The rule of the road, 1919-1986

A case study of standards change

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ABSTRACT

In 1919, 104 of the world's territories drove on the left and 104 on the right. Between 1919 and 1986, 34 of the keep-left territories changed to keep-right. No territories shifted in the opposite direction. This paper tests and largely sustains the counterintuitive hypothesis that the reason all changes were in one direction was less that there was any difference between keep-left and keep-right as rules, and more that the geographical position of many keep-left territories happened to put them under *pressure to change* from keep-right neighbors. This paper also discusses six other potential explanations of change, most of which played some role as well. Finally, it shows that the rule of the road is an example of standardization and convention. The explanations of change proposed for the rule of the road are familiar from many other cases of standardization.

INTRODUCTION

In 1919, 104 of the world's territories drove on the left side of the road and 104 on the right. By 1986, 34 of the keep-left territories had changed to keep-right. No territories changed in the opposite direction.

Why did this shift happen? And why were all 34 changes in one direction? Here are seven hypotheses—not, by the way, mutually exclusive ones—that might occur to a curious casual observer:

- Maybe there is something truly better about driving on the right side of the road, some sort of natural superiority. Recognizing this superiority, some territories have changed to keep-right.
- Even if keep-right is not *naturally* superior, perhaps it has been *practically* superior for many territories. For example, if the selection of cars built for keep-left drive is poorer than the selection of cars built for keep-right, it might make sense to switch to keep-right.
- Perhaps the territories that changed to keep-right did not choose to do so themselves. Maybe they were forced to by their colonial "masters" or by other more powerful countries.
- Perhaps the changes were purely symbolic statements of identity. For example, a country which was part of the British Empire and thus had a keep-left rule in 1919 might have changed to keep-right to symbolize their independence from Britain.
- Perhaps a lot more keep-left countries actually wanted to change to keep-right, but—for political, technical, or financial reasons—not all of them were able to.
- Perhaps keep-right was "helped along" by self-reinforcing momentum. As more and more territories changed to keep-right, the remaining keep-left territories had a stronger and stronger incentive to follow.
- Perhaps keep-right was helped along by a kind of momentum that had to do with the position rather than the number of keep-right countries. Maybe it just so happened that the keep-left territories tended to be surrounded by keep-right territories, and decided to harmonize their rule of the road with their neighbors.

This paper evaluates each of these hypotheses, showing to what extent each of them explains the changes in the rule of the road between 1919 and 1986. Since the rule of the road is a classic case of convention and standardization, each of these ideas turns out to be familiar either from theoretical writing on standardization or from other specific standards histories. The paper's central organizing goal, however, is a statistical test of the last hypothesis in the list above —the idea that many keep-left countries were bordered by keep-right countries and changed their rule of the road to bring about regional harmonization, and that the resulting expansion of the keep-right rule was a coincidence that had nothing to do with the intrinsic or rational

superiority of keep-right itself. My special interest in this hypothesis comes from Kincaid's (1986) suggestion that "harmonization with neighbors" was the main cause of changes in the rule of the road between 1919 and 1986. This paper uses a statistical approach to see to what extent this suggestion was correct.

What my investigation shows is that one can make a fairly accurate prediction of whether a territory changed its rule of the road between 1919 and 1986—regardless of what that rule actually was—simply by observing how many of that territory's neighbors had a contrasting rule of the road in 1919. That does not mean that the other hypotheses above are wrong. In fact, working them into this model improves its predictions. Still, the worldwide expansion of the keep-right rule in the twentieth century had less to do with anything about the relative merits of keep-left versus keep-right, and more to do with the geographical position in which keep-left countries happened to be in 1919.

BACKGROUND

The rule of the road

Considering the centrality of the rule of the road to daily life, very little attention has been paid to it. This is not so surprising if we remember that it is one of the many facts of everyday life that are "seen but unnoticed." We are all familiar with the rule of the road but we rarely stop to consider it.

There is, however, an excellent standard reference book on its history: Peter Kincaid's *The rule of the road: an international guide to history and practice* (New York: Greenwood Press, 1986). Kincaid is a professor of law at Macquarie University in Sydney, Australia. Most of the book is a painstaking collection of data on the history of the rule of the road in territories all over the world. The introduction summarizes earlier research on the topic, and gives balanced discussions of general questions, such as whether one rule of the road is superior to another, and what the rule of the "road" for other types of transportation is.

For each territory in the world, Kincaid lists the current (i.e., circa 1986) rule of the road, both graphically and in list form (pp. 192-195). Kincaid chooses 1919 as the other point at which

to take a graphical "snapshot" of the rule of the road worldwide (pp. 196-197). There are a number of good reasons to choose this year. World War I had just ended and international boundaries had been redrawn in a way that is relatively easy to compare with 1986. Motor cars had become common in many countries but the worldwide expansion of road networks had not yet taken place. From 1919 on, very few colonies were transferred from one metropolitan power to another in a way that forced a change in the rule of the road. The reassignment of German colonies during World War I was the last time when a change in colonial sovereignty affected the rule of the road in a large number of countries.

Though Kincaid's was the first systematic study of the rule of the road, interest in the topic goes back much further. For example, George Gould, a prominent American psychologist and friend of William James, was intrigued enough by the rule of the road to devote part of a book to it, just at the time that motor vehicle traffic was becoming a social issue (Gould 1908). Of course, passing rules are also a problem for horse-drawn vehicles, ships, trains, and even pedestrians. Lay (1992), Dufwa (1985), and Kincaid cite examples of legislation regulating these types of traffic going back as far back as the eighteenth century.

Standards and conventions

The rule of the road is an example of a standard. I like to distinguish between three levels of the standardization process, which I call the *task*, the *problem*, and the *solution*.[1] The *task* is usually a technology (in a broad sense of the term that includes writing systems and measuring scales) we want to use. The *problem* is an issue that needs to be resolved in carrying out the task, and which everyone who participates needs to resolve in a coordinated way. A *solution* is a particular way of resolving the problem. For example, if the task is the production and use of the typewriter, one problem is the design of the keyboard, and the Dvorak and QWERTY layouts are two of many potential solutions to the problem. In the case of the rule of the road, the task is driving—more specifically, driving on two-way public corridors. The problem is which side of the road to keep to when you meet oncoming traffic. There are only two possible solutions: keep-left and keep-right.

[1] The term "solution" has already been used in this way by Ullmann-Margalit (1977) and Schmidt and Werle (1998). Ullmann-Margalit also uses the term "problem" in a similar way.

Standardization is a social phenomenon, because it requires coordination from all the people in a group. Standards solutions are textbook examples of what Durkheim (1938:10) called "social facts." People are born into a world where everyone else uses them, and thus come to use them themselves. Solutions become reified, so that we think of them as facts of the natural world. When solutions differ from group to group, they become badges of group membership and symbols of identity.

No wonder that standardization, as well as individual standards problems, has attracted attention from virtually all of the broadly-defined social sciences, including sociology (e.g., Schmidt and Werle 1998); economics (Kindleberger 1983), political science (Krislov 1997), history (Kula 1986), law (Kincaid 1986), philosophy (Lagerspetz 1995), and linguistics (Daniels and Bright 1996).

Over the past several decades a loose tradition of social-science scholarship on standardization and convention has taken shape. Some of it, such as Kincaid (1986), Schroeder's (1991) article on the history of electrical plugs, or Middleton's (1966) informative book on the history of the thermometer, has been purely concerned with the history of individual standards problems. Other research has been more theoretical, trying to isolate features that are common to the story of all standards and conventions (e.g. Schelling 1960, Lewis 1969, Ullmann-Margalit 1977, Duncan 1984, Arthur 1994, Lagerspetz 1995). Yet other scholars have tried to show how the history of a specific standards problem illustrates themes common to standardization in general. Examples here are Zerubavel's (1985) study of the length of the week; Schmidt and Werle's (1998) three case studies of recent technological standards; and David's (1985, 1986) piece on the history of the typewriter keyboard. David's article made a large public splash and is still cited in the popular media.[2] Although these scholars come from many different fields, it is more useful to emphasize the similarity of their approaches, than to subgroup them along disciplinary lines. Indeed, Scheff (1967:34-36) and Lagerspetz (1995:25-29) have specifically drawn attention to the correspondence between the concepts used by Schelling (an economist

[2] See, for example, Peter Passell, "Why the best doesn't always win," *New York Times Magazine,* 5 May 1996, pp. 60-61. David's original article, though easy to understand, should not be taken as gospel. It was a rhetorical piece designed to orient economists' attention to history, not a systematic investigation of the history of the typewriter keyboard. It should be read in conjunction with the rebuttal by Liebowitz and Margolis (1990).

who was very interested in sociology and psychology) and Durkheim (a thinker claimed by both sociology and anthropology).

As standards go, the rule of the road sits at one extreme in its formal simplicity and clear-cut, non-fuzzy nature. The choice of solutions is completely binary: keep-left or keep-right. There are no compromise options. It is impossible for two standards to coexist on the same territory. Therefore all change in the rule of the road must be precisely punctuated, both temporally and spatially: when a territory changes rules, it happens at a definite point in time, and when we drive from one country to another, any change in the rule of the road will take place at the point where the road crosses the border between countries. Gradual transitions are impossible.[3] This limits the interest, depth, and nuance of the rule of the road as a social phenomenon, but does make it much easier to study and analyze. In fact, the simplicity of the rule of the road means that it often gets used as a demonstration example to illustrate basic principles of standardization and convention (Lewis 1969), of coordinative game theory (in my college microeconomics class), and even of the way social facts order our world.[4]

The rule of the road as a case study in standardization

The subtext of this paper is my attempt to build a bridge between the *historical* literature on the rule of the road, and the *theoretical* literature on standardization. While the rule of the road has been recognized as an example of standardization at least since Lewis (1969), no one has yet taken the time to fully reconcile the case and the theory.

In fact, the seven ideas I discussed in the introduction reflect perspectives on the evolution of standards that are found throughout this literature. They *also* correspond to Kincaid's own list of "reasons for changes in the rule of the road" (pp. 17-20). I have laid out each of these perspectives or hypotheses more clearly in Table 1. The first column suggests a

[3] To be fair, I should say that this is only true given a minimum level of road traffic. In a desert, for example, where roads are defined poorly and there is little traffic, the rule of the road might be irrelevant and in driving from one country to another the change of rule might not take place at any definitive point because there may be no oncoming traffic.

[4] Jonathan Steinberg quotes the following from Peter Bichsel's 1969 novel *Des Schweizers Schweiz:* "I come out of the boring *Nationalrat* onto the crowded street. The many cars drive past each other. I stand there for ten minutes and don't see a single collision. The autos do not collide because they drive on the right. Some time or other this parliament decided that automobiles must drive on the right. That is why there are no collisions. Parliament has ordered my world for me; it fulfils its task; my world is ordered." (From Jonathan Steinberg, *Why Switzerland?,* 2nd ed., Cambridge: Cambridge University Press, 1996, p. 139, Steinberg's translation.)

name for each perspective; the second gives an *abstract* summary of the perspective, using the generic term "actors" for the multiple autonomous units that choose a solution to any standards problem; the third summarizes how the perspective is applied to the specific case of the rule of the road; and the fourth presents the corresponding category of "reasons for change" from Kincaid.

My impression is that at the time he wrote his book, Kincaid was unaware of this correspondence between his case-specific theories of change and others' general theories. Similarly, the theorists of standardization have never systematically tested these perspectives on the case of the rule of the road—and in fact, most theorists of standardization have focused on only one or two explanations at a time (such as Arthur 1994, whose goal was to promote the self-reinforcing momentum hypothesis over the natural and rational superiority hypotheses). Most historians of individual standards have been aware of the multiplicity of explanations for their particular case, but have not always recognized that this is a common theme across different standards problems.

Table 1—Common hypotheses about standards solution change and choice

Hypothesis name	***Abstract principle, from theories of standardization***	***Applied to changes in rule of the road***	***Kincaid's category***
Natural superiority (1)	Some solutions are objectively better than others, on pre-social grounds	Since most humans are right-handed, one of the two rules of the road may be naturally better, and if so we will see a migration to it	"Inherent advantages," p. 25
Rational superiority *or* historically conditioned superiority (2)	Some solutions *appear* objectively better because of current circumstances. Human institutions are set up to favor particular solutions.	It would be more rational to choose keep-right or keep-left if, for example, the choice of cars adapted for one rule was larger, or if most of the world's roads were built for one rule	"Availability of cars," p. 19
Coercive force (3)	Rejects the idea that actors choose freely among solutions. Standards solutions are imposed by those in power	Territories may have changed their rule of the road because they were forced to by occupying powers such as the U.S., Germany, and Portugal or "cultural" powers like the U.S.	"Military occupation," p. 17; "Influence of powerful states" (?), p. 18
Statement of identity (4)	Standards solutions serve as a badge of identity for their adopters. Sometimes actors adopt a solution—even a unique or non-"rational" one—in order to show that they belong to a larger group, or to symbolize their separateness and independence from a group	Some changes in the rule of the road may have taken place for symbolic rather than practical reasons	"Political reasons," p. 19

Conditions for change (5)	Favorable or unfavorable conditions, that vary from group to group, may promote change that might not otherwise have happened, or block changes that would otherwise have made sense	Countries with a higher degree of infrastructural investment in the rule of the road might have had a more difficult time changing their rule	Not mentioned
Self-reinforcing momentum (6)	The number of early adopters is crucial. The more adherents the solution has, the more it will get. Balance of solutions exhibits path-dependence based on number of early adopters. Investors in solutions receive increasing returns to scale	Especially if neither solution is naturally superior, territories may just judge the relative popularity of the two and then jump on whichever bandwagon is most crowded	"Trend to world uniformity," p. 19
Harmonization with neighbors (7)	Standards choosers and rechoosers decide based on what "nearby" actors are doing, rather than a judgement of the whole field. Harmonization is key. Balance of solutions exhibits path-dependence, but based on distribution rather than number; on *who* adopted what rather than *how many*.	The most important motive for change may have been harmonization with neighbors. Territories may have been "fated" to change if they were surrounded by other territories with contrasting rules of the road	"Conformity with neighbors," p. 18; "National unity," p. 19 for countries where the rule of the road varied by province.

Conceptualization

Kincaid believes that local harmonization, which he calls "conformity with neighbors," was the "most common reason for change" in the rule of the road (p. 18). While Kincaid's historical and descriptive sketches give plenty of support for this assertion to anyone who reads his entire book, the statistical tests in this paper make it easier to judge its validity. I conceptualized each territory in the world as a node in a network, with lines linking territories connected by road. My idea was to count (for each territory) the proportion of neighbors with a *contrasting* rule of the road, and then to use several simple arithmetic and statistical techniques to evaluate the argument that conformity with neighbors really was the main motivation for change in the rule of the road.

To illustrate the cross-disciplinary ubiquity of my "network" or "adjacency" model, it is interesting to note that my immediate inspiration for this conceptualization was the linguist Leonard Bloomfield's (1933:46-47) visual metaphor for the structure of speech communities.[5] However, Schelling (1969, 1971, 1978), Young (1996, see below), any of the network theorists in

[5] Bloomfield observes that "Every speaker's language . . . is a composite result of what he has heard other people say." He goes on to suggest that the reader "imagine a huge chart with a dot for every speaker in the community," with lines connecting dots whose speakers had ever had a conversation. Speakers correspond to "territories" in the case of the rule of the road, and conversations to "road links."

sociology, or the "Game of Life" familiar to early computer programmers[6] could have inspired it equally easily.

There has, in fact, been one other attempt to use a network model to relate the history of the rule of the road to the theory of standards and conventions. Young tried to develop an "evolutionary model of convention formation" (1996:108) using the biological analogy of "punctuated equilibrium" (1996:112). He used the rule of the road as one of two case studies. Young had also read Schelling, Lewis, David, Arthur, and other literature on standardization and convention. He too saw that the rule of the road in one territory can affect the rule in a neighboring territory, and drew diagrams to illustrate the same sort of network model. Young's historical analysis of the rule of the road starts from the fact that after the French Revolution, France and the countries it occupied changed their rule from keep-left to keep-right "for symbolic reasons" (1996:113), and that by now almost all the rest of Europe has changed to keep-right too. Young's proposed theory of the evolution of conventions argues that any established convention "will eventually be dislodged by a series of random shocks"—the "punctuation" of the equilibrium —after which "society then careens towards a new convention" (1996:112). He concludes that "prompted by the [random shock of the] French Revolution, we have probably been witnessing just such a shift from left to right driving over the last couple of hundred years" (1996:116). Unfortunately it is impossible to agree with Young's conclusion, because there is in fact no evidence that the French Revolution prompted a change in the rule of the road in France or anywhere else.[7] Though Young does cite Kincaid, he overlooked the sections of Kincaid's book (1986:14, 99-100) that specifically refute the sources Young relied upon, showing that the French Revolutionary tale is a legend with no demonstrable basis in fact. The story of Young's article is an example of how even scholarly writing often repeats, as fact, tenacious urban legends about the origin of standards and conventions.[8] Young's article does observe that episodes of what I have called "coercive force" (which Young referred to as factors outside the neighborhood

[6] The "Game of Life," invented by John Conway, was first publicized by Martin Gardner in his "Mathematical Games" column in *Scientific American* (Oct. 1970, pp. 120-123; Feb. 1971, pp. 112-117).

[7] Young lists three sources for this fact: Hamer (1986), Hopper (1982), and Lay (1992). Hamer (1986) is a popular article on the rule of the road, with no citations, published in the *New Scientist,* a British weekly magazine. Hopper (1982) is an article from a scholarly journal, the *Transportation Quarterly,* but it was a diversion, in a popular style, without citations, reprinted from an oil industry periodical. Lay (1992:197-201) is the most scholarly of the three, but his source for information on the supposed French revolutionary change turns out to be . . . Hopper 1982.

[8] See my work in progress, "Justifying Standards." Another example from a recent scholarly book on standardization is Krislov (1997:30, 208), who says that keep-left is safer than keep-right without citing any source for the assertion.

model) alternate with periods in which standards development depends on the free choice of the actors involved for any number of different reasons (limited in Young's model to the desire for "local conformity," which is equivalent to Kincaid's "conformity with neighbors" and my "harmonization"). Although this observation is valid, Young's article does not succeed in demonstrating it historically.

DATA AND METHODS

My goal was to construct a data set that would allow me to test, for each territory in the world, the relationship between the degree of contrast among neighboring territories' rule of the road, and whether that territory later changed its rule of the road. The main steps in building the data set were:

(1) settling on an exhaustive way of partitioning the landmass of the earth into discrete territories, as if we were carving up the pieces for a giant jigsaw puzzle.
(2) finding out, from Kincaid's book, the rule of the road in each of those territories in 1919 and in 1986.
(3) determining the number and identity of each territory's neighbors.

The appendix describes the construction of this model in full. Building it required compromise and judgement. My model creates comparability out of diversity, and considers things equivalent that are clearly not the same. It reconciles the differences between 1919 geography and 1986 geography. It focuses on the similarities, rather than the differences, between independent nations and dependent satellites—all of which I called "territories"—and between six-lane expressways and rutted jungle tracks—all of which I considered bona fide "cross-border road links." Of course it is a distortion to lump together things that are so different. But no model could ever be perfect, and I feel I created the best possible workable model of the world road traffic system. Here I'll only discuss two of its shortcomings which will become important later:

Sub-national units. In three countries where the rule of the road varied by region in 1919 (Canada, Italy, and Cameroon), I set up each distinct region as a separate territory. While this is a faithful (if tautological) approach in most respects, there is no way in my model to capture Kincaid's "national unity" factor: the fact that as long-distance road travel became more common, countries had a tremendous incentive to have a single uniform rule of the road

throughout the entire nation, much greater than the modest rationale for harmonizing their rule with their foreign neighbors. Thus, for example, British Columbia, Ontario, and Nova Scotia now all have one rule. My model inappropriately allows for predictions of independent developments in the different regions of a country.

Time series problem. My model allows only for one "iteration" of change: it assumes that all decisions to change the rule of the road will follow from an evaluation of neighbors' rule of the road in 1919, not, say, in 1959. This might be a fatal flaw in my model, if it were not for the fact that there were only a few changes in the rule of the road which occurred in a chain fashion, with one node's change precipitating change in a linked "node." For example, only after Austria and Czechoslovakia changed to keep-right did Hungary have much incentive to follow, since it was then the one remaining country in continental Europe which still drove on the left. These domino-effect cases will show up in our lists of mispredictions later on. In theory it would be preferable to use a "survival" model of the development of the rule of the road, iterating the decision to change every year in order to capture the percentage of neighboring countries with a contrasting rule of the road *at the time of the change* rather than in 1919. However, there are diminishing returns to this extra effort and I feel that the basic trends are clear enough in this simpler analysis.

Variables

My basic data set listed the following values for each territory. (I also calculated *contrasts* and *pressure* values for 1986, but these are not relevant to the analysis here.)

rule1919: the rule of the road in 1919: keep-left or keep-right
rule1986: the rule of the road in 1986
change: whether a change took place
neighbors: the number of neighboring territories (defined as those with road links)
contrasts: the number of these territories with a contrasting rule of the road in 1919
pressure: the ratio contrasts/neighbors

My main research question thus became testing the relationship between *pressure* and *change*. In other words, did a territory with a larger percentage of neighbors with contrasting rules of the road in 1919 have a greater propensity to change its rule of the road by 1986? Below are further details on the operationalization of these variables.

Change

My dependent variable measured whether a territory permanently changed its rule of the road between 1919 and 1986 (0=no, 1=yes).

Pressure *and* Island

Pressure to change measures the pressure on a territory to change its rule of the road in the year 1919. It is simply the ratio of the number of neighbors with a contrasting rule of the road, to the total number of neighbors. In order to make the meaning of the variable values clearer, I subtracted one-half and multiplied the result by two to express *pressure* along a scale running from -1 to 1. (This non-power transformation has no effect on the regression analysis.) Thus a value of -1 means that a territory had full pressure *not* to change from all its neighbors. A value of 1 means that a territory was under pressure *to* change from all its neighbors. A value of 0 means an even balance between contrasting and compatible neighbors with no net pressure to change. For all territories, the mean *pressure* value was -.32 with a standard deviation of .57. Only 47 of the 208 territories had non-integral *pressure* values (neither -1, 0, or 1), reflecting the fact that, across territories, the median number of neighbors was only 2.

Islands—defined in this paper as territories with no neighbors[9]—were assigned a *pressure* value of 0, reflecting that they have no pressure from neighbors to either change or to maintain the status quo. Although this is logically justified, empirically only six of the 68 island territories changed their rule of the road between 1919 and 1986. It thus seemed that islands had somewhat more of an incentive to maintain the status quo than a *pressure* value of 0 would indicate, and I even considered giving them a *pressure* value of -1 instead. My solution was to set up a dummy variable, *island,* coding simply whether a territory was an island or not (0=no, 1=yes). This allows the effective *pressure* value for islands to float to whatever is most appropriate.

[9] All but three of the 68 islands also fit the canonical use of the term as territories surrounded by water. The exceptions were French Guiana, Guyana, and Surinam.

The Portugal issue

One might wonder why my model does not take into account whether a territory was or was once a British or French colony. The reason is that this would be very useful only if we were trying to predict which rule of the road territories observed in 1919. Territories with a British colonial past overwhelmingly drove on the left (for example, South Africa, Australia, Hong Kong, and Newfoundland). French influence was a clear predictor of keep-right (for example, in Algeria, French Polynesia, Vietnam, and Haiti). However, my dependent variable is *change,* not any particular rule of the road. If either Britain or France had changed its rule of the road between 1919 and 1986, one would have expected some of its colonies to follow, and being part of the extended British or French world would probably have been a significant predictor of change. But this did not happen.

But one colonial power *did* change its rule of the road between 1919 and 1986: Portugal, which changed from keep-left to keep-right on June 1, 1928. Four of its eight colonies followed suit. To capture this extra incentive to change, I created another variable, *portugal,* set at 1 for the six territories in my data set that were part of the Portuguese realm in 1928 and 0 for all others. (Goa and East Timor, the other two Portuguese colonies, were not included in my data set for reasons discussed in the appendix.) Without this variable, my model would fail to predict change in several of these territories.

To some extent, this is an explicit nod to the "coercive force" hypothesis. While it is possible to argue that Portugal was simply a strong influence on its colonies' rule-of-the-road decisions—a sort of super-neighbor—one can also argue that Portugal truly controlled the rule of the road in some of its colonies. However, during the period between 1919 and 1986, this type of influence was the exception. On the whole, this period was one in which relatively few such "outside" political factors were operative.

HYPOTHESES #1, 2, 6, 7: ANALYSIS

The harmonization perspective suggests the counterintuitive idea that, even though all of the territories that changed were keep-left territories, one might be able to successfully predict the outcomes of all 208 territories *without taking their 1919 rule of the road into account.* In other

words, one starts out without any assumption that the differential behavior of keep-left and keep-right countries stems from the differences in their rule of the road. One then uses the rule-independent notion of *pressure* to predict change. To the extent that we can successfully predict that differential behavior using this *pressure-only model,* we have a very strong argument in favor of the harmonization hypothesis.

The opposing view is of a model whose main independent variable is the 1919 rule of the road, thereby hypothesizing that there was pressure to change on keep-left countries *simply by virtue of the fact that they kept left.* This *rule-only model* does not discriminate between the natural superiority, rational superiority, and self-reinforcing momentum hypotheses, all of which would be consistent with such an explanation for change.

We are thus setting up a face-off between two theories of the motivations of change which make different predictions about the history of the rule of the road. The natural superiority, historically conditioned superiority, and self-reinforcing momentum hypotheses (#1, #2, and #6) are all variants of what we can call the *rule-dependency hypothesis,* which suggests that many countries that kept left changed to keep-right because of *something about keep-left itself* —namely, that it was a naturally, rationally, or numerically inferior solution. The harmonization hypothesis (#7) suggests that the countries that changed did so because they were under much pressure from their neighbors to do so—and that *only by coincidence,* many of these countries happened to be keep-left countries. The rest of this section will pit these two hypotheses against each other by comparing models based on both.

We will start with some simple arithmetic measures from my data set. Then I will present basic measures of statistical association between my independent and dependent variables. Next I will compare the results of three different multivariate regression models of change in the rule of the road. Finally I will analyze the case-by-case predictions of two of these models. To call a model successful, one would like it to mispredict outcomes for exactly those territories whose rule of the road development is accounted for by the other hypotheses from Table 1 (#3—coercive force; #4—statement of identity, and #5—conditions for change).

Arithmetic measures

I summed the *neighbors* and *contrasts* values for all keep-left and keep-right territories in 1919. In total, keep-left territories had 64 contrasting boundaries and 176 compatible boundaries. Keep-right territories had the same 64 contrasting boundaries but almost twice as many compatible boundaries (324).

The average *pressure* values for keep-left and keep-right countries were also significantly different, as Table 2 shows:[10]

Table 2—1919 average pressure values

	median *pressure*, 1919	**mean *pressure*, 1919**
keep-left territories	0	-.12
keep-right territories	-.58	-.52
		($p < .0005$)

A closer analysis shows that only three keep-right territories, but 18 keep-left territories, were under net pressure to change in 1919 (reflected in a *pressure* value greater than 0).

Clearly then, keep-left territories were under much more pressure to change than were keep-right territories. This does not by itself demonstrate that the higher pressure to change on keep-left countries explains why the only changes in the rule of the road were from keep-left to keep-right, but it is very suggestive. Regression analysis can tell us whether there is an actual statistical association between pressure to change and actual change.

Another way of understanding the difference between keep-left and keep-right territories' situations is to note that in 1919, 49 of the 104 keep-left countries were islands. But only 19 of the 104 keep-right countries were islands. The rule of the road on an island carries less influence on other territories than does the rule of the road in a territory with many neighbors. Overall, then, nearly half of the 1919 keep-left territories, but less than a quarter of keep-right countries, were in a position where their rule of the road did not contribute to any other territory's sense of pressure to change.

[10] This is not simply a by-effect of the *pressure* value for islands being set at 0. With islands excluded entirely, the means are -.22 and -.63 ($p < .0005$) for keep-left and keep-right territories respectively. In fact, even if the *pressure* value for islands is set at -1, the same relationship between means still holds (-.59 for keep-left and -.70 for keep-right territories), though no longer significantly ($p=.17$).

Univariate and multivariate logistic regression models

Logistic regression is a statistical procedure designed to show the relationship between a dichotomous dependent variable (such as *change*) and any number of independent variables (such as *pressure, island, portugal,* and *rule1919*). In this specific study, logistic regression is a simple tool that squeezes a maximally accurate prediction of change in the rule of the road out of whatever variables are put into it. There are two ways to measure and compare the success of different combinations of variables or "models": the number of correctly predicted cases, and the strength of the statistical association between independent and dependent variables. The number of correctly predicted cases is a simple and important measure, but it has a drawback. Logistic regression's dichotomized predictions are derived by rounding a scalar value for each case which ranges between 0 and 1. Anything above .50 becomes 1, while anything below .50 becomes 0. Statistical association measures are more nuanced reflections of the success of a model, which take into account not just whether the predicted values fall above or below .50, but also how much "residual" rounding is involved. Their drawback is that they do not tell us anything about the model's practical ability to predict outcomes. SPSS's logistic regression function returns several types of correlation measures; I have focused on the Nagelkerke r^2 values but have reported the -2LL change as well.

Table 3 shows the results of regressing the dependent variable *change* on each of the four independent variables, separately and successively. The p values show that each variable is significantly related to the dependent variable; the odds ratio shows the direction of the relationship.

Notice the r^2 and correctly-predicted values. While *pressure* and *rule1919* are both strongly related to *change, pressure*'s relationship is slightly stronger ($r^2 = .45$ versus .39). Moreover, remembering that 174 is the logical minimum number of correct predictions for any variable on which *change* is regressed, notice that *pressure* adds fifteen correctly predicted changes for a total of 189, whereas *rule1919* adds none. In other words, the association between *rule1919* and *change* reflects the general fact that all the territories that changed had kept left in 1919. In contrast, the *pressure* variable is not just strongly associated with the dependent variable; it is also able to successfully pick out many of the countries which changed.

Table 3: Individual logistic regressions

Variable	-2LL change	r^2	p	correctly predicted	odds ratio
pressure	63.29	.445	.000	189/208	12.2
island	4.57	.037	.033	174/208	0.387
portugal	7.90	.063	.005	176/208	11.5
rule1919	53.82	.387	.000	174/208	35600

Table 4 shows the results of multivariate regressions: models of change that take into account more than one of the independent variables. The first two models were constructed by adding the appropriate "minor" or corrective variables to the two major variables of *rule1919* and *pressure* respectively. The rule-only model adds *portugal* to *rule1919,* resulting in a slight increase in r^2 from .39 to .41 and two additional correct predictions. The pressure-only model adds *island* and *portugal* to *pressure,* increasing r^2 respectably from .45 to .53 and the number of correct predictions from 189 to 192. Comparing the rule-only and pressure-only models shows again that basing a model of change on the notion of pressure, rather than the notion of a territory's original rule, is much more successful both in terms of statistical association and correct predictions.

Table 4: Multivariate logistic regressions

	Rule-only	Pressure-only	Combined
pressure odds ratio		26.5	52.2
island "		.169	.0297
portugal "	4.53	30.6	11.0
rule1919 "	32400		408000
Total model r^2	**.406**	**.526**	**.745**
Correctly predicted	**176/208**	**192/208**	**197/208**
-2LL change	**56.902**	**77.206**	**120.403**

But the third, combined model shows that the best way to predict change in the rule of the road is to use a model based both on *pressure* and *rule1919*. This results in an r^2 of .75 and raises the number of correctly predicted cases to 197 of 208.

This supports both the rule-dependency hypothesis and the harmonization hypothesis. It suggests that both outside pressure, *and* simply being able to get rid of the keep-left rule, may have been reasons for territories to change their rule of the road. However, this should not make us lose sight of the fact that the most crucial factor in developing a good predictive model of

change in the rule of the road is the inclusion of the *pressure* variable. And strikingly, one can do a pretty good job of predicting the development of the rule of the road between 1919 and 1986, without even taking countries' original rule into account.

Comparing specific predictions

In fact, the combined model's success may actually be less than it appears. I base this judgement on an analysis of the combined and pressure-only models' specific predictions, keeping in mind the limitations of my experimental design. Surprisingly, the sixteen mispredictions of the pressure-only model are arguably more acceptable than the eleven mispredictions of the combined model.

Table 6—Case predictions for the pressure-only and rule-identity models

	Pressure-only model	***Combined model***
Correct predictions	192 of 208	197 of 208
Correctly predicts change from keep-left to keep-right	Angola, Argentina, Austria, Bahrain, Canada (Maritime), Canada (British Columbia), Cape Verde, Gambia, Ghana, Gibraltar, Guinea-Bissau, Italy (cities), Nigeria, Panama, Portugal, São Tomé and Principe, Sierra Leone, Sudan, Sweden, Yemen (Aden)	Angola, Argentina, Austria, Bahrain, Canada (Maritime), Canada (British Columbia), Cape Verde, Gambia, Ghana, Gibraltar, Guinea-Bissau, Italy (cities), Nigeria, Panama, Portugal, São Tomé and Principe, Sierra Leone, Sudan, Sweden, Yemen (Aden); **Cameroon (British), China, Czechoslovakia, Hungary, Somalia, Uruguay**
Fails to predict change from keep-left to keep-right	**Cameroon (British), China, Czechoslovakia, Hungary, Somalia, Uruguay;** Burma, Diego Garcia, Ethiopia, Iceland, North Korea, South Korea, Philippines, Taiwan	Burma, Diego Garcia, Ethiopia, Iceland, North Korea, South Korea, Philippines, Taiwan
Fails to predict preservation of keep-left		Pakistan, Thailand, Uganda
Fails to predict preservation of keep-right	Canada (central), Djibouti	

Many of the pressure-only model's mispredictions are straightforward consequences of the shortcomings of my experimental design. The mispredictions of central Canada and British Cameroon result from the problem of "sub-national units" referred to above. Though the model correctly predicts change from keep-left to keep-right in the eastern and western regions of Canada, it also predicts change from keep-right to keep-left in central Canada, based on its

having two of three contrasting neighbors. The setup of my experiment does not allow us to specify that Canada wanted a uniform national rule of the road, much less that British Columbia and the maritime provinces were peripheral regions with less power to influence the Canadian rule.

Similarly, the pressure-only model's misprediction of Uruguay, Hungary, and Czechoslovakia is a consequence of the "time-series problem," also referred to above. I sampled the makeup of each territory's neighborhood at only one single point in time (1919). It thus becomes difficult to predict changes in territories such as Uruguay and Hungary, which were highly "protected" in 1919 but later became surrounded by keep-right countries (after the changes in Argentina and in Austria and Czechoslovakia respectively).

Some of the pressure-only model's other mispredictions recall the other hypotheses listed in Table 1. Three of the mispredictions reflect the effect of "coercive force," which I did not formally account for except in the case of Portugal. The rule of the road in Diego Garcia was changed from keep-left to keep-right after the island (still nominally a British colony) was depopulated and taken over by the American military in 1972 (Kincaid, pp. 91-92). The 1945 executive order changing the rule of the road in the Philippines was specifically designed to make it more convenient for the American military occupation (Kincaid, pp. 147-150). The case of South Korea is somewhat similar (see Kincaid, pp. 135-137).[11]

The misprediction of Iceland shows that my approach fails to take into account any sense of regional belonging that does not derive from physical contiguity. Iceland has close cultural ties to mainland Scandinavia, and its change followed Sweden's by only a year (see Kincaid, pp. 116-120).[12]

[11] While it is tempting to think of coercive force as the explanation of the changes in Czechoslovakia and Hungary, it is important not to confuse reasons for the *timing* of a change in the rule of the road with reasons for the change itself. It would be wrong to say that Sweden changed the rule of the road *because* it is an officially Christian country, or that Hungary changed the rule of the road *because* it lay on the route of the German invasion of Russia. Sweden's change did take place on a Sunday (3 September 1967), when traffic was light, and Hungary's in the summer of 1941. But these factors only explain why these changes were not *timed* on, say, 4 September 1967 or in the summer of 1942. The degree of pressure that both countries were under made change *at some point* almost inevitable. In contrast, the American military occupation of the Philippines and Diego Garcia explains both the timing and the fact of change, since neither the Philippines nor Diego Garcia, as islands, were under any pressure from adjacent countries.

[12] While I have considered the self-reinforcing momentum and harmonization hypotheses as completely separate, there arguably exists a continuum connecting the two. What the two hypotheses share is the idea that a unit X makes a decision based on looking at other equivalent units in the system. At the self-reinforcing momentum end of the continuum is the idea of looking at *all* other equivalent units. Moving through the continuum progressively

I cannot offer as simple an explanation for the pressure-only model's other seven mispredictions (China, Taiwan, North Korea, Burma, Ethiopia, Somalia, and Djibouti).[13] But, in total, at least nine of its sixteen mispredictions are exactly what we would expect given the shortcomings of my model. The pressure-only model gets things wrong for the right reasons rather than right for the wrong reasons.

The combined model has a much higher odds ratio for *pressure* than the pressure-only model (see Table 4). This means its threshold *pressure* value for predicting change is much lower than for the pressure-only model. It predicts a change to keep-right in nine additional keep-left countries. Of these, six did change and three did not, which results in a gain of three correct predictions.

The combined model also has a tremendously high odds ratio for *rule1919* that effectively excludes any possible prediction of change in keep-right countries. Thus, correctly, it does not predict change in Djibouti or central Canada: a gain of two more correct predictions, for a total of five.

Of the combined model's eleven mispredictions, only four reflect shortcomings in my experimental design (Iceland, Diego Garcia, the Philippines, and South Korea). The combined model makes correct predictions about Hungary, Uruguay, Djibouti, and central Canada more or less solely on the basis of their 1919 rule of the road, when we know that the actual historical chain of events in these territories was more complex.

The question, then, is whether one prefers a slightly more successful model which covers up the errors in one's experimental setup, or a slightly less successful model which exposes them. I believe that the second route is more honest. What we have in the case of the pressure-only

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shrinks the number of units looked at, keeping *X* at the center. At the harmonization end of the continuum is the idea of looking at only those units of the system directly adjacent to *X*. The misprediction of Iceland points up the existence of this continuum, since it invites us to conceptualize adjacency in regional or cultural terms rather than strict geographical terms.

[13] Part of the problem is that the history of the rule of the road in the continental Far East and in the Horn of Africa is still somewhat obscure (see especially Kincaid's discussion of China, North Korea, and Somalia, pp. 86-88, 135-137, 154-155). Djibouti's failure to switch to keep-left despite being surrounded by keep-left neighbors may partly have to do with the fact that it did not become independent from France until 1978. Burma is an exceptional case: no one, including Kincaid (pp. 52-53), has been able to shed light on the rationale for its 1970 switchover. One entirely unconfirmed rumor says that "[the Burmese dictator] Ne Win changed driving customs...on the advice of a fortune-teller who vaguely suggested he move the country from left to right to improve his karma." See Joe Cummings and Tony Wheeler, *Myanmar (Burma): a Lonely Planet travel survival kit* (6th ed., Hawthorn, Victoria: Lonely Planet, 1996), p. 126.

model is a case of the exceptions proving the rule. In the combined model, the exceptions teach us something about the way logistic regression works, but do not help us put together a coherent story about the rule of the road. Thus I believe that the rule-dependency hypothesis, though not entirely invalid, is somewhat less accurate than it might appear from the success of the combined model. Once again, this highlights the importance of *pressure* in developing a predictive model of the development of the rule of the road.

HYPOTHESES #1, 2, 6, 7: DISCUSSION

It is striking that even though all the changes in the rule of the road were in keep-left territories, one can account for them fairly well without even taking the territories' 1919 rule of the road into account. The arithmetic data that I presented also shows how keep-left countries and keep-right countries differed in a way that encouraged many keep-left countries to change their rule of the road.

This suggests that the harmonization hypothesis, though counterintuitive, in fact reflects the truth about the way the rule of the road developed. While my data and analysis do not by any means disprove the rule-dependency hypothesis, they do suggest that it is not as important as one might guess at first acquaintance with the history of the rule of the road.

Remember, though, that "rule-dependency hypothesis" is actually a cover term for three separate hypotheses: natural superiority, rational superiority, and self-reinforcing momentum. To the extent that the rule-dependency hypothesis is valid, which of these sub-hypotheses does it reflect?

We can begin by dismissing the natural superiority hypothesis as logically unproven. There is no evidence that either keep-left or keep-right driving is fundamentally preferable to the other—by which I mean either safer, or more "natural" in the sense that a base-ten counting system is natural because we have ten fingers. No one has been able to show the superiority of one solution over the other. For example, Leeming (1969:23-27, 185, 203) speculates that keep-left is superior, based on a comparison of accident rates across countries. But he samples only three countries. It is obvious that the determinants of accident rates include much more about a country than its rule of the road, and Leeming does not press the point. For more on this topic,

see Kincaid's discussion of "inherent advantages" (pp. 25-27).[14] Note also that no territories seem to have mentioned natural superiority as a reason for change.

It is logically quite difficult to tease the ideas of self-reinforcing momentum and rational superiority apart. Indeed, a self-reinforcing "trend to world uniformity" in the rule of the road would make the favored rule rationally superior (by increasing the supply of compatibly built cars and making it easier for people trained in that rule to adapt to driving in foreign countries). Thus the notion of rational superiority is partly just the mechanism through which self-reinforcing momentum acts. According to Kincaid, officials in a few countries did cite both self-reinforcing momentum and rational superiority as reasons for change. Both Ghana and Iceland mentioned the worldwide trend towards keep-right; these two countries as well as the Sudan also cited the greater availabilty of cars with the steering wheel on the left (the most commonly mentioned rational-superiority argument; Kincaid, p. 18). Kincaid, however, downplays the car-availabilty argument by citing an Irish study which found that the cost to car producers of maintaining simultaneous production of both types of cars is insubstantial (see note 389 on page 123), and showing that the assumption on which this particular argument for rational superiority rests—that center-side steering is preferable to curb-side steering—is itself somewhat debatable (see pp. 27-32). Whether or not the idea of rational superiority is a sensible reason for change, though, it does seem that a small number of territories did believe in it.

The importance of the self-reinforcing momentum hypothesis comes less from its having been mentioned as a reason for change in the rule of the road, and more from the fact that recent

[14] For the rule of the road, and indeed for all conventions (such as the direction of writing) which have two solutions that are identified using the terms "left" and "right," logical arguments for the natural superiority of one solution or the other invariably proceed from the fact that most humans are right-handed (see Kincaid, pp. 1-8, 25-41). This suggests the broad outlines of a research strategy designed to answer the question: a comparison of the accident rates of right-handers and left-handers, both in keep-left and keep-right countries. If, for example, right-handers had a consistently lower accident rate in keep-left countries than in keep-right countries—*measured relative to left-handers rather than in absolute terms*—that would likely be a very strong argument for the natural superiority of keep-left. If no significant differences could be found, that would logically exclude the possibility of any natural superiority for either rule. (Note that either argument would depend on accepting accident rates as a definitive measure of the "success" of a rule of the road.) No such studies seem to have been carried out, although Peters and Perry (1991) do present some extremely tentative data from Canada, along with a discussion of some of the problems and misconceptions involved in this type of research.

For some other types of traffic there *are* plausible arguments in favor of keep-left or keep-right (see for example the discussion of postilion control in Kincaid, p. 6, and generally, Kincaid, pp. 1-8). Watson (1994) suggests (without proposing any rationale) that there could be a pre-social human tendency to keep right in pedestrian traffic. It is important to say that, as with many standards, the question of whether either rule of the road *is* naturally better is separate from the question of whether either rule of the road *is believed* to be better—a point on which Kincaid agrees (p. 17).

scholarship has hoped that self-reinforcing momentum would provide the key to understanding the evolution of standards. Several investigators, most notably Arthur (1994), have suggested that the number of people who adopt a particular standards solution is proportional to the number of people who already use it. Although changing standards solutions is not the same thing as adopting one for the first time, this suggestion might lead us to guess that an early "lead" in the number of keep-right countries caused more and more countries to switch to keep-right, eventually locking keep-right in as the world's dominant rule of the road.

This did not happen. Keep-left did not have fewer 1919 adherents than keep-right. The number of keep-left territories (104) was equal to the number of keep-right territories. Though keep-right territories covered two-thirds of the earth's landmass in 1919 and keep-left territories only one-third (see the calculations by Kincaid, p. 198), remember that this includes under keep-right the wastes of the Canadian and Soviet Arctic as well as Greenland and the Sahara Desert. In fact, measured in population terms, 985 million people lived in keep-left territories in 1919 as opposed to only 746 million people in keep-right territories.[15] It is probably significant that the only two countries which Kincaid reports as having mentioned self-reinforcing momentum as a reason for change (Ghana and Iceland) were countries that decided to change rather late in the period under discussion, when the excess of keep-right countries was starting to become clearer. Except for these few later cases, it is not really possible to use Arthur's idea—that the most popular standards solutions attract more and more adherents sheerly through force of numbers—to sustain a path-dependency analysis of the history of the rule of the road argument.

The harmonization hypothesis, like the self-reinforcing momentum hypothesis, is a path-dependent explanation. Both hypotheses would argue that just the setup of the rule of the road in 1919 *predisposed* keep-left to a decline, and that the world rule-of-the-road situation in 1919 somehow contained the seeds of its future development. But they consider different aspects of that situation as responsible for the predisposition.

The self-reinforcing momentum hypothesis rests on the idea of sheer numbers of adherents. According to the harmonization hypothesis, the crucial initial condition that set up

[15] See below, note --, for discussion of 1919 population statistics. This count excludes the five territories for which I could not estimate 1919 populations. Of these, four were keep-right countries (Burundi, Rwanda, Qatar, and the United Arab Emirates) with a total 1986 population of 13.7 million people. One (Lesotho) was a keep-left country; it had a 1986 population of 1.6 million people.

the spread and victory of keep-right instead had to do with the notions of *islandness* and *pressure to change*. The rule of the road is a case in which a standards solution attracted more and more adherents because of *who* adopted it rather than *how many* adopted it. 49 of the 104 keep-left countries—compared with only 19 of the 104 keep-right countries—were islands: territories which exerted no pressure to change on any *other* territory. The countries that were under positive pressure from their neighbors to change their rule of the road overwhelmingly kept left. The straightforward conclusion is that the *distribution* of the rule of the road in 1919 put very few keep-right countries under pressure to change to keep-left, but very many keep-left countries under pressure to change to keep-right. The corollary is that this was a coincidental effect rather than a consequence of some inherent or historical characteristic of driving on the left side of the road.

The success of the harmonization hypothesis in accounting for the history of change in the rule of the road shows that the notion of path-dependency as applied to standardization can be based on something more complex than just the number of early adopters. The future distribution of the solutions to a standards problem can be constrained not just by *how many* actors adopt each standards solution, but also by *who* adopts what, and what ties each adopter has to other actors in the network.

HYPOTHESES #3, 4, 5: ANALYSIS AND DISCUSSION

At this point, three hypotheses from Table 1 remain to be discussed: the idea of coercive force, the idea of symbolic factors or statements of identity, and the idea of conditions for change.

Coercive force and symbolic factors

The idea of coercive force, especially the weaker of its two varieties, has been an extremely important factor in the long-term development of the rule of the road. The strong variety of coercive force is change through military occupation. It is really impossible to explain the twentieth-century changes in Diego Garcia, the Philippines, and South Korea without introducing the idea of coercive force. Moreover, the four changes in the rule of the road not included in my data because they were later reversed—in Okinawa, the Channel Islands, the

Faroe Islands, and the second change in East Timor—were the direct result of military occupation. The weak variety of coercive force is the fact that a colony tends to follow the rule of the road of its metropole. This explains why British colonies tended to adopt keep-left and French colonies keep-right, as well as why many (but not all) of Portugal's colonies followed its 1928 shift from keep-left to keep-right.

However, during the period from 1919 and 1986 there were comparatively few coercive-force effects on the rule of the road. The value of studying this period is an understanding of what happens to a standards problem when users are relatively free to adopt different solutions to it. It is only during a period like this that it is possible to see factors like harmonization, self-reinforcing momentum, and natural superiority at work.

The symbolic factors hypothesis is of potential relevance only in a very few cases, and always as a secondary factor rather than a primary one. The existing literature on the rule of the road tells us that changing the rule of the road is not something that can be done lightly. Kincaid shows the tremendous financial outlay involved in changing the rule of the road in places such as British Columbia, Nova Scotia, Hungary, Iceland, Okinawa, and Sweden (pp. 69, 76, 115, 118-119, 133-135, 161), and historians of individual changes (e.g. Dufwa 1985:144-154) demonstrate the same thing. Not suprisingly, given the practical difficulty of changing the rule of the road, as well as the necessity of instantaneous implementation, there is no historically attested case in which the sole motivation for a switchover was to make a symbolic statement about national identity. All recent changes in the rule of the road (except possibly for Burma's) involved some obvious *practical* coordination with outside influences, whether it was that of an occupying military power, closely tied countries, neighbors, other regions of the same country, or even car suppliers.

The conditions-for-change hypothesis: a brief statistical test

According to the conditions-for-change hypothesis, the social and political characteristics of each territory might have influenced its ability to carry out change in the rule of the road. Put another way, territories with the same rule of the road and equal pressure to change, but different social or political conditions, might have had different propensities to change. I examined three

likely circumstantial variables for a relationship with change: vehicles per person, population, and years of independence. I was surprised at the lack of correlation.

The design of guardrails, traffic signals, pavement markings, public buses and trams, road signs, reflecting mirrors, and many other items are dependent on a particular rule of the road. The tremendous cost of changing the rule of the road comes largely from the cost of re-investing in this sort of public infrastructure (see again Kincaid, pp. 69, 76, 115, 118-119, 133-135, 161). I hypothesized that change in the rule of the road might be less likely in more developed countries with more infrastructure investment and thus a higher cost of change. I used the number of vehicles per person, circa 1986, as a rough proxy measure of a territory's investment in the rule of the road.

Similarly, I hypothesized that the cost or difficulty of change in the rule of the road might increase exponentially rather than linearly with the population of the territory, so that, considered per capita, it might be more difficult to bear in more populous countries. I therefore collected data on the population of each territory, circa 1986, as well.[16]

Finally, I hypothesized that change might be less likely in territories that were not independent. Thus for each territory, I counted the number of full calendar years of independence between January 1, 1919 and January 1, 1986.

My source for all three of these alternative measures was the 1988 *Encyclopedia Britannica Book of the Year.* Data on vehicles per person was missing for nine of the 208 territories. Population data was missing only for Diego Garcia, which currently has no non-military

[16] While it would make sense to use or incorporate 1919 population statistics in predicting change after 1919, this turns out to be very difficult. Population statistics for many of the world's territories in 1919 are either unavailable or unreliable. In the early part of the century there was much less sense of a "standard" political division of the earth's landmass and reference books did not share the current commitment to presenting data on an exhaustive and disjunct set of geographical categories, however obscure each individual one. I tried hard to assemble a list of circa 1919 populations using the 1921 edition of the annual *Statesman's Yearbook* (London: Macmillan). I managed to put together population estimates for only 203 of my 208 territories. For these 203 territories the Pearson correlation between log values of 1919 and 1986 population estimates was .97. Regressed against the variable *change* for these 203 territories only, the Nagelkerke r^2 values for the log values of 1919 and 1986 population estimates were .031 ($p=.051$, $OR=1.37$) and .037 ($p=.035$, $OR=1.40$) respectively. Given the similarity of these values, the in fact slightly higher predictiveness of the 1986 values, and the fact that I did not have any missing cases for the 1986 values, I chose to use the 1986 values as an estimate of population.

In the case of vehicles per person, it seems impossible to get 1919 statistics on vehicles per person for more than a tiny fraction of the territories involved. Since the goal here is not a precise investigation of the effect of the number of vehicles per person on change in the rule of the road, but rather a rough sense of whether change had anything to do with a territory's degree of infrastructural investment in a rule of the road, I felt that the 1986 statistics made my point in an acceptable way.

residents; I substituted a figure of 1,400, the population at the time the island's residents were resettled in 1972 (Kincaid, pp. 91-92). The *population* and *vehicles per person* variables both showed an extreme rightward skew. Applying a log transformation increased their normality to an acceptable level.

I first regressed *change* individually on each of these three circumstantial variables. Table 5 show the results.

Table 5: Individual logistic regressions

Variable	-2LL change	r^2	p	correctly predicted	odds ratio
vehicles p.p.	0.79	.007	.375	167/199	0.802
population	4.51	.036	.034	174/208	1.41
years indep.	2.35	.019	.125	174/208	1.01

Vehicles per person has essentially no relationship with the dependent variable *change.* Regressing *change* against it for the 199 territories for which I have data yields an r^2 value of only .01 (p=.38). This was unexpected, as I thought it would be the circumstantial variable with the most relationship to changing. What relationship there is is in the direction hypothesized (note the negative odds ratio). *Population* shows a modest association with *change* (r^2=.04, p=.03), but the relationship is the reverse of what I expected: territories with *more* people were more likely to change. *Years of independence* is less strongly correlated with *change* (r^2=.02, p=.13), but the correlation is in the direction hypothesized.

I then included these circumstantial variables in several types of multivariate regressions to test whether they were incrementally significant when added to the "pressure-only" and "combined" models outlined in Table 4. I tested *vehicles per person* separately from the other two variables because of its missing cases, and found that adding it to neither the pressure-only nor the combined model brought about significant improvement in the model (p=.27 and .46 respectively).

Population makes a significant contribution to the pressure-only model (raising r^2 to .55; p=.03, but one *less* correct prediction), but not to the combined model (p=.10). *Years of independence,* in contrast, makes a significant contribution to the combined model (r^2=.77; p=.03, and one *more* correct prediction), but not to the pressure-only model (p=.20). When

population and *years of independence* are added together, the incremental change is significant for neither the pressure-only nor the combined model (p=.08 and .09 respectively).

To interpret these results, note that both *population* and *years of independence* are strongly correlated with *island* (Spearman's rho=-.61 and -.62 respectively). It is fairly clear that small, dependent islands were relatively unlikely to change their rule of the road. It is harder to say whether the cause was their small population, their lack of independence, or their lack of neighbors.

These results are not very conclusive. It does seem that *vehicles per person* did not influence the development of the rule of the road at all, and that *population* did not influence the rule in the way that I conjectured. While the *population* and *years of independence* variables can contribute modestly to models of change, their collinearity with *island* makes it hard to evaluate their real importance. The significance of *years of independence* when added to the combined model may be the result most worth noting. Overall, at least for these three variables, it is very difficult to sustain a case that territories' internal circumstances promoted or precluded change in the rule of the road in any major way.

CONCLUSION

While no single explanation accounts for all 34 changes in the rule of the road, the harmonization hypothesis is clearly the best sustained by my analysis. Second place perhaps goes to the coercive force hypothesis, which, though relatively dormant, was still a factor between 1919 and 1986. The increasing momentum of the keep-right rule and its resulting perceived rational superiority, may have bolstered a few countries' decisions to switch in the 1960s and 1970s. In some cases change may have been a statement of identity but this seems never to have been a primary factor. The natural superiority of one rule of the road or the other is unproven and apparently irrelevant. And the most obvious of possible circumstantial factors do not turn out to be very clear predictors of change.

For students of the rule of the road, the explanatory power of the harmonization hypothesis demonstrates statistically what Kincaid already suggested through historical analysis: the twentieth-century century expansion of the keep-right rule is something of a fluke. It has

nothing to do with any *a priori* natural or rational merits of driving on the right side of the road. And though it may reflect to some extent a self-reinforcing mechanism of the kind discussed by Brian Arthur, if so this only began to kick in at the end of the period, affecting just a few cases. What the worldwide shift to keep-right driving really tells us is that at the dawn of the age of the motor car, many keep-left territories happened to be surrounded by keep-right ones.

It is important to temporally contextualize the relevance of the harmonization motive. 1919 to 1986 was a period in which increasing road traffic and road construction made neighbors' rules of the road matter in a way that they had not before. New international road connections, such as the Pan-American highway project, created an incentive to harmonize. Regional coordination, which had not been important in the nineteenth century, *became* important during these years.

For those of us who are trying to understand the adoption, spread, and change of standards solutions and other conventions, this analysis teaches us that there is no one key to understanding the evolution of standards, and that one must always look for unexpected and counterintuitive explanations. In the case of the rule of the road, different types of motives (for adopting or changing to a particular rule) predominated in different historical periods. Even in a period in which one mechanism stands out as dominant, like the one under investigation, others may be at work too.

The history of the rule of the road seems to support Arthur's (1994) argument that the popularity of a standards solution is not necessarily an indication of natural superiority. Yet it also cautions that a path-dependent mechanism may be based on something more complicated than the simple number of adopters of a solution. In the case of the rule of the road, the solution which "won out" was simply the one whose adopters had the most neighbors.

AFTERWORD: CONSOLIDATION AND FRAGMENTATION

Imagine that the world consisted of 64 territories configured like the squares on a chessboard. Imagine further that 32 of these territories kept left while 32 kept right. One can imagine two opposite styles in which these two rules of the road could be distributed. In the completely "consolidated" style, one side of the chessboard would be entirely keep-left and the

other would be entirely keep-right. In the completely "fragmented" style, keep-left and keep-right would be evenly distributed in a checkered pattern. One could measure the degree of consolidation or fragmentation by counting the total number of boundaries between territories, and then counting how many of these boundaries divided territories with contrasting rules. In the chessboard example, there would be 224 boundaries. In the completely consolidated style there would be a contrast across only 8 of these 224 boundaries; in the completely fragmented style there would be a contrast across all 224 boundaries.

It is quite easy to find out whether there has been a trend towards consolidation or fragmentation in the distribution of the rule of the road using the data that I collected. Between the 140 non-island territories in my model there were 250 boundaries. There was a rule-of-the-road contrast across 64 of these 249 boundaries in 1919, but only across 23 of them in 1986. The mean *pressure* value for these 140 countries in 1919 was -.46, but by 1986 this had dropped to -.84. These statistics tell us that there was consolidation and *de*fragmentation in the world's rules of the road between 1919 and 1986. Keep-left and keep-right countries aggregated into large blocs, and territories were in general under much less pressure to change than in 1919. The notions of consolidation and fragmentation are, like the *pressure* variable, measures independent of the identity of the standards solutions involved. They simply measure the "blocked-ness" of the distribution. An overall migration to keep-left could have created defragmentation as well.

The development of the rule of the road in the nineteenth century was not consolidated at all, because the fragmented British and French empires created a checkerboard of keep-left and keep-right territories. But the overall development of the system from 1919 to 1986, in an era of increasing road-building and international road traffic, has been towards regional harmonization of the rule of the road and the consolidation of blocs of keep-left and keep-right countries. This is not to say that that was the motive for each individual change. It points out, however, that all of the individual changes in the rule of the road created a definite overall effect, which did not really come about through the conscious design or intent of the participants in the system.

To use a more modern metaphor, what we have seen between 1919 and 1986 is analogous to the optimization or defragmentation utility for a computer hard drive, which bunches together the free and used blocks on the disk to eliminate fragments of files or free space. The difference is

that whereas a hard drive is an inanimate object, territories have the ability to act on their own. To use Schelling's (1978) terms, it is interesting to watch the micromotive of harmonization with neighbors bring about the macrobehavior of segregated traffic standards solutions.

APPENDIX

This appendix goes into detail on the construction of my data set, in particular the three difficulties of choosing territories, assigning each a rule of the road, and determining the number and identity of each territory's neighbors.

Choosing territories

The issue here is how to settle on a partition of the landmass of the earth that is exhaustive (with all of the earth's landmass accounted for) and disjunct (with each point part of one and only one territory).

Kincaid divides the world into 211 territories, reflecting the political boundaries of 1986. Although his division is reasonable, I decided to find one that was as "official" and standardized as possible. Since naming is one of the major ways in which we consecrate the existence of conventional categories, I used the international standard for naming territories (ISO 3166) as the baseline for my partition. This is the same standard that, for example, prescribes the two-letter country codes used in Internet addresses. Specifically, I used the copy of ISO 3166 from ftp://ftp.ripe.net/iso3166-countrycodes. This includes the "history" of the standard in a way that makes it possible to turn the clock back to 1986.

I then excluded several territories from this list. Excluded on the basis of lack of permanent population were Bouvet Island, Heard and McDonald Islands, the French Southern Territories, South Georgia and the South Sandwich Islands.

Some other territories were excluded not on the basis of size or population, but because it was not possible to determine their 1919 and 1986 rules of the road. These territories were the United States Minor Outlying Islands (including Wake and Midway), the former U.S. Trust Territory of the Pacific Islands (now Palau, the Federated States of Micronesia, the Marshall Islands, and the Northern Mariana Islands), Antarctica, Svalbard, and Wallis and Futuna. Kincaid's information on Wake, Midway, and the former U.S. Trust Territory is inconclusive (see pp. 103, 120, 140-141, 183). Antarctica does not really have any rule of the road (pp. 43-44). Kincaid gives no information on Svalbard or Wallis and Futuna (though their rules of the road probably follow those of Norway and France respectively), and Svalbard's proximity to Norway makes recognizing it as a separate territory dubious anyway (compare the case of the Channel Islands, below).

Pitcairn Island did not set a rule of the road until 1965, when the first motorized vehicles were used on the island and a keep-left rule was decreed (Kincaid, pp. 150-151). After some reflection I decided to include Pitcairn in the data set anyway. Pitcairn had an incipient keep-left rule as a British colony; it is not the only territory not to have had a legally codified rule of the road in 1919, simply the last to have officially decreed one, and it would be going down a slippery slope to exclude it; and it was theoretically possible for Pitcairn to change its rule of the road between 1965 and 1986. I felt that Pitcairn's behavior during that period was a worthy thing to have under investigation, and set its "1919" rule of the road as the rule it chose in 1965. Pitcairn's inclusion has little effect on the results anyway.

In a number of other cases the question was whether a geographical entity should "count" and be included as a territory or subsumed under some other territory. Though the Panama Canal Zone was

under American control in both 1919 and 1986, its rule of the road has always been the same as that of Panama and in fact control over changing the rule of the road in the Canal Zone was legally ceded to Panama in 1936 (see Kincaid, pp. 144). Thus I did not consider the Canal Zone a separate territory. Though the Channel Islands and the Isle of Man are given separate status in Kincaid's lists (see p. 194), and both are self-governing in some respects, they are not listed separately in ISO 3166, and both had the same rule of the road as the United Kingdom in 1919 and 1986. I therefore excluded them. One might object to this as inconsistent—after all, I separated Puerto Rico from the United States, Martinique from France, Tokelau from New Zealand, and Norfolk Island from Australia. But the truly "overseas" possessions of the United Kingdom such as the Falkland Islands, Bermuda, Hong Kong, and St. Helena (which includes Tristan da Cunha) are indeed treated separately. What is different about Northern Ireland, Wales, the Channels, Scotland, England, and the Isle of Man is that they are directly next to each other and have a clear sense of geographical contiguity despite being divided by water.

Since 1919 geography does not map perfectly onto 1986 geography, I often had to choose one or the other in settling on a single identification and configuration of territories. With several exceptions, I chose 1986 geography throughout. This means that territories such as Goa and the Baltic states, which had a separate existence at the close of the First World War but were part of another territory in 1986, were not included. In the Carpathian area, however, I used the interwar boundaries between Poland, Romania, Czechoslovakia, Hungary and the Soviet Union to calculate neighbors, since it somewhat more accurately reflected the situation at the time that Czechoslovakia and Hungary changed their rule of the road in 1938 and 1941. Strictly for convenience (it has almost no effect on the data) I also considered the former East Germany and West Germany as a single territory. The special strategies applied in the case of Cameroon and Togo are noted below. I did not "recognize" the Turkish occupation of northern Cyprus in my data (see Kincaid, pp. 88-89 for its effect on the rule of the road). Needless to say, all post-1986 changes in world political boundaries have been ignored.

The special problem of territories in which the rule of the road varied by province in 1919

In choosing territories the level of granularity[17] was set at the "territory," which was defined as a geographical unit recognized in ISO 3166. This was straightforward and unproblematic in most cases, since territories typically observe a single uniform rule of the road. However, in 1919 the rule of the road varied by province in Austria, Canada, Italy, Togo, and Cameroon. These cases invite a level of granularity lower than the territorial level, and indeed, that is how I resolved three of these cases. One could argue that, if one recognizes provinces within one territory, one should do so within all of them. But that would force me into the impossible task of defining the term "province" in a consistent way for the entire world.

I counted Canada as three countries: the Maritime Provinces and Newfoundland (which drove on the left in 1919), British Columbia (which also drove on the left), and the central swath from Quebec through Alberta (which drove on the right). In Italy, several major cities kept left while most, at least, of the rest of the country kept right. I considered Italy as two countries: Italy (cities) and Italy (everywhere else), with Italy (cities) bounding only Italy (everywhere else), and Italy (everywhere else) bounding Italian cities plus the countries that Italy bounds today. In the case of Austria, only the small province of Vorarlberg, next to Switzerland, drove on the right in 1919. Rather than setting up Vorarlberg as a separate territory, I ignored this minor exception.

[17] The term "level of granularity" refers to the level of a taxonomy below which one cannot or does not distinguish units. It is the lowest level of a taxonomy at which one recognizes the "entitativity" of a unit. Here, it refers to the lowest level of political unit listed in a taxonomy of the landmass of the earth.

In 1919, Togo (a former German colony) was divided into a British and a French sphere. The following year, Britain ceded most of its Togolese territory to France. The remaining part of British Togo was annexed to the Gold Coast in 1924. The Gold Coast was renamed Ghana upon independence. Ghana changed from keep-left to keep-right in 1974. In my 1919 snapshot, I considered the modern territory of Ghana and Togo as divided into two parts, one which kept left (congruent with the current boundaries of Ghana) and one which kept right (congruent with the current boundaries of Togo), even though this boundary was not finalized until the following year and the annexation did not happen for another four years. Although this obviously simplifies history, it does it in a more faithful and less objectionable way than setting up a third territory would have.

Cameroon presented a similar problem, but I resolved it in the opposite way. Before decolonization, Nigeria and British Cameroon drove on the left, while French Cameroon drove on the right. When independence came, British Cameroon and French Cameroon were united into a single country except for the smaller, northern, inland districts of British Cameroon, which had been administered through Nigeria and voted to join Nigeria. The coastal section of British Cameroon changed its rule of the road from keep-left to keep-right to conform to that in the much larger ex-French section of the new country. Later (in 1972) Nigeria changed to keep-right as well. In my 1919 snapshot I considered the territory of modern-day Nigeria and Cameroon as forming three territories: Nigeria, British Cameroon, and French Cameroon, which kept left, left, and right in 1919 and right, right, and right in 1986. I lumped the northern sections of British Cameroon with Nigeria.

Recognizing provinces or regions as full-fledged territories has an unfortunate effect on my analysis, in that my model cannot capture what Kincaid called the desire for "national unity": it is politically much more important that, for example, British Columbia and Alberta harmonize their rule of the road than that British Columbia and the United States do so. Thus British Columbia's adjacency to Alberta is more important than its adjacency to the United States.

Determining 1919 and 1986 rules of the road

Kincaid did not take an explicit "census" of the rule of the road in 1919. Rather, he gives chronological and alphabetical tables of changes in the rule of the road (pp. 198-202) which allow one to turn back the clock and create a snapshot of the rule of the road in 1919. Kincaid has confirmed in a personal communication (February 4, 1999) that if his tables do not list a change in the rule of the road for a territory, that does indeed mean that to the best of his knowledge that rule dates back to 1919. Kincaid in fact creates a cartographic snapshot of the rule of the road in 1919 (pp. 196-197), based on this assumption.

Since the structure of my data set allowed only for two values of whether a country had changed its rule of the road (yes or no), I had to ignore the four changes in the rule of the road that were later reversed. Three of these occurred not in entire territories, but rather in pieces of territories: the temporary wartime changes in the Channel Islands, the island of Vágar in the Faroes, and Okinawa (though Okinawa did not revert to keep-left until 1978). It was convenient to exclude these cases not only because of the reversal, but also because including them would have required considering each region as separate from its parent territory. The fourth case is East Timor, whose rule of the road changed from left to right (with Portugal in 1928) and then back from right to left (after the Indonesian takeover in 1976). While it is no problem to consider East Timor as a separate territory, the reversal is still impossible to handle in my data set and thus I had no choice but to exclude East Timor from the data set entirely. It would be possible to take account of it by using a survival model.

For the purposes of this study I accepted Kincaid's book as definitive. Kincaid reports that since 1986 a few new pieces of historical evidence have come to light that have led to minor complications or corrections to the story (two countries in particular are Paraguay and Ethiopia), and that he is

contemplating a new edition of his now out-of-print book. However, to take account of recent evidence, some of which has not yet been weighed completely, would be to open a Pandora's box.

Kincaid's data appears very trustworthy. Kincaid's own gradations of the "reliability of information" in his change lists (pp. 198-202) show that he has solid evidence for most post-World War I changes, though there are a few listed on the basis of "reasoned speculation" only. Kincaid gives detailed histories of the rule of the road in 69 "countries of interest," in which either "the rule of the road has been changed, or where there is something interesting about its adoption" (pp. 43-185; these "countries" sometimes include more than one territory). Some of these histories reveal Kincaid's uncertainty about the evolution of the rule of the road in a particular territory, but most cement his chronology with details and citations. For most of the other hundred-odd territories, for which Kincaid provides no prose history, the lack of information is not a problem and I felt fairly confident that their rule of the road in 1919 was the same as 1986. For a few, though, it might be reassuring to have more historical detail.

It is important to recognize the work involved in Kincaid's research. The rule of the road is a "seen but unnoticed" fact of life that is rarely considered as a subject in itself. Even many travel guidebooks forget to mention it.[18] Changes in the rule of the road are often quickly forgotten and transformed into folklore. In each of the 211 different territories, telling the history of the rule of the road required a different research strategy using different primary sources. The laws, contemporary newspaper articles, and commission reports that document the history of the rule of the road are extremely esoteric, and held by very few libraries. Faced with this task, Kincaid collected some of his material by correspondence with transport officials in different countries. It is remarkable that he was even able to determine the 1986 rule of the road in each territory. Though his historical sketches vary in depth and detail from territory to territory, as a whole they manifest extremely assiduous research, and the 185 pages of text include 622 footnotes. It is important for the analysis in this paper to have a thorough understanding of the limits of Kincaid's book. The fact that he left some questions unanswered does not reflect any lack of effort or care.

Counting neighbors

The number of neighbors for any territory is the number of adjacent territories which are linked to the territory by road. While most pairs of countries which share a land border have road connections, there are some that unequivocally do not. While Peru borders five countries, it only has three neighbors for vehicular traffic purposes, since Peruvians cannot drive through the wilderness into Brazil or Colombia. In many cases, making this sort of judgement is difficult. What counts as a road connection? Does it have to be paved? Does it have to have two lanes? Can it be a local road, or must it be part of a long-distance highway system? For example, the road connection between Algeria and Mali consists of shifting desert tracks which carry fairly little traffic and on which the rule of the road may be much less relevant than carrying enough water and not getting your rear axle bogged down in the sand. There are jungle tracks between Panama and Colombia, but it is difficult to know who uses them and how often. Atlas maps are not very reliable sources for information about roads like this. The minimum criterion for a connection should probably be that there be enough traffic along a sufficiently defined corridor of at least two lanes so that drivers in fact follow the local rule of the road as they approach and leave the border crossing. It is usually possible to pin down such information about any given border by consulting travel guidebooks like the Lonely Planet series, but it takes a lot of time in a well-stocked and tolerant bookstore to do so. I erred on the side of assuming that there *is* a road crossing between two countries if there was anything on the map that looked like it conceivably might be one. In the case of North and South Korea, I

[18] In December 1995 I did an informal survey of several dozen "getting around" sections in Lonely Planet guidebooks. Only about half of them mentioned the local rule of the road.

considered that they share a road boundary even though for political reasons there was probably no cross-border traffic in 1986. However, in a few "borderline" cases I made decisions in order to avoid misrepresenting the actual influences of neighbors on a territory's rule of the road. For example, the atlas shows what looks like a very crude road connection between Brazil and Guyana. But if it exists, it is local only and not connected to the rest of the Guyanese network, and since Guyana has no other road neighbors, counting it would vastly overstate the influence of Brazil on Guyana's decisions about the rule of the road. I excluded it.

My analysis can be criticized for not taking into account the varying "strength" or "importance" of a territory's neighbors and the varying length of its boundaries. Hungary's boundary with Austria is much longer and more heavily trafficked than Hungary's border with Slovenia. A more sophisticated analysis might attempt to take this into account. However, it is an attempt that might fail. Trying to measure the strength of the connections across each border by counting roads would run into even more devilish problems of comparability than this study already suffers from. Cross-border traffic statistics certainly exist for some countries, but they do not exist for all and the methods of collection are not always comparable.

There is really no alternative to these compromises and distortions when one tries to make systematic comparisons within the absolutely unsystematic, messy political geography of the world. It is easy to focus on the problem territories, but most cases are clear-cut. My atlas data and the data from Kincaid are as well researched as one could hope for, and in the overwhelming majority of cases, coding and interpreting it was straightforward. The compromises that I made were the minimum needed to be able to run the analysis and do not undermine the principle of it in any fundamental way. Most importantly—because having to exclude a territory contiguous with any other would have caused difficulties with my count of "neighbors"—Kincaid's data allowed for an almost certain determination of the rule of the road in 1919 for every one of the world's non-trivial territories.

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