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MANUSCRIPT

An equilibrium model of how regulative and normative institutions influence micro-economic and organizational behavior

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Abstract This paper investigates how pre-existing institutions foster economic development through trade. A non-cooperative game-theoretic model is proposed that combines three strands of social science: economics, political science, and sociology. Idealized market participants follow rational decision theory within a reward structure that embodies two types of institutions. Regulative institutions operate on threat of punishment, and normative institutions on perceptions of what is good and right. This composite model allows a more quantitative analysis of the question, raised by Douglas North, of how societies diverge from the efficient state predicted by classical micro-economics. The main finding is that value can be created by different types of institution even when they are imperfect, and the range of minimum–maximum effectiveness varies with the types of economic transactions that are technologically possible. It is hoped that further refinements of the model will yield greater understanding of how the success of societies and organizations can be predicted by a few simple rules.

Keywords Rational decision model · Economic growth · Institutions · Organizations · Trust

1 Introduction

The role of pre-existing institutions in the formation and preservation of markets for economic transactions is increasingly popular as a topic of research (Yellen 2011, e.g.). There is a widespread realization that any economic transaction, no matter

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how profitable, will only occur when all parties to the transaction can overcome their fear that any other party will use violence, deception, or other nefarious means to abscond with more of the value than was initially agreed (Selznick 1994; Sen 1997; Olson 1984; Olson and Kähkönen 2000; Greif 2006; Scott 2007; Ebner and Beck 2008; North 1990; North et al. 2009; Acemoglu and Robinson 2012). This recognition, shared by researchers in many different fields, has yet to challenge the elegance and ubiquity of the canonical microeconomic models of Adam Smith and Léon Walras despite many calls to do so (Keen 2003). Instead, the field of development economics has relied on empirical correlations between measures of institutional quality and measures of economic development (Chong and Calderón 2000). The field of organizational governance also remains more cognizant of classical and neo-classical organizational models than of the newer, less well understood, approaches of the newer works from Mintzberg (1991) to Pfeffer (2015).

There is no simple quantitative model that abstracts what we know about institutions to a level of generality similar to Boolean logic, with its stark choice between true $= 1$ and false $= 0$. Such a model would naively throw out much of what we know about the nuances of how institutions affect personal interactions. In exchange, it would produce complex phenomena by emergence from many small, simple decisions. The objective of this modeling effort would be to derive patterns of rational decision making that can explain historical observations about economic development under imperfect governance. For example, a party provides an institutional service necessary for stability can afford to give itself certain privileges and exemptions, so what is the trade-off? When is doing so tolerable and when does it start to adversely affect the society's success? This age-old question is as relevant as ever today, with international events highlighting the power of parties that appear unsustainably self-serving, but which continue to survive and thrive enough to merit mention in the evening news.

In the next section, we describe some of the prior work that has inspired our attempt to build such a model. Section 3 builds up the details of our quantitative model based on select ideas from prior work. Section 4 gives some quantitative outcomes of letting multiple institutions simultaneously act on the same population, including phase diagrams of distinct societal configurations. Finally, Sect. 4.5 summarizes the most significant ramifications of the analysis, and Sect. 5 summarizes the contributions, limitations, and expected future developments.

2 Background

The connection between institutions and prosperity has been explored by scholars in different fields, from sociology to history to economics. Three men who themselves conducted encyclopedic surveys as well as making recognized advances in the state of the art are Mancur Olson (Olson 1971, 1984, 2000; Olson and Kähkönen 2000), Dick Scott (Scott 2007), and Douglas North (North 1990; North et al. 2009).

2.1 Economics

"Development Economics" is the field that asks why different social structures (e.g., third-world economies and historical non-cooperative "dark ages") are slower to develop than modern economies. More recent efforts focused on why post-communist economies did not catch up to first-world economies as quickly as expected (Olson 2000). Today, there is a sober realization (following the 2008 financial crisis) that even the advantages (transparency, participation, rule of law) used to explain economic development are not completely accurate descriptions of the most advanced economies (Acemoglu and Robinson 2012), and that indeed all economics is development economics. We try in this paper to put the questions of development economics at the heart of basic microeconomic thinking.

Another sub-field of economics deals with the effects on economic activity of crime and the efforts to control it (Becker 1968). We propose that the thinking applied to criminal activity is also valid in the thought process of all economic actors, as are the ideas from behavioral economics about altruism (Dreber et al. 2014)

2.2 Sociology

Olson (1971) pioneered the marriage of sociology and economics by telling the story of the "stationary bandit", who transforms selfish violence into a special type of institution, "the state", in order to reduce future violence and gain more wealth. Among other explorations of the properties of what we are calling "Pi-institutions", several works (Olson 1984, 2000; Olson and Kähkönen 2000) show how Pi-institutions cause economic growth to ebb and flow in cycles, explaining economic variations across recent history and geography.

North (1990) expanded into book form several notions about how institutions foster wealth creation. Institutions facilitate economic interactions by reducing uncertainty, and the organizations that maintain an institution are distinct from the institution itself and can themselves be economic actors in competition with non-institutional actors. He employs these insights to explain several historical phases in the growth of the world's economy, and concludes by noting that the serious study on institutions is just beginning.

North et al. (2009) focuses on the protection against violence that institutions, especially of the regulative type, provide. The "natural state" describes multiple sovereign sets of institutions that coexist with their neighbors through a mutual agreement to maintain each other's monopoly not only on violence but also on legitimacy. This is contrasted to the "open state" when all economic actors have equal rights and sovereignty is maintained through different arrangements. North et al. (2009) concludes that a society that achieves the "open state" will have a higher level of economic performance, and offers economic development data to support this. It is not clear that events such as the global economic crisis of 2008 are not better explained with a more cyclical paradigm such as the one proposed by Olson (2000).

2.3 Organizations

Mintzberg (1983) took the study of organizations into a new era by augmenting the hierarchical command-and-control tools of classical organization theory with worker-centered methods. Hierarchical control and standardization of process are familiar from the works of Taylor, Fayol, Weber (Shafritz and Ott 1996). Mutual adjustment between co-workers, and standardization of inputs or of outputs, were described a part and parcel of the manager's toolkit. But in later works, Mintzberg (1991) re-asserted the power within an organization of the archetypal means of pooling human effort in the face of selfish human nature. He called them "Politics" and "Ideology". These are the two forces that we are concerned with modeling. Pfeffer (1981) described political power as the ability to reward and punish outside of strict unity-of-command hierarchy, and to do so consistently enough to achieve an expectation becomes self-enforcing. Associating power-based management with the "coercive institutions" of Scott seems appropriate, since both mechanisms operate on the justified perceptions of a whole class of people. Pfeffer (2015) expands on the distinction between a leader's motivation to improve the organization versus her or his need to improve her or himself. This distinction is too important to leave to pat moralization.

2.4 Game theory

A central component of the Theta–Pi mode is the "Prisoners' Dilemma" (Von Neumann and Morgenstern 1944), and its versatile cousing the iterated prisoners' dilemma (IPD; Maynard Smith and Price 1973; Bueno De Mesquita et al. 1999). Simpler and more generous IPD strategies famously out-compete more complex and selfish ones (Axelrod 1980, 1987; Nowak and Sigmund 1993). Other games, such as the "Dictator" and the "Anti-Prisoners'-Dilemma" game, have also been used as bases for squaring altruism with self-interest (Neilson 2009). Our model builds on the effect of permitting a choice to cease participating in the game as a means to avoid loss or to inflict damage (Aktipis 2004).

Game theory is not the only source of rational explanations of altruistic behavior. Inspired by psychological and biological research, social scientists have devised several models of how altruism can survive for reasons such as human docility (Simon 1990) and relative advantage (Bolton and Ockenfels 2000).

Complex agent-based systems have been used to describe how these systems evolve to transition to the observed macroeconomic states and structures (Gatti et al. 2010; Sunder 2006). Another body of research, inspired by Becker (1968), analyzes the consequences of crime on economic activity. Polinsky and Shavell (1999a, b) more explicitly modeled various elements in the economics of public law enforcement, and explained their consequences on social welfare. Notions of cooperation and punishment have been visited carefully through research that combined game theory with agent-based systems (Kulakowski 2009) and even more by reinforcing them with simulations based on evolutionary selection and adaptation (Darcet and Sornette 2008).

Finally, we mention the work on embedding altruistic tendencies into the rational decision process (Henrich et al. 2001; Hwang and Bowles 2012) as a more thorough precursor of the deliberately simplified approach that we plan to take.

2.5 Scott's typology of institutions

Scott (2007) proposed a three-way system to both classify and analyze institutions. While acknowledging that every institution really has elements of all three members of Scott's typology, we will simplify by focusing on the classification interpretation of Scott's typology. This typology distinguishes between:

(1) coercive/regulative/retaliative institutions that deal with establishing legal guilt or innocence;
(2) empathic/moral/normative/social-obligation institutions that distinguish shame and honor; and
(3) cognitive/cultural/informative/mimetic institutions that operate on the level of knowledge versus ignorance (or certainty vs. confusion).

Scott (2007) explains how a pattern of actions becomes an *institution* when past experience convinces many people share a reasonable expectation that *others* will also follow this pattern in future. This suggests that we can use the language of game-theoretic equilibrium to describe the process of institution formation.

Scott also distinguishes between the social need fulfilled by an institution and the needs of "institutional entrepreneurs" who maintain the institution. The institution, for example, of "Democratic Republic" might be followed, built and defended by groups that followed George Washington and wrote and continue to respect the US constitution.

We will now use Scott's typology to capture with some rigor the interaction between institution and the basic unit of economic activity, the trading pair. We take the three types in reverse order of relevance to our modeling effort.

2.5.1 Cognitive institutions

The economic effect of cognitive institutions is to facilitate trade by ensuring that the same meaning is attached to different symbols: common language, unified weights and measures, monetary instruments, notions of possession and legitimate ownership, and measures of the quality of goods. It is possible to gain the benefits of a cognitive institution by observing it in action. The only way to exclude a party from access to a cognitive institution is to use one of the other two types. If we are seeking to describe the long-term equilibrium state, then the passage of time will have ensured that all who stand to benefit from a cognitive institution have the means to obtain that benefit.[1] This allows us to neglect cognitive institutions in this paper.

[1] An exception to this is when the equilibrium state itself is path-dependent. When a different equilibrium is reached depending on what was assumed early on, then we have a self-fulfilling cognitive effect. We revisit this in Sect. 3.

2.5.2 *Coercive institutions*

The next type of institution classified by Scott (2007) has to do with laws, law enforcement and punishment or retribution. Whereas the classical IPD literature investigates individual retaliatory behavior (Maynard Smith and Price 1973; Axelrod 1980, 1987; Aktipis 2004; Prietula and Conway 2009), coercive institutions introduce the notion of a third-party law enforcer. Instead of the rational benevolent dictator proposed by Cohen et al. (2001), we can simply add an impersonal "probability of getting caught" to the decision parameters, and call it π (pi) (see Sect. 3.2). This allows the same simple representation to encompass the broadest interpretation of coercive institutions, namely any approach that building trust in a population through universal sanctions against violators. For example

(1) Mutual defense pacts,
(2) Social ostracism (Greif 1989),
(3) Kings, judges, nobles (North 1991),
(4) Laws and police,
(5) Fear of punishment in the afterlife.

2.5.3 *Empathic institutions*

Institutions such as the family, the tribe, and different ideologies that stress belonging to a universal group can all induce people to engage in economic transaction that they would normally fear. We propose to model the effects of the increased trust engendered by these institutions using a single variable, θ (theta), that describes a limited *expansion of the locus of utility*. We summarize this tendency with one generalization, ignoring many tempting venues for elaboration such as: cooperative rationales as classified by Sachs et al. (2004), personality traits as quantified (and partially dismissed) by Dreber et al. (2014), or vector representations like those of Ok (2002). We assume that some actors, some of the time, act as if they are maximizing the utility that accrues to themselves plus a small fraction θ of the utility that accrues to the select counter-parties in an transaction. This implies not only willingness to take a personal loss in exchange for a group gain, but also a preference for losing to a cohort over losing to a stranger. When this propensity is not only accepted but also routinely expected, it becomes part of the rational calculation of behavior, i.e., an institution. We call this the "empathic institution", "theta-institution", or θ-institution and describe it below in Sect. 3.1.

Expansion of locus of utility is a very sparse expression of a range of tribal behaviors that seem to have been neglected by post-enlightenment thinking despite being observed daily in politics, business and even sport. Examples of empathic institutions include:

(1) sharing and believing a mythology of common ancestry or metaphysical connection,

(2) "love thy neighbor" sermons, whether religious, nationalist, communist or military,
(3) conferring valuable social capital to those who follow rules such as
   – *altruism* self-identifying with others' misfortunes regardless of one's role, or
   – *integrity* taking responsibility for any harm one causes to counter-parties,

(4) analysis, either cognitive or by natural selection, a series of past transactions that led to success or failure,
(5) anticipation either cognitively or emotionally, a series of future transactions with similar partners.

Building a model of how Scott's institutions might operate on an individual rational actor, we are able to supersede the artificial dichotomy between "natural" and "open" systems in the language of North et al. (2009). It is only in the degree of closeness to the ideals (widespread concern for public good and of universal jurisdiction of criminal and tort law) that different societies differ. As Olson (2000) put it, rights-respecting markets with low predation bring more prosperity the closer a society comes to that ideal state, and less prosperity if (when) the society allows those benefits to erode. What we propose to add to this in Sect. 3 below is a quantitative treatment of this idea, with the goal of proposing that a smooth transit along this continuum, from the least commerce-friendly state of nature to its most enlightened hypothetical antithesis, can give rise to punctuated series of plateaus that represent distinct stages of economic development. More generally, we propose that extreme simplification in the basic building block of a socio-economic interaction can yield a better understanding of complex behavior.

3 Development of the theta–pi model

Consider a hypothetical farmer who knows he can gain from bringing his goods to market to trade with other farmers. He fears that he might be molested en route or cheated in the trade. This farmer faces a classic decision situation where risk has to be taken to get a shot at a reward. Assume, for the sake of symmetry, that the farmer also has a choice of bringing to market produce that he knows to be unsuitable for trade but which looks outwardly acceptable, or of going to market with weapons or a fast horse in order to avoid paying. The farmer's decision becomes a variant of the classic prisoners' dilemma when the two parties only discover one another's true choice after the transaction, not before (competitive equilibrium), and the payoff matrix (Table 1) has values that fit the following inequalities.

$T > S$: the temptation (T) to be the only cheater in a binary transaction is higher than the reward (R) of an honest transaction.

Table 1 Prisoners' dilemma payoff matrix

		Party 1 choice	
		Cheat	Trade
Party 2 choice	Cheat	P, P	T, S
	Trade	S, T	R, R

$S < P$: being the only cheated party ("sucker" S) is less valuable (more painful) than being one of two cheaters and getting punished (P).
$2R > T + S$: the total benefit to two honest parties ($2R$) exceeds the sum of the cheater's gain (T) and the sucker's loss (S).

A rational actor would prefer to stay at home if this type of interaction ($T \geq R$) is perceived to be the only type or even the predominant type on offer.[2] If we assign a value of zero to "stay at home", then S and P, being less attractive than staying at home, would be negative, and R and T would be positive.[3]

Transactions with $T < R$ are "self-enforcing". They can happen in every society, but they predominate in societies that do not have institutional mechanisms to deal with predatory behavior. As established in Sect. 1, this mechanism can take one of two forms.

3.1 Theta-institutions

The first component of the proposed theta–pi model is the theta institution, which works by increasing trust as a rational consequence of an *expanded locus of utility*.

If every actor a in a population comes to expect that any counter-party b with whom a transacts will consider some fixed proportion θ of the good or ill that befalls a, as part of the whole utility that b will maximize, then we have functionally defined an institution. This institution reduces fear of predation and hence increases economic activity.

Quantitatively, the variable θ (with value between 0 and 1) enters into the valuation of every transaction. The decision maker subject to the institution rationally acts to maximize the transaction's utility to the decision maker U, plus θC, a proportion of the transaction's utility to the counter-party. C is zero when there is no transaction ("stay home") or if a coercive institution nullifies a transaction ("caught", as described below). In this paper, we consider a constant θ that represents a functionally neutral average for the whole affected population. We

[2] In the context of an employee in a bureaucracy, this corresponds with keeping one's head down, nose to the grindstone, and not contributing ideas, critiques or initiative to the organization, out of fear that someone will steal the idea or use it against the originator.

[3] This does not consider the effects of marauding armies or roving slavers who invade homes. But if we consider the military advantage of defense over offense then it becomes clear that in order to raise the military force to be a marauder or slaver, one must first have an institution that delivers military fealty of soldiers to captains. This is what we are trying to build in this model, so we first focus on a historical period where this has not happened yet.

leave for future work the task of treating θ as a random variable with a certain distribution.

3.2 Pi-institutions

The other reason for people to trust a trade partner is that the trade partner might have a reasonable fear of being caught and punished by a law enforcer who also makes full restitution to the victim. We represent this probability with the variable π and define "getting caught" as receiving the worst possible outcome in the pay-off matrix without any cost to the counter-party.[4] Institutionalization follows when all actors expect a random trade partner to only choose to break the law if doing so rationally follows from the values of π (and θ) perceived by the partner. Personal agreement with or acceptance of the law, and even fair application of the law, are not conditions of institutionalization (unlike the case with theta-institutions). The model works when there is universal expectation that the law will be applied in a predictable way.

For any particular economic transaction, whether solely between farmers or whether also involving craftsmen, thieves or warriors, the degree of temptation T and sucker's payoff S relative to the transaction's reward R are the main determinants of the minimal strength of θ and π institutions necessary to make a transaction with those characteristics happen. Higher $\frac{T}{R}$ means that more are tempted to cheat, and higher $\frac{-S}{R}$ more trade is inhibited for any given probability of being cheated.

But how do the effects of θ institutions differ from the effects of π institutions? The answer requires further analysis. In Sect. 3.3, we focus on economically symmetric transactions, where the values for R, T, P and S are the same for both parties. We will introduce asymmetries in θ and π later in this paper (Sect. 4.3). We will defer to a separate paper economic transactions, such as employee–employer contracts, where the parties face very different payoffs for various behavior.[5]

3.3 Model description

The theta–pi model consists of a thorough mathematical treatment of the decision tree in is Fig. 1. The only assumption, vertiginously sweeping, is that all economic activity can be broken down into a large set *dyadic* interactions represented by this decision tree. This simplification would be extremely powerful if it can be shown that any complex interaction that is not symmetric or that simultaneously involves multiple parties can be broken down into an "atomic" set of interactions that are

[4] As mentioned in Sect. 2.5.2, this is over and above the risk of the trading partner retaliating or "cheating back", because legal pursuit is only triggered after the predatory behavior has taken place. Provided the aggrieved party did not also run afoul of the law, the culprit will be apprehended (with probability π) even long after the transaction is over. In addition, unlike individual retaliation, the cost to the law enforcer is not a factor in the decision to pursue.

[5] Existing economic theory, such as supply–demand curves under monopoly or competition, already yields well known conclusions regarding the causes and effects of asymmetry in transactions.

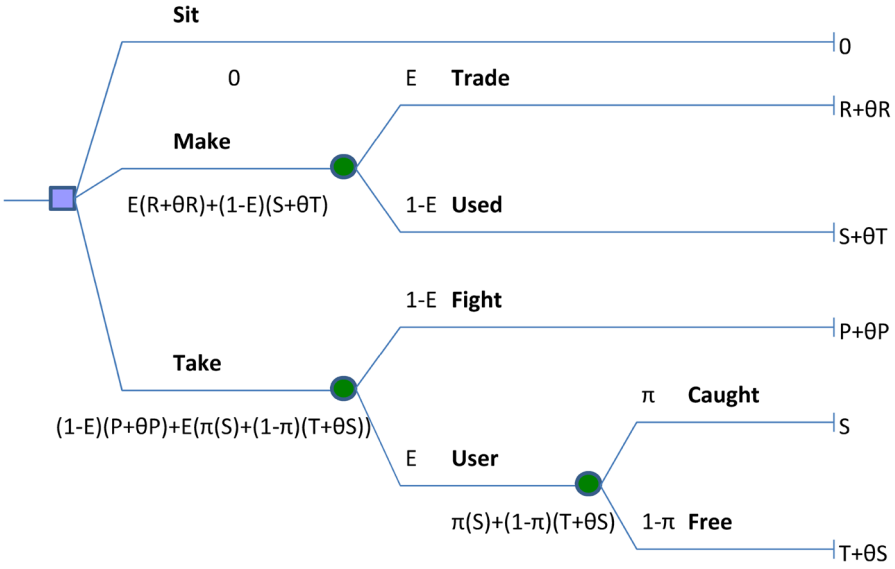


Fig. 1 Economic actor's *decision tree* under two institutions

dyadic and symmetric. More research will need to be done to show whether and when this assumption holds.

The choices faced by every participant in economic activity, subject to various parameters, are generalized as the following three options:

(1) staying home, which denotes opting out of the economy and is labeled with the short term "sit",
(2) transacting in good faith, which denotes productive activity and is given the short label "make", and
(3) transacting with intent to cheat or steal or engage in other activities that can be classified as predatory behavior, labeled "take".

E, the probability that the counter-party choosing to "make", is the main descriptor of the equilibrium state when two decision makers face off. The probability of being cheated given a decision to "make", and being extra-legally punished by the counter-party given a decision to "take", are both given by $1 - E$. Competitive equilibrium means that the average E of individuals responding to the tree is the same as the E that describes the expected behavior of the other party.

The payoff considered by the decision maker is $U + \theta C$ as explained above. If no interaction takes place, ("sit" decision or "Take + Caught" outcome), then $C = 0$. The strength of two types of institutions are represented by θ for the empathic institutions and by $\pi = \text{P[getting caught|"take" decision]}$ for the retaliatory institutions. The probability E of the counter-party choosing "make" over "take" is obtained by finding the equilibrium state after each party learns how others will behave, and excluding all "sit" parties since they will not be in the population that

any trader will face. The number of "make" interactions increases as θ and π increase. The model allows us to calculate the increase in wealth that comes from strengthening each type of institution. Hence, we can put a price on each, namely the amount that society as a whole would be willing to pay for the maintainers of each type of institution under different circumstances.[6]

4 Analysis and discussion of selected scenarios

4.1 Base case: perfect homogeneity

Consider a (fictitious) homogeneous population which can conduct a single type of economic transaction with a known payoff matrix. The competitive (Von Neumann) equilibrium can be found by inspecting the payoff matrix and finding the E that cannot increase or decrease without harming the party trying to make it increase or decrease.[7] Each person will follow the strategy that maximizes his payoff, and because the population is homogeneous, and there will be no uncertainty regarding the counter-party's behavior.[8]

The introduction of a uniformly effective police force that catches and punishes exactly a proportion π of all predators will lead to an institution where everyone faces the same decision tree. It might take time for everyone to learn the value of π and to learn that everyone else faces the same chance of being caught. But ultimately, the population reaches equilibrium, when everyone knows all there is to know about the state of the population, namely that preferences are homogeneous and knowledge is also homogeneous. The probability of encountering a predator can then therefore only be 0 or 1. Which one it is depends mainly on the temptation and sucker payoffs T and S, and the police effectiveness π. Clearly, and without any further calculation, the higher π becomes, the larger the pool of transactions that will be attractive due to the addition of transactions with higher T and S.

Similarly, the introduction of a set of beliefs, be it an expectation of future benefit, a genetic kin-selection evolutionary effect, or a set of shared myths about creation, identity or destiny, can lead to a uniform level of empathy in a population. Everyone in the population feels exactly θ of the pain or pleasure of the parties with whom they interact. If everyone faces the same decision tree and preferences are identical, then institutionalized empathy will again lead to $E = 0$ or 1. As with the coercive institution, the empathic institution can expand the economy by making a

[6] An organization entrusted with maintaining an institution of either variety may end up extracting more value than it adds. This imbalance is suggested by other researchers (Olson 1971) (notably). We plan to analyze this issue in depth using the theta–pi model in a future paper.

[7] Mathematically more complex equilibria are found by calculus or numeric methods, but the games the occur in this paper are all solved by inspection.

[8] Except for cases where an equilibrium fails to exist, such as when the payoff matrix is such that the winning strategy is a mixed strategy. For example a game like rock-paper-scissors only has an equilibrium in mixed strategies, namely to pick one of the three move at random exactly one third of the time. The prisoners' dilemma game does not have a mixed strategy equilibrium, but some of the derivative games used in this decision model might.

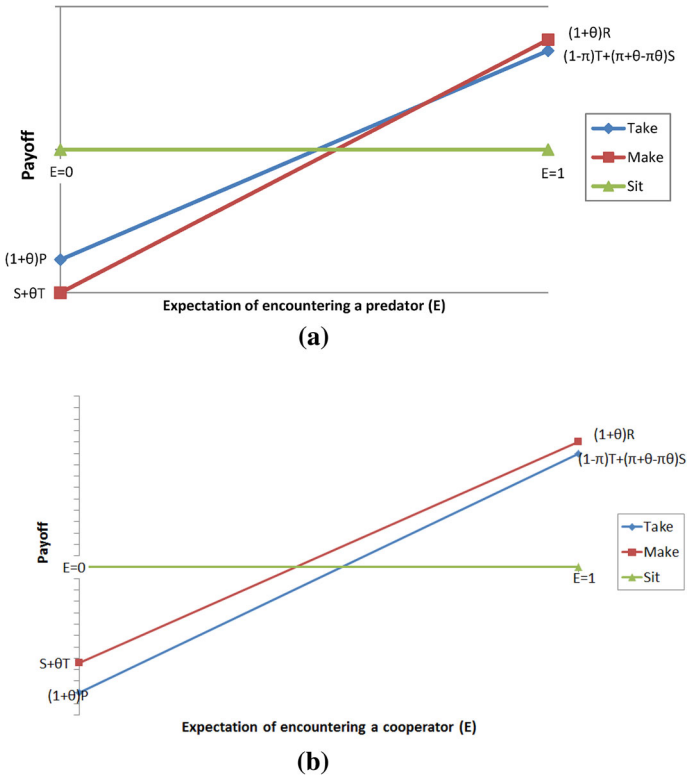


Fig. 2 Expected payoff of different moves in a homogeneous population. **a** "Make" and "Take" intersect. **b** "Make" always above "Take"

transaction with higher S and T less likely to lead to a net loss than staying at home. The higher θ becomes, the larger the pool of transactions.

An algebraic exercise can help determine the relationship between the two types of institutions and the level of economic activity. Figure 2a represents the value of each choice in the decision tree of Fig. 1, under different values of E. Remember that E is the probability of transacting with someone who chooses the "make" move, so in a population, it is the ratio of:

(1) the number of decision makers for whom "make" is the best choice, to
(2) the number of decision makers who choose not to "sit" and thus put themselves in the market.

An equilibrium exists if, at $E = 1$, the value of the "make" choice exceeds the value of the "take" choice. This can occur if π and θ are such that:

$$R(1+\theta) > \pi S + (1-\pi)(T+\theta S). \tag{1}$$

If this is not the case, then there is a probability of encountering a trade partner who chooses "take". In a homogeneous population at equilibrium, one decision maker preferring "take" means that all decision makers will prefer "take", so $E = 0$. If $E = 0$ then the value of "sit" will exceed that of the other two choices.

We mentioned in Sect. 1 that the equilibrium state could be path-dependent, which, in this case means that either $E = 0$ or 1 equilibrium could be reached depending on what the different parties knew or assumed about E early on. This happens when the "make" and "take" lines intersect above the "sit" line as in Fig. 2a, with the value of "make" higher at $E = 1$. If we denote by E_i the value of E at this intersection, then an initial expected E to the right of E_i will lead to a "decision", and population homogeneity expands this to mean $E = 1$ at equilibrium. However, if initial E is less than E_i then the logical choice would be to "take". E approaches zero as a result, but this only means that most of the population will choose to "sit". But when the limit is reached and all "sit", then there will be no participants in the population, so E becomes undefined.

With this analysis, we can now determine the values of π and θ that leads to one of these possible equilibrium states given any set of values of T, R, S and P. Figure 3 maps the regions corresponding to different encountered equilibria along the spectrum of institutional reach:

- The region under the curve corresponds to all decision makers choosing "sit", and consequently E will decrease to zero.
- The region above the curve corresponds to the population choosing "make", and consequently E will converge to 1.
- The dashed area illustrates the region in which the steady state is sensitive to the initial expectation of market participants.

The dashed area exists for certain values of T, R, S and P when not only Eq. 1 is true ("make" beats "take" at E = 1) but also when the "take" and "make" lines

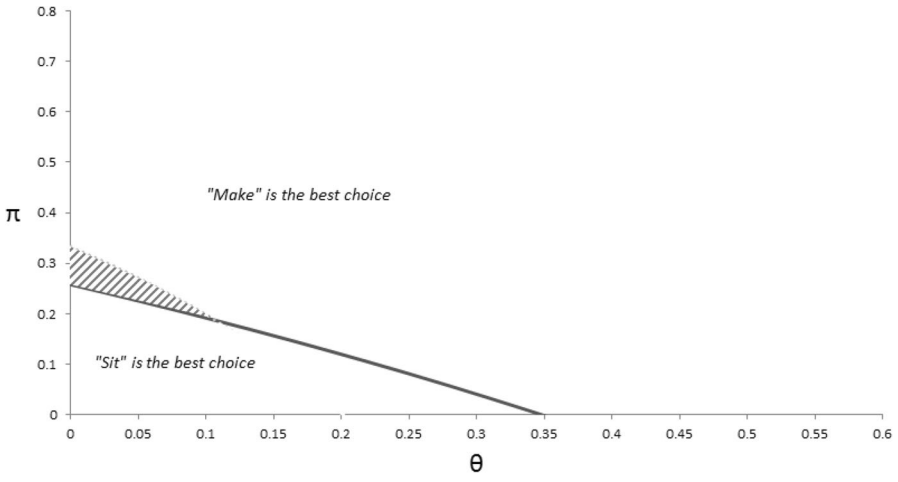


Fig. 3 Different steady state outcomes under the effect of institutions

cross above the "sit" (Value = 0) line, as shown in Fig. 2a. Algebraically, the dashed area exists when:

$$\pi < \frac{\theta^2(ST - PR) + \theta(T^2 + S^2 - 2PR) + (ST - PR)}{\theta^2 TS + \theta(T^2 + S^2 - ST) - (S^2 + ST)}. \quad (2)$$

The phase diagram illustrating the steady-state outcomes of different parameter combinations (Fig. 3) shows that there is a threshold beyond which any combination of empathic and coercive institutions start making it feasible for the society to benefit from any given transaction class (as typified by fixed T, R, S and P). The marginal value of an increase in the strength of each institution is the value of all economic transactions that become possible with the strengthening of that institution. This can be found by calculus provided we know how much economic opportunity is comprised of transactions with certain values of S and T to R and P. If we also know the cost of strengthening each institution, then we can formulate an optimization problem to find the least costly increase in each of π and θ needed to achieve maximum economic activity.

4.2 Variation in predominant type of transaction

To further explore the solution space of the theta–pi model for homogeneous populations, we can assume a fixed $R = -P$ value and vary the ratios of T to $-S$ to that value.

For face-to-face trade in small goods, such as at the farm fair introduced earlier, the values of $-S$ and T are in the same range as R and $-P$. The benefit of getting a bag of fruit by trickery is not much greater than the benefit of exchanging that bag for a perfectly good bag of fruit that you cannot consume. Similarly, the cost of losing a bag of fruit in an exchange against defective pottery, which might spoil or waste your oil or wine, is not much greater than the cost of exchanging bad fruit for the same leaky jug. This kind of transaction is of the low-T/low-S type, because of the relatively small difference between S and P, and between T and R.

We contrast this to the case of a long-distance merchant whose trade depends on agents in far-away places. If the agent is a "taker", the merchant stands to lose not only his profit but also his capital, while the agent gains not only his cut of the profit but a whole ship-full of merchandize. Similarly, a "taker" merchant could send an empty ship and then sue for payment for the cost of the capital as well as the lost profit. Long-distance trade offer high temptation to potential cheaters and a significant loss for the party cheated (Greif 1994). In other words, we could call this a high-T/high-S trade.

For a low-T/high-S transaction, we can look at the manufacturing sector, where an assembler might procure components from different suppliers. If one component is bad, then the assembled product will lose almost all of its value, incurring a high cost for the assembler. The temptation for a single supplier to cheat on this trade is low but the sucker payoff is high.

Conversely, a wholesaler who procures goods from a big number of manufacturers and then sells them to different clients might be tempted to steal the whole

load. However, each manufacturer would suffer only the loss of its own component. In this case, higher temptation is coupled with lower sucker-payoff (high-*T*/low-*S*).

The phase diagrams in Fig. 4 illustrates the effect of institutions on each of the four types of transactions.

Clearly, when temptation is low, as in the cases of the farmer and the assembler, cheaters can be completely deterred with smaller values of π and θ. The theta–pi model also tells us that both π and θ have almost equal effects on the size and the shape of the "make" region. However, the path-dependent region is broader as $-S$ increases.

When temptation is high, analyzing transaction while varying S leads to two interesting observations:

(1) When sucker's payoff is low, the curve separating a healthy economy from a suppressed one is almost horizontal, meaning only π is effective. The effect of θ seems to be more important as $-S$ increases and approaches T.
(2) As $-S$ increases, fewer transactions are deterred.

The first observation is mathematically substantiated by finding the straight-line approximation of the make/take curve and then by taking a derivative with respect to S. The slope of the curve is given as follows:

$$\frac{T-R}{(S-T)^2}. \tag{3}$$

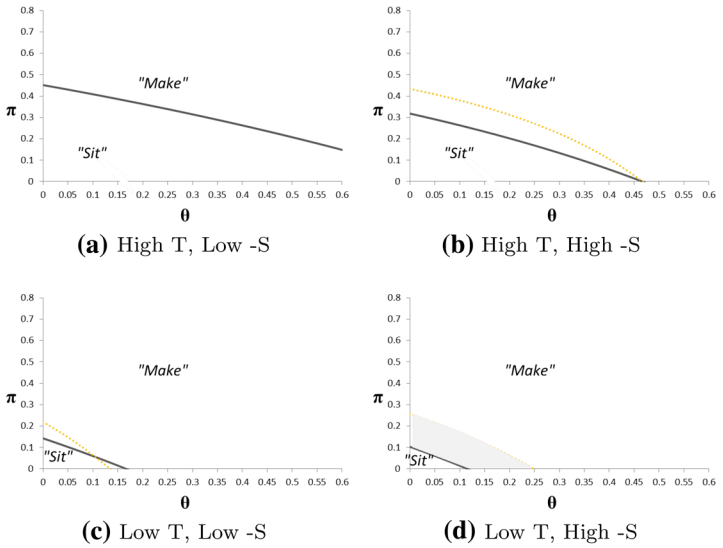


Fig. 4 Strength of institutions required for each category of transaction

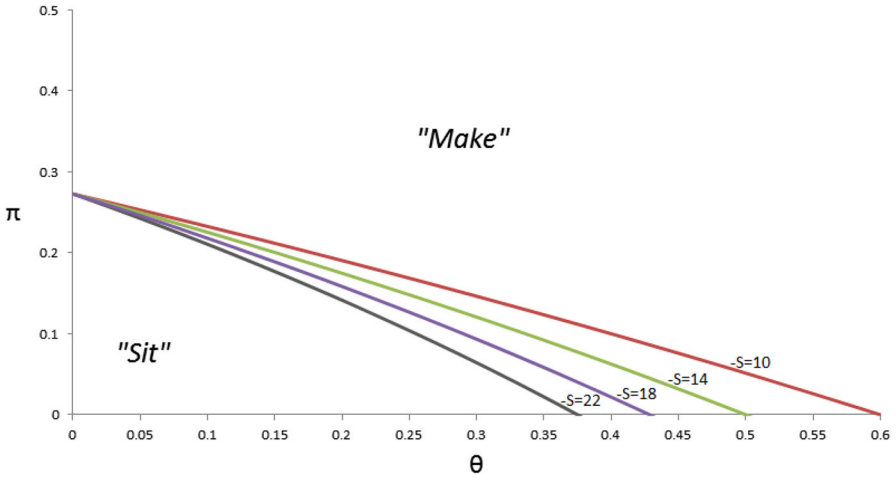


Fig. 5 Decrease in "Sit" area (T = 22, R = 10, P = −10, S = −10, −14, −18, −22)

This is significant because it tells us that certain types of technological development, which cause the $\frac{T-R}{(S-T)^2}$ threshold to be crossed, make it necessary to move from tribal societies dominated by loyalty to formal societies with a guardian class.

The second observation is depicted by Fig. 5 showing the decrease in the "Sit" area as $-S$ increases.

4.3 Variations in reach of institution

The above analysis assumed that the institutions have identical reach and hold on the population. It is more realistic to consider a police force that can catch some perpetrators more readily than others, or an ideology of universal brotherhood and charity that resonates better with some than with others. Given enough learning time and open flow of information, rational individuals can reach an equilibrium where each not only knows his or her own π (How likely am I to get caught if I attempt predatory behavior?) and θ (How much empathy do I feel for the loss or gain of those with whom I transact?), but also has an accurate picture of the distribution of π and θ in the population as a whole.

Consider the case where a fraction of the population is entirely exempt from facing coercion from law enforcers. This might arise from personal characteristics (fleetness of foot, disguise skills, etc.), from payoffs to corrupt law enforcers, or from ties of nepotism or employment to the enforcing organization.[9] The population is divided into two subgroups, each homogeneous within its ranks. If K is the

[9] It could also be said that the organization supporting the institution is collecting its dues in the form of impunity for a small class of individuals rather than in the form of direct taxation. The role of the king's retinue or "elite" in governance is much studied, (Olson 1971; Sekeris 2011, e.g.), but the theta–pi model adds in the effect of empathy on the process. The addition of empathy only slightly changes the value of nepotism as a motivation for governing "elites" to develop (Olson 1971).

percentage of the population facing a fixed value of π, then $1 - K$ is the percentage of the population for whom π is equal to 0. Both face the same *theta*. And the only guaranteed way to avoid dealing with the $1 - K$ exempt class is to avoid dealing with anyone at all.

The converse case is when θ is zero for some sub-population (e.g., the cynical class, which may or may not be congruent with the priestly or ideological elite that serves to maintain the institution), but π is constant for all. We will use the word "elite" in both cases to denote the exempt individuals, not by way of judging but simply as a convenient shorthand recognizing that those who make the rules are better positioned to break the rules. In both cases, the ability to either appear as, or to enforce equality of treatment with, the non-elite, is a central characteristic of the elite.

Suppose that π (or θ) is high and the elite is not numerous. The non-elite will face the decision tree in which "make" is always the better option, and consequently the payoff curves will not intersect, as shown in Fig. 2b. Meanwhile, the elite population, facing zero probability of getting caught (or zero empathy) could conclude from its decision tree that "take" is a better choice than "make" given the high E obtained.

As before, E will finally reach a ratio which is equal to the number of "makers" to the total number of agents participating in the market. E will converge to K : elite always chooses "take", while the rest "make".

However, if the elite gets too numerous, then it no longer makes any sense for anyone to "make" and the market collapse. The theta–pi model can tell us exactly the maximum elite size (or minimum non-elite size K_{min}) as a function of the market in question. There are two cases:

(1) For π or θ low enough that"make" is better than "take" for the non-elite population only near $E = 1$ (see Fig. 2a, then $K_{min} = 1 - E_i$. This is explained by noting that when $1 - K$ is larger than E_i, E starts to converge to K, but in the process then non-elite starts to prefer "take" and the market collapses.

(2) If π or θ is high enough that "make" is better than "take" for all values of E above the zero line (as in Fig. 2b), then K_{min} is given by the value of E at which "make" has a value of zero for the non-elite. If K is smaller than this intersection point, the non-elite has no reason to ever leave the "sit" state.[10]

4.4 Overlapping institutions

Would universal empathic (theta) institutions, or perhaps theta-institutions that affect only those exempt from pi-institution,[11] change this dynamic? Interestingly, not for long, says the theta–pi model. What happens is that the elite faces a decision tree in which "take" is only better than "make" when E is very near 1. If the elites

[10] Technically, for very large θ values, K might become smaller than 0.5 and the lower bound on it (K_{min}) would then be found using the make–take–sit values of the elite instead.

[11] That is, when the "nobility" is also "noble" in behavior.

are small enough in number, an equilibrium exists at $E = K$. If, however, the size of the elite is larger than $1 - E_i$, then, both groups will "make" until the overall expectation of encountering a cooperator (E) reaches 1. At this point, because the elites prefer the choice "take" at $E = 1$, they will once again pick that choice and start "take". As long as K does not change, the cycle starts again and keeps repeating itself. The period between each cycle depends on the rate of learning, but the oscillation continues as long as the underlying conditions remain the same.

Similar scenarios exist when the empathic institution has a limited reach and π is fixed for the overall population. A small portion of the population is then immune from the effect of empathy when engaging in market transactions.

For a more generalized treatment of the case where one theta-institution overlaps with one pi-institution, we adopt the following notation. The institution that constrains the full population (elites and non-elites) will be labeled the *universal* institution. The institution that affects only the non-elites will be called the *avoidable* institution.

We distinguish three phases as the universal institution gains in strength.

Phase 1 is when the universal institution strength, given by π or θ, is so lowthat the only equilibrium states are $E = 0$ and $E = K$.
Phase 2 starts when the universal institution becomes sufficiently effective tolead to additional equilibrium states. The "elite" of the avoidable institution may have a different equilibrium strategy than always "take" or the non-elite may have a different equilibrium strategy from always "make".
Phase 3 is when the universal institution is so strong that the difference between those who can avoid the avoidable institution and those who cannot makes no qualitative difference effect on the equilibrium.

4.4.1 Phase 1

Phase 1 corresponds to a non-existent or weak universal institution. As the avoidable institution gains in strength, the size of the elite is constrained by $\max(E_i, K_{min})$, where:

$$K_{min} = \frac{\theta T + S}{S + \theta T - (1 + \theta)R}. \tag{4}$$

And depending on the type of avoidable institution, E_i is given by:

$$E_i = \frac{P - S}{P + R - S - 2T + \pi(T - S)}, \tag{5}$$

or

$$E_i = \frac{P - S + \theta(P - T)}{(1 + \theta)(P + R - T - S)}. \tag{6}$$

If K is smaller than either limit, then size of the elite $(1 - K)$ is too big and the market collapses ($E = 0$). Otherwise, $E = K$. The shaded area in Fig. 6 corresponds to the $E = 0$ equilibrium state while the non-shaded area corresponds to $E = K$.

Figure 6b, c show two different topologies for the effects of increasing θ. The transition depends on the relative values of T and S in the underlying transaction. In Fig. 6, $T > -S$, which means that high empathy might lead an actor to favor being the sucker, since there is a net gain to society from a make–take transaction.[12] Now "take" is the best option for K of the population as E approaches 1, meaning they will "take" when there are enough "makers". E_i now becomes a lower bound on the elite size $(1 - K)$, and $(1 - K_{min})$ is the only upper bound.

Figure 7 provides a visual summary of the previous analysis and the different paths to either $E = K$ or $E = 0$. Figure 8 is a sample chart portraying the changes in elite size constraints as the universal institution increases in strength but is still below the effective threshold (i.e., still in Phase 1). The area above the curve corresponds to the equilibrium in which the elites are "taking" and the non-elites are "making" ($E = K$). The area under the curve is when both groups "take".

It is clear that until now, increasing the strength of the universal institution also allows a larger elite. E_i moves to the right, indicating lower values of the avoidable institution for the same upper bound on $(1 - K)$.

4.4.2 Phase 2

This phase is entered when the universal institution strength increases such that:

$$\pi_{univ} > \frac{T - R}{T - S}, \tag{7}$$

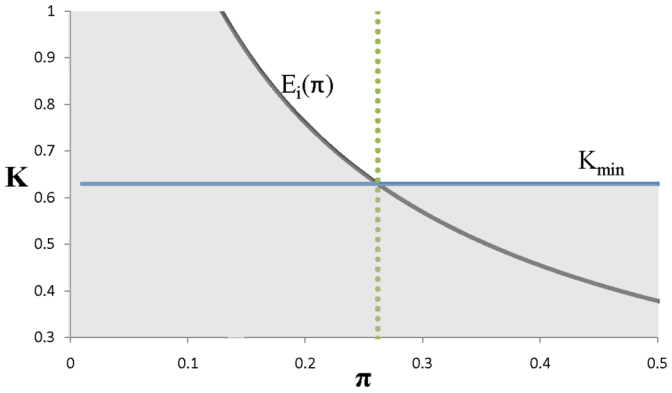
or

$$\theta_{univ} > \min\left(\frac{T - R}{R - S}, \frac{(T - S)^2 - (T - S)\sqrt{(T + S)^2 - 4PR}}{2(PR - ST)} - 1\right). \tag{8}$$

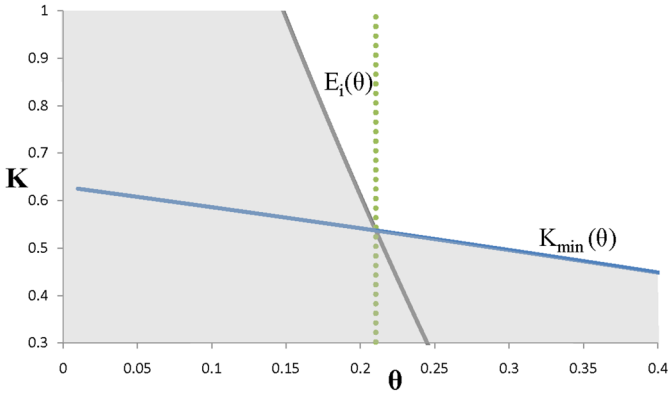
At this point, different equilibrium states appear as well as a different set of dynamics. The elite's "make" and "take" payoff lines intersect above the zero line (as in Fig. 2a), meaning they switch from "take" to "make" (or from "make" to "take") as E approaches 1. There is therefore, in addition to the original E_i for the non-elite, a new intersection point for the elite's "make" and "take" lines, which we designate as E_i^*.

Figure 9 illustrates the size constraints and the equilibrium states in this phase. Since we now have two E_i's, there are more scenarios than in Phase 1. The top horizontal line in all three sub-figures corresponds to E_i^* at a given universal π or θ. The hashed region immediately above the top horizontal line in Fig. 9a, b

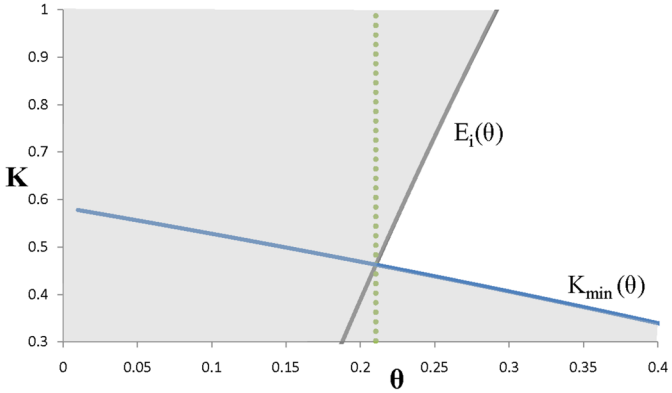
[12] We can call this Phase 1d for "degenerate", since transactions where being cheated is written off as a charity are unlikely to be the most prevalent in a society.



(a) Avoidable pi-institution, T=14, R=10, P=-10, S=-17



(b) Avoidable theta-institution, T=14, R=10, P=-10, S=-17



(c) Avoidable theta-institution, T=17, R=10, P=-10, S=-14

Fig. 6 Size of elite versus strength of avoidable institution in Phase 1

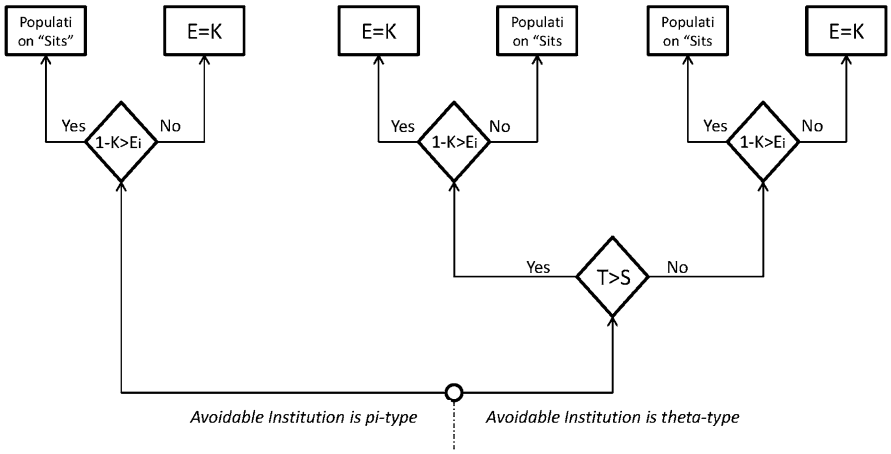


Fig. 7 Diagram of possible paths to either equilibrium state in Phase 1

corresponds to $E = 1$. In Fig. 9c, the dotted region immediately below the top line corresponds to the oscillating state described on page 19 above.

4.4.3 Phase 3

As the universal institution gets stronger, the non-elite's "make" and "take" payoff lines no longer intersect for any $E \leq 1$. This means that the strength (π or θ) of the avoidable institution and its reach (K) influence the equilibrium over a smaller zone in the phase space. In Fig. 9a–c, the top (red) horizontal line approaches the bottom horizontal line. When the lines touch, then the universal institution can be said to overpower the avoidable one. The equilibria are then the same as in the homogeneous case (Sect. 4.1). The conditions for this to happen are given by Eqs. (9) or (10) below.

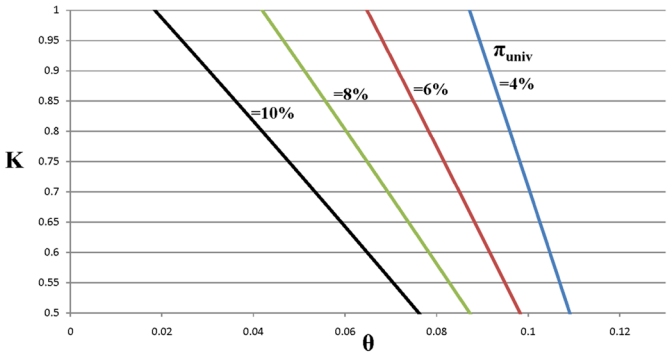
$$\pi_{univ} > \frac{PR - ST}{S^2 - ST}, \tag{9}$$

or

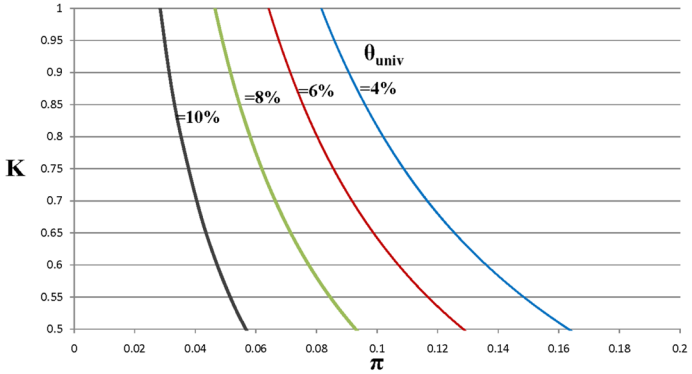
$$\theta_{univ} > \max\left(\frac{T-R}{R-S}, \frac{(T-S)^2 - (T-S)\sqrt{(T+S)^2 - 4PR}}{2(PR-ST)} - 1\right). \tag{10}$$

4.5 Interpretation

The addition of the theta-representation of empathy to the rational decision model interestingly shows that market creation might occur even in the absence of retributive institutions. In Sect. 4.2, we determined the types of symmetric transactions in which institutionalized empathy can entirely replace retributive



(a) Avoidable theta, Universal pi



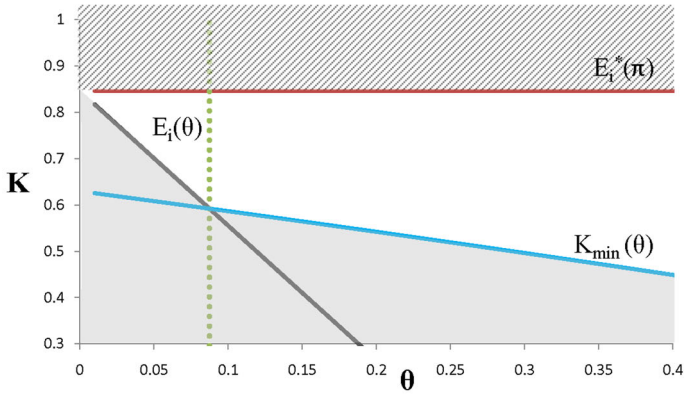
(b) Avoidable pi, Universal theta

Fig. 8 Threshold of market feasibility as universal institution strengthens (at T = 13, R = 10, P = −10, S = −13)

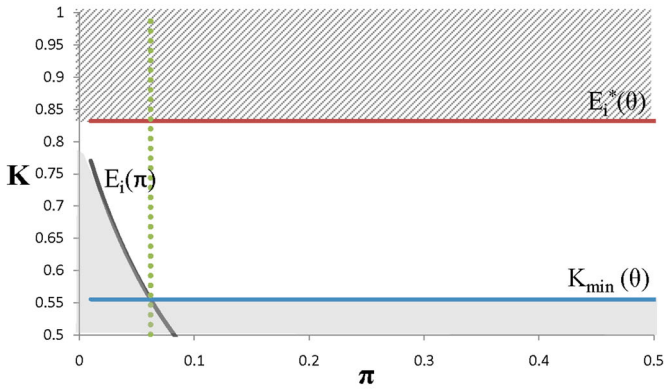
law in deterring predation and thus permitting transactions to happen. For example, a transaction in which $T = -S = 12$, either θ or π alone should be equal to $9\,\%$ in order for that transaction to happen. Furthermore, stronger empathy leads to a greater variety in the types of transactions that take place.[13]

When several types of transaction exist, empathy and retribution vary in their effectiveness. Transactions where $-S$ and T are close together, are more easily fostered by theta-institutions. In the case of the farmer, whose product of trade is fully produced by one entity, $10\,\%$ empathy can fully deter all predators. In the case of the long distance ship trade, empathy is still highly effective but the relative effectiveness of coercive institution seem to increase. While $\theta = 20\,\%$ is needed to deter cheaters , $\pi = 14\,\%$ is equally effective. When temptation is high but the pain or loss felt by the cheated party is relatively low, as in the case of the free-loader, the

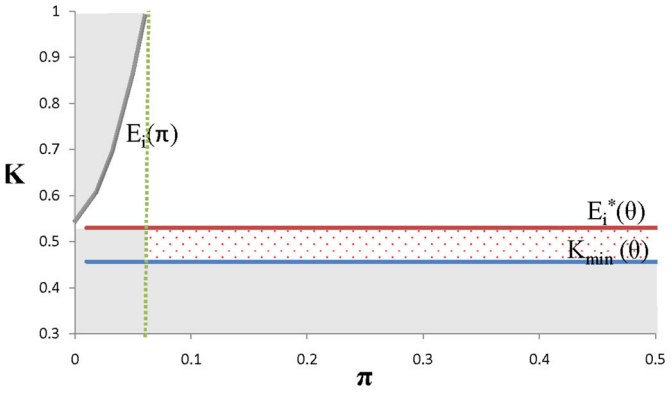
[13] When empathy rather than retributive action is the main institution, the "Make" line is parallel to the "Take" line, and "Make" is a better choice for a wider range of *E*.



(a) Avoidable theta-institution, T=17, S=-14, $\pi_{univ} = 0.17$



(b) Avoidable pi-institution, T=14, S=-17, $\theta_{univ} = 0.17$



(c) Avoidable theta-institution, T=17, S=-14, $\theta_{univ} = 0.22$

Fig. 9 Elite size versus avoidable institution strength (Phase 2, R = 10, P = −10)

effect of empathy seem to be almost non-existent, and only coercive means are effective.

When some of the population is exempt from either institution, predation is the equilibrium best course for the exempt class. The development of a universal empathic institution alongside an avoidable coercive institution can lead the exempt class to change their behavior. The first difference lies in how universal empathy limits the size of the exempt population (whom we refer to with the shorthand "elite"). More elite members imply more predatory transactions, and at some point this makes everyone "sit". Universal empathy speeds up the rate at which the size of elite must decrease to maintain the market for the same transactions.[14] The second difference concerns transactions in which $T > -S$. When temptation (T) is higher than the loss ($-S$) from a particular transaction, a significant amount of universal empathy could lead the elite to either alter its behavior in cycles, or diminish in size.

There are also some drawbacks to deploying empathy as a spur to economic activity, particularly when it is not universal. The first drawback is that there exists a zone in which some empathy is not yet effective and hence produces opposite effects: a little universal empathy in the presence of avoidable institutions can increase the tolerance of the non-elite for more predation by the elite, or to an increase in the maximum tolerable size of the elite.[15]

The second possible drawback is seen when $T > -S$: while universal empathy can indeed help avoid market collapse by allowing the elite to fill the role of "essential" predators, there is a deep chasm in the path to an ideal $E = 1$ state. For example, for transactions in which $T = 17$ and $S = -14$, and an avoidable retributive institution, $\theta = 14\,\%$ suffices to avoid market failure, but $\theta = 32\,\%$ is necessary for maximum social payoff.

5 Conclusions and further research

The theta–pi model introduced in this paper can be used to describe and analyze economically relevant institutions. By representing the coercive aspect of an institutions with one variable that represents probability of getting caught, and the empathic aspect with one variable that describes the extent to which the locus of utility is expanded, we are able to set up and solve rational decision problems that mimic complex phenomena.

These phenomena include:

– changes in the value of each institution as a function of technological change,

[14] This is explained by more a rapid increase in E_i due to both "Make" and "Take" curves moving closer together in contrast to only the "Take" curve inclining.

[15] The increase in universal empathy decreases E_i for the non-elite, while the elite's payoff curves remains functionally the same.

Table 2 Summary of phase distinctions

Perfect homogeneity	
$\pi < \frac{R-T+\theta(R-S)}{(1-\theta)S-T}$	$E = 0$: market collapses
$\pi < \frac{(1+\theta^2)(TS-PR)+\theta(T^2+S^2-2PR)}{(1+\theta^2)TS+\theta(T-S)^2-S^2}$	$E = 0$: market collapses
Otherwise:	$E = 1$: market is efficient
Overlapping institutions	
Phase 1: weak universal institutions	
$K < \max(E_i, K_{min})$	$E = K$: market enabled but not efficient
$K > \max(E_i, K_{min})$	$E = 0$: market collapses
Phase 2: significant universal institutions	
$K > \max(E_i, E_i^*, K_{min})$	$E = 1$: market is efficient
$E_i > K > E_i^*$	$E = K$: market enabled but not efficient
$E_i^* > K > E_i$	Oscillatory state: market efficiency changes periodically
$K < min(E_i, E_i^*, K_{min})$	$E = 0$: market collapses
Phase 3: strong universal institutions	
$K < \max(E_i, K_{min})$	$E = 1$: market efficient
$K > \max(E_i, K_{min})$	$E = 0$: market collapses

- discontinuities in the equilibrium state of a society as a function of institutional strength and reach (phase transitions), and
- the extent to which stewardship of an institution can provide both rent-seeking opportunities and cautionary limits on that behavior,
- perhaps most significantly for modern policy making, the theta–pi model shows the resilience of society in the face of human imperfection.

Table 2 gives a summary of phenomena generated by a simple two-institution scenario modeled in this framework.

These phenomena are necessarily very general, since this is a preliminary mathematical treatment of a modeling framework, not a fully-built data-based model. The theta–pi model can handle enough complexity to give transform sufficient observational and calibration data (which are beyond the authors' limited expertise), into non-obvious answers to questions such as: Under what conditions does the institution help an economy? How much value does it add? When is the party that gets the role of maintaining the institution tempted to engage in its own predatory behavior? How much cost would the society be willing to incur in order to maintain the institution?

Some of these questions were previously investigated in a qualitative (Skocpol 1979, e.g.) or qualitative fashion (North et al. 2009, e.g.). More recently, Pfeffer (2015) described how there is a proper balance between self-interest and group loyalty in the leaders who themselves promote norms and enforce rules in an organization. The theta–pi model further adds to the insights of North et al. (2009) by showing that increasing the size of the elite not only dissipates rent, but could

lead the society to completely lose the benefit of certain classes of market transactions, echoing Pfeffer (2015) on a larger scale. What none of the qualitative prior research can do, however, is account for special cases such as where the elite is periodically forced to switch to honest transactions, giving up some of its privilege, in order to continue to enjoy the full benefits of the market (Sect. 4.3). Yet other circumstances place a lower bound on the size of the elite, where a smaller elite would actually reduce the economic output of the society. Larger societies, with their greater variety in trade types, require different institutional frameworks from simpler societies. Technological advances and geographical expansion lead to the emergence of new types of transactions, changing the optimal behavior of the elites. Results like these suggest obvious falsification experiments. A failure to find instances of oscillation or of "good" corruption (Lessig 2013) would point to a serious flaw in the model. A future reversal in the historical to have more institutional complexity go hand in hand with growth (North 1990) would also point to an inconsistency in the theta–pi model.

5.1 Limitations of the model

Although the richness of the basic theta–pi model has been demonstrated, we have not enumerated all institutional phenomena explainable by the model's basic assumptions (i.e., locus of utility expansion as a stand-in for empathic institutions and expectation of retribution by an immune party as a stand-in for coercive institutions). We analyzed a few simple cases, but the full import of the model lies in its ability to describe complex systems of institutions with overlapping reach and continuously variable strength. Tribes and kingdoms throughout history have had webs of institutions to maintain their existence and growth, especially in light of the tendency of organizations to hijack institutions and collect rents from their control. Different overlapping jurisdictions of potentates that apply retributive justice, each with its own partially or wholly exempt class, coexist with different ethnic, religious and clan-based groupings that engender different degrees of empathy tin their in-group.

Arguably, biases introduced by the model assumption may also be a source of weakness in future development. Future research may in fact find scenarios similar to the one described by Huberman (1989) in critiquing earlier agent-based models: the synchronized nature of the model updates was creating spurious patterns in the results. Since agent-based modeling has been able to continue by correcting the faulty (and accidental) assumption, the theta–pi model should be able to incorporate similar future corrections. For instance, if there are effects of asymmetry or of non-dual cardinality in the interaction, they have yet to be demonstrated, so it is premature to worry about the computational costs of remedying them.

5.2 Future research

Specific directions of future research might include increasingly complex relationships, such as:

- multiple exempt classes with different values of the institutional parameter, e.g., $K_1, K_2, \ldots, K_n$ subject to $\pi_1, \pi_2, \ldots, \pi_n$, or continuous distributions like $\Pi(k)$, where k is the proportion of population for which $\pi \leq \Pi(k)$.
- Interactions between two overlapping institutions of the same type.
- Economic transactions that are not symmetric or not dyadic.

If it proves possible to model increasingly complex general forms, specific questions of human social and economic organization might be worth following. Circumstances of particular interest might include:

- The rise of early agrarian civilizations, following accommodations between mutually recognized theologies/priesthoods and mutually non-aggressive codes of justice/military units.
- The rise of unified coercive hierarchies under empires and unified empathic hierarchies under monotheistic religions, and their subsequent fragmentation.
- The road from Western Enlightenment thinking to today's globalized economy.
- The role of company spirit and clique loyalty in the growth of a business enterprize.
- Colonialism, banana republics, dictatorships, communism, fascism, etc., in the twentieth century.
- Repercussions of increased flow of information on institutional equilibria in the twenty first century.
- The repercussions of national independence movements, trans-national alliances, and business mergers and acquisitions.

As this goes on, it might become necessary to turn to numeric solutions instead of closed-form algebraic equations when considering some of the above extensions, or perhaps employ new simplifying assumptions. The field of microeconomics shows us that, despite a multiplicity of overlapping substitutable consumer choices, we still teach and research the equilibrium of on supply and demand under perfect competition or monopoly conditions. This shows that elucidation of general trends is a sufficient rationale for applying quantitative analysis to very high-level abstractions. Agent-based modeling is another promising methodology that can use a general principle (such as the theta–pi model) to analyze an arbitrary number of interacting structures that all follow similar rules.

It will require original research to tackle the combinatorial requirement of more a precise mapping to real life questions. The search continues for greater understanding and insight that can inform to real-world planning of governance, economic policy and individual initiative.

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References

Acemoglu D, Robinson J (2012) Why nations fail: the origins of power, prosperity, and poverty. Crown Business, New York

Aktipis CA (2004) Know when to walk away: contingent movement and the evolution of cooperation. J Theor Biol 231(2):249–260

Axelrod R (1980) More effective choice in the prisoner's dilemma. J Confl Resolut 24(3):379–403

Axelrod R (1987) Chap. 2, the evolution of strategies in the iterated prisoner's dilemma. Morgan Kaufmann, Los Altos

Becker GS (1968) Crime and punishment: an economic approach. J Polit Econ 76(2):169–217

Bolton GE, Ockenfels A (2000) ERC: a theory of equity, reciprocity, and competition. Am Econ Rev 166–193

Bueno De Mesquita B, Morrow JD, Siverson RM, Smith A (1999) An institutional explanation of the democratic peace. Am Polit Sci Rev 93(4):791–807

Chong A, Calderón C (2000) Institutional quality and poverty measures in a cross-section of countries. Econ Gov 1(2):123–135. doi:10.1007/s101010050002

Cohen MD, Riolo RL, Axelrod R (2001) The role of social structure in the maintenance of cooperative regimes. Ration Soc 13:5–32

Darcet D, Sornette D (2008) Quantitative determination of the level of cooperation in the presence of punishment in three public good experiments. J Econ Interact Coord 3(2):137–163. doi:10.1007/s11403-007-0027-x

Dreber A, Fudenberg D, Rand DG (2014) Who cooperates in repeated games: the role of altruism, inequity aversion, and demographics. J Econ Behav Organ 98:41–55. http://www.sciencedirect.com/science/article/pii/S0167268113003053

Ebner A, Beck N (2008) The institutions of the market: organizations, social systems, and governance. Oxford University Press, New York

Gatti DD, Gaffeo E, Gallegati M (2010) Complex agent-based macroeconomics: a manifesto for a new paradigm. J Econ Interact Coord 5(2):111–135. doi:10.1007/s11403-010-0064-8

Greif A (1989) Reputation and coalitions in medieval trade: evidence on the Maghribi traders. J Econ Hist 49(4):857–882

Greif A (1994) Cultural beliefs and the organization of society: a historical and theoretical reflection on collectivist and individualist societies. J Polit Econ 102(5):912–950

Greif A (2006) Institutions and the path to the modern economy: lessons from medieval trade. Cambridge University Press, Cambridge

Henrich J, Boyd R, Bowles S, Camerer C, Fehr E, Gintis H, McElreath R (2001) In search of homo economicus: behavioral experiments in 15 small-scale societies. Am Econ Rev 91(2):7378

Huberman BA (1989) Dynamics of computational ecosystems. Phys Rev A 40:404–421

Hwang SH, Bowles S (2012) Is altruism bad for cooperation? J Econ Behav Organ 83(3):330–341. doi:10.1016/j.jebo.2012.06.001

Keen S (2003) Standing on the toes of pygmies: why econophysics must be careful of the economic foundations on which it builds. Physica A 324(1–2):108–116

Kulakowski K (2009) The norm game: punishing enemies and not friends. J Econ Interact Coord 4(1):27–37. doi:10.1007/s11403-009-0045-y

Lessig L (2013) Institutional corruption defined. J Law Med Ethics 41:553

Maynard Smith J, Price GR (1973) The logic of animal conflict. Nature 246:15–18

Mintzberg H (1983) Structure in fives— designing effective organizations. Prentice Hall, Englewood Cliffs

Mintzberg H (1991) The effective organization: forces and forms. Sloan Manag Rev 32(2):54–67

Neilson WS (2009) A theory of kindness, reluctance, and shame for social preferences. Games Econ Behav 66(1):394–403. http://ideas.repec.org/a/eee/gamebe/v66y2009i1p394-403.html

North D (1990) Institutions, institutional change and economic performance. Cambridge University Press, Cambridge

North D (1991) Institutions. J Econ Perspect 5(1):97–112

North DC, Wallis JJ, Weingast BR (2009) Violence and social orders: a conceptual framework for interpreting recorded human history, 1st edn. Cambridge University Press, Cambridge

Nowak M, Sigmund K (1993) A strategy of win-stay, lose-shift that outperforms tit-for-tat in the prisoner's dilemma game. Nature 364(6432):56–58

Ok EA (2002) Utility representation of an incomplete preference relation. J Econ Theory 104(2):429–449
Olson M (1971) The logic of collective action. Harvard University Press, Cambridge
Olson M (1984) The rise and decline of nations: economic growth, stagflation, and social rigidities. Yale University Press, New Haven
Olson M (2000) Power and prosperity: outgrowing communist and capitalist dictatorships. Basic Books, New York
Olson M, Kähkönen S (2000) A not-so-dismal science: a broader view of economies and societies. Oxford University Press, New York
Pfeffer J (1981) Understanding the role of power in decision making. In: Power in organizations. Pitman Publishing, Marchfield, pp 1–32
Pfeffer J (2015) Leadership BS: Fixing Workplaces and Careers One Truth at a Time. HarperBusiness
Polinsky AM, Shavell S (1999a) Corruption and optimal law enforcement. Working paper 6945. National Bureau of Economic Research. http://www.nber.org/papers/w6945
Polinsky AM, Shavell S (1999b) The economic theory of public enforcement of law. NBER working paper 6993. National Bureau of Economic Research. http://ideas.repec.org/p/nbr/nberwo/6993.html
Prietula MJ, Conway D (2009) The evolution of metanorms: quis custodiet ipsos custodes? Comput Math Organ Theory 15(3):147–168. http://link.springer.com/article/10.1007/s10588-009-9056-4
Sachs JL, Mueller UG, Wilcox TP, Bull JJ (2004) The evolution of cooperation. Q Rev Biol 79(2):135–160
Scott WR (2007) Institutions and Organizations: Ideas and Interests, 3rd edn. Sage Publications, Inc
Sekeris P (2011) Endogenous elites: power structure and patron-client relationships. Economics of Governance 12(3):237–258. doi:10.1007/s10101-010-0093-8
Selznick P (1994) The Moral Commonwealth: Social Theory and the Promise of Community. University of California Press
Sen PA (1997) Choice. Harvard University Press, Welfare and Measurement
Shafritz JM, Ott JS (1996) Classics of Organization Theory. Harcourt Brace College Publishers, Fort Worth, Texas
Simon HA (1990) A mechanism for social selection and successful altruism. Science 250(4988):1665–1668. http://www.sciencemag.org/content/250/4988/1665
Skocpol T (1979) States and social revolutions : a comparative analysis of France, Russia, and China. Cambridge Universty Press
Sunder S (2006) Determinants of economic interaction: Behavior or structure. Journal of Economic Interaction and Coordination 1(1):21–32. doi:10.1007/s11403-006-0006-7
Von Neumann J, Morgenstern O (1944) Theory of games and economic behavior. Princeton University Press, Princeton
Yellen JL (2011) Macroprudential supervision and monetary policy in the post-crisis world. Business Economics 46(1):3–12. doi:10.1057/be.2010.35

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