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Punctuality - A Cultural Trait as Equilibrium

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PUNCTUALITY
A Cultural Trait as Equilibrium

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Abstract.   A people's culture, norms and habits are important determinants not just of the quality of social life but of economic progress and growth. In this paper we take the view that while the importance of culture is undeniable, the innateness of culture is not. We work here with a single example and demonstrate how a human trait which is widely believed to be cultural is at the same time a matter of choice. The example that we shall work with concerns punctuality. We show that punctuality may be simply an equilibrium response of individuals to what they expect others to do. The same society can get caught in a punctual equilibrium or a non-punctual equilibrium.

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1. Introduction

A people's culture, norms and habits are important determinants not just of the quality of social life but of economic progress and growth.   And indeed there are certain aspects of habits, preferences and behaviors that we associate with whole groups of people and think of as the nuts and bolts of culture.   When a lay person

hypothesizes that a certain nation or social class has done badly because the people are given to sloth, or when the anthropologist collects evidence to demonstrate that the Yanomami Indians of South America are so poor because they have little respect for property rights, or, for that matter, when the Yanomami Indians think of anthropologists as a not quite human group, they are all subscribing to some view of shared cultural traits and how these traits can have consequences for the quality of life and well-being of the group in question.[1]

It is a short step from this to think of culture as something that is pre-ordained, as something indelibly etched onto a people's psyche and so beyond the ambit of their choice. When in 1950 the British Chargé d'Affaires in Korea, Alec Adams, pronounced how they (the colonial masters stationed in Korea) entertained "the lowest opinion of Korean mores, ability and industry", and, more importantly, how he found it "hard to believe that they will ever be able to successfully govern themselves", he was subscribing to this view of innateness of culture (Clifford, 1994, p. 29). This erroneous prediction, so close to the Korean economic take-off, could not have contributed much to Mr. Adams' reputation as an economic forecaster. However, in his treatment of culture as something beyond the reach of a people's choice he was not alone.

In this paper we take the view that while the importance of culture is undeniable, the innateness of culture is not; and that societies can constructively think in terms of breaking out of 'cultural traps'. This is a large topic and we do not expect to do it justice in this short paper. Instead, we want to work here with a single example in order to demonstrate how a human trait which is widely believed to be cultural and, in all likelihood, is so to a large extent, is at the same time a matter of choice. While each individual may have no interest in opting out of his cultural trait, society as a whole may have such an interest, and each individual may in fact prefer to change if he or she had the assurance that so would others. In other words, the same set of people with the same innate preferences, endowments and abilities can settle into different cultural practices.

The example that we shall work with is punctuality and, by association, with related concepts such as tardiness, laziness and diligence. As we explain in the next section, social psychologists often think of punctuality as a cultural trait - something that is shared by the individuals in a certain group, for instance, a community, social class, or region. We shall here show that this may be true, but, at the same time,

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[1]While these are meant to be illustrative examples and not statements of fact, that the Yanomami view anthropologists as a rather special class is, however, probably true. "Anthropologists," writes Tierney (2000, p. 14), "have left an indelible imprint upon the Yanomami. In fact, the word *anthro* entered the Indians' vocabulary... . The Yanomami consider an *anthro* to be a powerful non-human with deeply disturbed tendencies and wild eccentricities."

punctuality may have little to do with innate characteristics or preferences of the group. It may be simply an equilibrium response of individuals to what they expect others to do (and they expect others to expect from them). The same society, in other words, can get caught in a punctual equilibrium or a tardy equilibrium. This is not to deny that punctuality may be habit-forming and the habit could be subject to evolutionary erosion or bolstering. A more detailed work (and maybe our own future research) will go into this, but our aim here is to focus on one core element of such a large agenda, namely the fact that punctuality can be both a shared social trait and an equilibrium response on the part of every individual.

There is nothing analytically novel in what we do. The idea of multiple equilibria is a familiar one in economics. One of the earliest formal modeling of it in the context of a social phenomenon was that by Stiglitz (1975), who has in subsequent work continued to stress its importance in understanding certain social realities, especially economic under-development and high unemployment (see Stiglitz, 2000; Hoff and Stiglitz, 2000; Basu, Genicot and Stiglitz, 2002), and there is a now a substantial literature on the subject. Closer to our current concern there is also a recent literature concerning coordination over time (e.g., Hvide, 2001; Ostrovsky and Schwarz, 2001). However, in the equally substantial literature in sociology and social psychology on punctuality there is very little recognition of this. The aim of this paper is to bring these two literatures together. We show that punctuality is a phenomenon where the possibility of multiple equilibria arises very naturally and therefore this ought to be recognized also in social-psychological analyses of punctuality.

The disposition of the rest of the paper is as follows. Section 2 discusses the literature on punctuality, Section 3 gives a simple example, Section 4 a simple model, and Section 5 concludes by briefly probing into some deeper aspects of unpunctuality. A background calculation for the analysis in section 4.1 is provided in an appendix.

2. Punctuality

Punctuality, or the ability of different individuals to exchange some words and then coordinate on time, is one of the crucial ingredients of modern life and progress. Social scientists - largely outside of economics - who did research on this, appreciated this fact well. Zerubavel (1982, p. 2) writes: "Standard time is thus among the most essential coordinates of intersubjective reality, one of the major parameters of the social world. Indeed social life would probably not have been possible at all were it not for our ability to relate to time in a standard fashion." And, following Durkheim, Clayman (1989, p. 660) observes, "As a general principle, organized social life requires that human activities be coordinated in time." Given this realization, it is

natural that punctuality has been a subject of intensive research in social psychology and sociology (see, for, instance, Lockwood, 1930; Mcleary, 1934; Dudycha, 1937, 1938; Levine, West and Reis, 1980; Marin, 1987; Kanekar and Vaz, 1993).

This large social science literature researching into the causes of punctuality seems to have treated punctuality as a matter of preference or a person's innate behavior trait. Thus, underlying Dudycha's (1938) empirical inquiry into punctuality is the presumption that people's punctuality is prompted by their "attitudes towards punctuality," that punctuality reflects a person's "early training" in school and at home. Based on a study of 15 men and 22 women in Cleveland State University, Richard and Slane (1990, p. 397) concluded that a person's "punctuality style is a persistent personality characteristic" and a trait that correlates well with a person's innate anxiety level, with punctual people exhibiting less anxiety in general.

These social psychologists and sociologists soon recognized that punctuality is not entirely an idiosyncratic individual trait, however, but a characteristic that often exhibits systematic variation across groups. Several studies have located systematic differences across the genders (for instance, Lockwood, 1930; Dudycha, 1937). But these differences seem milder than those across nations or geographical regions. Kanekar and Vaz (1993) motivate their study of undergraduate students in Bombay University by observing that (p.377-8) "Indians are notorious for their unpunctuality."[2] In their celebrated study of punctuality patterns in Brazil and the United States, Levine, West and Reis (1980) found systematic variations across these two societies. Taking extra care not to use politically incorrect language, they observe (p. 542) "Brazilians and people from the United States do differ in their time-related behavior in the direction predicted by stereotype."

This raises the question: Why these differences across nationalities? People have tried to explain these systematic differences in terms of deep cultural moorings or religion, such as the "fatalistic nature of the Latin personality" or the Hindu belief in determinism. When they have looked for more proximate causes they have found explanations in disruptive factors in the environment, which make it difficult for people to have control over time, or clocks and watches which do not function well. By studying a number of watches in Brazil and the United States, Levine, West and Reis (1980, p.542) find strong evidence in support of their hypothesis that one reason Brazilians are less punctual is that "public clocks and personal watches [are] less accurate in Brazil than in the United States."[3] Even in the early study of Dudycha

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[2]In contrast, one of us (Basu) was told by the late Sir Arthur Lewis how he found Indians to be punctual. It is worth noting that his sample of experience must have been predominantly Indians in England and the Americas. Our paper will show how the same people may behave differently when they find themselves in a different setting.

[3]While we do not know of any similar studies in India, our observation that time is often asked

(1938), he found that among the 307 college students surveyed, 20 attributed their lack of punctuality to "incorrectly set clocks or watches."

Such explanations leave open some important questions concerning the direction of causality; but that is not what we are concerned with here. Before describing our model, it is worth recounting, however briefly, one of the first proper empirical studies of punctuality. Lockwood's (1930) research is interesting, despite its occasional eccentricities, because it is based on a serious attempt to make sense of data on tardiness available from school records. During 1928-29 in Rushville High School, Rushville, Indiana, data were collected from students who arrived late to school and had to report at the principals office. They were made to fill up a form asking for the extent of delay in minutes and the cause of the delay. Lockwood classified the causes into eight categories: "work", the inevitable "clock wrong", "started late", "automobile trouble", "accidental or unusual cause", "sickness", the somewhat baffling category of "no reason" and then "overslept". He explained that he had difficulty classifying some of the declared causes of delay, such as, "Tore my trousers", "Held up by a long freight train", and (here we must express a certain admiration for the imagination of the student concerned) "Stopped to look at a queer animal in a store window". The problem of classifying these were solved by putting them in the category of "accidental or unusual cause". In some ways Lockwood was more carefully about the causality of tardiness than subsequent writers. Thus he notes (p. 539), "While everyone realizes the great difficulty of synchronizing clocks, the excuse 'clock wrong' can in no way justify tardiness." He found that boys were more often late than girls but girls, when late, were later than boys. He noted that lack of punctuality could become a habit and concluded that tardiness is more "a parent problem" than "a pupil problem".

We recognize that all the above explanations may have some truth. However, none of them touches on a less obvious explanation, which has little to do with innate characteristics or preferences or habit, but has much to do with equilibrium behavior. What we want to show is that even if none of the above factors were there and in fact even if all human beings were identical, we could get differences in punctuality behavior across cultures. Moreover, these differences could be small within each nation or community but vary a lot across nations or communities, exactly as observed. This is because whether we choose to be punctual or not may depend on whether others with whom we interact are punctual or not. It will be argued here that it is in the nature of the problem of coordinating over time that the extra effort needed to be punctual becomes worthwhile if the others with whom one has to

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of strangers in India with the question, "Sir, what is the time by your watch?" makes us believe that time does have an element of watch-dependency in India, similar to Brazil.

interact are expected to be punctual. To illustrate the argument, a simple example and a simple model are presented in the next two sections.

Though our analysis is abstract, we try to capture a kind of social reality which sociologists have written about, such as how ghetto culture breeds ghetto culture, making it virtually impossible for an individual to escape it. Hence, our argument could be thought of as a formalization of Wilson's (2002, p. 22) observation, "Skills, habits, and styles are often shaped by the frequency with which they are found in the community." (See also Swidler, 1986.)

The basic idea that leads to our explanation of why punctuality is a shared trait within cultures is not the obvious one that punctuality has externalities, namely, that one person's greater punctuality makes life easier for others who have to interact with him. It is the somewhat more complex idea of how one person's greater punctuality increases the worth of the other person's effort to be *more* punctual that is germane to our analysis. Again, as a technical concept this is well known in economics and arises in the guise of strategic complementarity or supermodularity in game theory and industrial organization theory. What is interesting is the observation that the problem of time coordination gives rise to supermodularity so naturally. No special or contrived assumptions are needed to get this result. It seems to be there in the nature of things. This is what we will try to demonstrate in the next two sections.

3. EXAMPLE

Imagine two individuals who have made an appointment. Each individual has two choices: to be *on time* or to be *late*. Let B be the gain or benefit to each person of the meeting starting on time, and let C be the cost to each person of being on time. Being late has the advantage that you can finish what you were doing. If you are reading a novel and not fussy about being punctual you can finish the novel and then get up for your meeting even though that may mean some delay. A punctual person on the other hand has to put down the novel and leave early. Basically, an unpunctual person always has the option of being punctual. Hence, it seems reasonable to assume that being punctual incurs a cost, here captured by C. Assume $B > C$, that is, both individuals are better off if they are both on time than if they are both late. If both are on time, then they each thus obtain the "net benefit" or "net return" $B - C > 0$, while if both are late, then they each by definition obtain 0 "net benefit" (the reference value). If one individual is on time and the other is late, then the meeting starts late, and the punctual individual accordingly obtains the net benefit $-C$. The late-comer in this case incurs zero net benefit.

If the two individuals make their choices independently, this interaction can be represented as a symmetric simultaneous-move game with the following payoff bi-

matrix (the first entry in each box being the payoff, here net benefit, to the row player, and the second entry is the payoff to the column player):

	on time	*late*
on time	$B - C$, $B - C$	$-C$, 0
late	0, $-C$	0, 0

This is a coordination game with two pure Nash equilibria, *(on time, on time)* and *(late, late)*, respectively. The strategy pair *(on time, on time)* is a *strict* equilibrium: if an individual expects the other to be on time (with a sufficiently high probability), then being late is strictly worse (since by assumption $B - C > 0$). This strategy pair is also *Pareto dominant*: it gives each individual the highest possible payoff, $B - C$, in the game. Hence, this is the outcome that both individuals would prefer to happen, and it is also the outcome that a benevolent social planner would prescribe. However, also *(late, late)* is a strict equilibrium: if an individual expects the other to be late (with a sufficiently high probability), then the *unique* best choice is to be late too (since by assumption C is positive). However, this equilibrium gives a lower payoff to both individuals than *(on time, on time).*

On top of these two pure Nash equilibria, there is also a Nash equilibrium in mixed strategies, in which both individuals randomize between being on time or being late. This equilibrium probability is the same for both players, and is such that it makes the other individual indifferent between being on time and being late.[4] However, the mixed equilibrium is unstable in the sense that if one individual expects the other to be on time with a probability that is slightly above (below) the equilibrium probability, then it is in that individual's self interest to be on time with probability one (zero). Hence, any perturbation of behaviors in a recurrently interacting population will take the population to one of the strict equilibria.

What prediction does game theory give in this class of games? All three Nash equilibria are *perfect* in the sense of Selten (1975), and, viewed as singleton-sets, each of them is *strategically stable* in the sense of Kohlberg and Mertens (1986). Hence, even the mixed equilibrium survives these demanding refinements of the Nash equilibrium concept. However, evolutionary game theory rejects the mixed equilibrium: the equilibrium strategy to randomize between being on time and being late is not *evolutionarily stable* (Maynard Smith and Price (1973), Maynard Smith (1982)). A population playing this strategy can be "invaded" by a small group of "mutants" who are always punctual: these earn the same payoff on average when meeting the

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[4]In this equilibrium, each player is on time with probability $p = C/B$.

"incumbents" who randomize, but they fare better when meeting each other.[5]   By contrast, each of the two pure strategies is evolutionarily stable.

Which of the two pure-strategy equilibria is more likely in the long run if individuals in a given population (culture, or society) are randomly matched in pairs to play the above punctuality game?   Kandori, Mailath and Rob (1993) and Young (1993) provided models with precise predictions for such recurrently played games. The basic driving force in their models is that individuals most of the time chose the action which is best in the light of the recent past play of the game.   For instance, if in the recent past virtually all individuals were late, then such and individual will choose to be late for the next meeting.   However, a second driving force is that now and then, with a small fixed probability, individuals make mistakes or experiments, and instead play the other action.   In both models, the combined long-run effect of these two forces is that the risk dominant equilibrium will be played virtually all the time.[6]   The concept of risk dominance is due to Harsanyi and Selten (1988), and singles out the equilibrium with the lowest strategic risk, in the sense of being most robust to uncertainty about the other player's action.[7]   In the above punctuality game, the socially inefficient equilibrium *(late,late)* is risk-dominant if and only if

$$\frac{C}{B} > \frac{1}{2} \ . \tag{1}$$

Likewise, *(on time, on time)* is risk-dominant under the reversed inequality.   In other words, the long-run outcome is *(late,late)* if the cost C of leaving early is more than half the benefit of starting the meeting early.

In the next section we briefly consider a simple model which generalizes the present example in two relevant dimensions.

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[5]A (pure or mixed) strategy in a symmetric and finite two-player game is an evolutionarily stable strategy (ESS) if there is an "invasion barrier" against all other (pure or mixed) strategies, in the sense that if the population share playing such a "mutant" strategy is below this barrier, then its payoff is on average lower than that to the "incumbent" strategy, see Maynard Smith and Price (1973), Maynard Smith (1982), and Weibull (1995).

[6]As the probability of mistakes or experiments goes to zero, the long-run probability for the risk dominant equilibrium tends to one.

[7]Consider any symmetric 2×2 coordination game (such as our punctuality game).   One of the two pure-strategy equilibria is said to risk-dominate the other if the strategy used in the first equilibrium is optimal for a wider range of probabilities - attached to the other player's equilibrium action - than the strategy in the other equilibrium.   This condition is equivalent to the condition that the unique mixed-strategy equilibrium in such a game assigns less than probability 1/2 to the first strategy.

4.   A SIMPLE MODEL

Many situations where punctuality matters involve more than two individuals and there is usually an element of randomness attached to arrival times. Suppose thus that there are n persons who decide at time $t = 0$ to have a meeting at time $t = 1$. Just as in the preceding example, the meeting cannot start until all n persons arrive. We are therefore considering an instance of what are called 'minimum effort games' (Bryant, 1983; Carlsson and Ganslandt, 1998). Each person can plan to be "punctual" or "tardy," for example by choosing an early or late departure time. A punctual person, one who leaves early, arrives at the agreed-upon time $t = 1$ with probability one. As discussed above, tardiness or unpunctuality is naturally associated with some degree of randomness in behavior, an aspect neglected in the preceding example (see also section 5). Hence, a tardy person, who leaves late, has a probability $p < 1$ of arriving on time and a probability $1 - p$ of "being late", that is, of arriving at, say, time $t = 2$.

   Let again B be the benefit or gain to each person of the meeting starting on time, that is, at $t = 1$ (as opposed to time $t = 2$). And let $C < B$ be the cost to each person of being punctual (leaving early). If k of the n persons choose to be punctual, the *expected gross benefit* ('gross' in the sense of not taking account of the cost C of being punctual) to each person is thus B multiplied by the probability of everybody being on time. Assuming statistical independence in the delays of "tardy" persons, the expected gross benefit is thus simply $B(k) = p^{n-k}B$. Let $\Delta B(k)$ denote the *increase* in the expected gross benefit when, starting with k persons being punctual, one of the tardy persons chooses to instead be punctual:

$$\Delta B(k) = B(k+1) - B(k) = p^{n-k-1}(1-p)B. \tag{2}$$

   Suppose all individuals decide independently whether to be punctual or tardy (whether to leave early or late), and that each of them strives to maximize his or her expected *net* benefit, that is the expected gross benefit of an early meeting minus the cost of "punctuality" if this is the individual's choice. If individual i believes that k other persons will choose to be punctual (leave early), then also i will choose to be punctual if and only if the resulting increase in the expected gross benefit is no less than the cost of punctuality, that is if and only if $\Delta B(k) \geq C$. Note that the expected return $\Delta B(k)$ to your punctuality increases in the number k of others who are punctual. This simple model thus illustrates that punctuality has a natural strategic complementarity (or supermodularity) property: if one more individual is punctual, then the marginal return to punctuality increases.

   It is now easy to see that there may be multiple Nash equilibria in this punctuality game. For instance, everybody choosing to be punctual (leave early) is an equilibrium

if and only if $C \leq \Delta B(n-1) = (1-p)B$. Likewise, everybody choosing to be tardy (leave late) is an equilibrium if and only if $\Delta B(0) = p^{n-1}(1-p)B \leq C$. Hence, both these polar equilibria co-exist if and only if

$$p^{n-1}(1-p) \leq \frac{C}{B} \leq 1-p \ . \tag{3}$$

See Figure 1 below, which has the timely-arrival probability p of a tardy person on the horizontal axis, and the cost-benefit ratio C/B on the vertical axis. The four curves plot the equation $C/B = p^{n-1}(1-p)$ for $n = 2, 3, 5, 10$, respectively, where lower curves correspond to larger n. Hence, for all parameter combinations $(p, C/B)$ below the straight line $C/B = 1-p$, "all punctual" is an equilibrium, and for all parameter combinations $(p, C/B)$ above the relevant curve (depending on n), "all tardy" is an equilibrium. As seen in the diagram, multiple equilibria do exist for a large set of parameter combinations $(p, C/B)$, and this set is is larger the more people, n, are involved in the meeting.
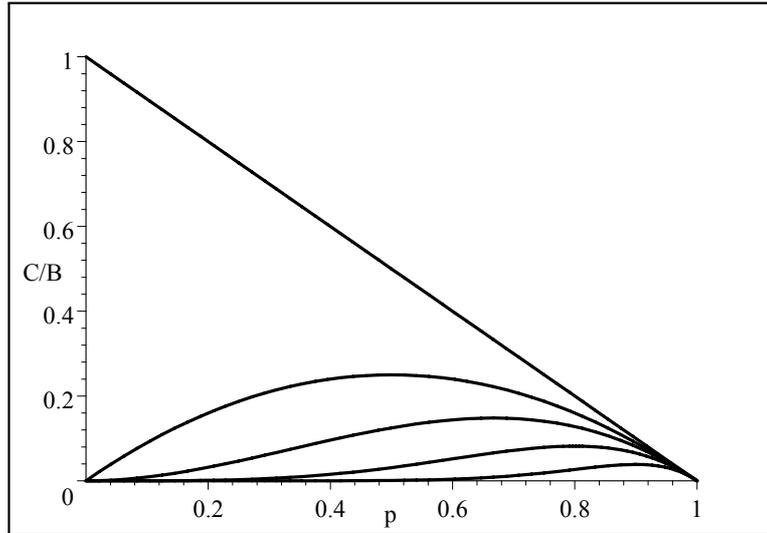

Figure 1: The parameter region where "full punctuality" and "full tardiness" co-exists as equilibria, for $n = 2, 3, 5, 10$ (lower curves for higher n).

The simple idea behind this model may hold some clues to tardiness, inefficiencies of several kinds, and to the poor quality of work and other such phenomena observed in developing countries. It shows how despite having no innate difference of significance, two groups can get locked into very different behaviors - one where they are

all tardy and one where they are all punctual. A social scientist who neglects the strategic aspect may be tempted to believe that if two societies exhibit sharply different behaviors, then they must have innate differences, such as different preferences or different religious outlooks on life or different genes. What we have just seen is that none of this is necessary. Some of the 'cultural' differences that we observe across societies could simply be manifestations of different equilibria in otherwise identical societies.

In reality certain behaviors tend to become habits. The person may then suffer some 'dissonance' cost if he or she has to behave otherwise. It is arguable that punctuality behavior falls into this category. Hence, even though one's decision to being punctual or not may be founded in trying to achieve some objectives, if one is punctual or unpunctual for a long time one may develop a direct preference for such behavior. Though it would be interesting to model the possibility of growing attachment to certain kinds of behavior and dissonance cost associated with trying to break out of it, we do not embark on such a study here.

There are many other and more direct ways, however, in which the model can be generalized, so as to accommodate a wider range of situations. For example, suppose that instead of the meeting only going ahead with a quorum of all n people, the meeting goes ahead at the early date, $t = 1$, irrespectively of how many have arrived, though with a diminished benefit to all present.[8] Those who arrive late simply miss the meeting and obtain utility zero. More specifically, suppose that if m individuals are on time, the meeting takes place with these individuals, each of whom receives the gross benefit $A(m)$, a non-decreasing function of the number m of individuals who are present at time $t = 1$. The model above corresponds to the special case when $A(m) = 0$ for all $m < n$ and $A(n) = B$.

Suppose that k individuals choose to be punctual (leave early), and hence arrive on time with certainty. Each of the remaining $n - k$ tardy individuals arrive on time with probability p. The expected gross benefit to each punctual person is then

$$P(k) = E\left[A(k + X)\right] - C, \tag{4}$$

where (again assuming statistical independence), the random number X of tardy individuals who happen to arrive on time has a binomial distribution with parameters $n - k$ (the number of trials) and p (each trial's success probability), $X \sim Bin(n - k, p)$. Likewise, the expected benefit to each tardy person is

$$T(k) = pE\left[A(k + 1 + X')\right], \tag{5}$$

where $X' \sim Bin(n - k - 1, p)$. The same argument as above leads to a sufficient condition for the existence of multiple equilibria, with condition (3) as a special

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[8]We are grateful to Geraint Jones for suggesting this generalization.

case.   In other words, as long as the payoff to punctuality depends positively on the number of other individuals who are punctual, the multiple equilibrium structure emerges naturally.

Another natural modification of our simple model is to let people choose departure time more freely. This is the topic of the following subsection.

4.1.   Fine-tuned departure times. In many real-life situations individuals do not have a binary choice between being "punctual" (leave early) or "tardy" (leave late).   Instead, a whole range of intermediate degrees of punctuality are available choice alternatives.   The departure time for a meeting can often be chosen on a more or less continuous scale. Suppose, thus, that each individual i can choose his or her departure time t_i anywhere in the time interval $[0, 1]$.   Suppose also that the probability p_i that individual i will arrive in time (that is, by time $t = 1$) is a decreasing function of i's departure time. This is the case, for example, if the travel time to the venue of the meeting is a random variable with a fixed distribution. Then $p_i = F_i (1 - t_i)$, where F_i is the cumulative distribution function of travel time for the individual (here assumed independent of departure time, but which may depend on i's location, mode of transportation etc.).   Let $C_i (t)$ be i's cost or disutility of departing at time t, which we assume is decreasing in t. Suppose, for example, that the cost is lost income: If i's wage rate is w_i per time unit until he or she departs for the meeting, then $C_i (t) = C_0 - w_i t_i$.   Let $B_i > 0$ denote the gross benefit to individual i of a meeting at the agreed-upon time $t = 1$.   Assuming statistically independent travel times, the expected net benefit (or utility) to individual i is then

$$u_i = B_i \prod_{j=1}^{n} F_j (1 - t_j) - C_0 + w_i t_i \ . \tag{6}$$

Suppose all individuals simultaneously choose their departure times. What are then the equilibrium outcomes? We focus on the special case of two persons with identically and exponentially distributed travel times.   However, in order to keep the example consistent with the basic model, we truncate the travel-time distribution so that even the latest departure, at $t = 1$, results in arrival by $t = 2$ for sure. The cumulative probability distribution function for travel time x is hence $F(x) = \left(1 - e^{-\lambda x}\right) / \left(1 - e^{-\lambda}\right)$.

In this case, a necessary first-order condition for an interior Nash equilibrium (that is, one where $0 < t_i < 1$ for $i = 1, 2$) is that the departure time of each individual i satisfies

$$t_i = 1 + \frac{1}{\lambda} \ln \left(\frac{w_i}{\lambda B_i}\right) + \frac{2}{\lambda} \ln \left(1 - e^{-\lambda}\right) - \frac{1}{\lambda} \ln \left(1 - e^{\lambda t_j - \lambda}\right) \tag{7}$$

This equation specifies i's optimal departure time as a function of i's wage rate, gross benefit of a punctual meeting, and i's expectation of j's departure time (see Appendix for a derivation). We note that i's departure time is increasing in i's wage rate, decreasing in his or her gross benefit from a punctual meeting, and increasing in i's expectation of j's departure time. Note, in particular, that the higher wage an individual has, or, more general, the higher an individual's opportunity cost of interrupting his or her usual activity, *ceteris paribus*, the later he or she departs - and the more likely it hence is that he or she will be late.

Equation (7) thus specifies the "best-reply curve" for each individual, and the intersections between these two curves constitute the interior Nash equilibria, see Figure 2 below, where the solid curve is 1's best departure time as a function of the expected departure time of individual 2, and the dashed curve is 2's best departure time as a function of the expected departure time of individual 1. When generating this diagram, we assigned individual 1 a higher wage/benefit ratio: $w_1/B_1 > w_2/B_2$. Consequently, in both equilibria, individual 2 chooses an earlier departure time than individual 1 - and is therefore more likely than individual 1 to be on time.
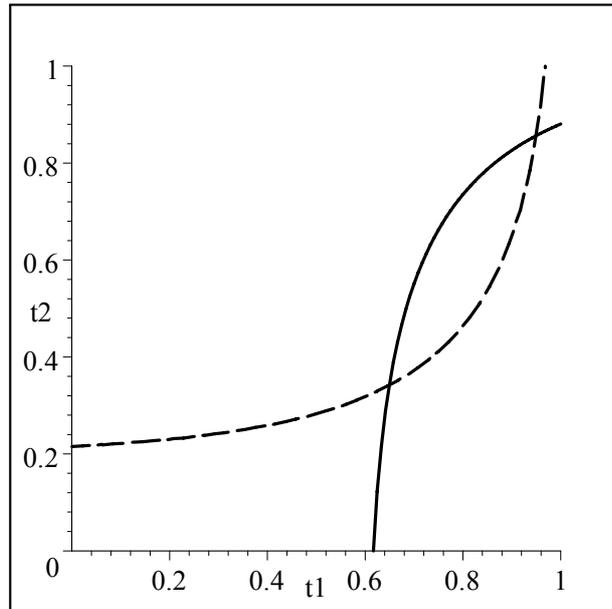

Figure 2: Interior equilibria in the special case $n = 2$, truncated exponential travel times with $\lambda = 3$, $w_1/B_1 = 1$ and $w_2/B_2 = 0.3$.

Besides these two interior equilibria, there is one equilibrium on the boundary, namely when both individuals leave as late as possible, $t_1 = t_2 = 1$, in which case the

meeting will be late with probability one. That this is indeed is a Nash equilibrium can be seen directly from equation (6): if one individual is expected to leave at time 1, then the probability is zero for an meeting at that time, and hence it is best for the other individual to leave as late as possible, that is, at time one.

Note finally that one of the interior equilibria, the one associated with later departure times, is dynamically unstable: a small shift in j's departure time gives an incentive for i to shift his or her departure time in the same direction. Hence, just as in the introductory example there are two stable "extreme" equilibria and one unstable equilibrium between these.

5. What is unpunctual behavior?

One question, that we have been on the verge of raising, but did not is: What constitutes unpunctual behavior? The reason why we could get away without confronting this question directly is because it was obvious in each of the examples considered above as to which behavior was associated with punctuality and which with the absence of it. But once we go beyond specific examples to confront the general question of what is the essence of the lack of punctuality, we run into a host of conceptual problems.

A person who is late and unpredictably so is clearly unpunctual. However, this is a case of sufficiency, but not necessity, in describing a person as unpunctual. Problems arise when we go beyond this clear case. Consider, for instance, a person who invariably shows up half an hour after the time he is supposed to show up. Is this person unpunctual? It all depends on what we mean by "the time he is supposed to show up", that is, what we take to be the base time to which he adds 30 minutes.

First consider the case where he comes 30 minutes after whatever time he is *told* to come (and maybe he expects other people to come 30 minutes after the time he tells them to come) and this is common knowledge. In this case we may indeed think of him as punctual. We will simply have to remember to tell him to come 30 minutes before the time we wish him to come; and when he invites someone for dinner that person has to remember to go 30 minutes after the time he is asked to go. When in France you are invited for dinner, something like this is true. Both sides know that if the announced time for the dinner is 7 p.m., then the intended time is 7.30.

Even here there may be a problem if meetings are called, and dinner guests are invited, by way of a public announcement of the time of the meeting or dinner, and we live in a society where some people follow the above time convention while others take the announcement literally. It may then not be possible to fine tune the message reaching each person, and so the person who is in the habit of arriving 30 minutes

late will indeed be late (unless of course the host targets the information for him and ends up having the other guests arrive early) and will be considered unpunctual. But if information could be fined tuned appropriately for each person, we would have to simply think of this person as someone who uses the language differently.

Now consider the case when the late comer, call him individual i, is a person who comes 30 minutes after what he believes is the time he is expected to come. In this case he is unequivocally unpunctual, and, on top, his behavior becomes hard to predict when he has to interact with another rational individual. Consider first the case where he has to use a certain facility, for instance, a laboratory or a tennis court, which can be booked according to a fixed (say, hourly) schedule. If this person treats the time when the facility is booked for his use as the time he is expected to show up, then, by virtue of his habit of delay, there will be 30-minutes of loss during which the facility stands idle, waiting for him. The problem gets messier if there is another person involved, who, for instance, calls a meeting with i. If the other person, say j, who calls the meeting, knows i's type, she may ask him to come 30 minutes before the time j wants him to show up. But if i knows that j knows his type, he may show up one hour after the time she asks him to come. Then again, if she knows that he knows that she knows his type, she may give him a time which is one hour before the desired time, and so on in an infinite regress. Indeed, if i's type is common knowledge, it is not clear whether it is at all possible for i to communicate with j about time. Time coordination, in other words, may become impossible with such a person. However, we would nevertheless not hesitate to call him unpunctual.

In closing it is worth mentioning that while we have, in this paper, considered problems involving timing decisions alone, it is possible that timing decisions interact with other kinds of decisions, causing a wider domain of reinforcement. In other words, instead of one person's tardiness reinforcing other people's tardiness, it may reinforce other kinds of inefficiencies in other people. Consider, for example, the problem of watch synchronization and tardiness. Some social scientists believe, as we discussed above, that the former causes the latter. Economists, on the other hand, are usually dismissive of this and think of tardiness as the cause of why people are content using clocks and watches that do not function properly. The kind of analysis we undertook in this paper suggests that, in reality, the causality may run in both directions because we can conceive of an equilibrium in which it is not worthwhile for watch producers to incur the extra cost needed to produce better watches and this is because there is so much lack of punctuality around that it is not worthwhile for each individual to spend much more on a better watch which would help him or her to be more punctual. In section 1 we wrote about how, as Joseph Stiglitz and others have suggested, economic under-development may be a kind of sub-optimal equilibrium in an economy with multiple equilibria. What we are suggesting - and this clearly

needs more research - is that other kinds of social phenomena, such as tardiness or the lack of 'work culture,' which are widely observed in less economically developed countries, may not be purely matters of coincidence but a necessary concomitant of that equilibrium.

6.   Appendix

A necessary first-order condition for an interior Nash equilibrium in the model in section 4.1 is that the departure time of each individual i (for $i = 1, 2$ and $j \neq i$) satisfies

$$\frac{\partial u_i}{\partial t_i} = -B_i F (1 - t_j) f (1 - t_i) + w_i = 0 \ .$$

Equivalently,

$$\frac{1 - e^{-\lambda(1-t_j)}}{1 - e^{-\lambda}} \frac{\lambda e^{-\lambda(1-t_i)}}{1 - e^{-\lambda}} = \frac{w_i}{B_i} \ ,$$

or

$$e^{\lambda t_i - \lambda} = \frac{w_i}{\lambda B_i} \frac{\left(1 - e^{-\lambda}\right)^2}{1 - e^{\lambda t_j - \lambda}} \ .$$

Taking the logarithm of both sides, one obtains

$$\lambda t_i - \lambda = \ln\left(\frac{w_i}{\lambda B_i}\right) + 2\ln\left(1 - e^{-\lambda}\right) - \ln\left(1 - e^{\lambda t_j - \lambda}\right),$$

which gives equation (7).

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