the religion.

The results with $S = 0.2$ are pictured in Figure 13 (and the case of $(S = 0.4)$ is discussed in Appendix Figure 23).



(a) The fraction of Community Task Provision (q)

(b) Overall Costs (Opposite of Welfare: $c\phi + q(t_c - t_m) + sign(S)K$)

Figure 13: Black dashed: S = 0 (no supernatural punishment; i.e., as in Example 3.4.1). Blue: S = 0.2; the welfare-maximizing equilibrium (solid), the equilibrium assuming active supernatural punishment (dashed). The shaded area indicates a region in which supernatural punishment is active. $K = 0.1$, other parameters are the same as in Example 3.4.1.

As we see in Figure 13, supernatural punishment is active only in a middle cost range. For very low costs c, it is better to just use a market, and once there is enough community (which often occurs for very high c), there is no additional need for the supernatural since community must be relied upon and already are satisfying the incentive constraints.

For the cases in which costly religion is in use, the use of community becomes non-monotone in the cost of law enforcement, as we see in panel (a) of Figure 13. For very low costs of law enforcement, only the market is used. As law enforcement costs rise, community comes into play as a complement to law enforcement. However, once law enforcement costs continue to rise, it becomes efficient to have a religion with supernatural beliefs. Once this is in place, it then

[14] This is consistent with empirical observations by Norenzayan et al. (2016); Roes and Raymond (2003). Once a community becomes large, then other enforcement becomes necessary and such beliefs become useful.

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replaces some of the need for community as a complement to law enforcement, as supernatural beliefs lower the amount of law enforcementg needed. Eventually, as law enforcement costs continue to rise, we see community increasingly used, but at a lower level than it would be absent supernatural punishment. Finally, law enforcement costs become so high that everything becomes community and religion is again displaced.

In terms of our starting observations across countries, all of the countries are in the first two regions in which some level of formal enforcement is used. Thus, the data are entirely from first two regions of the cost structure, so that we should expect to see a negative correlation of religion with productivity, presuming that the most productive countries also have more efficient law enforcement and lower costs per unit of enforcement.

We prove in the appendix that as S increases, the market is used alone for a larger range of costs and then the upper bound of costs for which both market and community are used in combination is also increased.

It is worth noting, that religion ends up being used sometimes in combination with the market without any community, and other times when both are present. We have restricted attention to the case in which communities are self-enforcing, but if we drop that assumption, then for some parameters, religion also appears paired with community (and no market), and in some cases with no community or law enforcement at all. This may shed some light on the somewhat noisy relationship between religion and overall productivity of a society. It is only at the extremes in which a society relies entirely on a very efficient law enforcement, or is entirely a small within community society, that religion is not part of the mix. Otherwise it is involved to some extent.

As a last point, we note that religions can operate at different levels and have different norms about when punishments apply. For a religion to be fully optimal in a large society that contains many communities, it is crucial that it punishes cheating on outsiders - people outside the boundary of one's own community or religion - and not just on insiders. Competing religions may be in conflict for various reasons which then may lead them to be suboptimal on this dimension and to permit or even encourage cheating of outsiders.

To highlight this point, we explore community-specific punishment in the Online Appendix (e.g., see Figures 24 and 25 and the accompanying proposition in Section B.5). Community can still be valuable, and an incentive complement to outside enforcement, but supernatural punishments do not directly enhance law enforcement and thus lead to lower welfare gains.

6 Corruption

One very basic effect of corruption is that it increases the cost of law enforcement: the legal apparatus does less of what it is supposed to do. The corresponding analysis of that facet is just a change in the cost of law enforcement and was included in the comparative statics in Section 3.4.

Here we examine a more subtle, but important, effect of corruption: there can be "false

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arrests" so that people are accused or found guilty of a breach of contract even if they did not commit a crime. False arrests change the interaction between law enforcement and community as they lower the informativeness of someone being caught or accused of cheating on the market, and so a community may no longer want to ostracize such a person. This decreases the complementarity between community and formal enforcement.

A somewhat surprising result concerning the interaction of corruption with community and its complementarity with law enforcement, is that a change in that corruption level can lead to either more or less reliance on law enforcement. One direction is expected: as corruption goes up, law enforcement becomes less effective and so is used less. The second direction is the subtle one. As corruption goes up, the community becomes a less effective complement to law enforcement, and so one has to rely on *more* law enforcement. We explore that second effect in more detail here, as well as its interplay with the first.

We model corruption as follows. The probability ϕ of being caught now happens γ of the time when the person is innocent, and $1-\gamma$ of the time when the person is guilty. So, γ captures the level of corruption.

The effective cost of policing is now $\frac{c\phi}{1-\gamma}$, as one needs a level of law enforcement of $\frac{\phi}{1-\gamma}$ to get a probability ϕ of being caught when one cheats.[15]

Most importantly, this changes the incentive constraints in a variety of ways. In this section, we examine the incentive constraints as if the community still ostracizes people who are caught, and then come back to examine whether the community wishes to ostracize people who are arrested in the face of corruption in the next section.

First, everyone expects a lower continuation payoff, since one expects a chance of $(1-q)\phi\gamma$ of being falsely arrested in any given period and so a probability of $\psi(1-q)\phi\gamma$ of being ostracized, and then $1-\psi(1-q)\phi\gamma$ of making it through any period.

This leads to a new continuation value from community:

$$V^{corrupt} = \frac{\delta\left(1-\psi(1-q)\phi\gamma\right)\left(t_s - t_c\right)}{1-\delta\left(1-\psi(1-q)\phi\gamma\right)}. \tag{1}$$

Thus, agents face a smaller effective discount factor when calculating incentives.

Due to the change in $V^{corrupt}$, the community incentive constraints become:

$$t_c \leq qV^{corrupt}. \qquad (IC^{com,corrupt})$$

Next, the new incentive constraint for market interactions becomes:

$$t_m \leq \phi(1-\gamma)f + \phi\psi qV^{corrupt}. \qquad (IC^{out,corrupt})$$

The chance of false arrests happen on either side, and so are not included.

Thus, we see the weakening of both incentive constraints due to the lower continuation value $V^{corrupt} < V$ from future community interactions, and we also see a decreased chance of being

[15]Again, for ease of exposition we work with the cost function $c\phi$, but the analysis extends.

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fined for actually cheating: $\phi(1-\gamma)f$. So, corruption erodes all of the incentives.

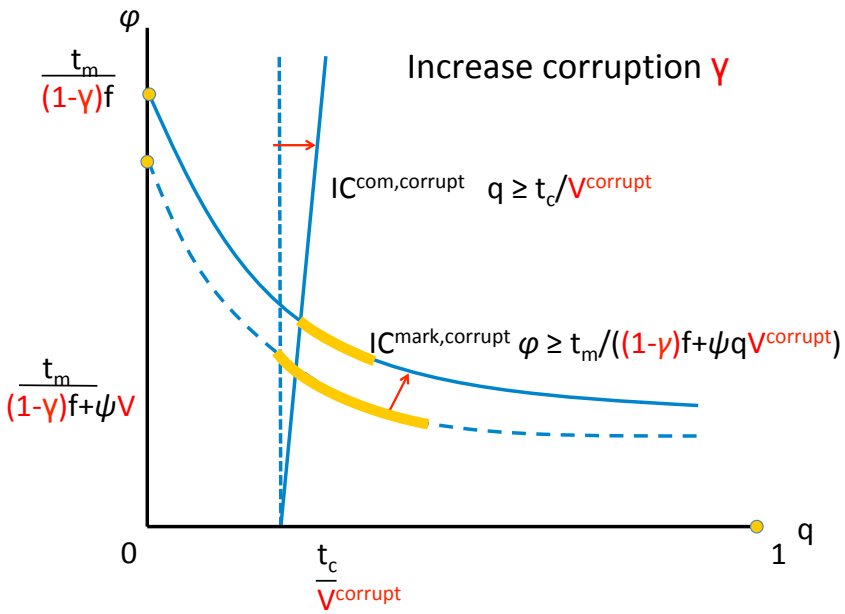
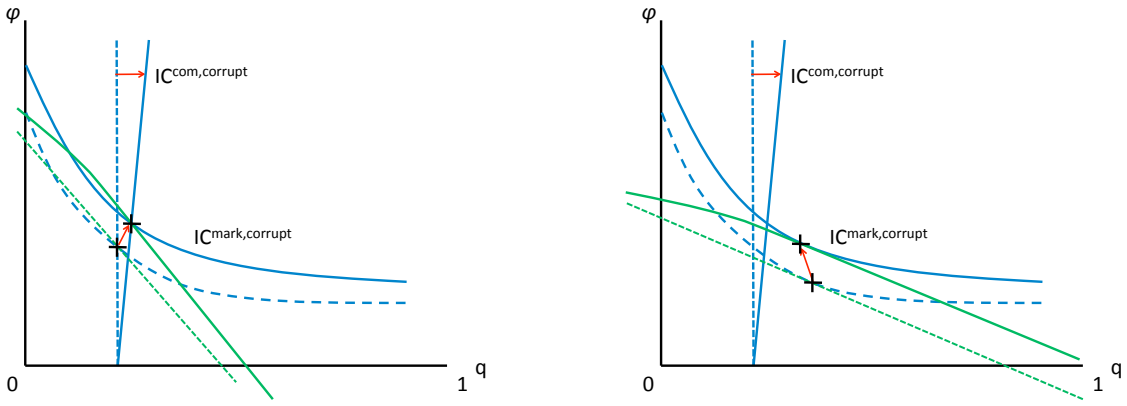


Figure 14: Both constraints get harder to satisfy with corruption. The community constraint shifts due to the lower value to future community cooperation. The outside constraint shifts due to changes in both the fine and the value of future community cooperation, and the relative way in which it shifts at different points depends on other parameters and the level of cooperation. At low levels of ϕ and high levels of q, the difference between $V^{corrupt}$ and V disappears.



(a) Community Reliance Increases

(b) Community Reliance Decreases

Figure 15: The reliance on community versus the formal sector can move in either direction as corruption increases.

In panel (a) of Figure 15, community needs to be used at a higher level to still be an incentive complement to law enforcement. In panel (b), community may instead decrease: it is

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less effective as a complement, and hence one has to rely on more law enforcement.[16] Generally, since both modes of enforcement are weakened as is their incentive complementarity, the best new equilibrium can be very different from the best old one.

Figure 15 does not capture all the ways in which there may be differences in community and formal market use due to corruption. For instance, another reason for the increase usage of community is that formal enforcement becomes less effective and the need for community as an incentive complement is increased - which can be manifested as a change from no community to a (discontinuous) jump in the use of community.

Moreover, in some cases corruption can be so bad that it no longer makes sense for a community to ostracize members that have been arrested. In that case, it is as if ψ is set to 0 and there is no longer any complementarity between community and formal enforcement. This means that one then moves either entirely to the community or entirely to formal enforcement. These are always points that are considered when we optimize in any case, but they become optima for more parameter values in the face of corruption.

Some of these comparative statics can be viewed by revisiting our running example.

In looking at overall welfare, we need to account for the cost of false arrests (per capita). This is captured by $qV(q) - qV^{corrupt}(q)$, where we now make clear the dependence of the value of community on q. The characterization of the welfare-maximizing equilibrium is given by the program:

$$\min_{\phi,q\in[0,1]^2} q(t_c - t_m) + C(\phi, q) + qV(q) - qV^{corrupt}(q)$$

$$s.t.\ \ q\left(qV^{corrupt}(q) - t_c\right) \geq 0,$$

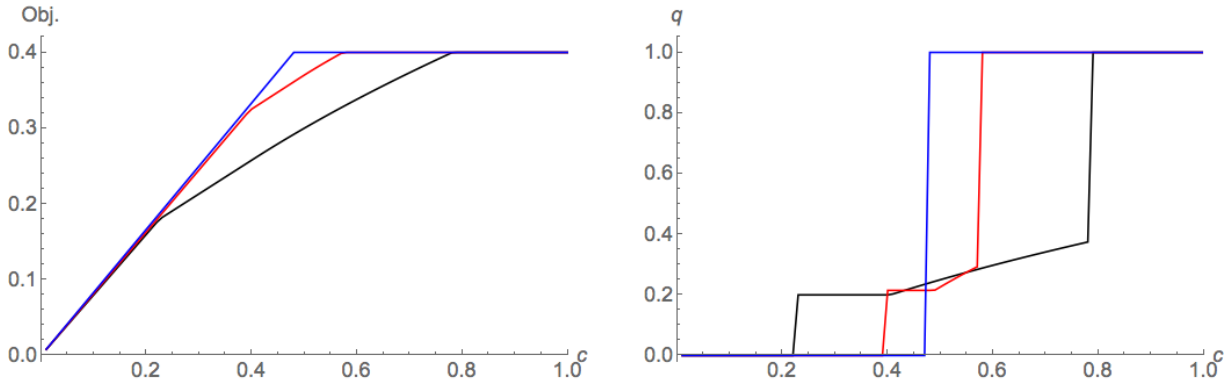
$$(1-q)\left(\phi(1-\gamma)f + \phi\psi qV^{corrupt}(q) - t_m\right) \geq 0.$$

An Example with Corruption

We examine several probabilities of false-arrest: $\gamma = 0$ (no corruption), 0.02, and 0.04. Other parameters are the same as in Example 3.4.1.

[16]For a numerical example of this case, consider Figure 16 (b): the level of community is lower with $\gamma = 0.02$ than the level with $\gamma = 0$, for c around 0.5.

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(a) Objective function (negative of welfare)

(b) Community fraction q

Figure 16: Notes: Dashed: $\gamma = 0$ (no corruption, i.e. Example 3.4.1), Red: $\gamma = 0.02$, Blue: $\gamma = 0.04$.

As we see in Figure 16, as corruption increases, the overall welfare decreases and the region of incentive complementarity between law enforcement and community shrinks until it eventually disappears completely. For lower costs c, more law enforcement is used and community disappears, while for higher costs c less law enforcement is used and more community is used.

6.1 A Moral Refinement: A Community's Reaction to Corruption and a Discontinuity in Welfare

Once corruption enters, people are falsely arrested. The welfare maximizing equilibria that we have in the analysis above have a peculiar feature. When community and law enforcement are both being used ($0 < q < 1$), the incentive constraints are satisfied and so *all* people who are arrested are actually falsely arrested. The equilibrium requires that people ostracize anyone who is arrested, since this is required as a threat to anyone who would cheat. So there is a cost of ostracizing falsely arrested people in order to enforce incentives to avoid real cheating.

Although this all holds together as an equilibrium (in a perfect Bayesian sense), it violates a basic moral refinement. Suppose that people refuse to ostracize people whom they believe were falsely arrested. This is added as a "moral" refinement to equilibrium: it rules out certain strategies of players. In this case, it eliminates the complementarity between community and law enforcement. It creates a discontinuity: as corruption enters and false arrests appear, a community that has such a moral constraint on its actions stops ostracizing arrested individuals since they know all of arrested people are actually innocent! In equilibrium described above: a community has an incentive to ignore arrests right from the start - all arrests are false.

This refinement leads to an abrupt discontinuity in how corruption affects welfare: there is a gap in welfare that comes once corruption is introduced.

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Proposition 4 *Consider a community that has a moral constraint on the strategies that it is willing to play and refuses to ostracize individuals whom they are sure are falsely arrested. If the welfare-maximizing equilibrium in the absence of corruption involves a mix of community and market, then there is a discontinuous drop in welfare from any positive level of corruption.*

This sort of discontinuity may be at work in many societies in which local communities have lost faith in their law enforcement agencies. There are many examples of such effects. For instance, "Black Youth Project 100" worked to undo a "permanent exclusion" policy of the New York City Housing Authority that ostracizes criminals and does not allow them to live in or visit housing projects. Activists in Chicago worked to eliminate the city's gang database, arguing that criteria for inclusion were vague.[17]

In our model, false arrest levels are extreme since incentives bind perfectly and nobody ever cheats; and so with any corruption, all arrests are false. There is no actual cheating in equilibrium as we have worked with homogeneous agents and no noise in their action. Although this is an extreme case, the discontinuity would be robust to the introduction of more noise into the model. One could introduce either heterogeneous types (some who have a greater preference to cheat) or some other noise in actions to get a positive amount of cheating and correct arrests in equilibrium. In that case, the community might tolerate a positive amount of arrests before ignoring them. Thus, the discontinuity observed in Proposition 4 would happen at a higher level of corruption. The message, however, would be the same: at some point, communities no longer react to arrests as false arrests are too large a percentage of arrests for them to tolerate, and then the complementarity between community and law enforcement is lost and welfare drops discontinuously.

7 Concluding Remarks

We have analyzed a simple and powerful incentive complementarity between exchanging informally within one's community and formally exchanging on a larger anonymous market. That incentive complementarity is affected by religion as well as corruption, as we have discussed: religion can enhance the complementarity under certain circumstances, while corruption erodes it.

We have kept the model unencumbered by heterogeneity in tasks, people, or communities. Extending the model to include such heterogeneities could provide interesting insights in many directions, including understanding which fraction of tasks will be done within a community as dependent upon technology, and provides an interesting agenda for further research.

First, introducing a heterogeneity in tasks would provide insight into how markets grow and whether they start by including simple low-cost tasks or more complicated high-cost tasks.

Second, introducing a heterogeneity in people's costs for providing tasks would provide insight into who specializes in which areas. It could also result in some equilibrium cheating by

[17]For more on both of these, see "Black Lives Matter Is Democracy in Action" by Barbara Ransby, Oct 21, 2017, New York Times.

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very high-cost individuals. This would introduce an interesting inference problem in the face of corruption: was someone falsely arrested?

Third, introducing heterogeneity in communities, (for instance, in size) could lead to different levels of incentive complementarity, so that only some could be trusted on market transactions.

Fourth, introducing heterogeneous and competing religions could give an idea of why religions with moral codes tend to exist: having a higher S would be advantageous. This might also introduce considerations of punishment only when dealing with someone of the same religion: one might be willing to cheat on a non-believer, if the religion allows it. Our base model could be an interesting foundation for studying the evolution and competition between religions.

Fifth, technological advances have led to many platforms on which people interact and transact, and the model could be reinterpreted and adapted to analyze the importance of linking people's identities across platforms and forcing them to use real rather than assumed identities (a growing practice on many platforms). The complementarities could be quite strong.

Sixth, one could also more explicitly model people's attitudes and reactions to corruption. When and how do people ostracize corrupt individuals? Does that affect the incentives of politicians, judges, and police?

In addition, we have assumed that each community has a fixed 'small' size. In further work it could be interesting to endogenous the size of community and relate it to various parameters in our model. For instance, larger communities might be associated with a lower t_c but also a worse ability to provide informal enforcement (e.g., as in Dixit (2003a,b)); on the other hand, people in smaller communities might know each other better and thus might be less willing to update from an arrest and less likely to ostracize and more likely to forgive than larger communities. These effects could impact the power of the complementarity with formal enforcement in interesting ways.

Finally, we have considered a model in which people are deterred when the incentive constraints are satisfied and so crime does not occur in equilibrium. Clear, the world is more heterogeneous and crime does occur. This introduces a tradeoff of ostracism: it acts as a deterrent (e.g., Buonanno, Pasini, and Vanin (2012)), but it also leads to increased recidivism as ex offenders have more difficulty in integrating into society (e.g., Funk (2004)). That tradeoff is beyond the scope of this paper, but is vitally important for understanding the ultimate effects of ostracism.

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A Supplementary Online Appendix

A.1 Proofs of Propositions 1 and 2.

We first provide an analysis for the special case of $C(\phi, q) = c\phi$, as that allows for closed-form solutions. We then provide the more general proof.

A.1.1 Analysis for $C(\phi, q) = c\phi$: characterizing the optimal ϕ, q.

In this part we provide a detailed analysis for $C = c\phi$ in closed form. One could easily extend these calculations to any linear cost function $C(\phi, q) = c_0 + c_1\phi + c_2 q$, for which $c_1 > 0$, with more complicated expressions. The analysis also applies to more general cost functions, but closed form solutions may not be available.

Recall that the optimization problem is to minimize the welfare cost

$$H(\phi, q) \equiv q(t_c - t_m) + C(\phi, q)$$

subject to the two constraints.

We first analyze the optimal ϕ for different possibilities of q, and then optimize overall.

When $q = 1$ (all community), $\phi = 0$ and hence the welfare cost

$$H^{all-com} \equiv H(0, 1) = t_c - t_m$$

When $q = 0$ (all market), binding $(IC)^{mark}$ implies $\phi^{all-out} = \frac{t_m}{f}$, and hence the welfare cost is

$$H^{all-out} \equiv H(\frac{t_m}{f}, 0) = c\frac{t_m}{f}$$

There is a mixture regime in between, with $q \in (0, 1)$ such that both community and law enforcement are active. This regime includes two situations, depending on whether $(IC)^{com}$ binds.

In particular, the mixture with a minimal community level has $(IC)^{com}$ and $(IC)^{mark}$ both binding. That implies that $q = \frac{t_c}{V} = \frac{(1-\delta)t_c}{\delta(t_s - t_c)}$ and $\phi = \frac{t_m}{f+\psi t_c}$. Therefore the welfare cost is

$$H^{mix-low} \equiv H(\frac{t_m}{f + \psi t_c}, \frac{t_c}{V}) = c\frac{t_m}{f + \psi t_c} + \frac{(t_c - t_m)t_c}{V}.$$

If the optimal q is above the level $q = \frac{t_c}{V}$, then only $(IC)^{mark}$ binds. In that case, minimizing H subject to $(IC)^{mark}$, has a solution (local minimizer)

$$(\phi^{mix-high}, q^{mix-high}) = \left(\sqrt{\frac{(t_c - t_m)t_m}{c\psi V}}, \sqrt{\frac{ct_m}{(t_c - t_m)\psi V}} - \frac{f}{\psi V}\right).$$

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The corresponding (local minimal) welfare cost is

$$H^{mix-high} \equiv H(\phi^{mix-high}, q^{mix-high}) = 2\sqrt{\frac{ct_m(t_c - t_m)}{\psi V}} - \frac{f(t_c - t_m)}{\psi V}.$$

From this, we can fully characterize the mixture regime:

$$H^{mix} = \begin{cases} H^{mix-low} & \text{if } q^{mix-high} \leq \frac{t_c}{V} \quad \text{(minimal community level)} \\ H^{mix-high} & \text{if } q^{mix-high} > \frac{t_c}{V} \quad \text{(high community level)} \end{cases}$$

q^{mix} and ϕ^{mix} are defined in a similar way. Intuitively, when $q^{mix-high} \leq \frac{t_c}{V}$, $(IC)^{com}$ binds: $q = \frac{t_c}{V}$ and the mixture regime is described by low community mixture in which both (IC)'s bind; whereas when $q^{mix-high} > \frac{t_c}{V}$, $(IC)^{com}$ is slack and the mixture regime adopts the local optimum.

Finally, the (globally) optimal regime is one that minimizes the welfare cost.

$$H^* = \min\left(H^{all-com}, H^{mix}, H^{all-out}\right)$$

.

A.1.2 Proofs of Propositions 1 and 2 for the more general cost function.

Recall that Propositions 1 and 2 are stated for

$$C(\phi, q) = cP(\phi, q),$$

in which $c > 0$ is a scalar, P is increasing in ϕ, non-increasing in q, and quasi-convex in (ϕ, q).

($H^{all-com}, H^{mix}, H^{all-out}$ are defined similarly to the analysis for $C = c\phi$ (in A.1), and the globally optimal welfare cost is still the smallest among the three, although closed-form solutions are no longer available for this more general case.

Proof of Proposition 1

Recall that $H^{all-com} \equiv H(0,1) = t_c - t_m + cP(0,1)$ and $H^{all-out} \equiv H(\phi^{all-out}, 0) = cP(t_m/f, 0)$, and so

$$H^{all-com} - H^{all-out} = t_c - t_m + c\left[P(0,1) - P(t_m/f, 0)\right].$$

Note that given the quasi-convexity of the cost function, and the strict convexity of the set of q, ϕ that satisfy IC^{mark} (for which $q > 0$) given $\psi > 0$, it follows that there exists a unique $q^{mix}(c) \in (0,1]$, $\phi^{mix}(c) \in (0, t_m/f)$ for every $c > 0$ which minimizes the objective function subject to both IC^{in} and IC^{mark} both holding (which requires $\phi > 0$).[18] Given the

[18]Note that the solution to this restricted program where we require both constraints to hold can involve $q = 1$, but that would always be dominated by the all community solution.

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differentiability of C for positive ϕ, and that $C = cP$, it follows from the Envelope Theorem (e.g., see Milgrom and Segal (2002)) that H^{mix} is differentiable in c at maximizing points.

First, we consider how the H's change with c.

$$\frac{\mathbf{d}}{\mathbf{d}c}H^{all-com} = P(0,1), \quad \text{and} \quad \frac{\mathbf{d}}{\mathbf{d}c}H^{all-out} = P(t_m/f, 0),$$

and it follows from the Envelope Theorem that

$$\frac{\mathbf{d}}{\mathbf{d}c}H^{mix} = \frac{\partial}{\partial c}H^{mix} = P(\phi^{mix}(c), q^{mix}(c)).$$

From the monotonicity properties of P (and the fact that $q^{mix}(c) > 0$, $\phi^{mix}(c) \in (0, t_m/f)$) that $P(t_m/f, 0) > P(\phi^{mix}(c), q^{mix}(c)) > P(0,1)$ and hence

$$\frac{\mathbf{d}}{\mathbf{d}c}(H^{mix} - H^{all-com}) > 0, \text{ and } \frac{\mathbf{d}}{\mathbf{d}c}(H^{mix} - H^{all-out}) < 0, \quad \forall c > 0. \tag{2}$$

Moreover, it is easy to see that $H^{all-com}$ is the smallest (among the three) for c big enough, while $H^{all-out}$ is the smallest for $c = 0$. Therefore, there exists two thresholds c^{mark} and c^{com}, such that

- $H^{mix} - H^{all-com} \geq 0$ whenever $c \geq c^{com}$
- $H^{mix} - H^{all-out} \geq 0$ whenever $c \leq c^{mark}$.

Now we consider how H's move in ψ.

Recall that ψ only enters the problem through IC^{mark}:

$$t_m \leq \phi f + \phi\psi q V, \tag{IC^{mark}}$$

and a larger ψ increases the right hand side of IC^{mark} whenever $q > 0$.

Therefore, the welfare cost $H^{all-com}$ and $H^{all-out}$ are both constant in ψ, while H^{mix} increases in ψ. Therefore

Observation: $H^{mix} - H^{all-com}$ and $H^{mix} - H^{all-out}$ both increase in ψ.

It follows from the above observation, condition 2 and the definition of c^{mark} and c^{com} that c^{com} increases in ψ, and c^{mark} decreases in ψ.

Now we are ready to prove the other statements in the proposition:

When $\psi = 0$, we must have $c^{com} < c^{mark}$, because the mixture regime is then never optimal: in this case IC^{mark} does not depend on q, and hence any (q, ϕ) with $0 < q < 1$ is strictly dominated by $(0, \phi)$, that is an all-market regime with the same level of ϕ.

This observation, together with the monotonicity of the two thresholds in ψ, implies that there exists some $\bar{\psi}$ such that $c^{com} < c^{mark}$ if $\psi < \bar{\psi}$, and $c^{com} > c^{mark}$ if $\psi > \bar{\psi}$. Notice that it is possible that $\bar{\psi} = \infty$. This $\bar{\psi}$ is the threshold that divides the two cases stated in the proposition.

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For part 1, $\psi < \bar{\psi}$ implies $c^{com} < c^{mark}$ and so the mixture regime is never optimal. That is, the optimal regime is either all-community or all-market.

Recall $H^{all-com} \equiv H(0,1) = t_c - t_m - cP(0,1)$ and $H^{all-out} \equiv H(\phi^{all-out}, 0) = -cP(t_m/f, 0)$, so

$$H^{all-com} - H^{all-out} = t_c - t_m + c\left[P(t_m/f, 0) - P(0,1)\right]$$

Therefore, $H^{all-com} > H^{all-out}$ iff $c > c^* \equiv \frac{t_c - t_m}{P(t_m/f,0) - P(0,1)} > 0$.

For part 2, $\psi > \bar{\psi}$ implies $c^{com} > c^{mark}$ and so the mixture regime is optimal for $c \in (c^{mark}, c^{com})$.

Finally, the characterization of the two sub-cases of the mixture regime(s) follows directly from the comparative statics of q, ϕ in c, which appears in the proof of Proposition 2. ∎

Proof of Proposition 2

Again we work with the welfare cost H, which moves in opposite directions to welfare Π.

Proposition 1 and its proof imply the statements in this Proposition *across* regimes, i.e., when the increase in c results in any change in the optimal regime. What is left is to show that the results hold also *within* each regime.

For the comparative statics regarding the welfare, it simply follows Envelope theorem that

$$\frac{\mathbf{d}H}{\mathbf{d}c} = -P(\phi(c), q(c)) \leq 0, \quad \forall c$$

, in which strict inequality holds for any $P(\phi(c), q(c)) > 0$, which necessarily occurs when $\phi(c) > 0$.

Now we show the second part of comparative statics, regarding ϕ and q.

In the *all-community* regime, both the welfare cost is $t_c - t_m$, $q = 1$ and $\phi = 0$ are all constant in c, so the stated results are trivial.

In the *all-market*, both q and ϕ are constant in c, and hence the welfare cost strictly increases in c.

Finally, in the *mixture* regimes, IC^{mark} is binding and this implies that ϕ can be written as a strictly decreasing function of q:

$$\phi(q) = \frac{t_m}{f + \psi q V}$$

and hence the optimization problem becomes

$$\max_{q \geq t_c/V} -H(q; c) \equiv -q(t_c - t_m) - cP(q, \phi(q))$$

It follows from P decreases in q that $H(q; c)$ is super-modular in (c, q), and therefore the optimal q increases in c, and so the optimal ϕ decreases in c. ∎

A.2 Proof of Complementarity: Proposition 3

We provide some more general results, to which Proposition 3 is a corollary. We begin with a characterization of when strict increasing differences is satisfied.

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LEMMA **1 (Strictly increasing differences)** *Consider a cost function* $C(\phi, q) = c_0 + c_1\phi + c_2 q$*, for some scalars, for which* $c_1 > 0$*.*

Strict increasing differences holds for some $\{(q, \phi), (q', \phi')\}$ *such that* $q' < q, \phi' < \phi$ if and only if $\psi > 0$*,* $q \in (0, 1)$*, and the community and outside incentive constraints are satisfied at* (q, ϕ)*, and* IC^{mark} *fails at each of the other three combinations (or* IC^{out*} *fails in case that* q' *also fails to satisfy* IC^{com}*).*

More generally, if $C(\phi, q)$ *is such that* $-C(\phi, q)$ *satisfies weak increasing differences (relative to any* $q' < q, \phi' < \phi$*), then strict increasing differences holds for some* $\{(q, \phi), (q', \phi')\}$ *such that* $q' < q, \phi' < \phi$ *if* $\psi > 0$*,* $q \in (0, 1)$*, and the community and outside incentive constraints are satisfied at* (q, ϕ)*, and* IC^{mark} *fails at each of the other three combinations (or* IC^{out*} *fails in case that* q' *also fails to satisfy* IC^{com}*).*

Proof of Lemma 1

Recall that the incentive constraints are:

$$t_c \leq qV = \frac{\delta q(t_s - t_c)}{1 - \delta}, \tag{IC^{com}}$$

and

$$t_m \leq \phi f + \phi\psi qV. \tag{IC^{mark}}$$

Also,

$$t_m \leq \phi f, \tag{IC^{out*}}$$

is the outside incentive constraint that covers the case in which IC^{com} fails to hold (which also means that $q < 1$).

It follows directly that IC^{com} is independent of ϕ. Therefore, from the definition of $\Pi(\phi, q)$ it follows that there are two possible cases for $\Pi(\phi, q) - \Pi(\phi', q)$, depending on the incentive constraints.

Case 1:

$$\Pi(\phi, q) - \Pi(\phi', q) = -c_1(\phi - \phi'),$$

if

(i) IC^{com} holds for q and IC^{mark} holds at both q, ϕ and q, ϕ',

(ii) IC^{com} holds for q and IC^{mark} fails at both q, ϕ and q, ϕ',

(iii) IC^{com} fails for q and IC^{out*} holds at both ϕ and ϕ', or

(iv) IC^{com} fails for q and IC^{out*} fails at both ϕ and ϕ'.

Case 2 (only possible when $\psi > 0$):

$$\Pi(\phi, q) - \Pi(\phi', q) = -c_1(\phi - \phi') + (1 - q)(t_s - t_m).$$

if either

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(v) IC^{com} holds for q and IC^{mark} holds at q, ϕ but not at q, ϕ', or

(vi) IC^{com} fails for q and IC^{out*} holds at ϕ but not at ϕ'.

Therefore, the only way to satisfy (SID) is for $0 \leq q' < q < 1$ and

$$\Pi(\phi, q) - \Pi(\phi', q) = -c_1(\phi - \phi') + (1 - q)(t_s - t_m)$$

while

$$\Pi(\phi, q') - \Pi(\phi', q') = -c_1(\phi - \phi')$$

This requires that one of (v)-(vi) applies for q and one of (i)-(iv) for q'.

Given that $q > q'$ and $\phi > \phi'$, some possible combinations are ruled out. For instance (i) at q' implies that it holds for q too, and (vi) at q implies that (vi) holds for q' too.

Thus, we are left for one of (ii)-(iv) at q' and (v) at q. Note that (v) rules out (iii). Thus, we are left with (ii) or (iv) at q' and (v) at q.

Note also that having (v) and either (ii) or (iv) requires that $\psi > 0$, since it means that the outside constraints must depend on the level of q.

Thus, we can conclude that (SID) applies *if and only if* IC^{com} holds for q and IC^{mark} holds at q, ϕ but not at q, ϕ'; while either IC^{com} fails for q' and IC^{out*} fails at both ϕ and ϕ', or IC^{com} holds for q' and IC^{mark} fails at both ϕ and ϕ'; and $\psi > 0$.

To see the proof of the second statement, note that as a direct extension of the above proof, under the conditions

$$\Pi(\phi, q) - \Pi(\phi', q) = -(C(\phi, q) - C(\phi', q)) + (1 - q)(t_s - t_m)$$

while

$$\Pi(\phi, q') - \Pi(\phi', q') = -(C(\phi, q') - C(\phi', q')).$$

By the weak increasing differences condition of $-C$, it then follows that

$$\Pi(\phi, q) - \Pi(\phi', q) > \Pi(\phi, q') - \Pi(\phi', q'),$$

as claimed. ∎

Proposition 3 is a corollary of the following.

PROPOSITION **5 (Complements)**

Consider a cost function such that $-C(\phi, q)$ satisfies weak increasing differences (relative to any $q' < q, \phi' < \phi$). Then

1) *Community and law enforcement are complements whenever they are used together in an optimal equilibrium: if (q^*, ϕ^*) is optimal and $0 < q^* < 1$, then community and law enforcement are complements at (q^*, ϕ^*).*

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2) *Moreover, community and law enforcement are complements at* (q^*, ϕ^*) *for which* $0 < q^* < 1$ if $\psi > 0$ *and* IC^{out*} *is binding and* IC^{com} *holds at* (q^*, ϕ^*).

3) *In addition, if* $C(\phi, q) = c_0 + c_1\phi + c_2 q$, *for some scalars, for which* $c_1 > 0$, *then community and law enforcement are complements at* (q^*, ϕ^*) *for which* $0 < q^* < 1$ if and only if $\psi > 0$ *and* IC^{out*} *is binding and* IC^{com} *holds at* (q^*, ϕ^*).

Proof of Proposition 5 We first show statement 2), then 3), then 1).
First we show statement 2)**.** Consider any q^*, ϕ^* that are optimal with $q^* \in (0, 1)$. We show a stronger result:

a) for every (q, ϕ) such that $q > q^*, \phi > \phi^*$, (WID) holds, and

b) for every (q, ϕ) such that $q < q^*, \phi < \phi^*$, (SID) holds.

(q^*, ϕ^*) being optimal implies that IC^{mark} must be binding and IC^{com} must hold. Therefore, both IC^{mark} and IC^{com} must also hold for any $q > q^*, \phi > \phi^*$. It then follows that

$$\Pi(\phi, q) - \Pi(\phi^*, q) = C(\phi^*, q) - C(\phi, q) \geq C(\phi^*, q^*) - C(\phi, q^*) = \Pi(\phi, q^*) - \Pi(\phi^*, q^*), \ \ \forall q > q^*, \phi > \phi^*,$$

in which "$\geq$" follows the assumption that $-C(\phi, q)$ has weak increasing differences.

So we have proved part *a*).

For part *b*), consider any (q, ϕ) such that $q < q^*, \phi < \phi^*$. We first show that (v) is satisfied relative to q^* and any $\phi < \phi^*$: it follows that IC^{com} holds for q^* and IC^{mark} holds at (q^*, ϕ^*) but not at (q^*, ϕ) (since IC^{mark} is binding at (q^*, ϕ^*)).

Now we show (ii) or (iv) is satisfied relative to q $(< q^*)$ and any $\phi < \phi^*$. If IC^{com} holds for q, then since IC^{mark} was binding at q^*, ϕ^* and $\psi > 0$ it must fail at q, ϕ^* and q, ϕ. If IC^{com} fails for q', then since $\psi > 0$ and IC^{mark} is binding at q^*, ϕ^*, it must be that IC^{out*} (a stronger constraint) fails at both q', ϕ^* and q', ϕ'.

As a result, it follows from the proof of Lemma 1 that

$$\begin{aligned}
&[\Pi(\phi^*, q^*) - \Pi(\phi, q^*)] - [\Pi(\phi^*, q) - \Pi(\phi, q)] \\
=& \ -(C(\phi^*, q^*) - C(\phi, q^*) + (C(\phi^*, q) - C(\phi, q)) + (1 - q)(t_s - t_m) \\
\geq& \ (1 - q)(t_s - t_m) \\
>& \ 0
\end{aligned}$$

Again "$\geq$" follows $-C(\phi, q)$ having weak increasing differences. So, we have shown part *b*) and therefore completed the proof of 2)

Next, we show statement 3). First observe that the "if" part is a corollary of 2), because $C(\phi, q) = c_0 + c_1\phi + c_2 q$ satisfies weak increasing differences. What is left is the "only if" part; that is, complementarity does not hold at any (q_0, ϕ_0) such that

c) IC^{com} fails, *or*

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d) IC^{com} holds, but IC^{mark} fails, *or*

e) IC^{com} and IC^{mark} both hold, but IC^{mark} is slack.

In any the above cases, part 2 of the definition of complementarity fails. We apply the proof of Lemma 1 to show these in turn.

For *c*), there exists some small enough neighborhood of (q_0, ϕ_0) such that IC^{com} also fails for every (q, ϕ) in the neighborhood. So IC^{out*} shall be considered and it is independent of q. Therefore, the same case ((iii), (iv), or (vi)) must apply to both q and q_0, and hence (SID) fails.

For *d*), IC^{mark} fails for (q_0, ϕ_0) implies that there exists some small enough neighborhood of (q_0, ϕ_0) such that IC^{mark} also fails for every (q, ϕ) in the neighborhood. Moreover, in the same neighborhood, in case $q < q_0$ and IC^{com} fails for q, then IC^{out*} would also fail for $\phi < \phi_0$ since it is a stronger constraint than IC^{mark}. As a result, (ii) or (iv) applies to q and q_0 (could be different). In either case (SID) fails.

For *e*), there exists some small enough neighborhood of (q_0, ϕ_0), such that every (q, ϕ)in the neighborhood IC^{mark} holds for both $(\bar{q}, \phi_0)$ and $(\bar{q}, \phi)$ in which $\bar{q} \equiv \max(q_0, q)$. Therefore (i) or (iii) holds for $\bar{q}$ which implies (SID) holds.

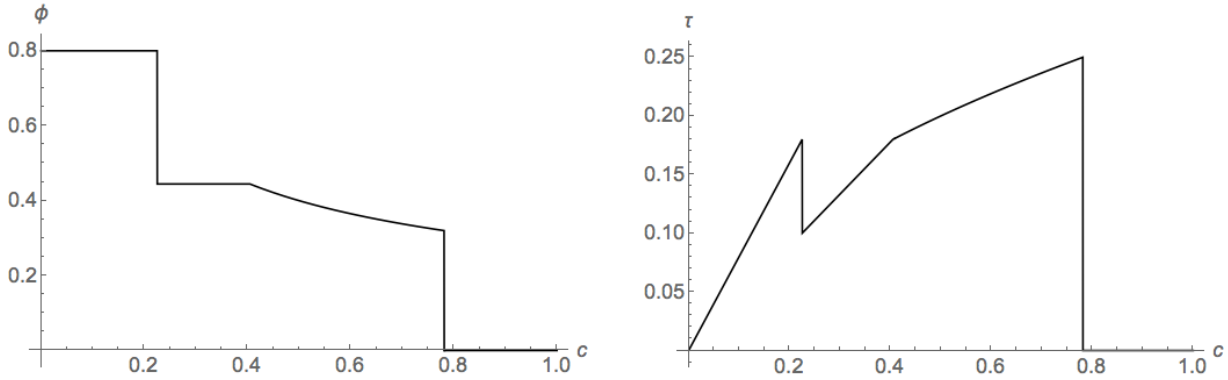
So, we have completed the proof of the "only if" part.

Finally, note that statement 1) **is a corollary to statement** 2): for (q^*, ϕ^*) to be an optimum with $q^* \in (0, 1)$, IC^{mark} must be binding at (q^*, ϕ^*). Therefore the community and law enforcement are complements at (q^*, ϕ^*). ∎

B Supplementary Online Appendix: Additional Comparative Statics

First, providing further details behind the example of comparative statics pictured in Figure 9, Figure 17 pictures the associated changes in the rate of law enforcement ϕ and associated costs of law enforcement, and again the two points of discontinuity are clear.

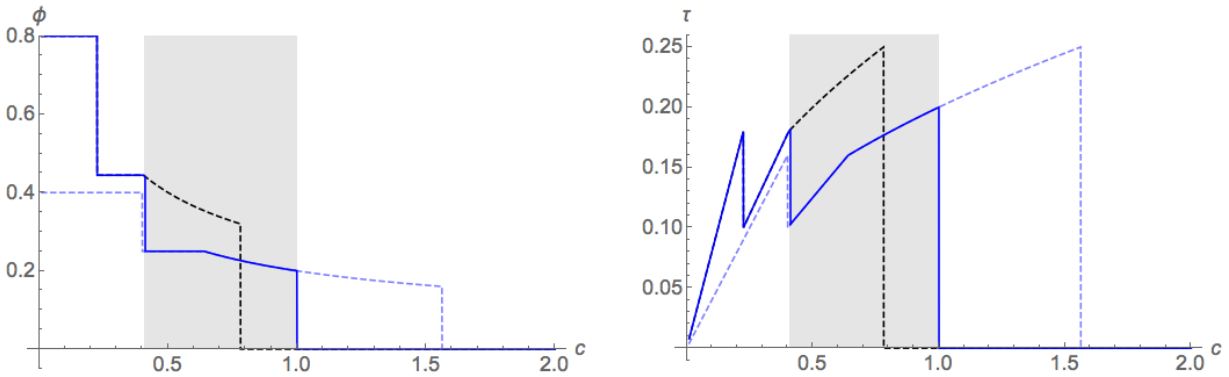
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(a) Amount of law enforcement (ϕ) (b) Cost of law enforcement ($c\phi$)

Figure 17: More comparative statics in the cost of law enforcement.

Next, we examine additional details to the example pictured in Figure 13 of comparative statics with costly religion. The optimal amount of law enforcement follows a quite jagged pattern in this example, as pictured in Figure 18, because it is affected by discontinuous use of community, which is then replaced by religion, and then eventually goes back to using community as a complement, and eventually is replaced entirely by community.



(a) Amount of law enforcement (ϕ) (b) Cost of law enforcement ($c\phi$)

Figure 18: Notes: Black dashed: S = 0 (no supernatural punishment, i.e. Example 3.4.1), Blue: S = 0.2; the welfare-maximizing equilibrium (solid), the equilibrium assuming active supernatural punishment (dashed). Shaded area indicates the region in which supernatural punishment is active. $K = 0.1$, other parameters are the same as in Example 3.4.1.

B.1 Comparative Statics in the Discount Rate and Cost of Autarky δ, t_s

We continue our discussion of comparative statics with changes in parameters that only affect the incentive constraints, but not the welfare costs ($c\phi + q(t_c - t_m)$, so parameters other than c, t_c, t_m).

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We begin with δ or t_s. By changing δ or t_s, the incentive constraints shift as in Figure 19.

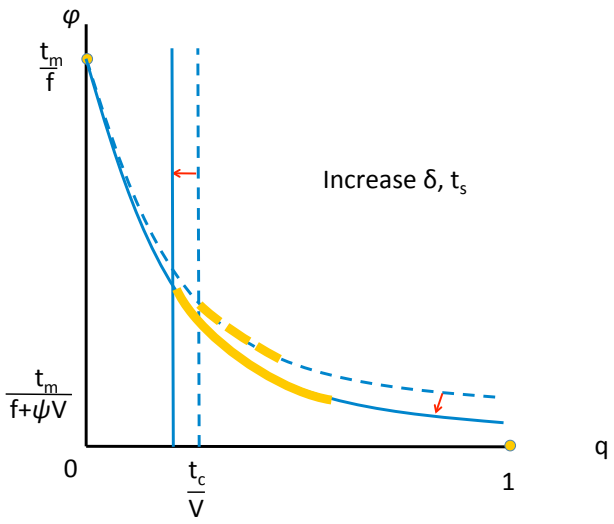
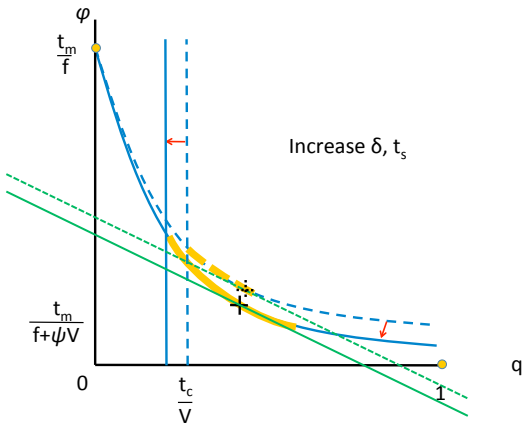


Figure 19: Comparative statics as δ and/or t_s are increased.

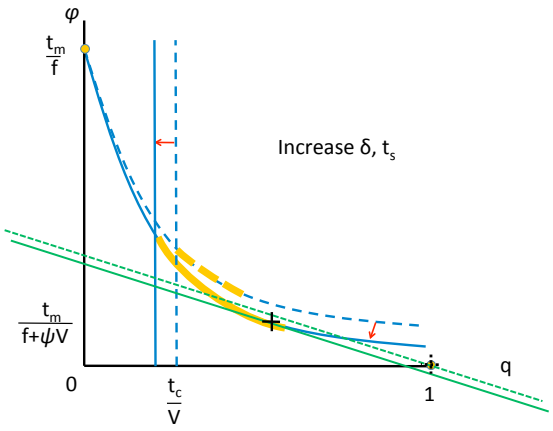
Depending on circumstances, this can lead to five possible changes in outcomes. Two of the possibilities is that there is no change in the welfare-maximizer. If the solution was $q = 0$ or $q = 1$, and the cost c was sufficiently large or small, then there is no change.

However, there are also three other possibilities as pictured in Figure 20:

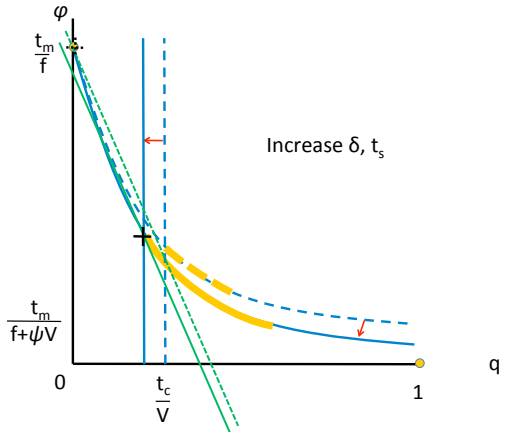
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(a) The initial welfare-maximizer involved interior q



(b) The initial welfare-maximizer involved all community: $q = 1$



(c) The initial welfare-maximizer involved all market: $q = 0$

Figure 20: Comparative Statics in the discount rate and cost of autarky, δ and t_s.

PROPOSITION **6 (Comparative Statics in the discount rate and cost of autarky, δ and t_s)** *An increase in δ and/or t_s leads to an increase in V, and as a result:*

- *If $1 > q > 0$ then qV weakly increases, ϕ weakly decreases, and welfare strictly increases (Panel (a) of Figure 20); q strictly decreases if $f < \psi t_c$.*
- *If $q = 1$ then either there is no change (optimal regime remains the same); or the mixture regime(s) become optimal and as a result q decreases, ϕ increases and welfare strictly increases (Panel (b) of Figure 20).*
- *If $q = 0$ then either there is no change (optimal regime remains the same); or the mixture regime(s) become optimal and as a result q increases and ϕ decreases and welfare strictly increases (Panel (c) of Figure 20).*

Following any increase in V, regime change only goes from *all community* or *all market* to *mixture*, but not the opposite. In particular, an increase in V favors the *mixture* regime with

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an enhanced complementarity. Therefore, as V increases, the *mixture* regime(s) become more beneficial (higher welfare) and more affordable (both incentive constraints being less restrictive).

Proof of Proposition 6

An increase in δ or t_s affects the problem only through an increase in $V \equiv \frac{\delta(t_s - t_c)}{1-\delta}$. We only need to show the comparative statics in V.

Recall that the analysis of optimal regimes are presented in Proposition 1 and Part A.1.1.

We start with $1 > q > 0$. We are in a mixture regime, with either a *high community level* or (2) a *minimal community level*: (1) If it is a *high community level*, then $q = \frac{t_c}{V}$ strictly decreases in V, $\phi = \frac{t_m}{f+\psi q V} = \frac{t_m}{f+\psi t_c}$ is a constant in V, and therefore the welfare strictly increases in V. (2) If it is a *minimal community level*, then (ϕ, q) follows the interior solutions. $\phi^{mix-high} = \sqrt{\frac{(t_c - t_m)t_m}{c\psi V}}$ strictly decreases in V, and $q^{mix-high} = \sqrt{\frac{ct_m}{(t_c-t_m)\psi V}} - \frac{f}{\psi V}$. $\frac{d}{dV}q^{mix-high} = \frac{-1}{2V}\left[\sqrt{\frac{ct_m}{(t_c-t_m)\psi V}} - \frac{f}{\psi V} - \frac{f}{\psi V}\right] \leq \frac{-1}{2V}\left[\frac{t_c}{V} - \frac{f}{\psi V}\right] < 0$ if $\psi t_c < f$. In addition, the optimal regime may change from a *high community level* to a *minimal community level*, but the above comparative statics hold under such a change.

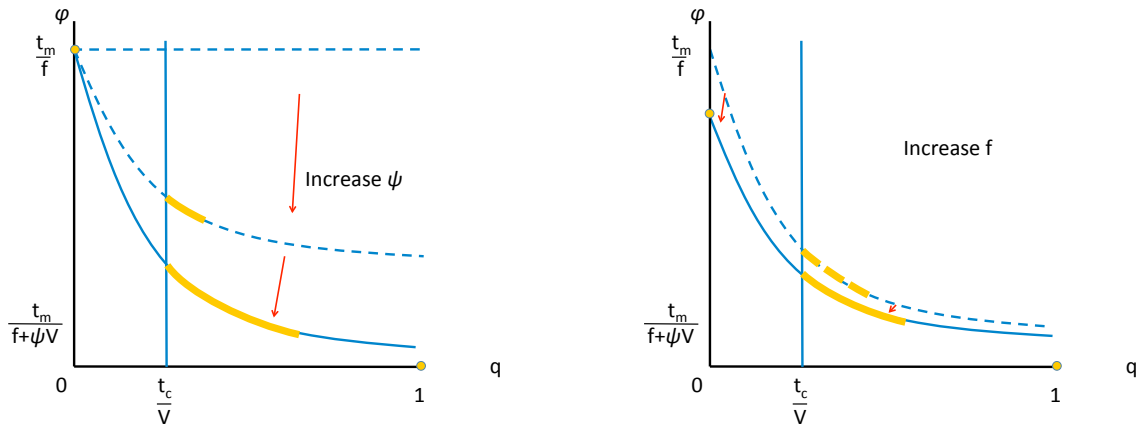
For $q = 1$ or $q = 0$, nothing changes in V unless there is a regime change. An large enough increase in V may change the optimal regime to the *mixture* (high or low community) since both (IC^{com}) and (IC^{mark}) become less restrictive. When the regime change(s) happen, q, ϕ and the welfare change as stated by construction of the optimal regimes.

Finally, we notice that following any increase in V, regime change only goes from *all community* or *all market* to *mixture*, but not the opposite. This is because an increase in V makes the *mixture* regime(s) more affordable and increases the welfare in it, but changes nothing in the two other regimes. ∎

B.2 Comparative Statics in the Fines and Chance of an Arrest Being Known to the Community f, ψ

Changes in ψ and f are similar to changes in δ, t_s except that they only change the outside incentive constraint, as pictured in Figure 21. These two cases differ slightly from each other, since changes in f also change the intercept of the outside incentive constraint, while ψ only changes the relative slope.

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(a) Comparatives statics in ψ (b) Comparatives statics in f

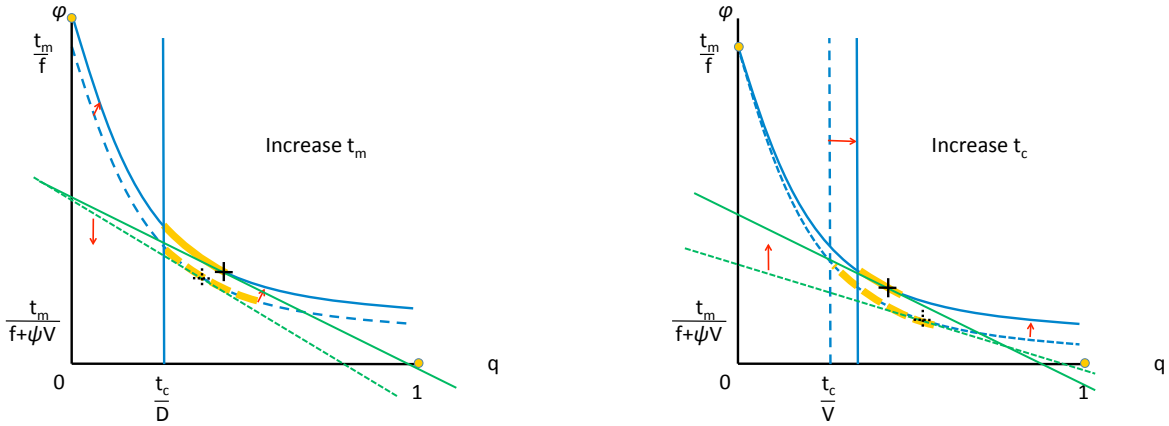
Figure 21: Comparatives statics in ψ, and f.

Since these are similar to the case of δ, t_s we omit a statement of the proposition.[19]

B.3 Comparative Statics in the Cost of Community and Outside Production, t_c, t_m

Changes in t_c, t_m affect both the costs of enforcement as well as the incentive constraints. Thus, these are the most complicated and ambiguous.

Given the multiplicity of possible outcomes, we omit a full statement of a proposition, but we illustrate the main effects in Figure 22 for the case in which the initial and final solutions involve interior q. The other cases are in which there is a shift to a corner solution.



(a) Comparative statics in t_m. (b) Comparative statics in t_c.

Figure 22: Comparatives statics in t_m, t_c.

[19]For f there is an extra case because of the change in intercept.

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The relative gain of getting help outside, $t_c - t_m$, increases when a society industrializes, and/or during the urbanization process. This would correspond to a decrease in t_m and an increase in t_c. As illustrated in Figure 22, this would correspond to the opposite move from that pictured in panel (a) combined with the move pictured in panel (b). The main effect of such a change typically results in a lower q, which is consistent with the anecdotal evidence (e.g., Putnam (2000)) that more industrialized societies tend to use less community and more law enforcement.

There are also some situations in which it could lead to a jump from a corner solution of all market to minimal use of community, as the outside incentive curve shifts down - for instance with a large drop in t_m and no change in t_c. So, the overall effect can be ambiguous in some extreme cases.

B.4 More examples with costly supernatural beliefs

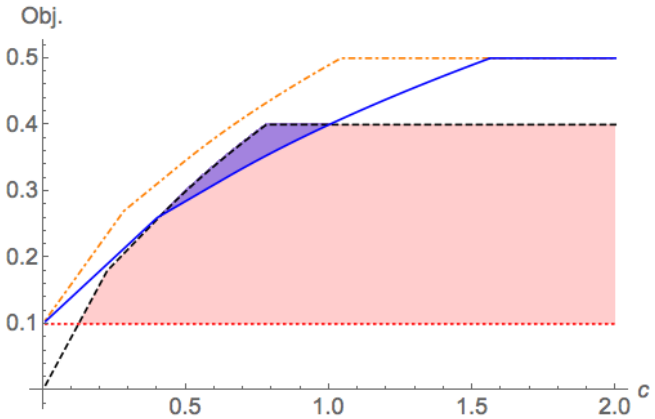


Figure 23: Notes: Objective (cost) function in the unit cost of law enforcement c, when there is a constant cost $K = 0.15$ associated with any positive level of supernatural punishment. Note: Dashed: S = 0, Orange dotdashed: S = 0.1, Blue: S = 0.2, Red dotted: S = 0.4. Curves are the cost functions assuming active supernatural punishment. The shaded areas indicate the net amount of cost saved by supernatural punishment, when it is indeed active.

The blue curve ($S = 0.3$) was already discussed in details in Section 5.2. For some level of supernatural punishment (e.g. $S = 0.15$, the red curve), the benefit of supernatural punishment never exceeds its cost K, and in this case the supernatural punishment is never active for any c.

B.5 Community-specific supernatural beliefs

Next, we consider religions in which supernatural punishment applies only to within-community interactions - so it is a sin to cheat against someone within one's own community/religion, but it is not a sin to cheat on those who are not from one's own community. Here one can think of the community as being those from the same religion or sect.

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Generally, this shifts the community constraint, but does not shift the outside constraint. This can still have an impact, but will tend to have less impact on welfare than situations in which incentives in both realms are boosted. The welfare is positively shifted only in the minimal-community-mixed-regime, but not in the other three possible regimes. A similar effect applies to the thresholds of regime changes: only the thresholds of the minimal-community-mixed-regime are affected. Example 1 and Proposition 7 illustrate these effects. Furthermore, community-specific religion can tilt things more towards community than if both were affected, as the effect only enhances the community constraint.

Of course, this could be the point of such religions, as they tilt things more towards communities which have religious boundaries, and give people a reason to abide by their community religion. In a world with multiple religions or erosion of community due to markets and formal institutions, one might expect religions to become more community specific. The cost is that there is lower total welfare than if religions punish bad behavior even with outsiders.

To be specific, S appears in (IC^{comS}) but not in (IC^{mark}):

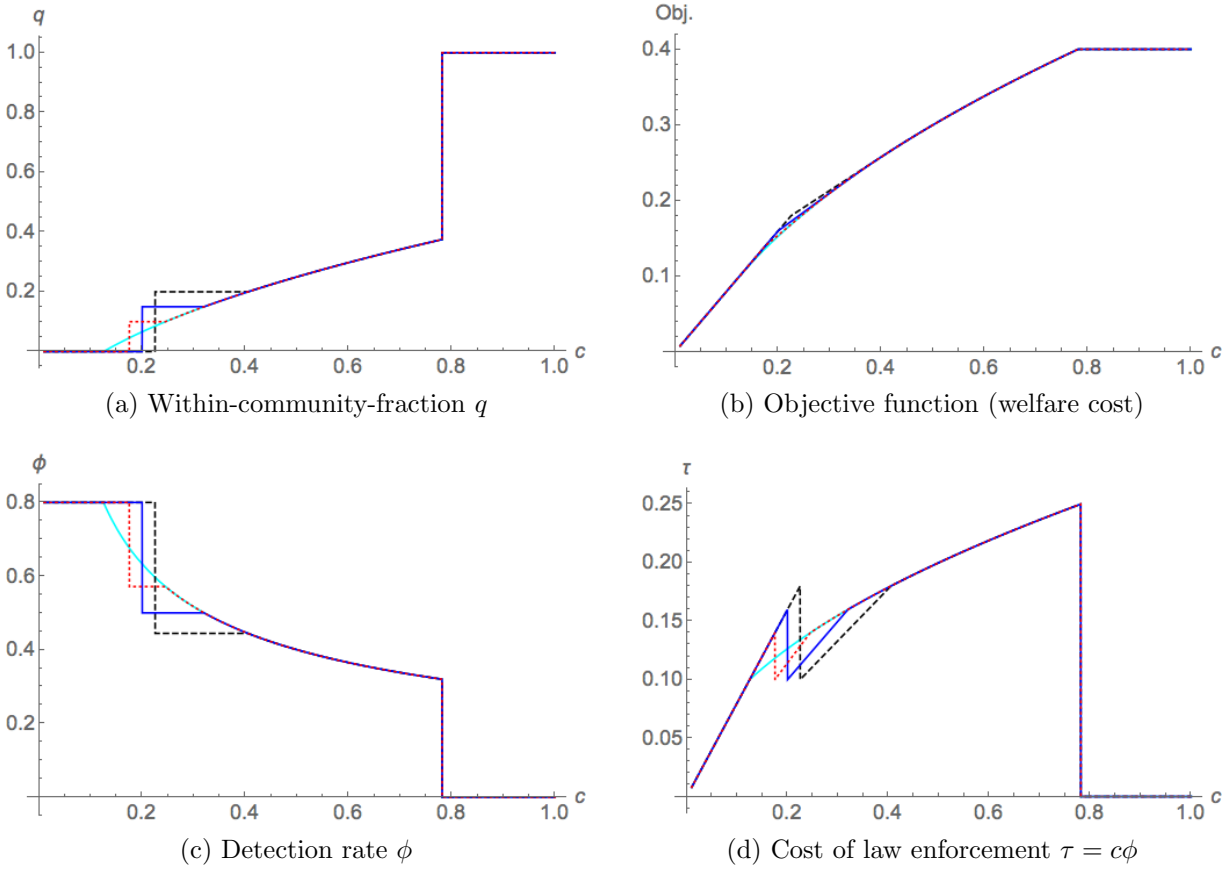
$$t_c \leq S + \frac{\delta q(t_s - t_c)}{1-\delta}, \tag{IC^{comS}}$$

$$t_m \leq \phi f + \phi\psi\frac{\delta q(t_s - t_c)}{1-\delta} \tag{IC^{mark}}$$

The following example is one in which community-specific supernatural punishment has a small impact on welfare even ignoring that it is costless (i.e. $K = 0$).

Example **1 (Community specific supernatural punishment)** *Consider the above setting in which punishment only applies to the interactions within-community. Parameters are the same as in Example 5.1, and $K = 0$, so that there is no cost associated with supernatural punishment.*

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(a) Within-community-fraction q

(b) Objective function (welfare cost)

(c) Detection rate ϕ

(d) Cost of law enforcement $\tau = c\phi$

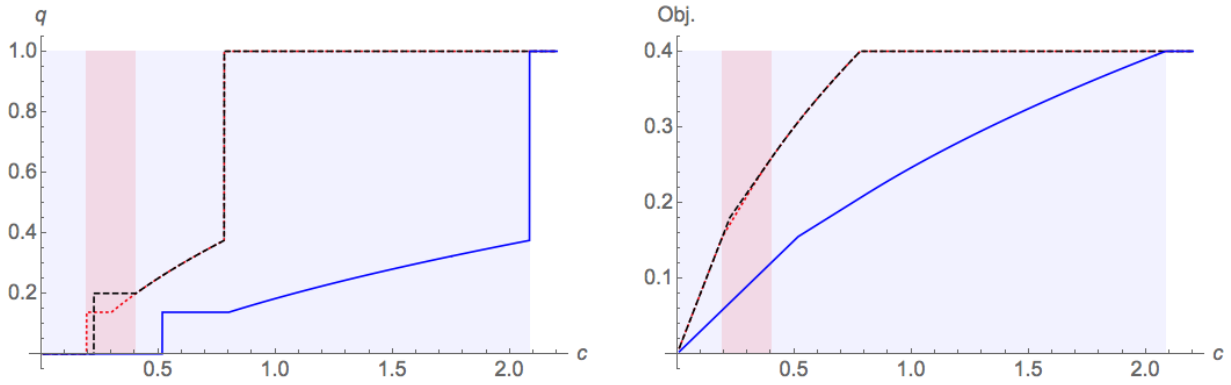
Figure 24: Notes: Dashed: S = 0 (no supernatural punishment, i.e. Example 3.4.1), Blue: S = 0.2, Red dotted: S = 0.4, Cyan: S = 0.8. The first four levels of supernatural punishment are also considered in Example 5.1. One additional level $S = 0.8 = t_c$ is included as a benchmark case: $S \geq 0.8$ (IC^{comS}) never binds.

With the same strength of supernatural punishment as in Example 5.1, existence of supernatural punishment has little impact on the welfare (less than 0.01167 *reduction in costs). Community-specific supernatural punishment alters the optimal system only when* (IC^{comS}) *is binding.*

Comparison between community-specific and universal supernatural punishment.

The effects of supernatural punishment S differ across the two cases: the "community-specific" in which punishment only applies within community, and "universal" in which it always applies to all interactions. This is illustrated in Figure 25, which pictures these two different cases at the same level of supernatural punishment ($S = 0.2$), as well as the baseline case ($S = 0$).

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(a) The fraction of Community Task Provision (q)

(b) Overall Costs (Opposite of Welfare: $c\phi + q(t_c - t_m) + sign(S)K$)

Figure 25: Black Dashed: S = 0, no supernatural punishment; i.e., as in Example 3.4.1. Blue: S = 0.25, universal punishment affecting both community and outside. Red dotted: S = 0.25, community specific punishment only affecting punishment within community. Compared to the baseline case, the effects of supernatural punishment differ between universal and community specific. Universal punishment substantially reshapes the optimal equilibrium (panel a, in terms of the optimal community level q) and lowers overall costs (panel b); whereas when the same level of punishment applies within community only, its effects are very slight. The shaded areas highlight the regions (of law enforcement costs c's) where welfare is strictly higher with supernatural punishment, compared to the baseline case. That region is much wider in the "universal" case than in the community-specific case.

Recall that there are (at most) four possible optimal regimes (i.e., Proposition 1): "all-market", "mixed-with-minimal-community", "mixed-with-above-minimal-community", and "all-community". These regimes are listed in terms of the corresponding c's (from low to high), and separated by the three thresholds $c_k^{mark} \leq c_k^{mix} \leq c_k^{com}$, in which the subscript $k = 0, c$, or u refers to the baseline no supernatural punishment (0), community-specific punishment (c), and the universal punishment (u) cases, respectively.

When S is community-specific, its only role is to lower the minimal (self-enforcing) community level $\underline{q} \equiv \frac{t_c - S}{V}$, and therefore lowers the thresholds of the second (from left) regime "mixed-with-minimal-community". The community-specific S strictly improves social welfare for $c \in (c_c^{mark}, c_0^{mix})$ (the red shaded region in Figure 25): in (c_0^{mark}, c_0^{mix}), a positive supernatural punishment S relaxes (IC^{comS}), which was binding without it; and in (c_c^{mark}, c_0^{mark}), the positive S allows some community to be used in the optimal equilibrium.

When S is universal, an increase in S relaxes both incentive constraints: it not only lowers $\underline{q}$, but also allows for a smaller law enforcement effort ϕ. As a result, a positive S affects the thresholds of all the our regimes, and strictly improves welfare for a much wider region, as long as $c < c_c^{com}$ (the blue shaded region in Figure 25).

The two cases also differ in the *direction* of changes in thresholds: community-specific S lowers c^{mark} and c^{mix}, so that community is active for a larger region of c's; whereas universal S increases all the three thresholds c^{mark}, c^{mix} and c^{com}, so that market is used more.

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The above observations are summarized in Proposition 7. The subscripts denote difference cases: u refers to the universal supernatural punishments, and c the community-specific case.

PROPOSITION **7 (Comparative Statics in Supernatural Punishment S)** *As S increases ($S_2 > S_1 \geq 0$), welfare weakly increases. Moreover,*

- *if supernatural punishment is universal, welfare strictly increases as long as some market is used after the change ($0 < c < c_{u2}^{com}$, or $q < 1$); as for the thresholds, $c_{u2}^{mark} > c_{u1}^{mark}$, and in addition $c_{u2}^{com} > c_{u1}^{com}$ when $C = c\phi$;*
- *if supernatural punishment is community-specific, welfare strictly increases only for the "mixed-with-minimal-community" regime ($c_{c2}^{mark} < c < c_{c1}^{mix}$, or $q = \underline{q}$); as for the thresholds, and $c_{c2}^{mark} < c_{c1}^{mark}$ and $c_{c2}^{mix} < c_{c1}^{mix}$, while $c_{c2}^{com} = c_{c1}^{com}$ remains constant.*

Proof of Proposition 7

An increase in S weakly increases welfare because it relaxes one or both incentive constraints.

When S is universal: in $(0, c_{u1}^{com})$, (IC^{mark}) was binding before the increase. As a result, the increase in S brings a marginal benefit of at least $c > 0$ (in saving the cost of law enforcement); in $(c_{u1}^{com}, c_{u2}^{com})$, the welfare in "all-community" does not change in S and observe that "all-community" is optimal under S_1 but dominated by a mixed regime under S_2, therefore welfare is strictly higher when S increases from S_1 to S_2.

As for the thresholds: for c^{com} observe that $H^{mix-high}$ decreases in c and decreases in S whereas $H^{all-com}$ is constant in both c and S. Thus, c^{com} – as the solution to $H^{mix-high} = H^{all-com}$ – must increase in S.

For c^{mark}, assume $C = c\phi$. By definition c^{mark} solves $H^{mix-low}(c; S) = H^{all-out}(c; S)$. Similar to the analysis A.1 (which was for $S = 0$), it follows that

$$c^{mark} \equiv \left[\frac{1}{f} - \frac{1}{f + \psi t_c - \psi S}\right]^{-1} \frac{(t_c - S)}{(t_m - S)} \frac{(t_c - t_m)}{V}$$

increases in S (as both of the first two terms increase in S).

Now we turn to the second case where S is community-specific. In this case, S only relaxes the within-community incentive constraint, (IC^{comS}), and has no effect on (IC^{mark}). Therefore, welfare strictly increases only when (IC^{comS}) is binding, before or after the increase. In particular: in $(c_{c1}^{mark}, c_{c1}^{mix})$, (IC^{comS}) was binding under S_1 and is relaxed under S_2; in $(c_{c2}^{mark}, c_{c1}^{mark})$, "all-market" was the optimal equilibrium under S_1, whereas under S_2 "all-market" leads to the same welfare but is dominated by a mixed equilibrium with positive level of community, as the increased supernatural punishment requires a smaller minimal community level.

In terms of the overall costs H's, $H^{mix-low}$ (strictly) decreases in S and c, whereas $H^{all-com}$, $H^{all-out}$ and $H^{mix-high}$ all decreases in c but invariant in S. Therefore, c^{com} – as the solution to $H^{mix-high} = H^{all-com}$ – is invariant in S.

Now consider c^{mark}, the solution to $H^{mix-low} = H^{all-out}$. It follows from the same steps in Proof of Proposition 1 that $\frac{\mathbf{d}}{\mathbf{d}c}(H^{mix-low} - H^{all-out}) < 0, \quad \forall c > 0$. Intuitively, a smaller overall

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cost is saved in the "mixed-with-minimal-community" regime as it adopts a smaller level of law enforcement ϕ than the "all-market" regime. In addition, it follows from the above observations regarding H's that $H^{mix-low} - H^{all-out}$ decreases in S. Therefore, c^{mark} decreases in S.

Finally, consider c^{mix}, the threshold that separates the two mixed regimes. Observe that $q^{mix-high}$, the optimal community level in the "mixed-with-above-minimal-community" regime, increases in c and invariant in S. Therefore, c^{mix} – as the solution to $q^{mix-high} = \frac{t_c - S}{V}$ – decreases in S. ∎

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