Punctuality: A Research Agenda

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Abstract

We address the issue of punctuality from an economics and from a strategy point of view, dealing both with theoretical and empirical approaches. Our empirical work is based on a dataset of construction projects from the petrochemical industry. We propose a series of games that characterize basic elements of strategic behavior in the context of punctuality. The preliminary and theoretical analyzes serve as a springboard for a research agenda on the economics and strategy of punctuality.

Keywords: punctuality, timing, culture, competitive advantage, organization economics, international business, development.
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1 Introduction

Punctuality is the soul of business.—Thomas C. Haliburton.

Punctuality plays a central role in modern economics. As James Surowiecki put it,

The fundamental challenge for a modern economy is to coordinate the actions of millions of independent people so that goods may be produced and services delivered as efficiently as possible. It’s a lot easier to do this when people are where they’re supposed to be when they’re supposed to be there. (The New Yorker, April 5, 2004.)

Punctuality is also an important component of firm strategy. For example, in the early 1990s Finnair started several quality improvement efforts, with a special emphasis on ground service operations. Since 1996, the company has consistently been ranked among the top three European carriers in punctuality. For example, luggage retrieval at Helsinki airport average 12 minutes, one of the fastest in the world.¹

In this paper, we address the issue of punctuality from an economics and from a strategy point of view, dealing both with theoretical and empirical approaches. We start with a discussion of possible definitions of punctuality (Section 2). Our empirical work is based on a dataset of construction projects from the petrochemical industry, which we describe in Section 3 and explore in Section 4. In Section 5, we propose a series of games that characterize basic elements of strategic behavior in the context of punctuality. The preliminary empirical and theoretical analyzes serve as a springboard for Section 6, where we set out a research agenda on the economics and strategy of timing and punctuality.

2 What is punctuality?

When talking about punctuality, the first question one is faced with is its definition. Broadly speaking, one is not punctual if one does not do something on time, e.g., one does not arrive on time. Consider the case of a construction project. If the project is scheduled to finish by time \( t \) and the contractor only finishes at time \( t' > t \), then we say the contractor was not punctual. But suppose that it is common knowledge that all construction projects take 10% longer to complete than the “engineering” estimate. Suppose that \( t' \) is greater than \( t \) by 10%. In that case, we should say that

¹See http://www.asq.org/pub/qualityprogress/past/0701/45the inter.html
the project was on time. In other words, what should be relevant is the actually expected date of completion, not the nominally expected date of completion.\textsuperscript{2}

Now suppose that the owner of the project works on complementary projects that are scheduled to be ready by time $t$. The value from these projects will only accrue if our construction project is ready by time $t$. Suppose moreover that the contractor in charge of the construction project on average takes time $t$ to finish it, with a standard deviation $\sigma$. From the project owner’s point of view, it does not matter if construction ends before time $t$. If it ends after time $t$, however, then the owner loses value insofar as the overall revenue stream only begins after the construction project is completed. This example highlights the fact that, in many cases, it’s not the average time that matters. In fact, for a given average time, the greater the variance the less punctual the contractor is.

Now consider two different contractors. The first one takes an average $t'$ to finish a project; the second one, $t'' > t'$. Both have the same variance of ending time. If the average times for completion are know to all, should we say that they are equally punctual? Punctuality cannot simply be finishing things before the appointed time. If that were the case, a contractor could always choose an expected $t = \infty$ and would have little difficult in being “punctual.”

An additional important dimension is the precision of completion time estimates. Suppose the first contractor estimates to complete a project in June 2008, whereas the second one simply indicates 2009. If the first one ends in August 2008, we would day he was not punctual; whereas, if the second one ended his project during 2009, we would say he was punctual, regardless of when in 2009 the project was completed.

All of these examples highlight that there are various ways in which one can talk about punctuality. In Section 4.1, we estimate the correlation between various measures to determine if there are any patterns of punctuality, that is, contractors or owners who tend to be more punctual according to one measure are also more punctual according to others.

\section{A dataset from the petrochemical industry}

In this section, we describe the genesis of the data set we will be using in our project. We also provide some basic descriptive statistics. We focus on projects in the petrochemical industry. Table 1 summarizes the four main phases in such projects: initial study, planning, engineering, and construction.\textsuperscript{3}

Our data was obtained from reading the \textit{Oil and Gas Journal} (OGJ), the industry’s main trade journal. Whenever a project is under way, and while it is under

\textsuperscript{2}So if research seminars start exactly 5 minutes after the appointed time, one might say that they start on time, since all the concerned parties understand that the starting time is 5 minutes
Table 1: Phases of a petrochemical construction project.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time-to-build</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Months</td>
<td>Perc.</td>
</tr>
<tr>
<td>Under study</td>
<td>1.5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Being planned</td>
<td>9.1</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>5.5</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>13.3</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29.4</td>
<td>100</td>
</tr>
</tbody>
</table>


way, the *Oil and Gas Journal* publishes regular progress reports. Table 2 exemplifies a series of reports from a series of consecutive issues of the OGJ. These observations identify a project of an ethylene plant taking place in Antwerp, Belgium and owned by the firm Finaneste. The first report gives implicitly an indication of when the project got under way. The end of the project is obtained by direct report or indirectly by the lack of additional progress reports.

Specifically, the variable $\hat{T}$, expected time to project completion, is obtained from reports in OGJ. Frequently, this date is adjusted as the project proceeds. We use the first reported date. Regarding the variable $T$, actual time for completion: If the starting date is not explicitly reported, we assume the mid-date between the first issue when the project was first reported and the previous issue. Likewise, the actual end date, unless explicitly reported is taken to be the mid-date between the last issue reporting the project as on-going and the next issue.

The database contains 2135 total observations, from 24 April 1978 to 16 October 1995, covering 36 different issues of the OGJ. Each observation corresponds to a dated box in Table 2 and includes more variables than the ones listed in this table. All of the observations in Table 2 correspond to the same project. There are a total of 683 investment projects. The mean number of observations per project is 3.1, the minimum 1 and the maximum 14.

There are 170 different firms in the database and 683 different investment projects. On average, each firm invested in 4.0 different projects (with a min of 1 and a max of 30). The number of distinct firms investing in the three different regions is as follows: Europe 85, Japan 27, and US 70. The total is 182, which means that in 12 projects (=182-170 different firms) the firm owning the project also made an investment in one of the other regions.

Out of the 683 total projects, 338 were located in Europe, 65 in Japan, and 280 in the US. The number of projects per product is as follows: ethylene 157, HDPE 61, LDPE 49, LLDPE 22, polyethylene 39, PP 120, propylene 74, PS 37, PVC 51, styrene 34, VCM 36 (and for 3 projects the product name is missing).

Out of the 683 total projects, 14 were abandoned (or assumed to be so): 11 in Europe, 2 in the US, and 1 in Japan. Out of the 14 abandoned, 6 were ethylene plants, 2 polyethylene plants, 3 PP plants, 1 propylene plant, 1 PS plant, and 1 VCM plant. These abandoned projects were equally distributed among the existing firms with only 1 firm with 3 abandoned projects (and all the others max 1 abandoned project).

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3Throughout the paper, we will frequently refer to construction projects. However, we really have in mind the entire process leading to the construction of a new plant, including the phases listed in Table 1.
Table 2: Typical set of observations per project.

<table>
<thead>
<tr>
<th>Journal Issue</th>
<th>Company</th>
<th>Location</th>
<th>Product</th>
<th>Capacity</th>
<th>Cost</th>
<th>Type</th>
<th>Status</th>
<th>Exp. Compl.</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-87</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>$ 404 MM</td>
<td></td>
<td>Under Study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr-88</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Under Study</td>
<td></td>
</tr>
<tr>
<td>Oct-88</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Under Study</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contr.: MW Kellogg</td>
</tr>
<tr>
<td>Apr-89</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Engin.</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lic: MW Kellogg; Contr.: MW Kellogg and Foster Wheeler</td>
</tr>
<tr>
<td>Oct-89</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Engin.</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lic: MW Kellogg; Contr.: MW Kellogg and Foster Wheeler</td>
</tr>
<tr>
<td>Apr-90</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Under Constr.</td>
<td>Dec-90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lic: MW Kellogg; Contr.: MW Kellogg and Foster Wheeler</td>
</tr>
<tr>
<td>Oct-90</td>
<td>FINANESTE</td>
<td>Antwerp, Belgium</td>
<td>Ethylene</td>
<td></td>
<td>450,000 mt/y</td>
<td>$ 404 MM</td>
<td>New</td>
<td>Under Constr.</td>
<td>Dec-90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lic: MW Kellogg; Contr.: MW Kellogg and Foster Wheeler</td>
</tr>
<tr>
<td>Apr-91</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3 presents some summary statistics of time to build from our current (limited) dataset. We cover 8 different products from 1978 to 1995 in Japan, the U.S., and various European countries. We are currently working on a much larger dataset including all countries in the world where petrochemical capacity was added between 1996 and 2004.

### 4 Empirical patterns

Having described our dataset, we now turn to some preliminary empirical analysis. In this section, we do two things. In Section 4.1, we propose a series of measures of punctuality and compute their correlation, looking for firm and country level punctuality patterns. In Section 4.2, we run some simple regressions to estimate the main cultural and economic determinants of punctuality.

#### 4.1 Measures of punctuality

In Section 2, we saw that there are various ways of measuring punctuality. In this section, we compute these measures and estimate their correlations. We consider the following measures of timing and punctuality:

- Expected time to project completion for project $i$: $\hat{T}_i$.
- Actual time to project completion for $i$: $T_i$.
- An indicator variable $I_i$ that equals 1 if $T_i < \hat{T}_i$ and zero otherwise.
Table 4: Summary measures of punctuality.

<table>
<thead>
<tr>
<th>Measure</th>
<th>unit</th>
<th>Europe</th>
<th>Japan</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E(T_i)$</td>
<td>month</td>
<td>20.6</td>
<td>25.4</td>
<td>15.6</td>
</tr>
<tr>
<td>$I(T_i &lt; \hat{T}_i)$</td>
<td>month</td>
<td>65.8</td>
<td>66.7</td>
<td>65.8</td>
</tr>
<tr>
<td>$E\left(\frac{T_i - \hat{T}_i}{\hat{T}_i}\right)$</td>
<td>%</td>
<td>-44.4</td>
<td>17.3</td>
<td>1.3</td>
</tr>
<tr>
<td>$\sigma\left(\frac{T_i - \hat{T}_i}{\hat{T}_i}\right)$</td>
<td>%</td>
<td>511.1</td>
<td>45.7</td>
<td>60.3</td>
</tr>
<tr>
<td>$R^2$ of $T_i = a + b \hat{T}_i$</td>
<td>%</td>
<td>21.8</td>
<td>70.0</td>
<td>27.3</td>
</tr>
</tbody>
</table>

- Percent deviation of actual time with respect to expected time:
  \[ d_i \equiv \frac{T_i - \hat{T}_i}{\hat{T}_i}. \]
- Average of $d_i$
- Standard deviation of $d_i$.
- Adjusted $R^2$ of the linear OLS regression (with a constant) of $T_i$ on $\hat{T}_i$.

Table 4 presents values of these measures with projects grouped by country. Some facts stand out. First, according to one measure the various countries seem remarkably similar: two thirds of the projects are completed before the estimated time, regardless of where the project takes place. However, according to any other measure the three countries considered are very different.

The average project takes the longest in Japan and the shortest in the U.S. However, in terms of the percent difference between actual and expected time the ordering is different: projects in Europe are completed on average before expected time, about the expected time in the U.S. and 17% longer than expected in Japan. However, this expected average difference hides significant differences in within region variation. Whereas Japan has the lowest standard deviation of $d_i$, Europe shows a remarkably high level of variation.

Our last measure of punctuality, adjusted $R^2$ of the linear OLS regression (with a constant) of $T_i$ on $\hat{T}_i$, seems to confirm the above idea. Japan is, by a long shot, the most predictable country, followed by the U.S. and Europe.
Table 5 shows the percentage of on time projects by European country. The results suggest that some of the high variation found in Europe may be cross-country variation. However, we should note that, for most countries, the number of observations is rather small.

### 4.2 Cultural and economic determinants of punctuality

What determines that some firms are more punctual than others? In addition to firm specific determinants, we can think of two possible sets of factors: cultural and economic. Consider first the culture factor. It is well known that some cultures accentuate punctuality more than others. A firm located in a country where punctuality is not a value will have a harder time working on time. But in addition to cultural traits, countries also differ with respect to economic factors. In particular, we would expect the opportunity cost of time to vary with a country’s level of economic development.

In this section, we perform some simple regression to ascertain the importance of cultural and economic conditions in determining a firm’s level of punctuality.

To be completed.
5 Punctuality games

The trouble with being punctual is that nobody’s there to appreciate it.—Franklin P. Jones.

Many economic activities involve more than one actor. A construction project, in particular, is the result of the efforts of several firms: the project owner, the contractor, and a variety of subcontractors, not to mention various governments and non-government organizations. To the extent that these various parties have differing interests, it seems natural to consider the strategic interaction among them from the perspective of game theory. In this section, we present some simple “punctuality games” which we think capture some of the essential elements of the strategic interaction in situations such as capacity construction in the petrochemical industry.

The games we will consider assume that a project’s value is only gained when two tasks have been completed. Each of these two tasks is performed by a player (e.g., contractor and subcontractor), who independently decide how much effort to put in order to be punctual. The two games differ with respect to the particular functional forms that describe the link between effort and actual time for completion.

5.1 A game of timing

Consider a game with two players, \( i = 1, 2 \), whose inputs are required for the completion of a given project. The player might be the project owner and the contractor; or the contractor and a sub-contractor. The project is completed when both tasks are completed, that is, \( t = \max\{t_1, t_2\} \), where \( t \) is the project completion time. At time zero each player chooses effort \( x_i \) to complete his task “quickly.” Specifically, we suppose that \( t_i \) is exponentially distributed with mean \( 1/x_i \).

Player \( i \)'s payoff includes two components: the cost from effort, \( C_i(x_i) \), which is increasing in \( x_i \) and is paid at time zero; and the payoff from project completion, which we normalize to 1 at the time of completion and discount to time zero according to the interest rate \( r \). We thus have

\[
\pi_i(x_1, x_2) = E\left(e^{-rt}\right) - C_i(x_i),
\]

where \( E(\cdot) \) is the expected value operator.

Before presenting formal results regarding the equilibrium of the game, it is useful to consider the following extreme value result:

**Lemma 1** Let \( x_i, i = 1, 2 \) be independently and exponentially distributed with mean \( \mu_i \). Then

\[
E\left(\max\{x_i\}\right) = \mu_1 + \mu_2 - \frac{\mu_1\mu_2}{\mu_1 + \mu_2}.
\]
When player 1, for example, increases the expected time for completion of his task \((\mu_1)\), the project completion time increases by less than the increase in \(\mu_1\). The reason is that the binding constraint may not be player 1, in which case the increase in \(\mu_1\) has no effect on project completion time. In particular, if \(\mu_2\) is very high, then an increase in \(\mu_1\) has a very small effect on expected project completion time. In fact, straightforward computation shows that

\[
\lim_{\mu_2 \to \infty} \frac{\partial E \left( \max \{x_i\} \right)}{\partial \mu_1} = 0.
\]

In words, if player 2 is very slow then player 1’s incentives to move fast are very small: it won’t help completing the project earlier. This is the intuition underlying Proposition 1: in the simple timing game, best response functions are upward sloping.

In game theory terms, Lemma 1 is related to the slope of the players’ reaction functions. Specifically, player \(i\)’s optimal choice of \(x_i\) is increasing in \(x_j\); that is, effort choices are strategic complements (Bulow et al, 1985).

Suppose now that each player’s cost function is given by \(C_i(x_i, \xi_i)\), where \(\xi_i\) is a parameter such that \(\partial C_i / \partial \xi_i < 0\). In words, players with a higher \(\xi_i\) have an easier time moving fast in the construction project. It can be shown that the above game is is supermodular:

\[4\] the more effort player \(j\) puts into completing her task rapidly, the greater the marginal benefit to player \(i\) from completing his task rapidly. In other words, player \(i\)’s best response function is strictly increasing.

**Proposition 1** The timing game is strictly supermodular.

One implication of Proposition 1 is that the equilibrium values of \(x_i\), \(\tilde{x}_i(\xi_i, \xi_j)\), are increasing in \(x_i\):

**Corollary 1** \(\frac{\partial \tilde{x}_i(\xi_i, \xi_j)}{\partial \xi_k} > 0\), \(k = i, j\).

So, for example, a given player \(i\) facing two players, \(j\) and \(k\), with \(\xi_j > \xi_k\), will adopt a higher \(x_i\) when facing player \(j\). We will return to this in Section 6.1.

Another implication is that the equilibrium value of player \(i\), \(\Phi(\xi_i, \xi_j)\), exhibits complementarities:

**Corollary 2** \(\frac{\partial^2 \Phi_i}{\partial \xi_i \partial \xi_j} > 0\).

In Section 6.4, we will consider various implications of this result.

\[4\]See Fudenberg and Tirole (1991) for definitions.
5.2 A game of precision

One problem with the previous game is that players are not controlling solely the precision of their time to completion; they are also changing the mean value of time to completion. This results from the fact that the exponential distribution only admits one parameter. Both variance and mean increase together with $\mu$.

An alternative is to consider a case when each player’s completion time is Normally distributed: $t \sim N(\mu, \sigma)$. In order to make this a “pure” punctuality game, let $\mu$ be exogenously fixed (and the same for both players). Each player’s strategy is therefore to choose a value of $\sigma$ (or, equivalently, $h \equiv 1/\sigma$, the precision of their plan).

The disadvantage of working with Normal distributions is that no analytical solution exists. Accordingly, we decided to attack the problem by means of numerical computation. We assumed that each player has a cost function

$$C(h_i) = \frac{h_i}{\omega_i},$$

where $\omega_i$ denotes the ease with which player $i$ is punctual.

We have been able to show that each player’s best responds curve, $b_i(h_j)$, has a slope that is positive and lower than one. This implies there is a unique equilibrium in the game where players simultaneously choose $h_i$. It also implies that, just like Corollary 2 indicates for the first punctuality game, equilibrium payoff is supermodular: players are better off if matched according to values of $\omega_i$. Specifically, suppose there are two players with high $\omega$ and two players with low $\omega$. Then total payoff is highest when the two players with high $\omega$ team together and likewise for the two players with lower $\omega$. (Note: these results need to be checked more carefully.)

To conclude, our numerical results form the second punctuality game suggests that Proposition 1 is more general than the case of exponential distributions.

6 A research agenda

In this section, we briefly describe some of the research areas on punctuality that we believe deserve further research work. Some of these are closer to economics themes, some to strategy, some to organization theory. Sections 6.1 and 6.2 deal with two strategy issues: multinationals and business alliances. Section 6.3 focuses on issues of firm organization. Finally, Sections 6.5 and 6.4 deal with two problems from economics.

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5There are some asymptotic results for extreme statistics of $n$ independent variables, but we are only interested in the case of two players, or at most a small number of players.
6.1 Multinational firm strategy
Consider again the game introduced in Section 5.1: two players simultaneously choose effort $x_i$ to be punctual, at a cost $C_i$ which is a function of $\xi_i$, player $i$’s “ease of punctuality.” Corollary 1 implies that player $i$’s equilibrium effort is increasing in $\xi_i$. In words, when facing a player $j$ who has greater ease in doing things on time, a given player $i$ should optimally make a greater effort to be punctual as well.

Insofar as different countries, and the firms in those countries, differ in their punctuality cost functions, the above result has clear implications for international business strategy. In fact, our punctuality game, together with our estimates of country specific effects, can provide a quantitative measure of how much a firm’s punctuality strategy ought to vary from country to country.

6.2 Firm alliances and competitive strategy
To a great extent, firm alliances are akin to marriage. Becker’s (1973) theory of marriage thus has important implications for the efficient and the equilibrium patterns of firm alliances. One of Becker’s main points is that, if the marriage payoff function exhibits complementarities, then equilibrium matching is assortative: better men get matched with better women.6 (Becker assumes each player is characterized by a one-dimensional parameter.)

As we saw in Section 5, punctuality games lead to equilibrium payoffs exhibiting complementarities: see in particular Corollary 2. This suggests that Becker’s results apply in a world of business alliances where firm characteristics such as punctuality are a central factor for success.

To put things more formally, consider a two-stage game with an even number of $n$ firms, each characterized by $\xi_i$ as in Section 5.1. In the first stage, firms are matched in pairs. In the second stage, each pair plays the punctuality game of Section 5.1. In other words, if punctuality were the only dimension on which firms were differentiated, then we would expect alliance patterns to bring firms together in an assortative way: the more punctual with the more punctual, the less punctual with the less punctual.

Consider for example video game hardware manufacturers and video game software writers. (Some firms, like Sony, are both.) Timing is quite important in the video game industry. Moreover, it is clear that hardware without software, or software without hardware, have no value. We thus have a problem similar to the punctuality games considered in Section 5. Another example is alliances between U.S. and European airlines. Again, we would expect a structure similar to the games

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6Specifically, the core of the matching game involves assortative matching.
in Section 5. Insofar as timing is the central issue, we would expect firms to partner
to assortatively according to this characteristic.

Naturally, punctuality is not the only thing that matters; but it certainly plays
an important role. Moreover, we believe many of the other relevant dimensions,
such as product quality, also exhibit significant complementarities. We thus believe
the idea of assortative matching plays an important role in business alliances.

Finally, notice that assortative matching magnifies the marginal gain from an
increase in $\xi_i$. Such an increase has a direct effect, the increase in $\Phi(\xi_i, \xi_j)$, the
equilibrium payoff when firm $i$ is matched with firm $j$. But it also has an indirect
effect, namely a better match, say with firm $k$ such that $\xi_k > \xi_j$. In industries
where business alliances play an important role, firms with a higher $\xi$ thus have a
“super-competitive advantage”: not only they are better than firms with a lower $\xi$,
but they also get matched with better firms than their lower $\xi$ rivals.

Formally, let $\tilde{\Pi}_i(\xi; \Xi)$ be firm $i$’s payoff in the two-stage game where $\Xi$ is the set
of all other firms’ $\xi$ values. For simplicity, assume a continuum of firms (as oppose
to a finite number, as above). Then,

$$\frac{\partial \tilde{\Pi}_i}{\partial \xi_i} = \frac{\partial \hat{\Pi}_i}{\partial \xi_i} + \frac{\partial \hat{\Pi}_i}{\partial \xi_j} \frac{\partial \xi_j}{\partial \xi_i}.$$  

(1)

where $\xi_j$ is the value of $\xi$ of the firm matched to firm $i$. Obviously, the concept of
super-competitive advantage is not limited to timing games. Whenever we have a
game that induces assortive matching, the two effects in (1) will appear.  

6.3 Punctuality and organizational structure

(Note: this section is very incomplete.)

One of the main themes in organization theory is the trade-off between cen-
tralized and decentralized decision making. The issue of punctuality brings one
additional dimension to this debate. Suppose that a given project requires two
tasks to be completed. Suppose moreover that these tasks are performed in parallel.
One of the costs of decentralization is that it is hard to estimate the opportunity
cost of delay in task $i$. If task $i$ is ahead of task $j$, then the opportunity cost will be
zero or very low. Any additional effort that is put in speeding up such tasks would
be a waste.

Punctuality in teams. In Section 5, we considered games between parties
with potentially different or maybe even conflicting interests. The above games
apply best to situations such as business alliances or the relation between contractor

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7There is some similarity with the direct and strategic effects in oligopoly. See Tirole (1989).
and subcontractor. However, the issues of punctuality, synchronization, and so forth, are equally important at the organizational level. In this case, the team theoretic approach may prove more appropriate. Suppose that $i$ and $j$ are two divisions within the same firm. Suppose moreover that both divisions have the same objective, namely firm profitability. Finally, each division makes its decisions independently.

In this context, it can be shown that the optimal solution is an equilibrium, but the equilibrium solution is not necessarily optimal. This is related to the work of Milgrom and Roberts (1990), who look at complementarities between multiple firm decisions. If these complementarities are sufficiently strong, then the possibility of multiple equilibria arises, with some equilibria being Pareto dominated by others.

6.4 Culture and economic development

I’ve been on a calendar, but never on time.—Marilyn Monroe.

It is a common perception that punctuality depends greatly on personal and cultural habits. Robert Levine, a well known social psychologist, argues that cultures can be divided into those which live on “event time” and those which live on “clock time.” Under event time, events dictate schedules; under clock time, schedules dictate events. Within a given culture, punctuality habits may also differ according to class. In Brazil, for example, lack of punctuality is a sign of success.

Once we correct for economic factors, we still observe significant country fixed effects in levels of punctuality. What is the source of these “cultural” punctuality effects? One possibility is that these differences are genetic and thus impossible to change. But another, tantalizing, possibility is that countries are playing different equilibria of the punctuality game. In this context, an interesting question is, what is the economic cost of an inferior punctuality equilibrium?

Recently, the Ecuadoran government started a campaign to improve the country’s punctuality habits:

Hundreds of institutions ranging form local councils to airlines have signed up to a promise to keep to time. Stragglers are barred from entering meetings . . . A local newspaper is publishing a daily list of public officials who turn up late to events.

Participación Ciudadana, the civic group behind the campaign, reckons that lateness costs Ecuador $724m (or 4.3% of GDP) each year. Cinemas, football matches and church ceremonies generally begin on time. But more than half of all public events start late. (The Economist, November 20, 2003).
Estimates of the cost of lack of punctuality vary. Ecuador’s International University puts the figure at $2.5bn. They also claim that students are the least punctual (late 22 percent of the time), followed by businessmen (11.6 percent) and the working class (1.3 percent).\textsuperscript{8}

As mentioned above, one reason why some economies are systematically less punctual than others is that they have fallen in a low punctuality equilibrium. The games presented in Section 5 are characterized by strategic complementarities, and it is well known that such games are prone to admit multiple, Pareto ranked, Nash equilibria.

A related concept is what we might call “unpunctuality multiplier.” In a sequential setting, a given economic agent may be forced to be unpunctual because a previous economic agent was unpunctual. For example, if a train driver misses a scheduled arrival then many commuters will miss their meetings, which in turn may lead to a series of other economics agents to miss their own deadlines; and so forth.

Some recent economics literature has attempted to address the possibility of systemic punctuality traps of the sort considered above. We would like to continue developing these issues at a theoretical level, and perhaps point to possible ways of estimating the economic magnitude of losses from inferior equilibria.

6.5 Business cycles and time to build

In a seminar paper, Kydland and Prescott (1982) analyzed the relation between time to build and the business cycle. Our results suggest two possible extensions of their work. First, average time to build is likely to be an endogenous variable; in particular, it depends on firm effort. Moreover, the precision of time to build is also likely to depend on firm effort. The endogeneity of time to built and punctuality decision suggests a number of interesting research questions. In particular, we are interested in estimating how those decision vary along the business cycle.

Suppose that a construction project takes one year if high effort is put on punctuality, or between one and two years if effort is not made. An average business cycle, in turn, takes for several years. In this situation, the expected opportunity cost of delay is higher in periods of boom. That is, when demand is higher the opportunity cost of being capacity constrained is higher. Other things equal, we would expect projects to be more punctual during those periods. But no all things are equal. In particular, the cost of punctuality is likely to be higher in boom periods. An additional complicating factor is that the average construction period may be of the same order of magnitude as the business cycle. In this case, the above calculation may be reversed, since the opportunity cost at the time of project completion is

\textsuperscript{8}See AFP, October 1, 2003.
inversely correlated to the opportunity cost of time at the time of project inception.

The above discussion has focused primarily on time to build. When we say the opportunity cost at the time is higher during a period of boom, we mean that delaying a project by one period implies a higher level of forgone revenues. But let us consider specifically the precision of time to build (one possible measure of punctuality). Since the peak of the cycle is also a period where the cycle curve is concave, we conclude that the value of punctuality (in the sense of precision) is also higher during a boom (by Jensen’s inequality).

To summarize, from a theoretical point of view it’s unclear how the business cycle will affect firm decisions regarding time to build and the precision of time to build. Our plan is to start this project from an empirical approach, namely searching for empirical regularities; and then elaborate on possible explanatory theoretical models. A more ambitious, follow-up project, consists of looking at the reverse direction of causality: how firm decisions regarding time to build and punctuality influence the nature of the business cycle.
Appendix

Proof of Proposition 1: By assumption, the distribution of $t_i$ is given by $f_i(t_i) = x_i \exp(-x_i t_i)$. It follows that the distribution of $t \equiv \max\{t_1, t_2\}$ is given by

$$f(t) = x_1 \exp(-x_1 t) \left(1 - \exp(-x_2 t)\right) + x_2 \exp(-x_2 t) \left(1 - \exp(-x_1 t)\right).$$

It follows that

$$E\left(e^{-rt}\right) = \int_0^\infty e^{-rt} f(t) \, dt = \frac{x_1 x_2 (2r + x_1 + x_2)}{(r + x_1)(r + r_2)(r + x_1 + x_2)}.$$

Straightforward computation yields

$$\frac{\partial^2 \pi_i}{\partial x_1 \partial x_2} = \frac{2r}{(r + x_1 + x_2)^3} > 0.$$

Since $E\left(e^{-rt}\right)$ is the only part of the payoff function that depends on $x_1$ and $x_2$, the result follows. ■
References


